

Proceedings of the International *fib* Symposium on the
**Conceptual Design
of Structures**

held in Attisholz Areal, Switzerland, September 16-18, 2021

edited by:

Corentin FIVET,
Pierluigi D'ACUNTO,
Miguel FERNÁNDEZ RUIZ,
Patrick Ole OHLBROCK

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ISSN 2617-4820

ISBN 978-2-940643-12-7

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themes & contributions

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Structuring a common ground: vectors, notes & stories

Tiphaine Abenia, Agathe Mignon, Camille Fauvel

tiphaine.abenia@epfl.ch, agathe.mignon@epfl.ch, camille.fauvel@epfl.ch

Abstract

This article proposes to open up the understanding of the notion of structure in order to widen its role as a crucial actor in the making of architectural and urban narratives. Merging explicit and potential dimensions, material and immaterial realities, this proposal goes beyond the dichotomy between structural exhibition and concealment.

Following Buckminster Fuller's thoughts [1] inviting us to consider structure as a plural notion going beyond material concerns, the article investigates three levels of definition attached to structure. The first level is the most literal and material one, where structure reads as the built skeleton of the project. The second level focuses on structure as a strategy of (dis)assembly, allowing us to introduce transformation and the notion of time. The third level is an immaterial level fostering an interpretation of structure as a framework for multiple narrative developments. Behind this division, an additional and transversal level appears, situating the potential of structure as an organizational and relational support, active from the design stages to the construction site.

Through a selection of case studies, developed within the laboratory of ALICE at the EPFL, this article investigates the porosities and the mutual implications of such levels. Through a decade of ongoing pedagogical practice, ALICE has explored a wide spectrum of interactions between those levels and introduced the concept of *protostructure* defined as a structural primitive state. Five cases will serve as the main material to tackle a variety of design trajectories that differ in time and context, driving the construction of different narratives on architectural sustainability.

Introduction

For more than 10 years, the ALICE laboratory at EPFL has been teaching design studio to first-year students in the architecture section. The first year, as imagined by the Professor Dieter Dietz [2], is a real machine: 10 to 16 studios - depending on the year - led by the same number of studio directors participating in a common program, but refining it according to their culture and personal expertises. From this thinking of a common adaptable framework came the desire to stimulate a pedagogical dialogue.

At first anonymous, the matrix proposed to the students is a set of project rules allowing them to share a common scale, directions, and limits and thus to compare, assemble and join. Supported by the research carried out by Agathe Mignon in the context of her doctoral thesis [3], the matrix took on the name of *protostructure*. Both an imaginary reference system and a physical framework, the *protostructure* will soon be at the core of several experiments carried out on a 1:1 scale with all the first-year students. The last five projects form the corpus supporting this contribution: House 1 (EPFL Campus, Lausanne, 2016), House 2 (Toni Areal, Zürich, 2017), House 3 (Kanal, Brussels, Belgium, 2018), House Garden 1 (Evian, France, 2019), House Garden 2 (*The (Real) Book*, Geneva, 2020).

If a chronological evolution is evident with each realization bringing a new milestone of understanding, the purpose of this article is to explore other ways to link their trajectories. We propose to explore these case studies through the prism of three levels of definition attached to structure [3]. The first level is the most literal and material one, structure is read as the built skeleton of the project. The second level focuses on structure as a strategy of (dis)assembly, allowing us to introduce transformation and the notion of time. The third level is an immaterial level fostering an interpretation of structure as a framework for multiple narrative developments. Behind this division, an additional and transversal level appears, situating the potential of structure as an organizational and relational support, active from the design stages to the construction site.

1. Structure as a Built Frame

For the first year of the HOUSES pedagogical program, the Alice laboratory team proposes to the first-year students to occupy a timber structure built at scale 1:1.



Fig. 1 Vectors. Construction site of House 1 (House 1, EPFL Campus, Lausanne, 2016)

1.1. Vectors: Repeating Structural Frames

Measuring 11 meters wide by 11 meters long and 11 meters high, the *protostructure* of the House 1 project (EPFL Campus, 2016) has the format of a house and its construction is directly inspired by balloon-framing. This construction system, which appeared at the end of the 18th century in the United States, was based on the concomitant development of the wood industry and the small hardware industry: wood became available in small sections and nails could be manufactured easily and in large quantities. Unlike traditional framing, which works by assembling massive pieces of wood and working between them, the balloon-frame system is based on a logic of frames made up of nailed boards. It thus allows a fast construction which requires little labor and is thus particularly well adapted to the field of the individual housing [5]. The structure set up in the pedagogical context of the HOUSE program uses its codes in a construction made up of a succession of frames assembled by horizontal ledgers. The analogy with this system is pushed to the implementation of uncut sections assembled thanks to a logic of overlapping.

The repetition of the frames at regular intervals and their assembly by ledgers establishes a system of reference by describing an orthogonal reference. At the scale of the structure, all the frames are parallel to each other and the pieces for their assembly are perpendicular to them, creating three axes of reference. At the scale of the frame itself, the logic is reproduced. The joints between the pieces of wood use the geometric properties of the boards and are made at right angles. However, the intervals between the frames and between the assembly ledgers respond to different structural issues and are therefore not equivalent to each other. Without necessarily being orthonormal, the reference system drawn by the structure proposed as a basis of work offers, by the nature of its construction, a series of vectors on which a broad set of projects can be implemented.

1.2. Nodes: Materializing a Reference System

The design of the frames and the assembly of the parts between them therefore describes a particular coordinate system, each node of which constitutes a reference point. Unlike a theoretical mathematical reference point, the structure's reference point includes the thickness imposed by the construction. Each

node is not simply the crossing of vectors but the assembly of several pieces of wood together. It therefore has an orientation, a meaning, that differs according to its location in the structure. Like the vectors described by the assembly of the frames, the network of nodes does not follow a regular system but has its own logic in response to the geometry of the structure.

The first phase of the design studio consists of appropriating the code of this landmark through the tool of drawing. Each of the students reproduces, by hand, the plan and section of the structure in order to grasp its dimensions and spatiality. The structure as it is composed proposes several spaces of different natures, according to the height or the position in the plan, which are thus locatable and characterized by this system of coordinates. In pairs, the students then invest this collective system by grafting their project onto it and developing a program. This phase allows each student to appropriate the code of this structure, which acts here as a support, just as the grid of a sheet of paper would have. Without constraining the nature, the dimensions or the appearance of the projects for which it is the starting point, the structure offers a common ground for experimentation.

1.3. Stories: Balancing Parts and Whole

If the structural character of this construction is ensured thanks to its role as a support for the design brief and thus its power to organize and contain the collective project, the same cannot be said of the statics. The construction of the structure does not have the capacity to carry the additions that the projects represent, it only carries its own weight. During its erection, many parts are added to reinforce the initial design in order to guarantee its stability. Both represented in a 1:5 scale model and built to scale 1:1, the basic structure is unable to support the weight and stresses due to the addition of material. By constituting a part of the whole, each of the interventions must then consider its own load and ensure the balance of the whole. This translates into the need to establish the structural scheme of each project and to confront it not only with the one established for the whole structure, but also with the ones from the other surrounding projects in order to compose a global scheme.

This choice has a great influence on the nature of the projects produced in the first HOUSES program. If they each respond to specific programs and deploy different spatialities, they are linked by their belonging to the collective construction. The same is true for the structure that constitutes the basis of the exercise. If some of the pieces added to ensure its balance are eventually replaced by certain parts of the projects, the structure persists in the midst of the students' interventions and built of the same wood, it melts into the density of the construction. In the specific context of this exercise, the structure plays with the complexity of its definition to go beyond the role of purely static support. Without cancelling the need to understand and implement a stable construction, it accompanies the development of the project by giving the rules of the game.

2. Structure as a (dis)Assembly Strategy

Confronted with a specific context, the *protostructure* becomes an instrument for reading and interpreting it. Horizontal and vertical lines are the essential guides of the site, establishing a template whose order, levels, and limits are given by the surrounding elements. From a distinct support object, the *protostructure* acquires a potential for growth and transformation.

2.1. Vectors: Setting Expansion Capacities

In Zurich (House 2, 2017), the gantry of the first version House 1 (developed as if in vitro on the campus) was duplicated along a line to follow the motorway slip road that hosted it. This expansion movement gives a strong directionality to the whole. The *protostructure* is no longer a finished object, but a system seeking its limits within the context in which it is deployed. Within it, the projects develop in contact with their environment, adapting to it and responding to it. Like a fishbone, the installation is oriented - with a beginning and an end - but retains its modularity by section, which allowed it to later be dismantled and then partially reassembled (with a slightly different order) on the wasteland of Malley in Lausanne. This segmented reassembly allowed the project to adapt itself to a new context. Named Re-play, this new iteration became the site for new experiments.

Increasing its adaptability, the system will proliferate even more and in a multidirectional way in Brussels (House 3, 2018). Colonizing the ground floor of the showroom of the former Citroën factory, the *protostructure* found here its limits where it meets the building's boundaries. It is a three-dimensional

grid in which the proportions of the resulting cell are reduced, increasing the density of the grid. It then became possible to subtract elements, resulting in a hollow core to give more air and height.

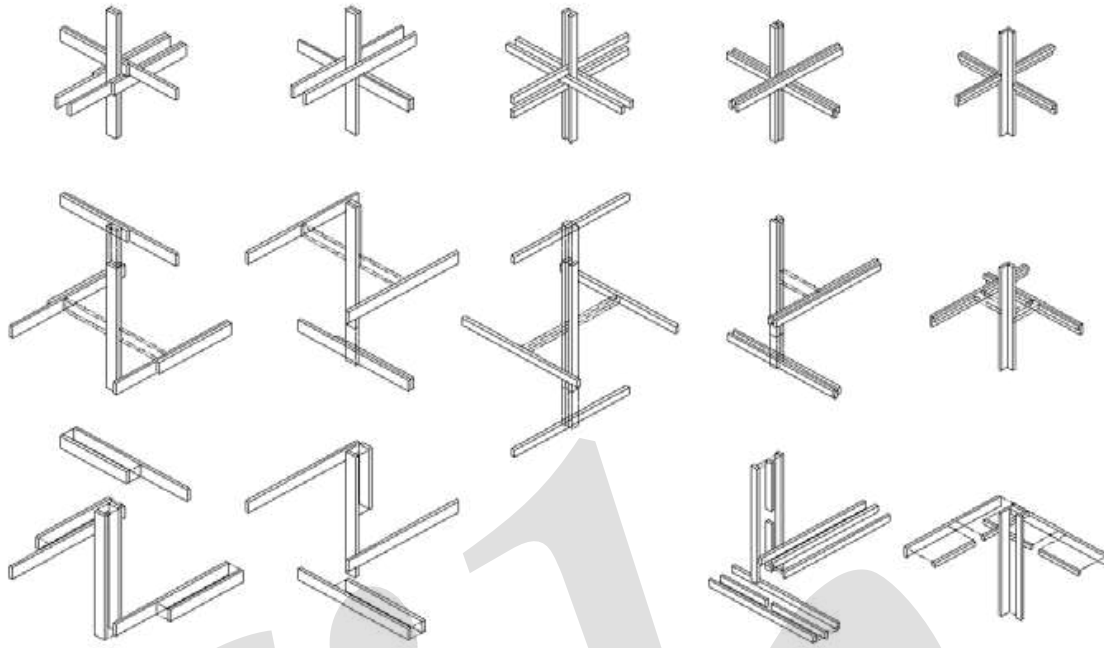


Fig. 2 Nodes. Constructive catalog of the protostructure junctions through the years (House 1, EPFL campus+ENSA Versailles, 2016-2018; House 2, Zurich+Malley, 2017-2020 ; House 3, Brussels, 2018-2020 ; Houses/Gardens 1, Evian, 2019-ongoing ; Houses/Gardens 2, Geneva, 2020)

2.2. Nodes: Integrating Demounting Strategy

This eminently urban project from Brussels explored the repetitiveness of a very simple knot, using a pinch strategy, which allowed reinforcements and additions to be developed on all sides. We are neighbors and, by immanence, we are transformed by vicinity (even if only visual). Dialogue is then not instituted, it is not obligatory, it is simply there *de facto*, with or without words and formalization.

In this inextricable situation, the *protostructure* is cut, knotted, reknotted, but nevertheless keeps its properties of total (dis)assembly. As for House 1, the knot, like the vectors, is a guide. It supports a vocabulary of the encounter that allows to safeguard one of the visceral potentials of the *protostructure* : the possibility of an elsewhere, of an otherwise...with the same elements. The respect of this common vocabulary also allows for a segmentation of the construction process. The *protostructure* was initially assembled on its own. It then housed the projects of the 11 studios, which were entirely prefabricated in Lausanne and transported by semi-trailer to finally be assembled in barely 10 days of intense activity.

The installation, although completely collapsible, is extremely well integrated into its context. Like its predecessor, it cannot be moved and segmented as it stands. Its potential for reuse belongs to the theme of mutation. Like an exquisite corpse, the support frame allows one to change the order of assembly of the pieces to suit another situation. Moreover, the predominantly bolted assemblies and the clamp of the node, added to its indoor location, make it entirely recoverable. Ironically, due to a lack of foresight and planning, the project was reduced to a pile of matches. Thoughtlessly cut up, the materials were transformed into waste. The sustainable logic of assembly (keeping full lengths of 5 meters joists) only met a theoretical relevance for this project.

We have investigated to understand if the dismantling strategy was too deeply linked to the design process, not allowing any other organization to take over the recycling process. A tender process has been organized by the organism managing the place and several answers has been received from specialists of the reusing question. The method was feasible but, due to a stress linked to the first COVID period, the process has been abandoned. Nevertheless, the dismantling - even disassembling - to the board, threaded rod, washer and nut, as proposed here, takes time [6], requiring arms to carry, eyes and hands to sort. Time and human energy consuming for the first part of the loop, reusing is still generally considered as economically unviable.

2.3. Stories: Stimulating Unexpected Longevity

In 2019, the grid extended from the mouth of the Venauge on Lake Geneva to Evian on the other side. There, the buvette completed in 1957 by Jean Prouvé for the Evian thermal baths became a generating element of departure with which the students entered into dialogue. The expansion of the grid, both in plan and in section, also made it possible to spread over the steep slopes of the thermal town towards the high woods and the Grange au Lac (a concert hall designed by Patrick Bouchain for the Evian Resort in 1993). The protostructure is then only partially materialized, but its complete deployment through the drawing allowed the Lake Geneva to be considered as a federating geographical entity and no longer as a border. Changing scale, the grid became territorial. This gesture of transcalarity profoundly transformed the protostructure as a pedagogical and design tool, marking the beginning of a new study cycle for the first year, turned towards the Lake Geneva basin.

Without inherent physicality, the matrix is initially regular and without limits. In this mathematical expansion, the choice of reference levels makes it possible to establish neighboring relationships. Then the encounter with elements of the context such as a tree, gives it edges to follow, an existence. It is stopped, cut, deformed, and thereby gains its thickness. The square, non-oriented cell is first a measuring instrument of the territory, but once materialized, takes on a structural role. The knot tightens, the horizontal and vertical elements intertwine to better support each other, the interaxis sometimes doubles to become directly load-bearing. The protostructure does not “land”, but melts into the ground, leans on the slope, settles down, becomes one with the place. So much so that some projects remain beyond their original timeframe. After two years in place, they are still standing, sound and well. No longer completely ephemeral, they have, by a gentle mutation, passed into the camp of the provisional that seeks to last. This is not “for lack of a better term”, but an opportunity seized, partially stimulated by the imaginary world conveyed by the Grange au Lac and Bouchain’s design attitudes. At ALICE, students and studio directors initiate projects without a program: the main aim of which is to play with the context in order to open it up to visitors with no other goal than, maybe, an impromptu stroll, an unexpected stop, a endless lunch break.

In Evian, the parts with the most fragile structural resolution, will be dismantled before winter 2019. Unbolted, unscrewed, sorted, they were not stored in pieces and will not come back to life elsewhere. The raw material was used the following year to start a new cycle on the banks of Lake Geneva. The spatial experience generated by the projects, so closely linked to the site, could not be carried over elsewhere this time. As for the remaining projects, they are surprising. In particular, their durability and their visitation patterns (weak but existing and benevolent) supported the alternative to maintain them, to follow their evolution.

From this patient observation, a practice of care took root. In spring 2021, a new teaching cycle will take place in Evian, on the site of the remaining projects [7]. A cycle designed on site to understand what becomes of a provisory that has lasted. The site of the installation - a gently sloping wooded plot of land, private but without fences - is gradually taking on the vocation of a public space. After having built the house there, we will try to cultivate the garden. The protostructure, at once a support, a tool, and a guide, still relies on a clear posture. One can then stick to it or transgress it, as it is the case with any set of rules.

3. Structure as a narrative framework

3.1. Vectors: Tracing territorial datum

In the fall 2021, the ALICE first year program restarted with the will to tackle the Great Geneva area, a cross-border agglomeration counting more than 200 municipalities. To open a dialogue with this vast territory, the shift in the framing already initiated in Evian is strongly reinforced. Instead of thinking of a localized and centralized main intervention, the Great Geneva House-Garden project is envisioned as a network of small interventions precisely sparse across the territory, a vast playground to host the reflections and interventions of the 10 design studios. To support the activation, by dissemination, of this large area, a common narrative is needed. Here, the design of the protostructure plays a crucial role. Its main principles remain open to modifications according to each site specificities: its dimensions, orientation, and subdivision are direct supports of negotiation. In particular, the different levels attached to the horizontal elements of the protostructure are carefully thought through. Each level, following the x and y axis, is not only related to the body and its potential of movement, but is also a response to its immediate surroundings. A specific datum can be created as a response to the local canopy height,

whereas another one can echo the average level of the Rhône river. In the words of the pedagogue Donald A. Schon, the protostructure then actively encourages a “reflective conversation with the materials of the situation” [8]. This conversation connects the student-architect and the site through the protostructure which is understood as a sum of vectors fostering an active dialog with an existing site and its lines of strength and potential.

Hence, the protostructure can help to open a dialog with one’s immediate surroundings, initiating stories of negotiation and installation. On a wider scale, it also helps connect a specific intervention to other sites, through the definition of transversal datum shared among a whole territory. To build a common ground linking projects that are not only physically far away from each other, but are also visually totally disconnected from each other, requires strong narrative lines. The proposal was to trace, using the vectors carried by the protostructure, common territorial datum. Altimetry of structuring site elements across the Great Geneva territory were identified [9], becoming levels of reference attached to the protostructure and forming a latent stratification shared among all the students. Those altimetry lines became immaterial strings connecting different sites, encouraging students to question the characteristics of their own location in relation to the experience of other students working at the other edge of the Great Geneva.

3.2. Nodes: Building a Shared Operative Language

The will to activate a large territory by a multiplication of small, precisely located interventions is somewhat reminiscent of the unbuilt project *Magnet* from the architect Cedric Price. This project proposed ten small urban structures to be placed in cities to stimulate public movement. Each structure was designed to make underused sites operate more beneficially by enhancing access and social experience for all. The magnets were understood as temporary catalysts of specific locations, for a specific timeframe. All the envisioned structures dealt with typical urban conditions and relayed on a paradigmatic urban vocabulary (platform, stairways, grand arch, arcade, promenade, pier, etc.): “[the magnets] all reference architectural elements that extend human circulation” [10]. This last point is of importance in the understanding of structure as a narrative framework. A *Magnet* is neither a finished object, nor an isolated statement. Each of the ten structures rather participates in the construction of an open-ended lexicon for intervention, precisely defined in terms of desired effect and intended impact but quite undetermined in terms of form and materiality. Those characteristics allow Price and his associates to think of implementing the Magnet series in very different urban contexts such as London or Tokyo.

Something similar is at play in the ALICE Year One pedagogy, not only for the Great Geneva House-Garden project but in all the iterations previously discussed. As newcomers into the ALICE laboratory, one of the first striking observations concerns the specific lexicon used. In the first place, the use of words and notions - unknown for outsiders - is disruptive. After few months though, the teaching team endorsed it and, more importantly, the use of the lexicon strongly spread among the students. “Protostructure”, “protofigure”, “cell”, “node” ... a whole set of notions landed in the studios, now supporting the on-site investigation and the design process. A common new language? Yes, but one still opened to a plurality of exemplifications and interpretations. The notion of “node” gives us a good example. Attached to the DNA of the protostructure, it literally speaks of the constructive junction between the x, y and z orthogonal axis. It also relates to the junction between the protostructure’s vertical elements and the ground. For the launching of the second semester 2021, 4 of the 10 studios [11] ran an experiment around the versatility of the notion of node. In groups of 2, the students were asked to design their own node, at the basis of the cell and therefore of the protostructure development. This constructive choice was not meant to be carried out “in vitro”, it was meant to be linked to their site-specific conditions (such as “feet in the water”, “steep slope”, “dense forest”, etc.). The nodes were built by each pair at scale 1:1 and positioned on site. The variety of the nodes that resulted from this experiment was very important. This large spectrum led to discussions regarding the strength, directionality, and capacity of (dis)assembly of each node. At the end of the day, if we collectively agreed that several scenarios were relevant for a given situation, we also observed that each of those iterations was the bearer of a particular story. The way we choose to anchor to a site already conveys a specific narrative by grounding a structure deeply or not, by grasping existing elements, by supporting others, etc.

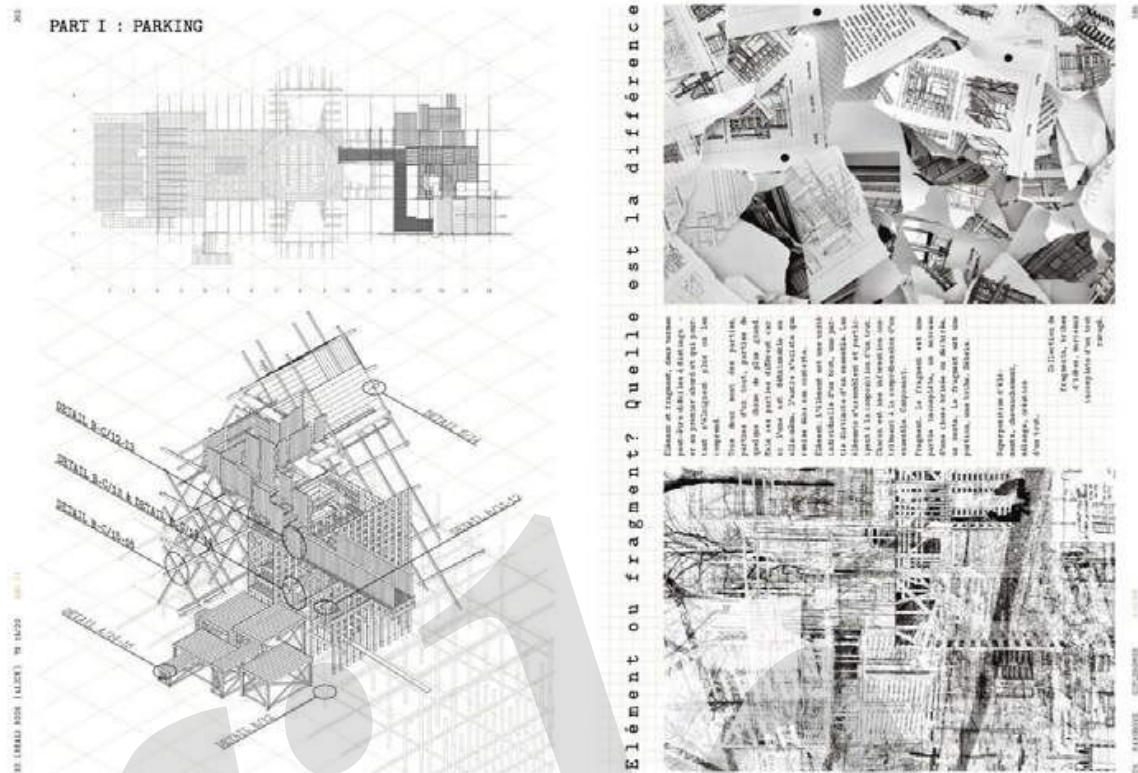


Fig. 3 Stories. Excerpts from The Real Book (Houses/Gardens 2, Geneva, unbuilt, 2020)

3.3. Stories: Structuring a Book as an Archipelago of Stories

From datum to lexicon, from negotiation to constructive imaginary, the notion of structure shows a powerful capacity to support the development of a collective narrative. This capacity was further tested in March 2020, when the period of confinement due to the COVID-19 pandemic shook the entire world and impacted our working spaces and pedagogy. The different sites planned for construction (on the banks of the Arve and Rhône rivers in Geneva) were only visited twice by the students when they suddenly became physically out of reach, accessible only through memories and digital tools. Whereas the possibility of a construction on site was less and less likely, another construct was on its way: a soon-to-be book of 828 pages, collecting the work of the 10 studios [12]. The transition from a built project to a printed book was not hazardous: the protostructure, introduced as a collective framework enhancing dialog and collaboration, probably laid the groundwork for such an alternative response. The structure of the book is in itself telling: rather than chapters, The Real Book consists of islands forming an archipelago of thoughts and projects. Each island (the production of a studio or of a group of cooperating studios) can be looked at autonomously or in discussion with the others thanks to a shared template holding the heterogeneity of the proposals and mediums under few common rules. The table of contents begins with an initiative driven by students from different studios: “A1.1 Transversal narrative”. It consists of a series of short texts, punctuating the whole book, revisiting the last months spent in confinement and questioning the impact this context had on the construction of a common narrative. They observed: “What is certain is that a real difficulty of tuning the different imaginaries intervenes in time of distancing. It nevertheless seems judicious to go beyond this observation and to conceive this diversity as a real energy of the projects” [13]. Instead of seeking to align the interpretations, which would have probably led to a series of compromises and a search for the lowest common denominator, the students agreed that it was appropriate to work with divergent views and histories (including fictional narratives, myths, and speculations). Rather than juxtaposed, those narratives ended up actively cohabitating within The (Real) Book framework, very much like the students’ projects entered into dialog within the material protostructure.

Conclusion

Through the successive pedagogical experiences of the HOUSE 1 program, we had the opportunity to explore different aspects of the notion of structure and the implication it can have in the construction of the architectural narrative.

In the first part, we have seen how the mode of construction of the structure can frame the project exercise by creating a system of reference points. In a second part, we discussed the capacity of the structure to contribute to a strategy of modular assembly, to the expansion of the project, and perhaps to its dismantling and reuse of parts. Finally, in the last part, we introduced the importance of a common extended lexicon around the notion of structure, fueling the architectural project and narrative.

A fourth aspect appears in a transversal way. Beyond the final architectural production, working with a structural grid offers both organizational and relational potential. The catalog of parts and assemblies creates a common working base that allows for adaptation to very different project scales by facilitating logistics. This catalog also makes it possible to regulate the relationships between the various actors in the project by creating a specific vocabulary that is transversal to all the parties.

It is this last aspect that seems to us to be the most important in a pedagogical context. The *protostructure* that constitutes the basis of the work aims to highlight two major issues in architectural production. It is a tool that allows, through a set of simple rules, to understand and react to very diverse environments with the same rigor and it also constitutes a lexical field that leads to thinking of the project as a collective act.

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Proceedings of the International *fib* Symposium on the Conceptual Design of Structures

held in Attisholz Areal, Switzerland, September 16-18, 2021

The conceptual design of structures is at the heart of the design process and when the most fundamental and influential decisions are taken for a project. It merges experience, intuition, tradition, site constraints, technical solutions and, above all, the genius and sensitivity of the designers.

The International *fib* Symposium on the Conceptual Design of Structures 2021 generates a fruitful exchange event for academics and practitioners from engineering, architecture and other disciplines on the topic of the conceptual design of structures. The focus is placed on experiences made particularly during the design process. The discussions reflect how a project emerges, how design decisions are taken, how responsibilities are distributed, how obstacles and constraints are handled, how fundamental design principles are applied and the way the individual members of the design team collaborate.

edited by:

Corentin FIVET,
Pierluigi D'ACUNTO,
Miguel FERNÁNDEZ RUIZ,
Patrick Ole OHLBROCK

International Federation for Structural Concrete
Fédération Internationale du Béton
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ISSN 2617-4820
ISBN 978-2-940643-12-7