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PROTOTYPE PAVILION IN TEXTILE REINFORCED CONCRETE (TRC)

EPFL FRIBOURG / WORK IN PROGRESS / 2016–2022

EDITORIAL
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This publication documents the ongoing interdisciplinary research project “A Prototype Pavilion in Textile Reinforced Concrete (TRC)” by the EPFL laboratories ALICE and IBETON and research partners from the FAUFBA, Salvador de Bahia, Brazil. The TRC Prototype Pavilion, built by students and researchers in civil engineering and architecture at EPFL Fribourg, is a proof of concept of a long-established research on TRC’s structural, spatial, tectonic and social potential. The construction of the pavilion is modular and conceived to be dismantled, its aim is in the first place to test and expose innovative and sustainable construction knowledge.

The TRC Prototype Pavilion builds on research conducted during the ENAC teaching unit ‘Argamassa Armada’ (EPFL, since 2016) which is named after the Brazilian term for ferrocement. The teaching unit ‘Argamassa Armada’ analyzes and reiterates in textile reinforced concrete (TRC) selected structural elements developed by João da Gama Filgueiras Lima, Lelé (1932-2014) in ferrocement. This crossing of Brazilian industrial knowledge and contemporary research on non-corrosive fiber reinforcement creates the conceptual basis for the design, mold fabrication and casting of new slender elements in textile reinforced concrete, the conceptual basis for the TRC Prototype Pavilion (since 2019).

Textile reinforced concrete (TRC) is a relatively new construction material that is rapidly gaining popularity as an alternative to ordinary reinforced concrete for thin members. In TRC, several layers of high strength fabrics (typically carbon, alkali-resistant glass or basalt fibers) are embedded within a high-performance cementitious mortar. The insensitivity to corrosion of the fabric reinforcement allows reducing concrete cover to minimum static needs (required to develop bond stresses) and thus opens the possibility to cast extremely thin and light elements, typically 10-30 mm thick. In addition to this aspect, the textile fabric is usually arranged in the form of semi-flexible bidirectional grids, allowing to easily adapt to complex shapes and to efficiently arrange the fibers in the regions of the largest tension demand. The implementation of non-metallic reinforcement allows for the use of low clinker-content cements since no passivation of the reinforcement is required. This has shown a potential to drastically reduce the CO2 footprint of concrete, leading to a more sustainable application of the material, which, together with the slender thicknesses leads to a new conception and image of concrete construction at large.

Textile reinforced concrete allows to reiterate a building technique—Argamassa Armada—that was highly developed in Brazil but in the last years nearly abandoned due to problems of corrosion. An important aspect of Argamassa Armada / TRC is its social sustainability: the radical lightness of TRC elements allows to build infrastructural and architectural components with limited means (molds and elements can be lifted by hand) and in contexts with poor infrastructure or difficult access due to the topography. TRC elements can be produced using raw material from the local soil and combine industrial processes with local craftsmanship and unskilled labour. This will allow inhabitants of the informal city to co-construct their own environment by using a resilient, durable and sustainable building technology which uses a minimum of material to build high strength and large span elements affording structural security and spatial quality. The TRC Prototype Pavilion functions as an experimental construction site and knowledge interface that explores and exposes these aspects in built form.

A PROTOTYPE PAVILION IN TEXTILE REINFORCED CONCRETE, SUMMER WORKSHOP AT EPFL FRIBOURG (ongoing, since 2019)

STUDENTS

2019
EPFL: Michele Albertini, Yacouba Bally, Lucas Barrière, Laurianne Chassot, Arnaud Delfino, Vincent Devillers, Thomas Drouin, Battsooj Enkhbaatar, Mohammad Hossein Esmaeelzadeh, Gabriele Falconi, Sylvain Freiburghaus, Adrien Glaus, Lancelot Graulich, Marco Lnadert, Isaac Monnin, Selimcan Ozden, Madeleine Pugin, Abdu Rahmaty, Enea Sala, Lucas Shooner, Karl Valfells
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2020
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2021
Jeremy Bussat, Valentin De Britto Tavares, Thibault De Oliveira, Micky, Gerardi, Marc Gerber, Téo Golay, Bruno Känel, Kevin Navarro Cruz Pereira, Lionel Progin, Chloé Schindler, Pierluigi Surano, Nicolas Tireford, Alexandre Vallet

2022
Manon Bertola, Dimiti Descloux, Adam El-Hamadeh, Juan Garcia, Iris Gibourg, Lancelot Graulich, Alberto Johnsson, Hervé Laurendeau, Vincent Luetto, Bryan Marques, Anna Mccuan, Flavio Nogueira, Ghita Ouassini, Débora Pereira Correia, Roman Ramseyser, Karen Schuker, Noemi Tschabold, Karl Valfells, Medhi Wermuth

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Oria Abbas (2022)

TECHNICIANS EPFL FRIBOURG

Claude-Alain Jacot,
Stéphane Pilloud (since 2022)

Fig. 1.1 TRC Prototype Pavilion, EPFL Fribourg, 2022

Fig. 1.2 TRC Prototype Pavilion, EPFL Fribourg, 2022

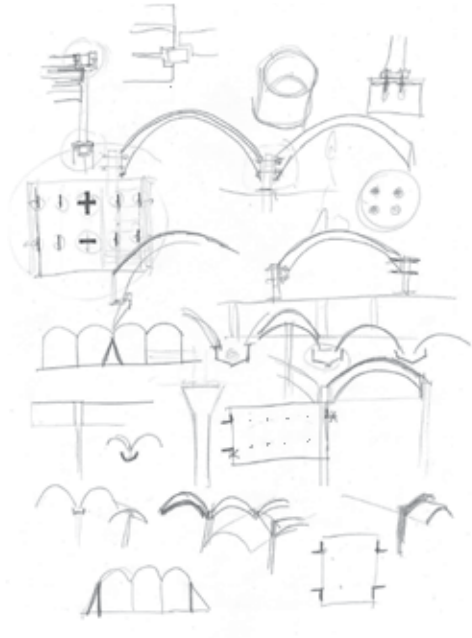
Fig. 1.3 Barrel shell vault after taking off of upper part of mold, 2022

Fig. 1.4 Wall elements, detail of connection to slab, 2022

Fig. 1.5 Adjustment and fixation of slab elements, 2022

Fig. 1.6 TRC Prototype Pavilion, EPFL Fribourg, 2022


Fig. 1.7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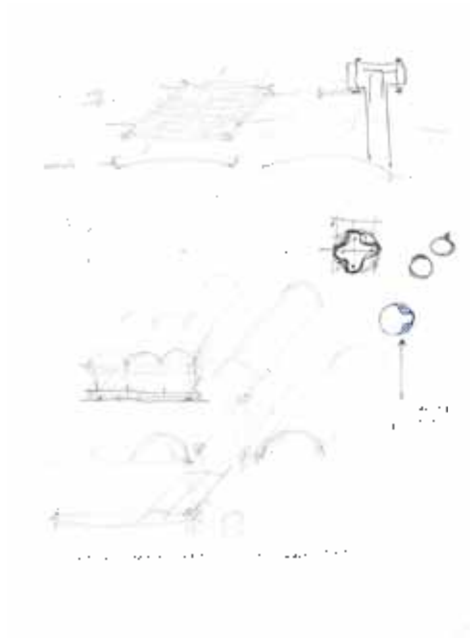
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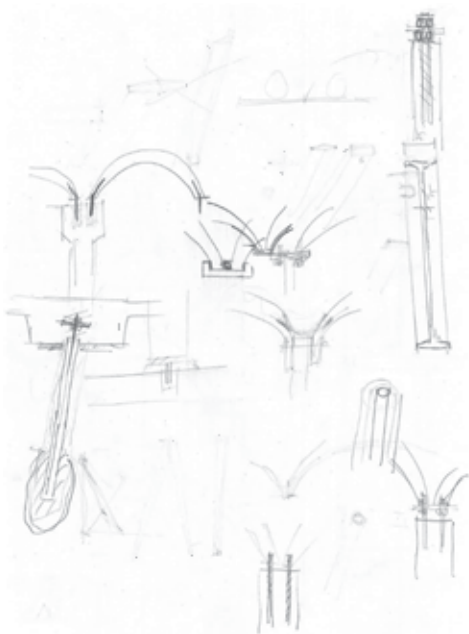
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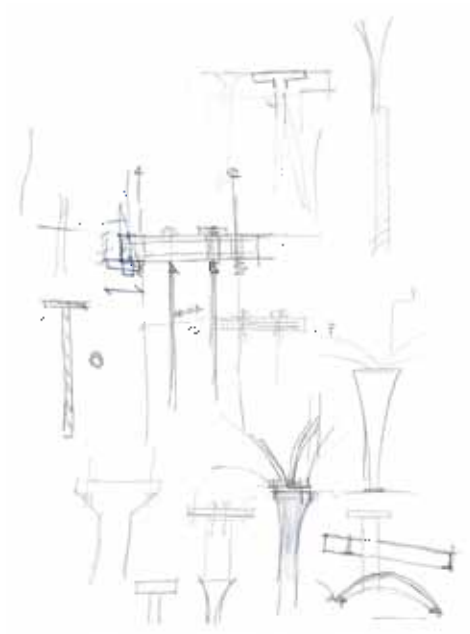
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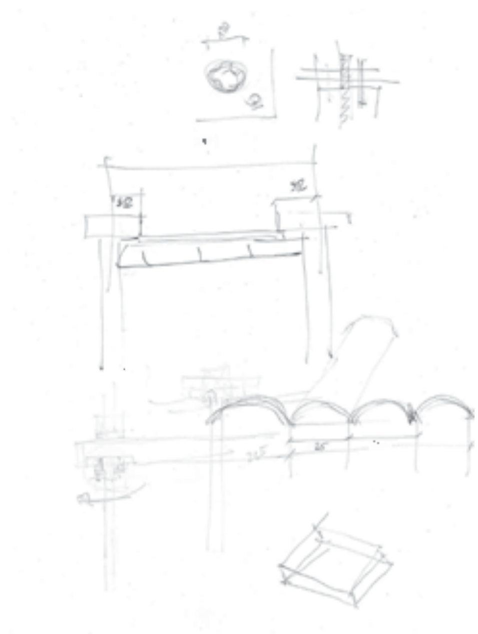
Fig. 1.12


Fig. 1.13

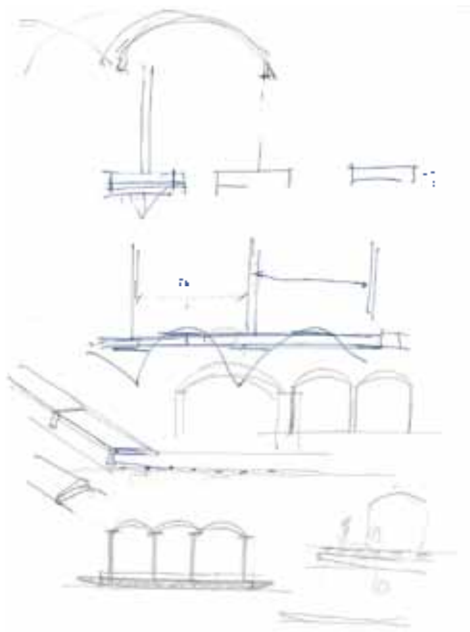
Fig. 1.14

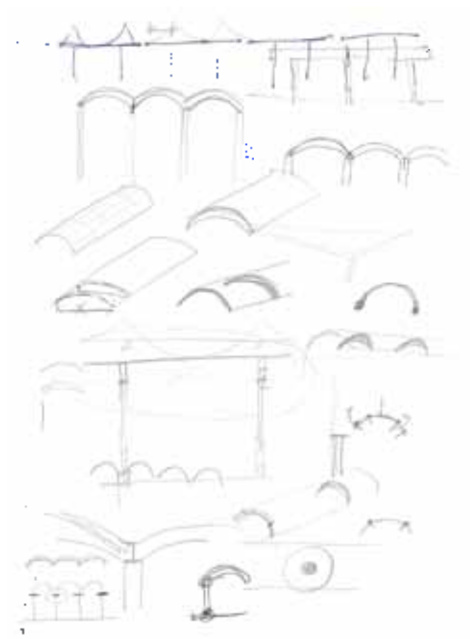
Fig. 1.15

Collective sketches, 2018

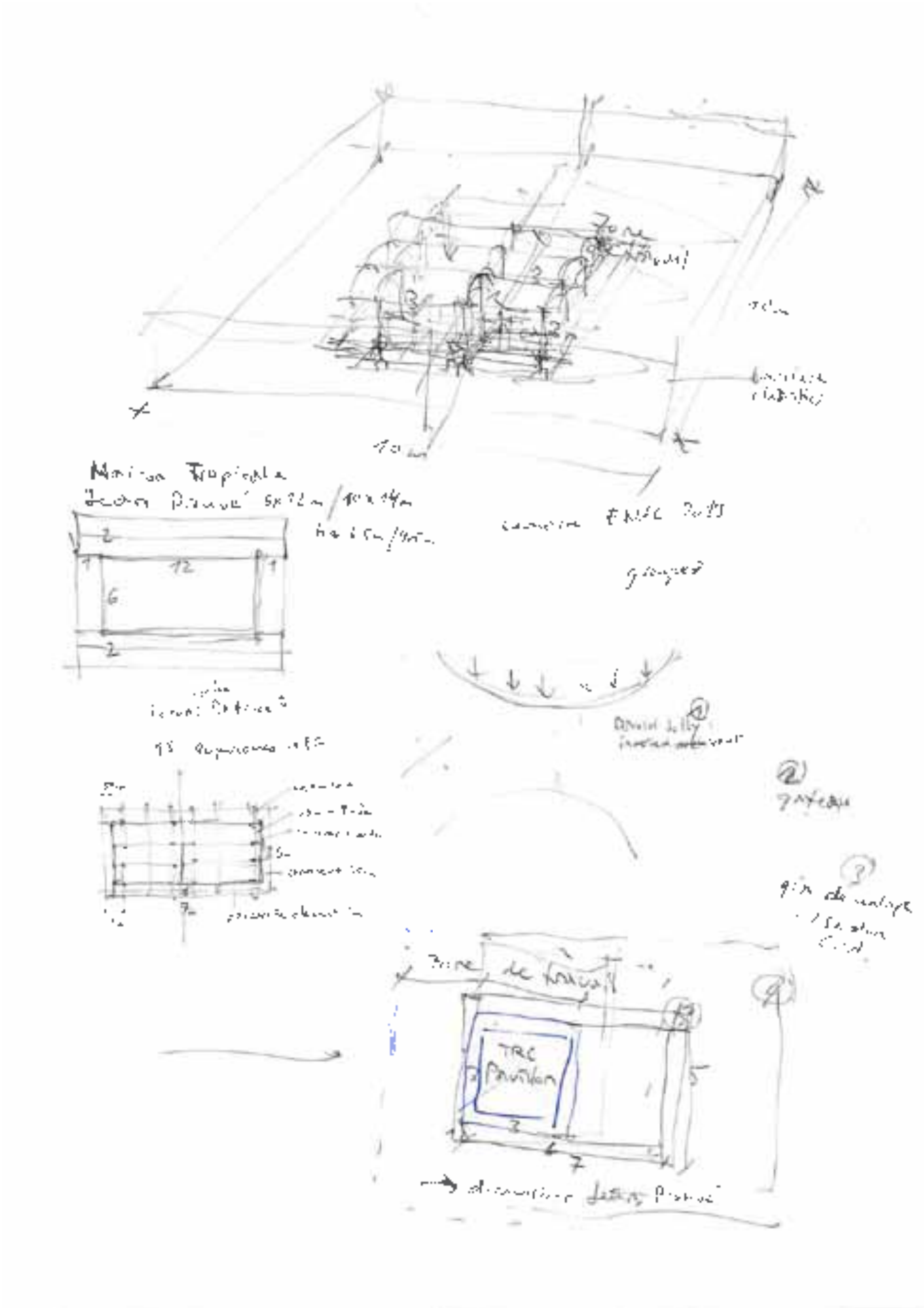

Fig. 1.16

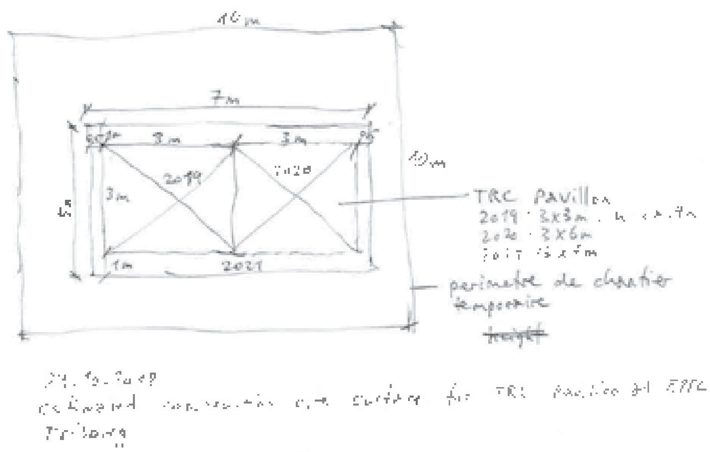

Fig. 1.17

Sketches of TRC pavilion and worksite with dimensions, 2018

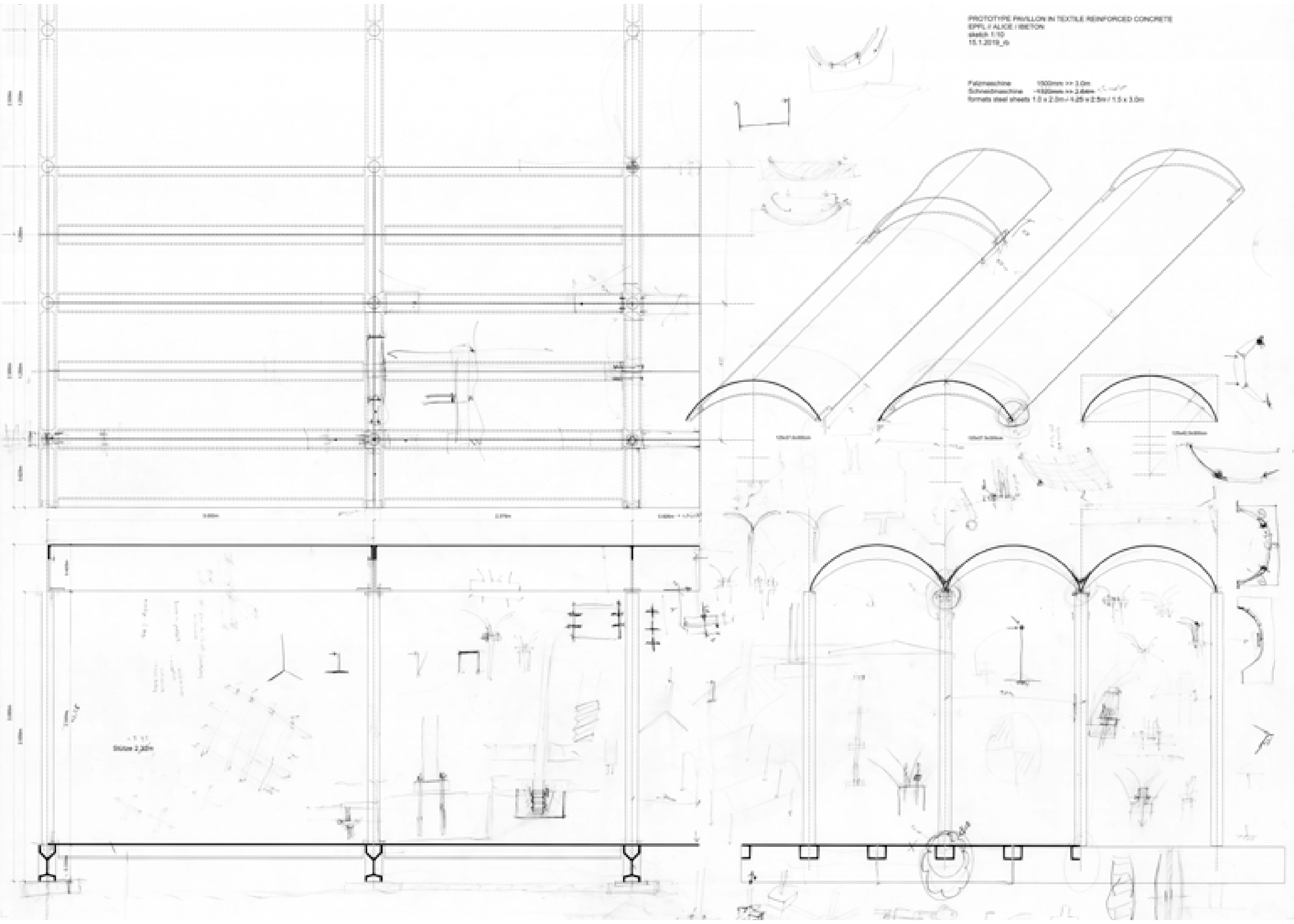

Fig. 1.18 Collective sketches of connections on printout of drawing of hypothetical prototype pavilion with precursor elements based on Lelé, 2019

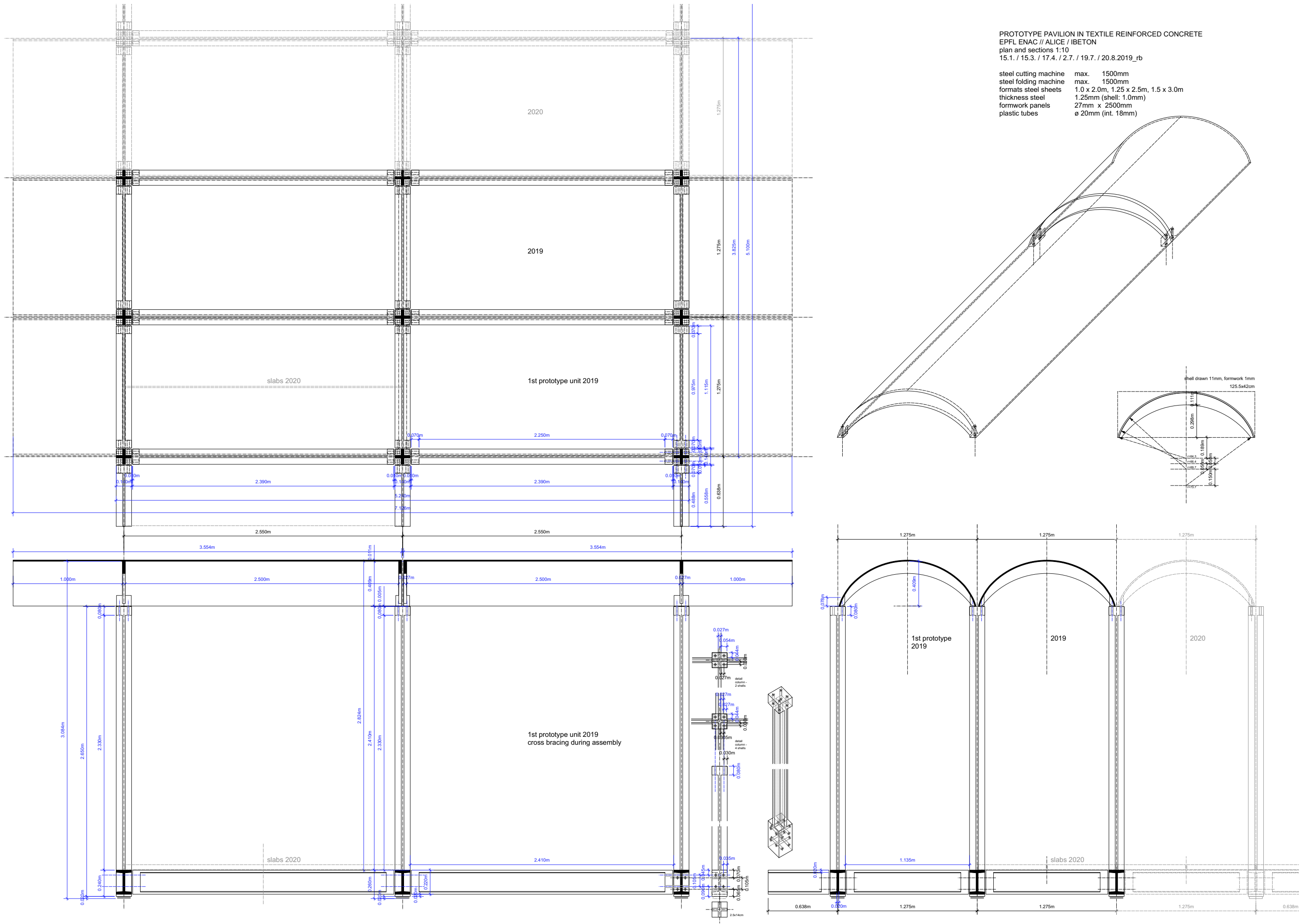

Fig. 1.19 Processual drawing of prototype pavilion with new TRC elements, 2019

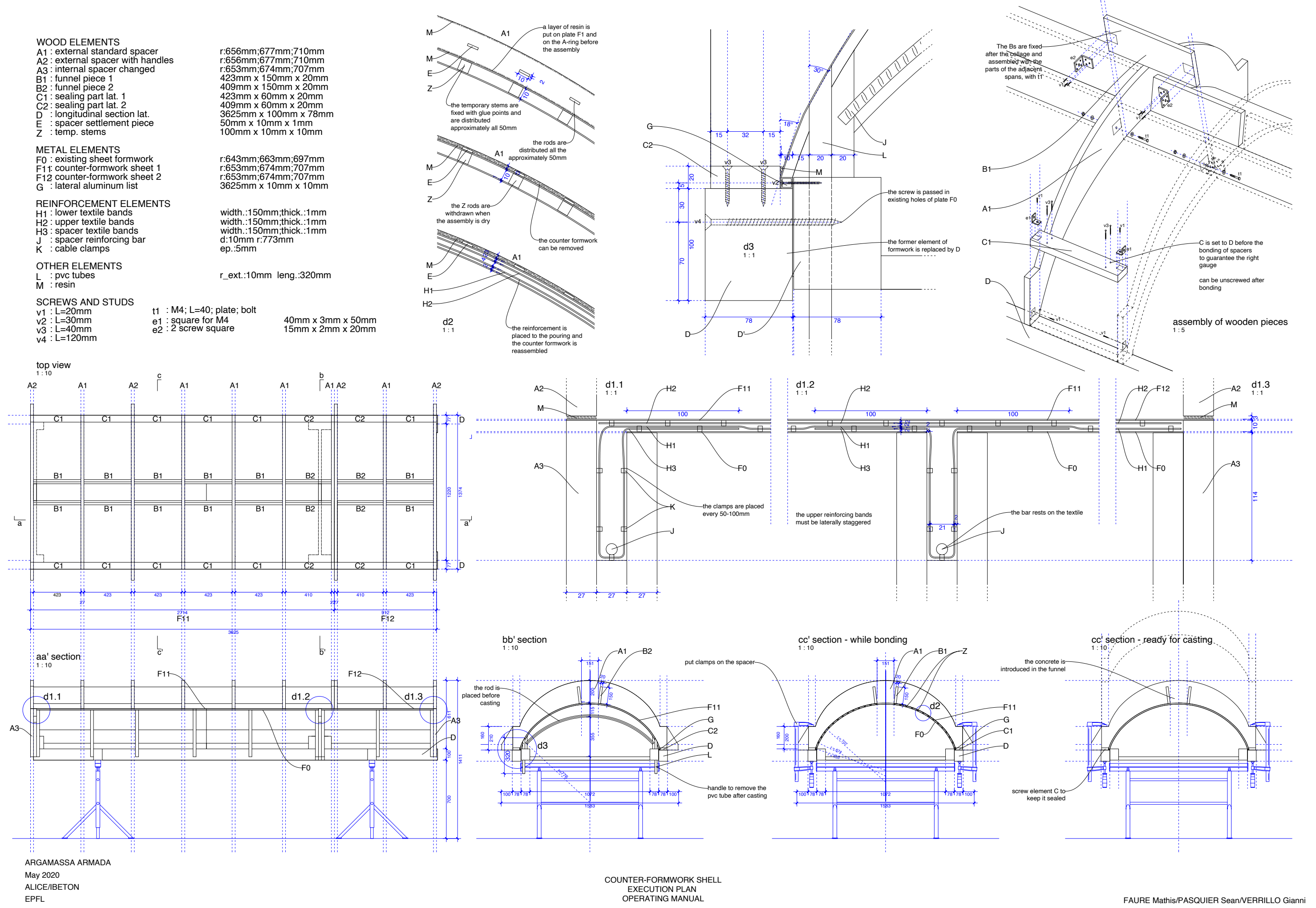

Fig. 1.20 Drawing of upper part of mold of barrel shell vault, sheet 1, 2020

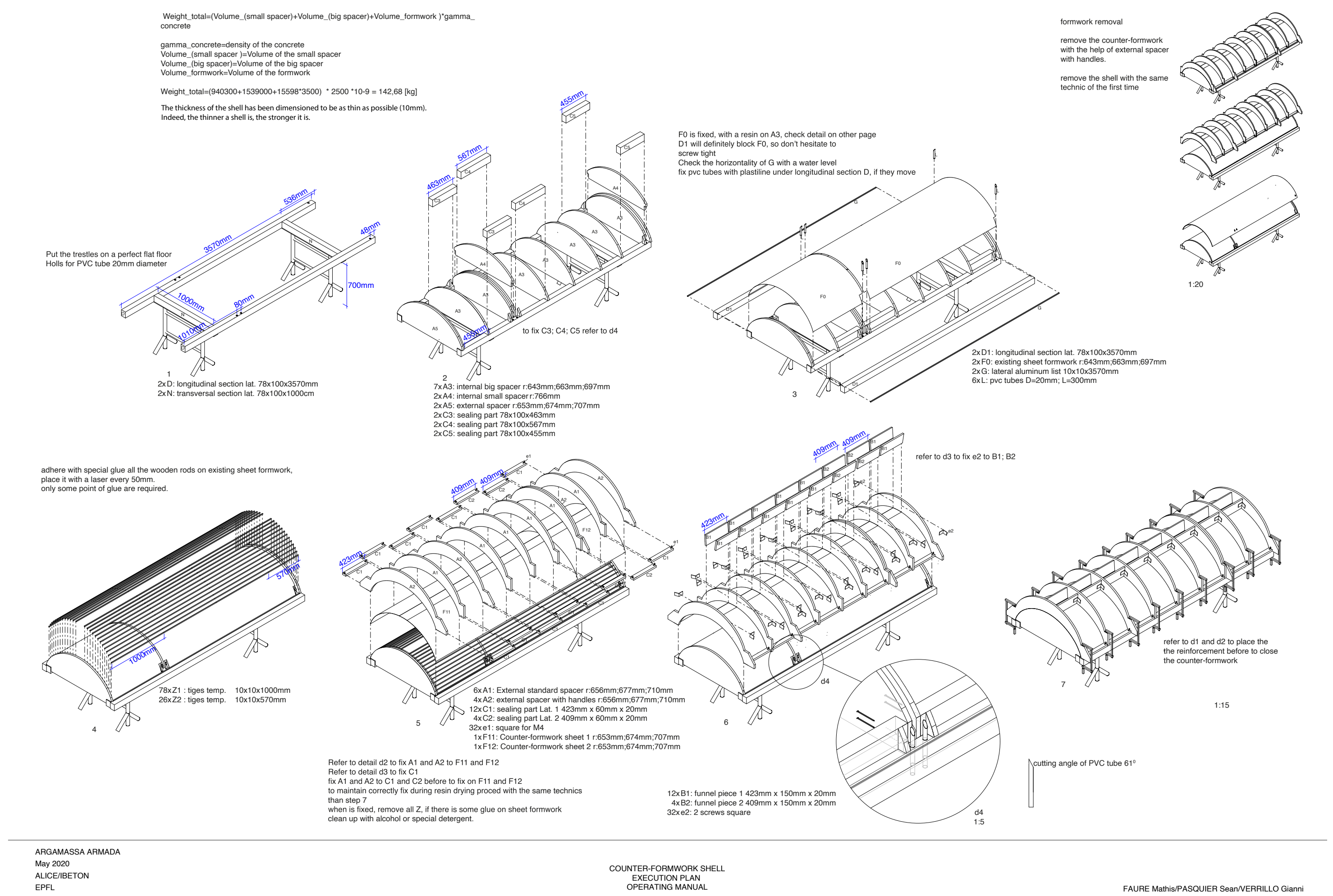

Fig. 1.21 Drawing of upper part of mold of barrel shell vault, sheet 2, 2020

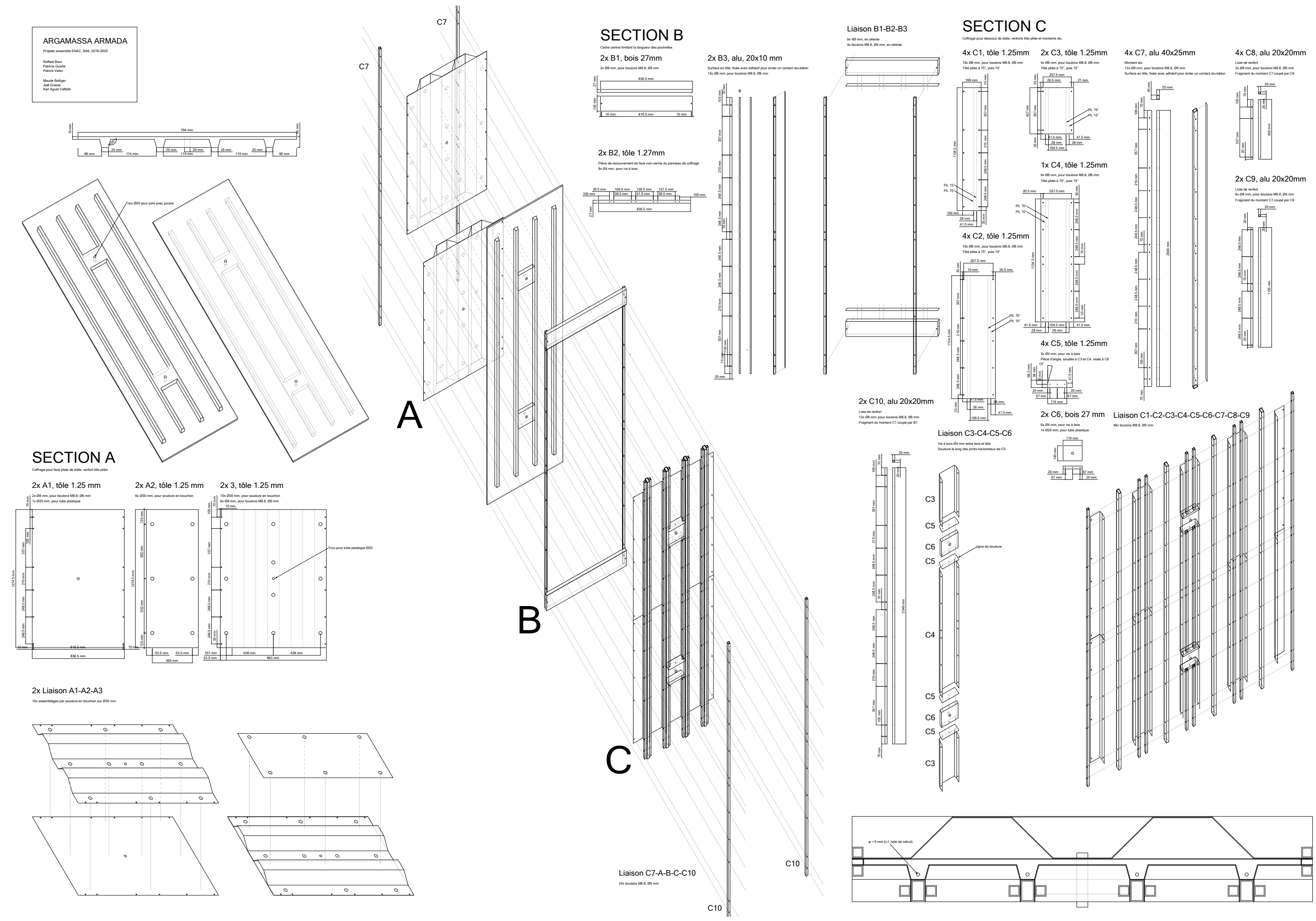

Fig. 1.22 Drawing of mold of slab prototype, 2020

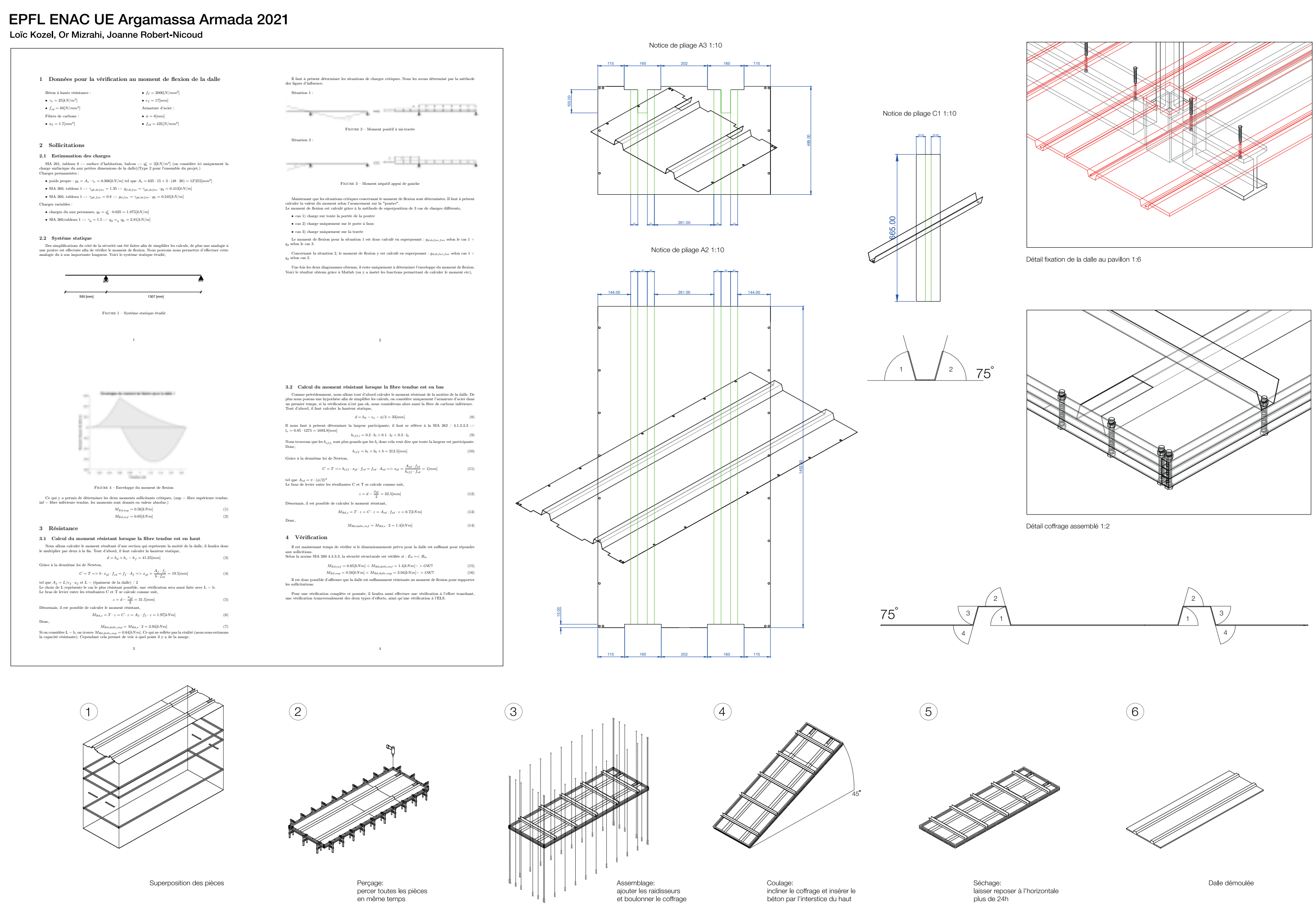

Fig. 1.23 Drawing of mold of new slab protoype, 2021


Fig. 1.24 Closing of mold of slab element, 2022


Fig. 1.25 Casting of barrel shell vault, 2022


Fig. 1.26 Unmolding and curing of slab element, 2022


Fig. 1.27 Casting of barrel shell vault, 2022

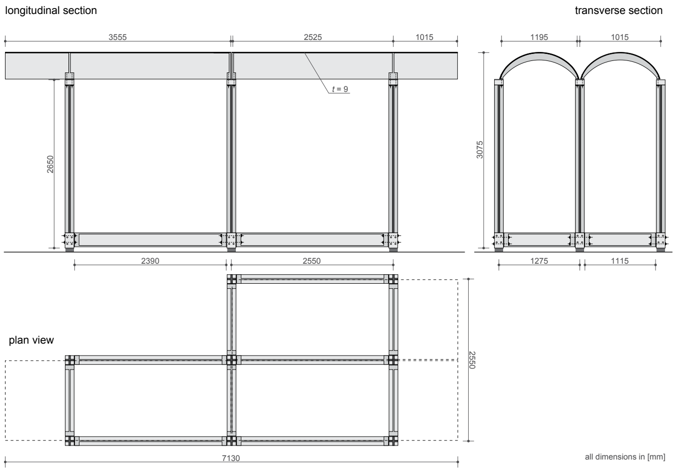

Fig. 1.28 Dimensions of 1st prototype unit, 2019

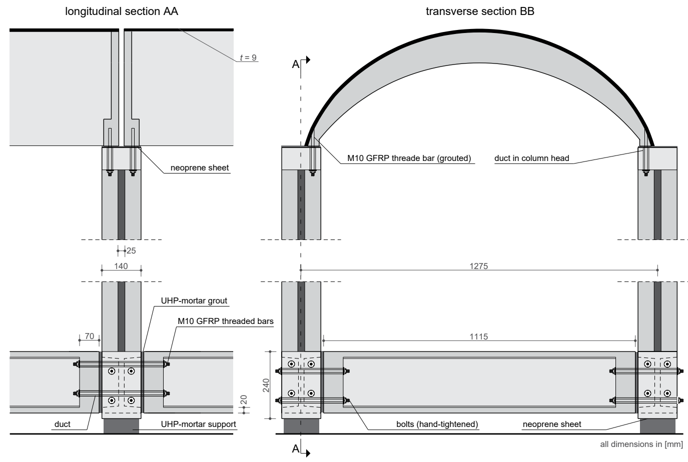

Fig. 1.29 Connection-details, 2019

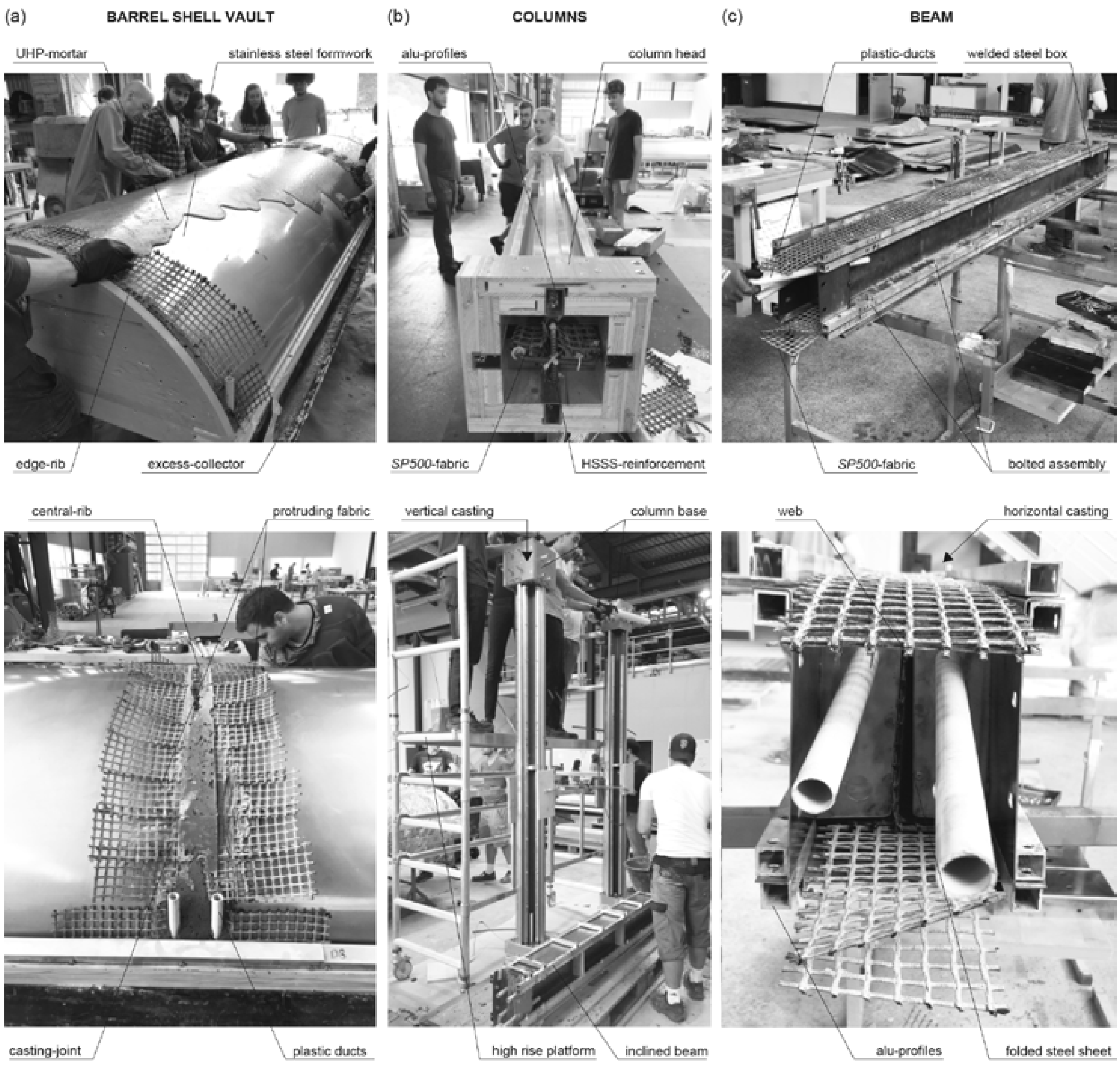

Fig. 1.30 Technical descriptions of elements, 2019

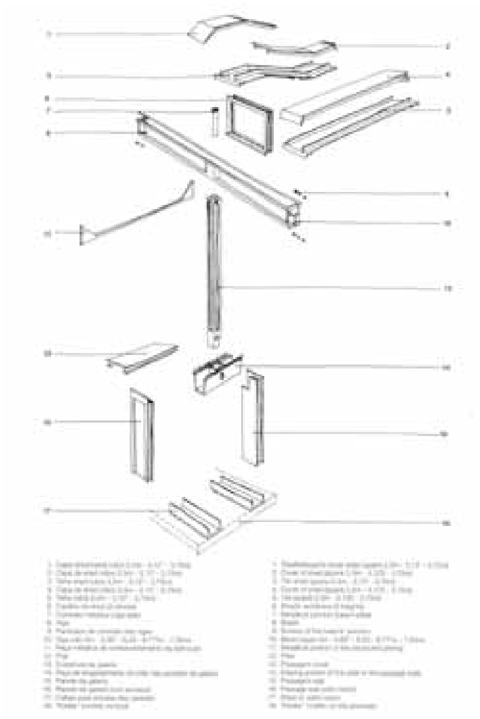

Fig. 2.1 Lelé, Study for future Sarah hospitals, 1988

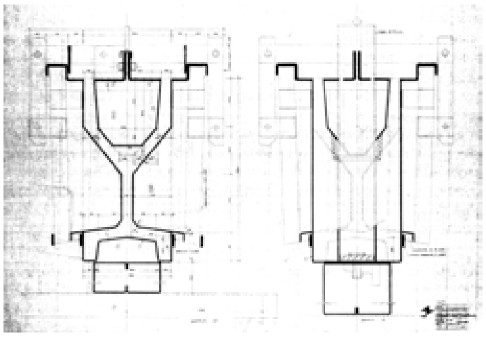

Fig. 2.2 Lelé, Drawing of mold of beam, scale 1:1

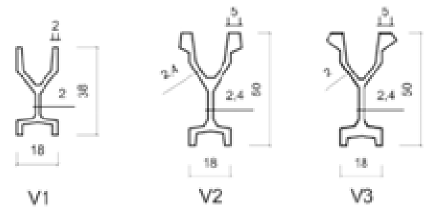

Fig. 2.3 Lelé, Evolution of beam, 1982–90

Fig. 2.4 Lelé, CTRS Factory, Salvador, 1991–2009

Fig. 2.5 Lelé, 2nd School Factory, Rio de Janeiro, 1984–86

Fig. 2.6 Lelé, 1st School Factory, Abadiania, 1982–84

Fig. 2.7 Lelé, Escola transitoria, Abadiania, 1982–84

Fig. 2.8 Lelé, Drainage Canal, Rio de Janeiro, 1984

Fig. 2.9 Lelé, Infrastructural works, Salvador, 1980

Fig. 2.10 Poster FAUFBA, 2017

Fig. 2.11 Lelé, Connection of two beams, 1984

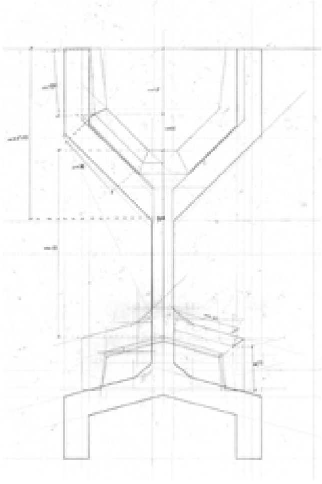

Fig. 2.12 Iterative drawing of beam, 2017

Fig. 2.13 Plywood mold of beam, 2016

Fig. 2.14 1st TRC prototypes, 2016

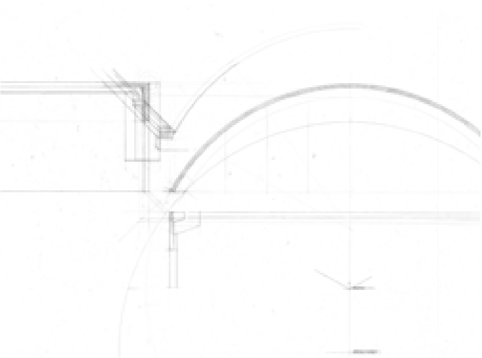

Fig. 2.15 Drawing of shell mold, 2017

Fig. 2.16 Plywood mold for shell, 2017

Fig. 2.17 1st barrel shell vault, 2017

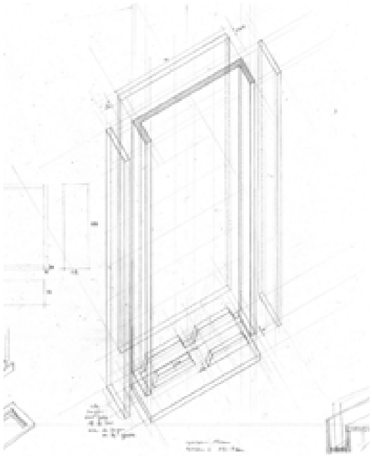

Fig. 2.18 Drawing of wall mold, 2017

Fig. 2.19 1st mold in folded sheet metal, 2018

Fig. 2.20 Unmolding of passarelle slab, 2018

Fig. 2.21 1st connection test of two TRC beam elements based on Lelé, 2018

Fig. 2.22 Structural test of beam at IBETON, EPFL 2018

Fig. 2.23 Exposition of TRC elements, EPFL 2018

Fig. 2.24 Lower part of mold, 2019

Fig. 2.25 Upper part of mold, 2020

Fig. 2.26 Load test on shell cantilever, 2022

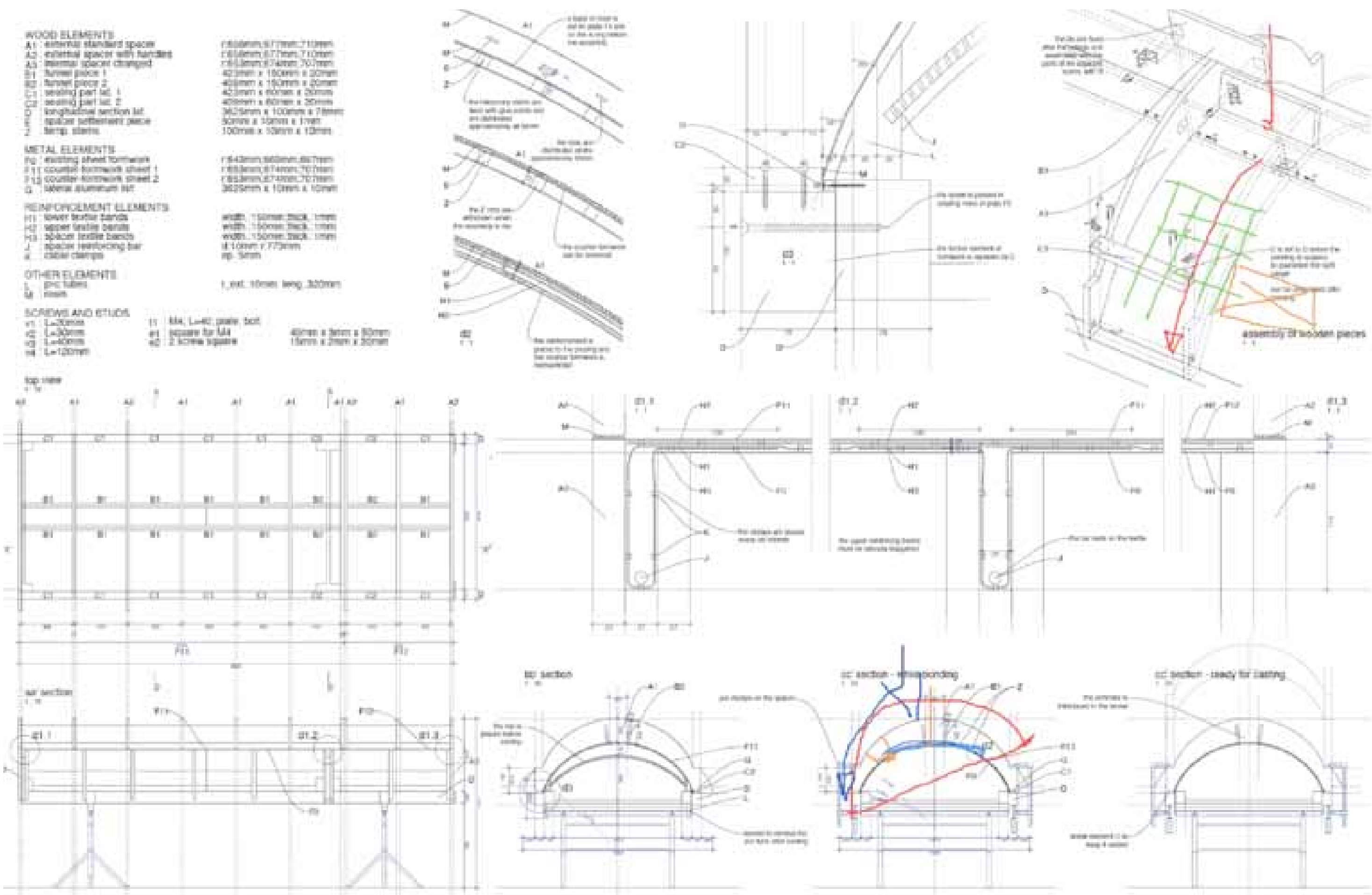

Fig. 2.27 Sketches on drawing of new mold for shell, EU ENAC 2020

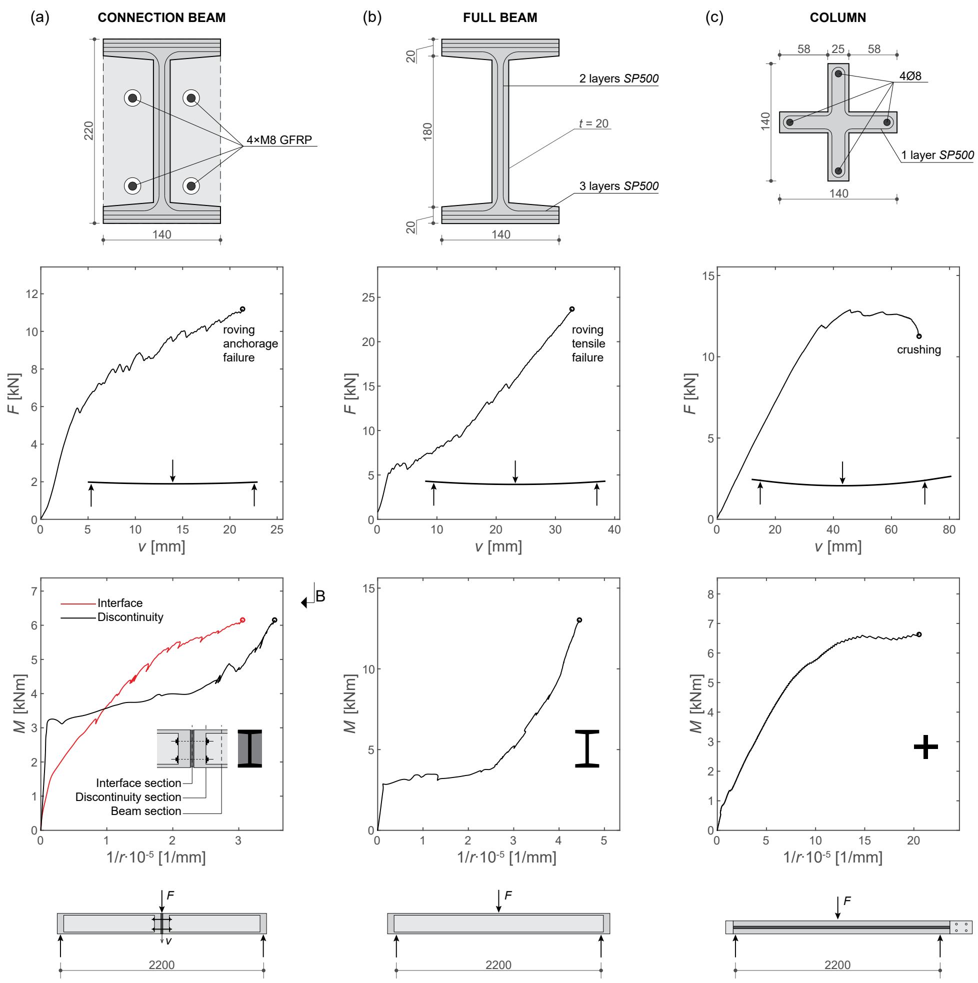

Fig. 2.28 Structural tests of TRC elements, IBETON 2019

Fig. 2.29 Assembly of column mold, 2019

Fig. 2.30 Casting of columns, 2019

Fig. 2.31 Detail of column capital, 2022

Fig. 2.32 Prepared mold parts of foundation beam, 2019

Fig. 2.33 Foundation beams holding formwork for foundations, 2019

Fig. 2.34 Students carrying foundation beam, 2019

Fig. 2.35 Precast elements ready to be mounted on foundations, 2019

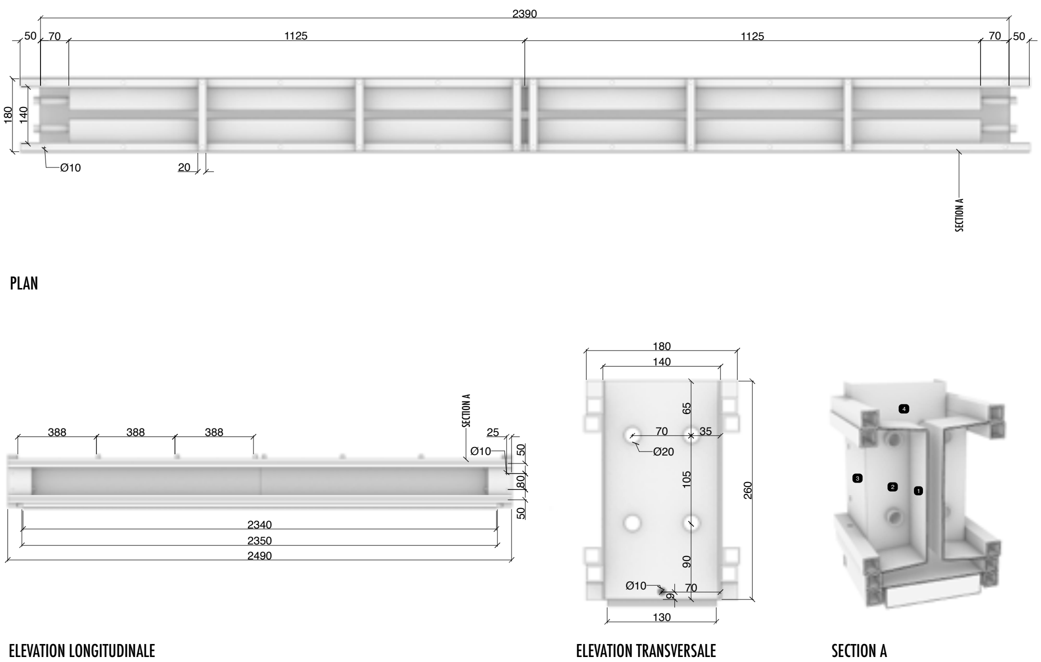

Fig. 2.36 3d drawing of mold of foundation beam, 2019

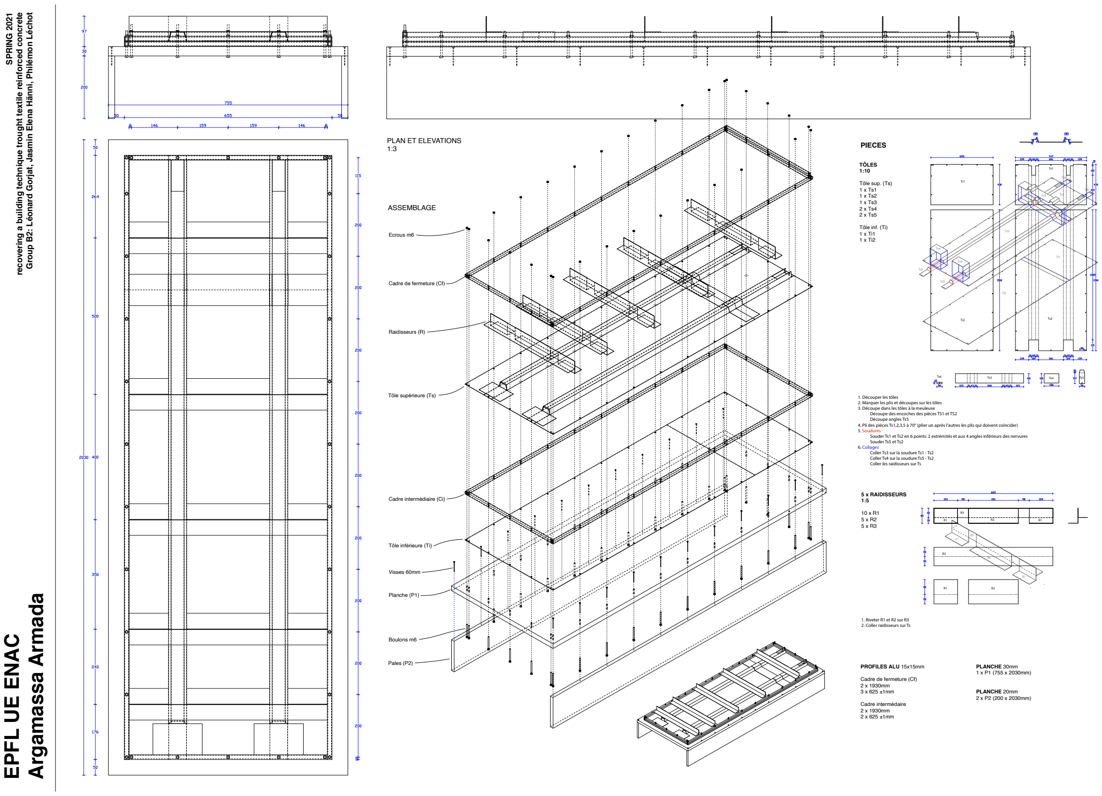

Fig. 2.37 Drawing of mold of slab prototype, UE ENAC 2021


Fig. 2.38 Preparation of carbon fiber reinforcement on mold, 2021


Fig. 2.39 Molds of slab elements inclined for casting, 2021


Fig. 2.40 Mounting of slab elements, 2022


Fig. 2.41 Fixation detail, 2022


Fig. 2.42 Unmolding of stair prototype, 2021


Fig. 2.43 Mold elements of stair prototype, 2021


Fig. 2.44 Positioned stair prototype, 2021


Fig. 2.45 Carbon fiber reinforcement, 2021

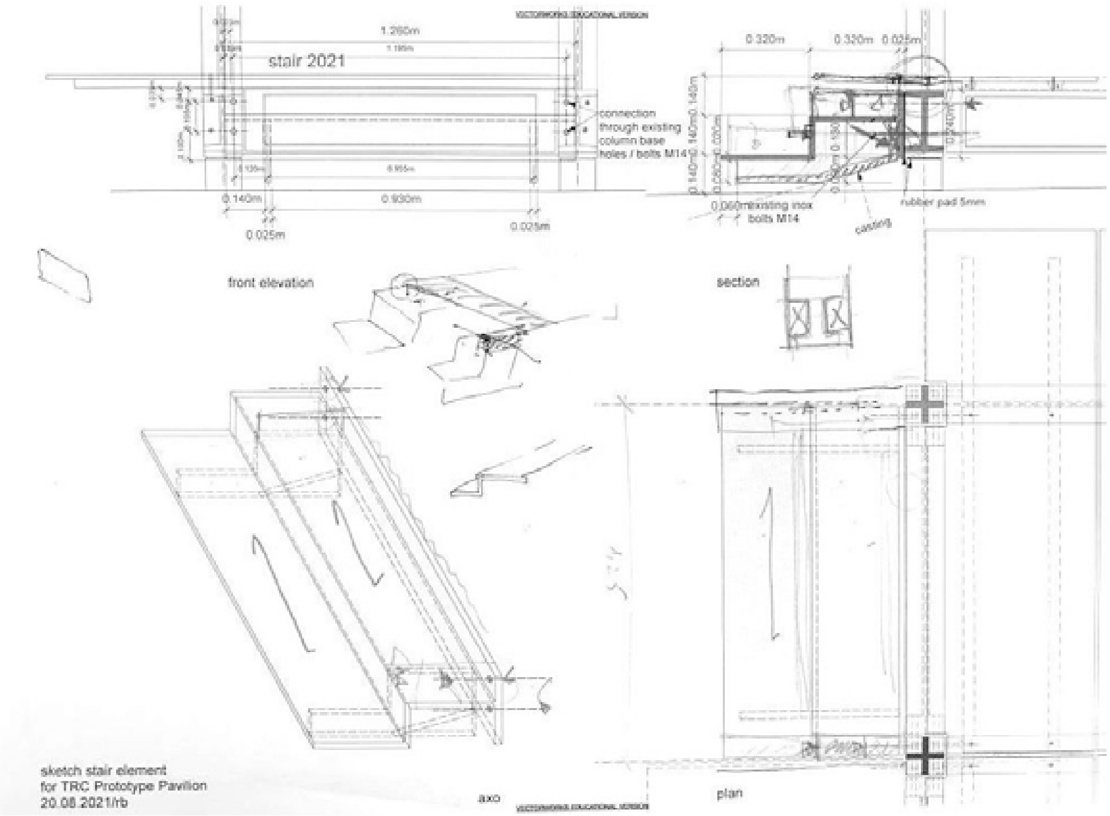

Fig. 2.46 Sketches of connection details on printed drawing, 2021

Fig. 2.47 1st wall elements, ‘inside’ view, 2022

Fig. 2.48 1st wall elements, ‘outside’ view, 2022

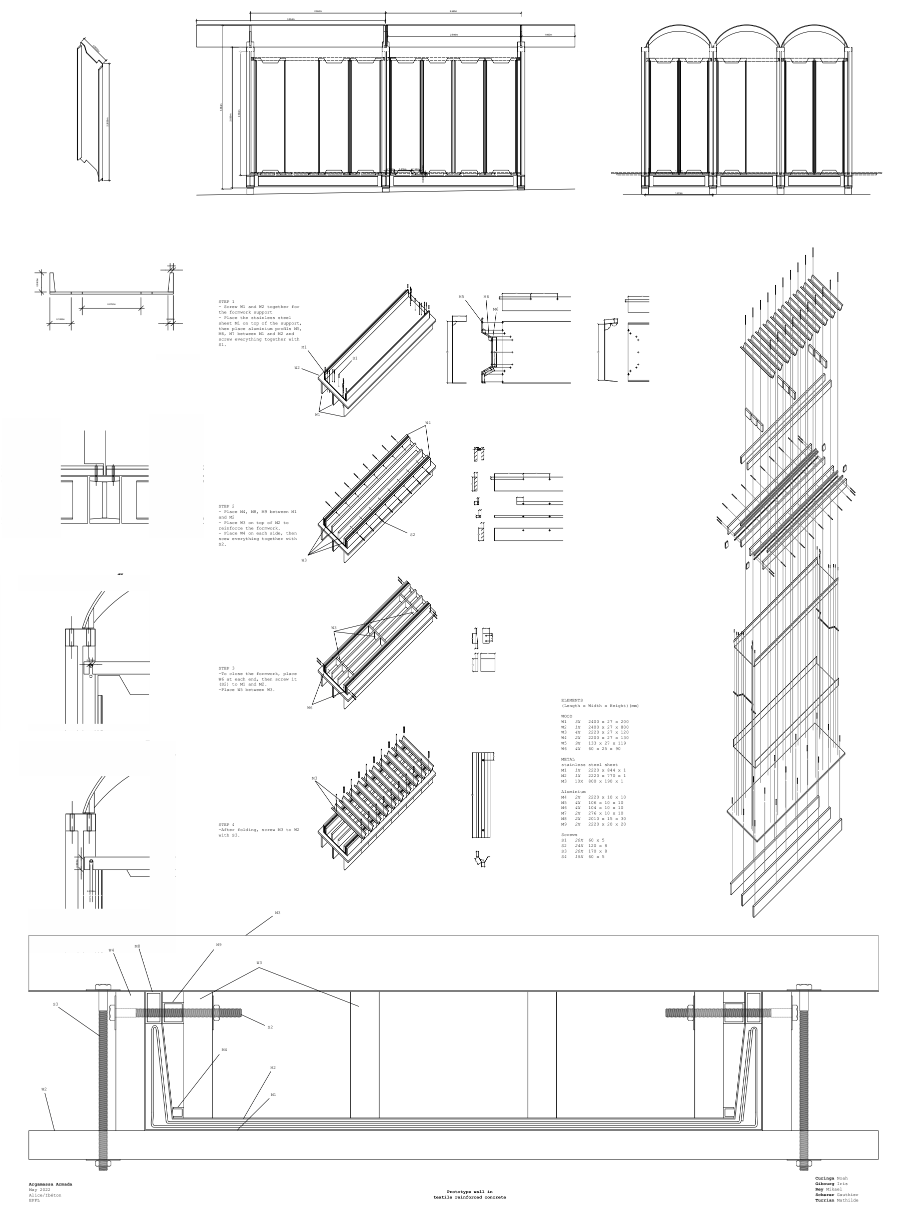

Fig. 2.49 Drawing of mold for wall prototype, UE ENAC 2022

Fig. 2.50 Mounting of foundation beams, 2020

Fig. 2.51 Preparation of foundation beams for new slab elements, 2022

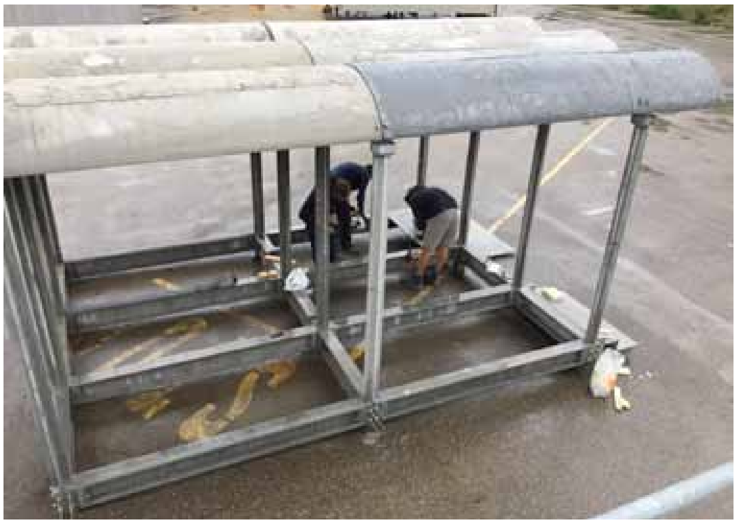

Fig. 2.52 Drilling of fixation holes for new slab elements, 2022

Fig. 2.53 Layout of new slab elements, 2022


Fig. 2.54 Winter 2019-20

2019

3 shells (open formwork)
8 colums
5 long foundation beams
5 short foundation beams
8 temporary foundations


Fig. 2.55 Summer 2020

2020

2 shells (closed formwork)
4 colums
3 long foundation beams
4 short foundation beams
3 large slabs ('metadalles')
4 temporary foundations


Fig. 2.56 Summer 2021

2021

9 new slabs
1 stair


Fig. 2.57 Summer 2022

2022

2 new shells
(reworked formwork)
15 slabs
3 walls

ARTICLES BY THE AUTHORS

2022 Kopinski Ekerman, S., & Guaita, P. (2022). Prototype pavilion in Fribourg: towards an upgrade of argamassa armada through Textile Reinforced Concrete. *ARQUISUR Revista, 12* (ARTICLE), 48-55.

2021 Guaita, P., Baur, R., Fernández Ruiz, M., & Fernández-Ordóñez Hernández, D. (2021). A prototype pavilion in textile reinforced concrete: a tool for research and pedagogy. In *International fib Symposium-Conceptual Design of Structures 2021* fib. The International Federation for Structural Concrete.

2020 Valeri, P., Guaita, P., Baur, R., Fernández Ruiz, M., Fernández-Ordóñez, D., & Muttoni, A. (2020). Textile reinforced concrete for sustainable structures: Future perspectives and application to a prototype pavilion. *Structural Concrete, 21*(6), 2251-2267.

2019 Valeri, P., Guaita, P., Baur, R., Fernández Ruiz, M., & Muttoni, A. (2019). The potential of textile reinforced concrete for design of innovative structures. In *Proc. of the International fib Symposium on Conceptual Design of Structures*

2018 Valeri, P., Guaita, P., Baur, R., & Fernández Ruiz, M. (2018). Pedagogy through artisanal construction of thin-walled concrete elements: a dialogue between engineering and architecture. In *IV Int. Conference on structural engineering education without borders*

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Modulart, Labo, Recherche, 04.2020
https://www.modulart.ch/fr/beton-textile-et-modularite-au-service-de-la-durabilite/

2019 *EPFL students push the boundaries of concrete engineering*
EPFL news 16.10.2019
https://actu.epfl.ch/news/epfl-students-push-the-boundaries-of-concrete-engi/

Patricia Guaita, Raffael Baur, Miguel Fernández Ruiz,
David Fernández-Ordóñez

A PROTOTYPE PAVILION IN TEXTILE REINFORCED CONCRETE: A TOOL FOR RESEARCH AND PEDAGOGY

Proceedings of the International fib Symposium on Conceptual Design of Structures Sept. 16-18, 2021, Attisholz, Switzerland

ABSTRACT

This paper presents a work performed in the last years on a Textile Reinforced Concrete (TRC) Prototype Pavilion, raising questions about research on architecture and engineering within a pedagogical context. The construction of the pavilion explores how a hands-on approach builds up multi-layered knowledge and constitutes a common ground of communication on which architects and engineers meet. Through the act of construction, architects and engineers work together, generating new knowledge and experiencing how tacit knowledge is built-up and transmitted. It also allows for the processes of conception and manufacture to feed and to enrichen each other. This action of making knowledge (greek techne) constructs a thought or a concept as a tangible physical entity, acting as a communication interface between the work and the mind, spanning over different disciplines.

The paper highlights the fact that the act of building is not only an intellectual and technical task. Within an education context, students experience the complete process of observation, analysis, conception, execution and testing. The direct investigation of materiality is thus essentially an invention and innovation process: an iterative cycle building up knowledge trough observation on the making. Through their corporal experience, students identify and engage with the research work, leading to collective action and to individual responsibility. Such engagement opens up perspectives on architectural, engineering as well as social, economic and environmental questions for the 21st century: sustainable and resilient construction, economy of means, adequacy of expression.

1 A PAVILION AS AN INSTRUMENT TO DEVELOP AND TO EXCHANGE KNOWLEDGE

This contribution is based on a long experience of pedagogical research in developing transdisciplinary strategies for designing and building projects in full scale and real-world conditions. The format of building a prototype construction by students of architecture and engineering offers the opportunity to work at the intersection between research and practice, of teaching and learning, of engineering and architecture. Our professions become more and more specialized and technical and thus we have less and less contexts to have an exchange of knowledge and to advance together in the necessity and evolution of developing the built environment.

Fig. 3.1 / 3.2 TRC Prototype Pavilion: elements and systems; EPFL Fribourg 2020 / 2022 (Figures updated 2022)

Within this context, this paper presents the process of conception and construction of a Textile Reinforced Concrete (TRC) Prototype Pavilion designed and built as part of a research collaboration between a team of architects and engineers at Ecole Polytechnique Fédérale de Lausanne (EPFL, Switzerland). The project was originated as an investigation on the potential of TRC to update lightweight building techniques with concrete (as argamassa armada), and has evolved into an exploration in the pedagogy of making through prefabrication and tectonic innovation [1].

The TRC Prototype Pavilion (see Fig. 3.1/3.2) was constructed during two summers (at the time of publication of the fib paper; four summers at the time of this publication) at EPFL Fribourg by a group of students and researchers both from architecture and civil engineering. However, it is the result of a series of prior explorations during several academic years. Through observation, drawing and testing, different elements were developed. It is thanks to this iterative process that the necessary knowledge and innovation on the process of construction (formwork, reinforcement, concrete casting, curing and erection) is generated and allows defining useful and efficient building elements to constitute a prototype pavilion.

The TRC prototype pavilion is not thought as a final product, with a plan to be designed, built and exploited. On the contrary, it remains open to transformation. The interest of its construction is learning in the process, improving and understanding the potential of TRC as a sustainable alternative to ordinary concrete construction. The pavilion is thus intended to be a first step towards an adaptable tectonic system, a construction that will be further developed the next years and that leads to a new lightweight building paradigm, forecasting a new and different conception and image of concrete construction.

2. MATERIALITY: LIGHTNESS, STRUCTURAL PERFORMANCE AND ARCHITECTURAL LANGUAGE

A major breakthrough in current construction approaches using cementitious-based materials (mostly concrete) can be identified in the use of non-corrosive reinforcement as for instance fabrics in carbon fibres (see Fig. 3.3 / 3.4). Such an approach removes the need to protect reinforcement from corrosion. As a consequence, reinforcement covers can be significantly reduced with respect to current values. Required centimetres for the covers in ordinary concrete construction become millimetres in TRC [2].

This leads to thinner and lighter structures, where the concrete matrix is used for static needs only and not for protection of reinforcement. In addition, the amounts of clinker required for the cementitious matrix can be dramatically reduced (no need for rebar passivation) reducing the total CO2 footprint of the construction.

Other than sustainability aspects related to the environment, the possibility of building lightweight elements opens the door to self-construction by local communities. This allows for a socially-sustainable approach, allowing to build in high- and low-tech environments with a particular opening to the informal city.

Despite the new potential offered by this material, a clear vision on how to implement it in construction is yet unclear. Probably, inspirations shall not come as an evolution from ordinary (massive) concrete construction, but from thin and lightweight elements, such as shells, Nervi's work in ferrocement and Filgueiras Lima (Lelé)'s work in argamassa armada [3]. Interestingly, the possibilities offered by a light material with a high potential to be prefabricated are also connected to steel construction and its approach to assemble and to connect pieces.

The construction of thin members with TRC allows for a rational manner to exploit the sustainable and durable qualities of TRC while affording spatial quality and allowing inhabitants of the informal

Fig. 3.3 / 3.4 TRC elements: shell 9mm thick / foundation beams, column, slab; EPFL Fribourg 2019 / 2020

city to participate in the production of their own shelter and habitat. The use of TRC allows to combine industrial processes (factory production) with local craftsmanship and labour. Such an approach allows for an efficient transfer of knowledge and technology to multiple environments, allowing also for its adaptation to local contexts. Another important aspect is the potential of TRC for recycling industrial waste products (as fly ash) and its potential capacity to be recycled in the future as for ordinary concrete construction. The use of precast elements in TRC, with convenient connections allows to create flexible and reusable structures in agreement with the concepts of circular economy.

3. ATELIER: TOOLS AND ACTIONS

One of the hypothesis of the TRC research project is that craftsmanship constitutes a common ground on which architects and engineers meet. The practical, artisanal construction of a structural element and formwork system (i.e. a concrete reality which embodies a unity of architecture and engineering, of research and practical experience), does not demand for a division of analysis (calculation) and design but fosters a constructive understanding including the above mentioned environmental and social considerations.

Working in an atelier (studio) format allows the interaction of our hands and minds, which is an efficient manner to build up and exchange not only technical knowledge but also savoir faire and tacit knowledge between architects and engineers, teachers and students as well as between cultures of different continents.

In the process of life, neurologic structures emerge simultaneously with the development of skills and knowledge. Knowledge is a result of life, of its experiences and of the consciousness of individuals [4]. Every skill, also the most abstract ones, start from physical processes [5]. Understanding of techniques is established thanks to the application of an imagination on action. This process or “material consciousness” is the extension of thinking from the mind to the nervous system [6] and from the hand to the material world.

Our hands are an interface between our brain and the real world, giving us the possibility to interact with ourselves, with materials and processes.

Thinking through action [7] allows understanding and solving situations and to develop an intuitive and tacit knowledge. In many cases, the work of the craftsman is done without a predefined theory of his own work, but by applying experience and intuition to precise contexts. Sharing experience, by dialogue and physical interaction, is thus the most efficient manner to transmit tacit knowledge [8].

Despite the fact that it is possible to distinguish between explicit and tacit knowledge, it is very hard to separate them in practice. Tacit knowledge is subjective and only by doing and through verbal exchange and physical discussion others can have access to it. Such a process generates a type of culture which can be identified as the addition of actions taken in response of specific contexts. One of the tasks of the architect and engineer is to transmit such a culture of tacit knowledge by means of different tools [9].

The distance between an architect or engineer and the process of making has become larger in the last decades as a result of intermediate actors [10]. Also, concepts and physical artefacts have become more and more separate. However, separating design and execution of a work separates the teaching and professional competences, leading to incomplete professional profiles in respect to the complexity of building.

In the atelier, learning is encouraged by the development of technical and spatial skills in reciprocal interaction, fostering a poetic understanding of construction, (see Fig. 3.5 / 3.6). Supported on tools

Fig. 3.5 / 3.6 Casting molds of slab elements in atelier Pop Up / worksite outside of atelier: mounting of shell; EPFL Fribourg 2021 / 2019

rooted in the core of the profession (drawing, models and physical prototypes), materials are transformed into spatial artefacts. Such actions promote intuition, sensitivity and knowledge transfer [11]. The work integrates all processes implied in construction: conceptual design, material innovation, fabrication and assembly. Such a physical approach is intuitive and allows students for a deeper understanding of building processes and to feel capable of modifying, transforming and developing our environment.

4. INTERDISCIPLINARY

During the construction, students work directly with concrete. By designing, building and testing, they enter into a reciprocal relationship, such that construction becomes a projective activity. Everything is fabricated in the atelier, from sketch to prototype, drawing, formwork, reinforcing, casting, erecting and assembling. This way of working faces students to construction reality and its material qualities.

Every generation of students inherits elements built by previous ones, thus a constructive language evolves. Their work is thus not isolated but belongs to a context and collaborative effort, to a culture of making. The construction of the pavilion shows that design and fabrication is a collective act. The time and effort involved in building with one's own hands reflect interactions with others.

Students need to understand and go through the complete process of analysis / observation, conception, execution and testing. This generates a deep learning impact in an interdisciplinary context. The gained experience and confidence of being actively involved in an innovation process encourages students to question and further develop any given task or reality in their coming careers. The interdisciplinary and collaborative nature of the process, which is necessary accounting for the complexity of the situation, can serve as model for any future activity.

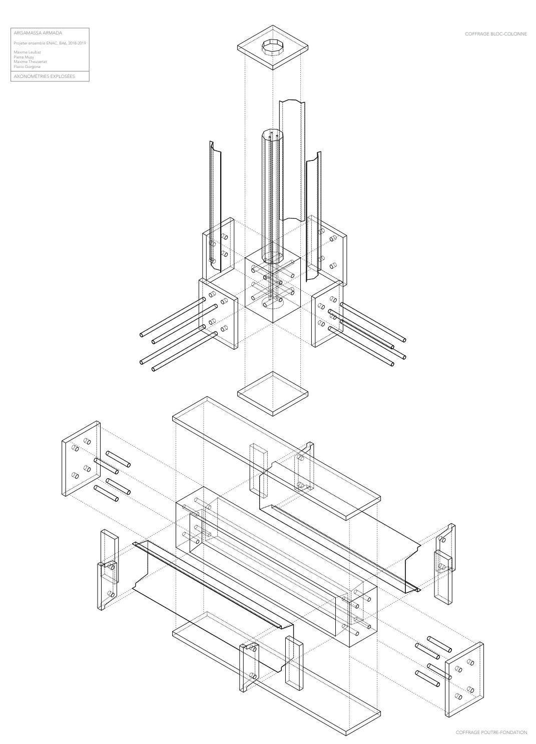
5. DRAWING AS A COGNITIVE TOOL

Drawing constitutes a very powerful and critical tool of conceptual design. By articulating thought, it acts as a communication interface between the work and the mind [12] and between different disciplines; it is the most powerful language of communication in the working together between architects and engineers. The act of drawing is physically apprehended: the care in the drawing translates into a care in the making.

During this project on TRC, it is proposed to investigate analytical drawing methods capable of exploring structural and architectural concepts and solutions. Through analytical drawing, students enter into dialogue with the construction process in a direct manner. They get a sense for the adequacy of tools and refinement of solutions. This allows investigating the relation with scale and space, with tectonic articulation in relation to structural idea. An important contribution is also devoted to structural analysis, as the tool to make transparent the parameters and dependencies of the design process and to open the work to predict the structural response.

Drawing is a cognitive process where the dynamic relation between making and thinking is essential. The construction of points and lines on a piece of paper leads students to the notions of scale, size, proportion, transparency and composition, leading to build up their own tacit knowledge. The slow and tactile nature of the drawing process encourages the development and understanding of detail as a key moment of construction and as a mediator, relating a structure to the body and to the subject perceiving it.

Exploratory working drawings were done at different scales and incorporating calculation notes and a notion of sequence and time of the construction process, leading to generate a complete



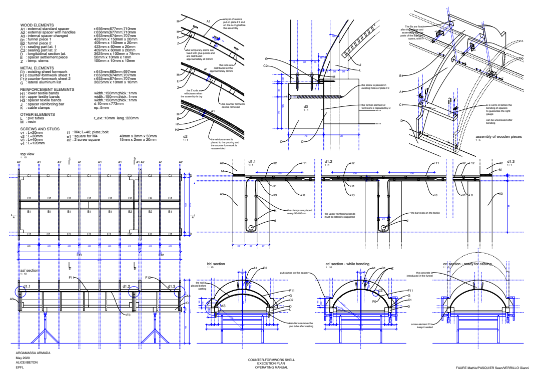


Fig. 3.7 / 3.8 Drawing of mold of foundation beam with connection details / drawing of mold of barrel shell vault; ENAC UE Argamassa Armada 2019 / 2021

documentation of all the necessary information for the fabrication of a TRC element (meta-drawing (see Fig. 3.7 / 3.8)). This multi-scalar approach, opening and creating multiple relationships, overcomes typical difficulties of conventional presentations based on a linear sequence and acknowledges the potential of parallel and iterative processes in the conception and construction, allowing invention, experimentation and discoveries. These 'tactile' drawings allow the observing eye (mind) to survey (travel) from one detail to another while integrating all information into a mental construction.

6. CONCLUSION

This paper reflected on the conception and fabrication process of an experimental pavilion in TRC, where the process of conception and manufacture feed each other to develop a thought or a concept into a concrete physical entity.

It is shown that interactions between architects and engineers can occur naturally with the hand as interface between the ideas and the produced artefacts. In order to make a step forward in the process of building, it is important not only to share technical aspects, but mostly tacit knowledge. The latter, compiling multisensorial experiences, can only be transferred in an efficient manner by means of the making.

Working in an atelier format, with interdisciplinary teams composed of architects and engineers with different levels of experience and backgrounds, reveals to be a very powerful tool to address the challenges of tomorrow, opening a common ground for action and experience in between the body, nature and technology.

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Fig. 1.31

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