RILAB - architectural envelopes

From spatial representation (generative algorithm) to geometric physical optimization (scientific modeling)

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Augmented graphical thinking operates by integrating algorithmic, heuristic, and manufacturing processes. The Representation and Ideation Laboratory (RILAB-2018) exercise begins with the application of a parametric definition developed by the team of teachers, allowing for the construction of structural systems by the means of the combination of segmental shells and bending-active. The main objetive is the construction of a scientific model of simulation for bending-active laminar structures has brought into reality trustworthy previews for architectural envelopes through the interaction of parametrized relational variables. This way we put designers in a strategic role for the building of the pre-analysis models, allowing more preciseness at the time of picking and defining materials, shapes, spaces and technologies and thus minimizing the decisions based solely in the definition of structural typological categories, local tradition or direct experience. The results verify that the strategic integration of models of geometric physical optimization and spatial representation greatly expand the capabilities in the construction of the complex system that operates in the act of projecting architecture.

Keywords: *architectural envelopes, augmented graphic thinking, geometric optimization, bending-active*

INTRODUCTION

The progress made in the fields of information technology and digital interfaces in the architectural disciplines suggest the substitution or coexistence of the traditional concept of representation with that of simulation. While representation is based in the separation of the sign and the reality it refers to, simulation poses a scientific analogy between that representation and reality. Scientific modelling of both objects and phenomena entails the translation from one formal language able to operate universally, where the model is a simplified representation of an entity or complex process. Altough the parts and their relations are represented both in the traditional project model and the current simulation model, the differences are found in the specific techniques and methods for the translation of the object of analysis.

Simulations are new lenses for observations, decision-making, projectual choices and evaluation of the effectivity of those choices. Drawing and simulation are different but complementary ways of reading and recollecting and together they make a difference in the project attitude. Once the simulation method is adopted, the implicit values of the drawings may not apply, or are used for communicative purposes only. Simulation tends to an identification between the model and the actual building, blurring the distinctions between design (coded drawing of the architect) and construction (interpreters and executors), which has been the basis of the definition of architecture since Renaissance. The medium of the simulation does not necessary imply an understanding of the representation. Interpretation plays a minor role in the perception of the simulation, thus the experience is taken in its nominal value as an outcome and frequently not as a process in itself.

These instruments and variables of analysis give rise to a process that, given its efficiency, approaches sustainability through the optimal performance of materials used, and may unveil unknown attributes. The use of empirical-analytical research techniques as metodological tools foster the optimization of the relation between the active structural efforts, the material performance and the geometric design from the very first instances of the architectural project process. The aforementioned processes constitute emergent oportunities in our discipline in the age of the 4th Industrial Revolution. (congress main topic)

In our case, the construction of a scientific model of simulation for bending-active laminar structures has brought into reality trustworthy previews for architectural envelopes through the interaction of parametrized relational variables. This way we put designers in a strategic role for the building of the pre-analysis models, allowing more preciseness at the time of picking and defining materials, shapes, spaces and technologies and thus minimizing the decisions based solely in the definition of structural typological categories, local tradition or direct experience.

AUGMENTED GRAPHIC THINKING

Historically we needed more data than we had. Today, for the first time, we seem to have more data than we need. The growing importance of data analysis in the information society is one of the paradigms of our time. Finding effective and efficient ways to analyze them to develop predictive models that focus decision-making on a "performance-oriented architecture" are proposed as an integrative and innovative approach between architectural design, built environment and the environment. The optimization of means and resources leads us to work indirectly with a reality mediated through its records.

At the same time we can calculate, manufacture and compose customized variations on all scales with industrial materials that were standardized for mass production. While generative algorithms enable processes to search for open solutions over time, digital manufacturing is integrated by complementary techniques and procedures, simplifying and automating the execution of the complex geometries that result. The computational making allows us to create our own project instruments through the substitution; adaptation and device generation; robotic prostheses and numerical control machines.

Augmented graphical thinking operates by integrating algorithmic, heuristic, and manufacturing processes. It broadens horizons through representation, simulation, computational design, digital manufacturing and computational making.

RILAB - REPRESENTATION AND IDEATION LABORATORY

The Representation and Ideation Laboratory (Laboratorio de Representación e Ideación, RILAB) is a theoretical and practical module oriented as an Experimental Workshop, within the Architecture Master's Degree (FADU-UNL). In RILAB (2010-2018), we base our work in the project process excercises, aiming not only at learning the know-how and skills to manipulate new analog and digital instruments of projection, but also tackling the understanding of what these tools of representation and prefiguration
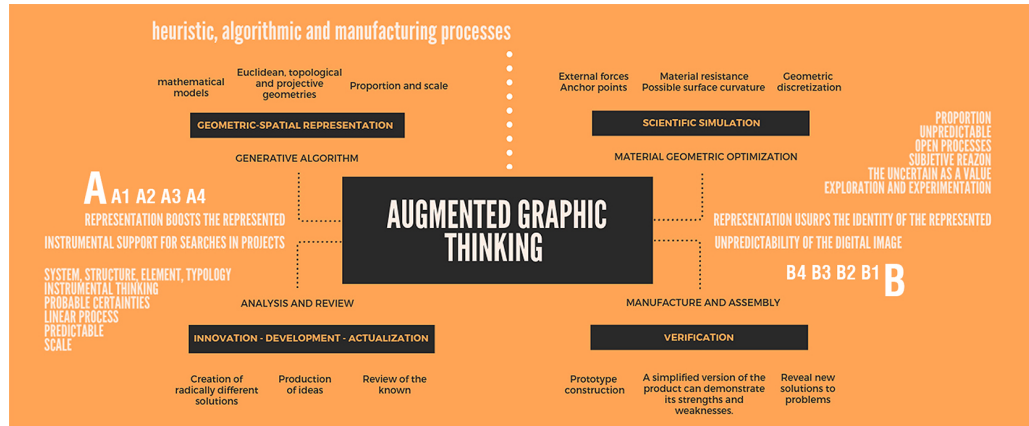
mean for the conception and ideation of the architectural discipline. Our main objective is to adapt the available technical resources with an integrating and strategic vision in order to obtain an ample capacity in the construction of the complex system that intervenes in the act of projecting architecture.

The intentional use of non-conventional resources of representation and projection are meant to assume an experimental risk though the utilization of non-habitual conceptual foundations in the epistemological and instrumental foundations of Architecture. In the last decades, shape, space and material decisions began with processes of open ideation, non-linear and mixed systems (analog and digital), whose results have more characteristics of the process itself (indices, distance between times, transits, movements, displacements, actions such as folds-unfolds-refolds, databases) than to the adoption of compositive categories (system, tipology, structure). Those strategies and multiple project approximations posit a "disruption" in the traditional graphical architectural thinking. The disruption incorporates chance as creative value and claims an argumentative absence of rationality of mediums and ends as a deterministic linearity which generates shape and space.

For almost a decade of work we have migrated from spatial representation through folding and re-folding of complex surfaces, to the definition and manufacturing of components (using generative algorithms), to the geometrical-material optimization (by means of an experimiental scientific modelling based on the calculus of finite elements.)

BENDING ACTIVE LAMINAR ENVELOPES

Digital Materiality, as current status in architectural design, sets the design focus on resource optimisation (materials and energy) in addition to the instrumentalization of bending-active, introduce a new layer of integration in architectural design. The necessary specification of material behaviour reclaims the traditional form-finding techniques as a methodological antecedent for material exploration. The empirical and analytical physical model exploration for the logic conception of the complex forms is amplified with the implementation of numerical calculation computing and its capability for simulation and digital evaluation.

"Optimisation-oriented design focus resides in the way that material performance is understood and instrumentalized to revert the modern paradigm of the industrial revolution, of homogeneous, static, inert materials of isotropic, uniform composition, which led the material to be conditioned to its pas-

sive use, preset with typologies of spatial and structural dispositions anchored to the paradigms of classical mechanics".(Gronda, Chiarella, Veizaga, 2017)

The active bending, understood here as a design approach and not as a predefined structural typology brings in a new layer of integration in architectural structure design and opens new complexities for the process of architectural design. The last excercise proposed to the attendees at RILAB has set the following goals:

- TO REFLECT on the conceptual and technical implications of the analog/digital ideational media through a practical drill of geometric generation and optimisation of laminar envelopes with complex surfaces.
- TO EXPLORE the possibilities of integration of parametric design to the NURBS and Mesh modeling thorugh the production of a self-supporting laminar envelope.
- TO VERIFY the structural advantages of laminar envelopes generated through bending-active flex on the basis of analog-digital form-finding strategies.
- TO BUILD a physical prototype model of bending active laminar envelope through unfolding and graphical description of the strategy for assembly process of its components.

The exercise begins with the application of a parametric definition (with few restrictions) developed by the team of teachers, allowing for the construction of structural systems by the means of the combination of segmental shells and bending-active. This way the students are provided with a very simple definition of Grashopper for the searching of digital shapes with the Kangaroo physics engine (tools which, in general, the class has never worked with before). The Kangaroo physics engine aids the students to improve their intuitive understanding of the structural behaviour of the geometrically complex shapes. Kangaroo has made new developments in interactive simulation, optimisation and shape searching within Grashopper which can provide the students with an accurate esti-

mate bending geometry and, for this reason, the tool has been selected for the RILAB-2018 workshop. The main benefit in the shape searching on Kangaroo is that the designer can integrate a quick simulation in the first design stages without the need of writing a routine of dynamic relaxation and therefore, can guide de design towards informed and optimized solutions. The potential of this design strategy lies in the unlimited variety of topologies and geometric expressions that can be generated. This is how a round trip between digital simulation and physical verification begins with the aim of optimizing the different design proposals.

In a second stage, the shape is discretized for the digital manufacturing of the surface segmented in developable components. For digital manufacturing, a laser cutting machine and standarized rigid plates are used. Materials and digital manufacturing tools have been selected in accordance with their feasibility and suitability in connection with the prodution environment. The goal set for this stage is to verify the prototypes physically and in scale by using highly restrictive materials for efforts other than bending-active flex.
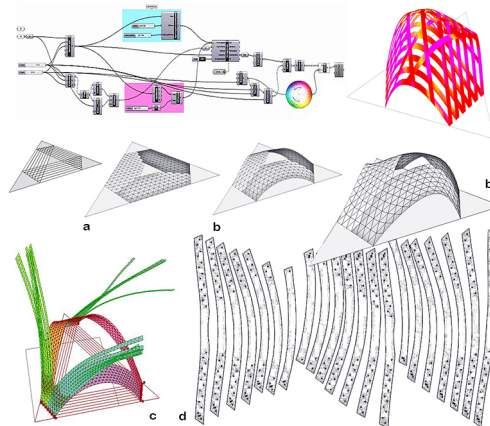

Figure 2
Parametric definition developed by the team of teachers and shape discretized for the digital manufacturing of the surface segmented in developable components.

In these practical drills of generation and control of spaces and architectural envelopes, we observe that two instances (stages or actions) are manifested be-

tween representation, ideation and the use of technologies (augmented graphic thinking), and they oscilate in priority and hierarchy during the first stage of the design process:

a) REPRESENTATION BOOSTS THE REPRESENTED

The first of them prioritizes that representation or digital simulation acts as INSTRUMENTAL SUPPORT FOR SEARCHES IN PROJECTS. It is more conducive, linear and forseeable, and lets the student make slow progress with plausible certainties where instrumental reasoning guides the whole process. The work is based on design antecedents (a recollection of shapes and tipifying solutions gathered by the student in the early stages of her disciplinar training). Traditional concepts of System, Structure, Element and Typology as the common conceptual foundations of our discipline can be encouraged without causing contradictions in these instrumental actions. Graphic media and representation systems hereby ensure precision and exactness of the projectual process. Working with the notion of Proportion over that of Scale in the proposed excercise seemed strained given the chosen modality. The metric condition of the designed object strives to make itself visible as soon as possible and it is precisely in the determination of the scale when this condition is regained. Several students approached the drill from these expectations, boosting the importance of the application of these rationales, whereas others simply sheltered in the certainties posed by the modality, without being able to achieve and transcend the first objective of the drill.

b) REPRESENTATION USURPS THE IDENTITY OF THE REPRESENTED

In this case, there is high level of exploration and experimentation where UNPREDICTABILITY OF THE DIGITAL IMAGE acts as a brainstorming, luring situations, shapes, paradigms and referents from past memories, especially from early stages of the university training. Processes tend to be more open and non-linear, and exploration puts temporarily on hold the traditional notions of System, Structure, Element and Typology to focus on the spatialties

suggested by the new resolutions derived from the "bending-active laminar structures". Here, the exploration of conceptual resources and instrumental technical means shifting from disciplinar orthodoxies and advance towards new realizations and appropriate project capabilities, perhaps in the direction of contemporary issues and spatialities. Purely metric and scaled to fit workflow causes discomfort. The temporary use of spatial proportions facilitates the exploration relating to nearly-topological relations (which relate continuity-discontinuity lacking metric exactitude). It is perhaps the rationality in the mediums and ends, such as shape-generating deterministic linearity what proclaims new project approaches. The students that were able to address this potential arising from the drill have faced the limits of the materiality in the stage of physical verification, forcing them to reconsider their initial project decisions. In both exposed procedures, the obtained results are highly satisfactory, which demonstrate the amplitude of possible workarounds for the proposed drill.

This excercise mainly focuses in the processes of analog-digital shape-searching, and introduces experiments based on the bending-active flex fundamentals, a structural system that relies specifically in high elastic strains to generate and stabilize complex geometrical shapes based on initially flat elements. This procedure allows to build continuous surfaces in a free way with structural efficiency from simple curve laminar elements - developable strips. The process of building is simple and affordable, with resources widely available in the local market, and are industrialized and comercialized in the near environment of production, which makes the projectual experience feasible.

DISCUSION

Contemporary architecture has caused a change in paradigm as regards the concepcion of the façade, which ceases to be a heavyweight, structural element of buildings to become an envelope, skin or membrane with the capability of protecting the inside, act
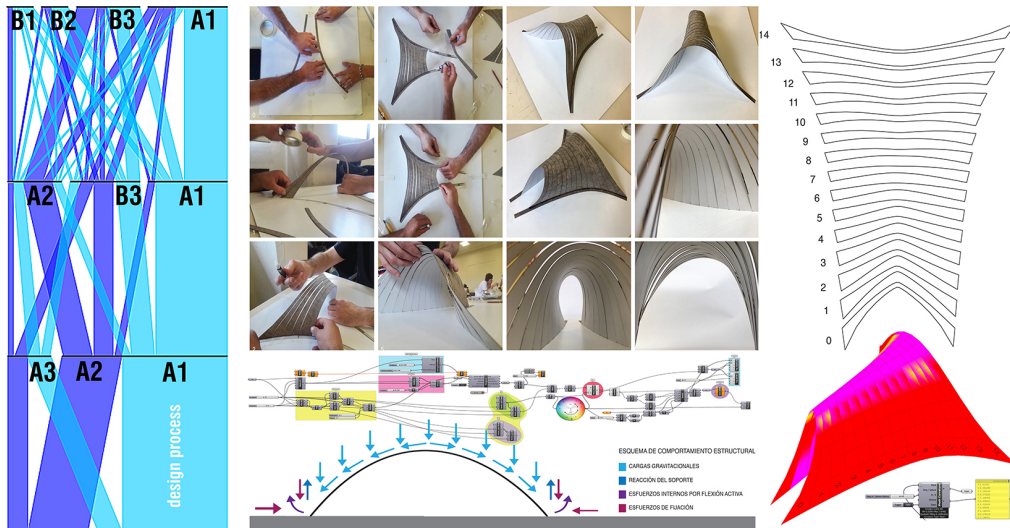
Figure 3
Analysis of the design and synthesis process of the exercise of: Bochatay, Giorgis and Muñoz (RILAB2018)
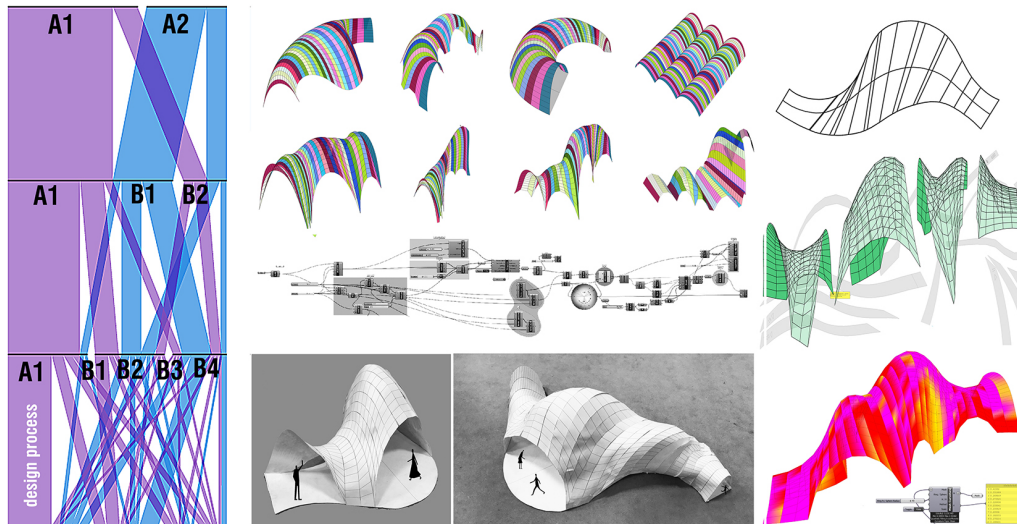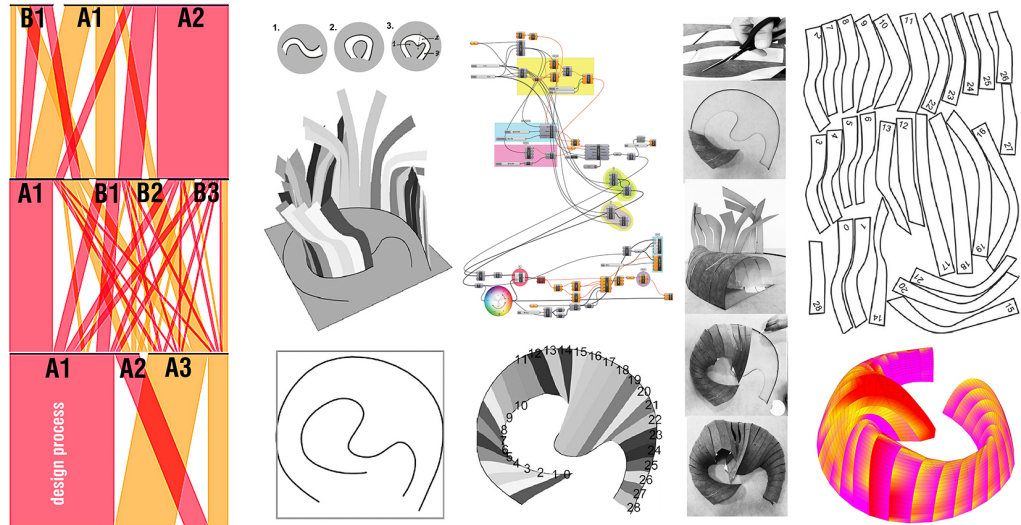

Figure 4
Analysis of the design and synthesis process of the exercise of: Aguiar, Burgos, Cernigoi and De Vido (RILAB2018)

Figure 5
Analysis of the
design and
synthesis process of
the exercise of:
Bancora, Bianchi,
Grilllo and Pereyra
Mussi (RILAB2018)

as a subtle, more sophisticated filter for the sun and wind, improving the thermal and perceptive inner conditions. The envelope is filter, transparency, protection, privacy, movement, screen, absorber and inner well-being. Far from incorporating sophisticated materials, we are interested the question of how can we expand the properties of spatial envelopes and architectural skins from Parametric Design, Digital Production and Digital Materiality in the instances of ideation. The potential of the developments resides in defining the materiality of the skin departing from the definition of a variable geometry that responds to external environmental data and constitute bending-active structural components. This investigation is included in the theoretical-methodological context of Active Matter, defined and caracterized by the state-of-the-art process of assimilation of digital logic, the "new" material condition and the implementation of integral processes in the field of Architecture. The research presents a design approach that reverts such separation and division in its methodology.

By establishing feedback between digital media and physical prototypes, the creative process revisits the material characteristics, structural properties and changes in scale. The educational objective was to use a parametric model, not as a representation tool, but as an instrument for exploration of shapes in real time (brainstorming), which will incorporate both the physical behaviour and the simulation of the effort to the bending. The physical models and testing of materials were documented, and a first set of observations provided the students with a starting point for the study of the behaviour of structures, given the level of freedom for the generation of shapes in digital environments and, given the restrictions imposed by the materials, design decisions relate mainly with simple geometrical actions. In particular, the insertion of rigid materials reconfigures the design space.

On the grounds of the discoveries (in the field of) structural behaviour, "generalized" design rules for bending-active structures are highlighted. With the objective of supporting the ongoing investigation on bending-active flex structures, a set of experiences based on simple actions that illustrate the potential of the design strategies are proposed to illustrate the flexion as a self-training process. The

primary stress is found in a prospective system of form-finding prearranged with the focus on comprehensive and dynamic design, which may lead to a real-time structural shape discovery which maximises the operational relationship between geometry, materials and structure, a significant shift in the design processes which operates over the collective generalizations and organization of formal structures and preconceived information. The design focus based in performance is beginning to register the new paradigm; the Digital Materiality allows for a direct, non-representative connection towards a vision of Architecture as dynamics in response to contextual materials, behaviours and contributions.

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