sergio ekerman

lelé: dissonant paths to prefabrication and building sites

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production studies series

This booklet is part of the *Production Studies Series* - a set of 12 publications, each introducing a case central to the formation of this new field of studies and exemplifying its concerns. The series has been created as part of the research project *Translating Ferro/Transforming Knowledge in architecture, design and labour for a new field of Production Studies* (TF/TK). Funded by the Arts and Humanities Research Council and the Fundação de Amparo à Pesquisa do Estado de São Paulo, the project was led by Professors Katie Lloyd Thomas and João Marcos de Almeida Lopes. From 2020 to 2024 TF/TK has brought together dozens of researchers, practitioners and activists from across various countries and institutions.

Sérgio Ferro's writings provided the common theoretical and critical ground for discussions within the project. His work, first presented to an English-speaking audience in 2014 during the 11th Architectural Humanities Research Association conference[1] at Newcastle University, has since gained international recognition, the singularity and analytic power of his work resonating beyond its native sphere of circulation in Brazil and France. A key achievement of TF/TK is precisely the translation and publication in English of a substantial part of his writings.[2] Each of these critical editions, overseen by Silke Kapp and Mariana Moura, have been meticulously carried out, through successive bilingual sessions, open to all affiliated researchers within the project and to guest collaborators, aimed at a collective reading of the translated pieces, text by text, chapter by chapter. From the beginning of the project, Ferro's writings have been a cornerstone of the research network, vital to the maturation of the field, stimulating debates and collaborations.

It was in this environment of intercultural and interdisciplinary exchanges that each of the volumes in this collection was produced, from its editorial conception to its circulation. Together with an edited collection, *Building Sites: Architecture, labour and the field of production studies*,[3] which features chapters by the research team, with many crossovers of concerns with the *Production Studies Series*, they form part of a broader effort to define and structure a field of studies that we have been calling 'Production Studies'. Production Studies (PS) undoubtedly refers to already established interests, although often dispersed across studies of architecture, construction, self-building, cultures of construction, and participatory design. The PS field is proposed here as an axis which is both methodological and empirical, capable of bringing together objects apparently as diverse as cooperative, participatory and collaborative practices of design and work; processes that connect and separate design and the building site; agents and relationships directly involved in the formal and informal production of space; public policies for habitat design and production, in the countryside and in cities; pedagogical and disciplinary experiences that privilege forms and relations of production in the built environment; technical experiments or formal dilemmas capable of interrelate to 'situations in conflict' relating to production, from traditional practices and forms of knowledge, to actors external to academic, scientific or technological institutions.

Production Studies (PS) provides an empirical axis revealed in the study of specific cases located in time and space, which illuminate methodological, theoretical and political concerns. Inspired by the work of Karl Marx, William Morris, Sérgio Ferro, ProBE (the centre for research into the Production of the Built Environment), Peggy Deamer and the Architecture Lobby, amongst many others, the aim of the *Production Studies Series* is to promote the study of architecture/construction at the clash of various dichotomies: labour and capital; production and consumption; knowledge and power; technology and domination; autonomy and heteronomy. It seeks to overcome the design 'of' production through a shift to design 'for' more equitable and joyful forms of production. PS proposes a methodological approach that examines conflicts within architectural works: in their built materiality - visible or indexical; within work processes and relationships; within construction sites; and understands design creations, or ideas and solutions for construction as material productions. It views them in their mediations with political economy, labour history, the social history of culture, the anthropology of technique, the sociology of labour and not least with the know-how of construction workers. This intellectual endeavour is inherently a political ambition, in an understanding of theory, technique, art as types of practice, as part of the praxis of production and, therefore, as a form of action in reality. As weapons of class struggle, these forms of practice either work for its reproduction or for its transformation and overcoming; we recognise that while all too often production functions as a weapon of domination, it can also be a means of emancipation.

The booklets published in this series stand independently, each with its own institutional, theoretical and empirical backgrounds, expressing authors' prior research and experience. But it was amidst the constancy and intensity of face-to-face and remote meetings within the TF/TK network; in the influx of and contentions between different methods, interpretations and references; in the sharing of various practical experiences, that the relevance of each of them might be appreciated in the context of the Production Studies we set out here.

The cases in this collection each focus on the 'production' aspect of the built environment, aiming to expand our traditional methods of studying and understanding architecture and construction, thus emphasizing the material, practical, economic, social and even bodily dimensions of work involved. They are not interested in supposedly original or paradigmatic architectural forms. Nor are they distinguished by a peculiar attraction to the nature, advancement or particularity of construction techniques. Neither do they assume the existence of a pure, universal rationality of construction sites. Their purpose is instead to illuminate their contradictions and conflicts, to review productive and political experiments capable of facing the deterioration of working conditions in contemporary construction sites across the planet. Ultimately, it is about observing, from an architectural point of view, in its broadest sense, the effects of the social division of labour - including divisions of gender, race, nationality and class - in the production of the built environment and natural resources.

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notes

1 Katie Lloyd Thomas, Tilo Amhof and Nick Beech (eds), *Industries of Architecture*. London: Routledge, 2016.

2 Sérgio Ferro, *Architecture from Below*; *Design and the Building Site*; *Construction of Classical Design*. Translated by Ellen Heyward and Ana Naomi de Sousa; edited by Silke Kapp and Marianna Moura. London: MACK, 2024.

3 Matt Davies, Will Thomson, João Marcos de Almeida Lopes, Katie Lloyd Thomas (eds). *Building Sites: Architecture, labour and the field of production studies* London: Routledge, forthcoming.

10

In music, ‘dissonance’ is defined as a ‘coming together of unpleasant sounds to the ear’, an absence of harmony, synonymous with the characteristic of something that does not match when compared with something else. Dissonance, though it is viewed as unstable and disturbing, reflects a relevant condition. It is not necessarily something negative, but a vital counterpoint to ‘consonant’ experiences, whether in music or other areas.

With respect to the fields of architecture, construction, and prefabrication, this text[1] proposes to associate the concept of ‘dissonance’ with technical development and technological experiences that provide a necessary critique of productive characteristics deriving from the traditional organization of building sites. In Brazil, this is an environment typically characterized by poor working conditions, inequality, insecurity, low levels of education and technological development, low productivity, high costs, and waste.

The goal of this case study is to contribute to ‘Production Studies’ - a theme common to the Production Studies Series - in order to deepen critical awareness of experiences related to prefabrication and industrialization in Brazilian construction since the second half of the 20th century. Specifically, this theme will be explored as it pertains to the work of architect João Filgueiras Lima, known as Lelé (1932-2014), who has been celebrated in Brazil for his inventiveness and ‘fringe’ activity, especially in light of his development of factories dedicated to the construction of public buildings, most notably between 1979 and 2010.

In addition to architect Sérgio Ferro, other authors such as American architect Ian Terner (1972), Brazilians architect Paulo Bruna (1973) and civil engineer Teodoro Rosso (1978,1980), and French sociologist Benjamin Coriat (1983) will all be invoked as benchmark examples to support this analysis, allowing us to contrast different views on the field of architectural production.

The study also seeks to address texts and practical experiences dating back to the 1970s and 1980s that confronted clichés used in the analysis of prefabrication and industrialization processes in civil construction since last century. Specifically, it aims to highlight experimental alternatives to the recurring choice to use heavy mechanization and the inadequate notion which follows from of it of delayed industrialization in in the country’s construction sector. The often-frustrated wager on heavy industry often results in transforming technology into a tool for increasing profit in construction without the necessary improvement in on-site working conditions; architectural and construction quality of the final product; or improvement in the housing conditions of a significant portion of the Brazilian population, whether in cities or rural areas.

Specifically, this case study highlights Lelé's experiences with lightweight prefabrication, examining his factories and the metal moulds he used for the production of industrialized prefab ferrocement ('*argamassa armada*')[2] components, representative of the synthesis between pre-production, production, and rearrangement in the building process as applied to design, the workshop, and the building site. The ensemble he developed offers alternatives for the organization of production processes, especially in the case of the factory built in Abadiânia, Goiás, in central Brazil between 1982 and 1984. This example is offered as a response to certain issues raised by Sérgio Ferro in his call for a 'design of production' (Ferro, 2010, p. 59), forged within the building site itself, offering an exercise in the encounter between technology and autonomy (Terner, 1972), and opening up new horizons for the architect-urbanist within the context of 'production studies'.

'possible' prefabrication in latin america

João da Gama Filgueiras Lima, also known as Lelé (1932-2014), arrived in the Brazilian Midwest in 1957, the year Brasília's construction began. As an employee of the Institute of Pensions and Bankers Retirement (IAPB),[3] Lelé showed interest in rational and and industrialized architecture in the beginning of his career when he built camps and wooden sheds for the building sites of Superquadra 108 Sul, designed by Oscar Niemeyer. Being far from Rio de Janeiro, the country's capital at that time, and with limited communication,[4] Lelé had to learn to build under challenging conditions, thus breaking the isolating barrier between design and the building site, without ceasing to understand production as the foundation of his architecture. Lelé's choice of prefabrication from the very start stems from a professional trajectory that immediately challenged the rationalization of labour on the building site, and always understood architecture as a result of how these issues are managed together.

In 'Construction of Classical Design' Sérgio Ferro describes historical movements during the Middle Ages that from the Romanesque to the Gothic, transformed cooperative production on the building site into a heteronomous space. For Ferro this process was symbolized by the emergence of the architect working with white gloves, the master of the 'hand-held compass' instead of the 'big dividers' and the 'separate design'.

> (…) the proto-architect, to move up in life and not decline like his companions, leaves the building site behind (*first* negation), starts drawing in the *loggia* on a reduced scale (*second* negation, as he is no longer drawing on

> the building site or to actual scale); drawing entirely while avoiding contact with act of doing, so that he is gradually sucked into *Gestaltpsychologie* (*third* negation, moves away from production); and with this he loses the experience of the act of occupying, crucial to defining interior space and responsible for the diminishing relevance of the exterior aspect in the previous period (*fourth* negation), etc. It is with our backs turned and without a rearview mirror that we generally advance in a situation of freedom (Ferro, 2021, p. 54-55).

This historical moment marks the emergence of the 'project' drawn as an element separate from construction decisions, which reorganizes itself and acquires new dynamics. To this day, it implies a significant disconnect between two processes that have become complementary but discrete—design and the building site.

Based on his experience in Brasília, Lelé became an activist for a movement which looks to the reconnection between the architect, the hand-held compass and the big divider, as well as the idea of design as a building exercise in contemporary times. The public factories he built, designed and managed are an example of this (re)encounter. What stood out most, among other devices, was the the design and operation of metal moulds used to manufacture '*argamassa armada*' elements that characterized Lelé's work during the 1980s and 90s. In these factories, we observe another intersection between Ferro's and Lelé's thoughts, namely a practical response to Ferro's call for the 'need to replace the design *for* production with a design *of* production, exchanging the drawing that comes from outside and is unaware of the building site for another that arises from the experience of the productive body' (Ferro, 2010, p. 59). Lelé's factories and moulds, which materialize a dissonant vision of prefabrication, were simultaneously a place where design and construction could come together and where the the design of production as a protagonist of architecture could be developed.

Whereas throughout the 1960s and 70s Lelé observed and experimented with heavy[5] prefabrication processes developed in the 'post-war' era to address housing shortages in regions like communist Europe,[6] in the 80s he conducted experiments within the framework of debates fuelled by different theoretical and practical works. As early as the beginning of the previous decade, such research sought other horizons and greater adaptation of these technologies to the South American context, and this was a moment when Lelé would awaken to the possibilities of industrializing ferrocement systems and lightweight prefabrication produced in public factories. At the time he chose to adapt the technology brought to Brazil by Pier Luigi Nervi in the 1950s, later developed at the São Carlos School of Engineering within the University of São Paulo.

The use of '*argamassa armada*' as a premise for improving the Camurujipe River Valley (*Vale do Rio Camurujipe)* region in Salvador, Bahia, was the starting point for the technological development of the material and its application in urban interventions and slum urbanization. The period between 1979 and 1989 was marked by the construction of four different but interconnected factories: Salvador's Urban Renewal Company - RENURB, Bahia (1979-1981), Abadiânia, Goiás (1982-1984), Schools Factory (*Fábrica de Escolas*), Rio de Janeiro/RJ (1984-1985), and Community Equipment Factory - FAEC (*Fábrica de Equipamentos Comunitários*), Salvador/Bahia (1986-1989)[7]. These factories provide most of the elements and equipments used to tackle relatively unprecedented challenges regarding the fight of the poorest population in Brazil for their share of urban space. Subsequently, '*argamassa armada*' would also become part of the construction technology developed by the Technology Centre of the Sarah Kubitschek Network (CTRS), which operated in Salvador from 1994 to 2018 at the peak of Lelé's career, and the development of an innovative perspective on prefabrication in architecture.[8]

Lelé's decision to shift focus from heavy prefabrication (used for example in the building of the Administrative Centre in Salvador in the late 1970s) to lightweight prefabrication and '*argamassa armada*' constituted a response to a debate established in that period, which counteracted different ways of seeing these construction processes. Texts like 'Architecture, Industrialization, and Development', a doctoral thesis by São Paulo architect Paulo Bruna, published in 1976 which is influential in Brazil to this day, represent a more 'traditional' view on the subject, advocating for widespread adoption of heavy prefabrication of reinforced concrete for the development of the national civil construction industry.[9] It is based on the 'mechanization + rationalization' binomial that sees prefabrication only as a phase of the industrialization process, hitherto unattained (Bruna, [1976] 2002, p.19). Bruna also notes aspects of broader conditions in the Brazilian economy that, along with these concepts, give rise to the development of the paradigm of the notion of 'retrograde,' which always sees prefabricated processes as something incomplete, incapable of addressing the real needs of civil construction's industrialization.

The same year Bruna finished his text, in 1972, American architect Ian Donald Terner, who collaborated with English architect John Turner on a joint study of self-built houses, published the article 'Technology and

Autonomy' in the *Freedom to Build* anthology. In it, Terner records his thoughts on the conjunction between the thesis of 'dweller control' and the industrialization of construction and, therefore, on self-building with the technical assistance of prefabrication tools. Terner synthesized the industrialized process as one composed of four prominent stages: (1) systematization and standardization of products, (2) labour specialization; (3) concentration of production and marketing, and (4) mechanization of production (Terner, 1972, p. 216). In opposition to Bruna, he argues that a foundation of *partial industrialization* should be adopted by countries with such a demand for self-building, which is rich in creating product systems and job specialization, albeit with decentralized production and limited mechanization, thus discarding the major efforts and risks surrounding the creation of a heavy prefabrication infrastructure for building houses for the masses. Terner also proposes the development of 'mass-produced components that are light, cheap, easy to use' (Terner, 1972, p. 223), something close to the proposal Lelé consolidated a few years later in Abadiânia, as we will see below, and which he calls 'partially industrialized intermediary technology.'

In 'Design and the Building Site' (1976, published in 1979), Sergio Ferro questions analogously the relationship between prefabrication processes and the increase in mechanization, despite the intrinsic potential of these technologies to change certain harmful aspects of the 'serial manufacturing' of the building site. He emphasizes, however, that even when rationalized, processes that include prefabrication in architectural construction are still a form of manufacturing, which he calls 'heterogeneous manufacturing.' For Ferro, involved in experiences conducted by the *Arquitetura Nova* group, which he participated in the early 1960s, it was hard to develop heterogeneous manufacturing in Brazil due to existing technological gaps, a phenomenon described by Terner in his writings and experienced by professionals like Lelé throughout their professional careers.[10]

São Paulo engineer Teodoro Rosso, who founded the Brazilian Construction Centre in 1969, was also involved in the prefabrication field in Brazil. The Centre became a reference in the field and advocated for private initiatives as investor and enabler of the industrialization of construction. In 1980, Rosso sought to further understand the situation of construction rationalization in the country. In his text titled 'Construction Rationalization,' he asserted that the construction industry's low operational performance depended on a diverse set of factors and that the issue was dependent upon a profound definition of the relationship between industry and architecture. He advocated for greater development of the integration between industrialized components and modular coordination, with a view to creating an open industrial cycle similar to what can be found in the automotive industry.

The exploration of the limits of prefabrication and the industrialization of construction is also a theme in the works of sociologist Benjamin Coriat. In his 1979 work 'Travailler en chantier. Quelques tendances de la recherche actuelle' he differentiates between industrialization processes in the factory and on the building site. Coriat introduces the concept of 'building site form' to define this 'industrial' context outside the factory, always subject to the idiosyncrasies of the terrain, in contrast to the concept of 'factory form'. Coriat's work helps understand the challenges that prevent the simple transposition of the industrial and factory development stage of highly standardized objects like automobiles to the field of architecture. Terner, Ferro, Coriat, and even Rosso sought out, in the previously mentioned excerpts, a different perspective from Bruna's. They admitted the need for 'dissonant' arrangements and interpretations to foster inventions capable of addressing the specific challenges facing industrialization of construction.

This perspective on prefabrication in architecture is also present in the concept of 'possible industrialization,' as discussed by the Spanish engineer Julian Salas Serrano in the pertinent book '*La Industrialización Posible de La Vivienda Latinoamericana*' (Serrano, 2000). The text articulates different technological experiences and visions around the idea of limited and 'possible' industrialization to address housing deficits in the so-called 'global south,' especially in Latin America. Salas argues that, despite its defects, few constructive ideas are as useful as rationalization when it comes to dealing with the scale of the continent's housing problem. As an antithesis to what he calls 'Subtle Industrialization,' which corresponds to the 'massive use of industrially produced serial parts,' while still unable to determine a truly industrialized building site, Salas defends the concept of 'possible industrialization,' a set of intermediate, partial technologies that make advances in certain aspects of rationalization, as advocated by Terner, including the industrialization of steel reinforced grout systems developed by Lelé and his team.

When describing the rationalization of construction and prefabrication processes in mutual aid self-building collectives in São Paulo in the 1990s, architect Pedro Arantes explored a concept similar to that of Salas. For him, architects involved in these collective self-organised processes aimed at 'increasing productivity, not by expanding exploitation or reducing the quality of the work, as occurs in traditional building sites, but through a huge effort to rationalize popular techniques and, sometimes, giving extra importance to a “modifying technique”, to quote Sérgio Ferro’ (Arantes, 2002, p.213-214). According to Arantes, the small pre-cast ‘*argamassa armada*’ factories installed in self-organised building sites in São Paulo in the 1990s established a model of ‘possible industrialization’ within housing construction (Idem, p. 214).

Experiments of this kind have been practiced in Latin America since the 1960s, as exemplified by The Experimental Housing Project (PREVI) in Peru and the mutual aid self-build collectives of Uruguayan Federation of Cooperatives for Mutual Aid Housing’(FUCVAM) in Uruguay, among others. Like Lelé’s factories, they created disparities that point not only to a ‘possible industrialization’ of civil construction in Latin America but also to less precarious working relationships than those in conventional building sites. Aligned with the principles of autonomy advocated by John Turner and his contemporaries, self-build experiences with mutual technical assistance constituted one of the most fertile fields of participatory action in Latin America, often supported by prefabrication and construction rationalization processes.

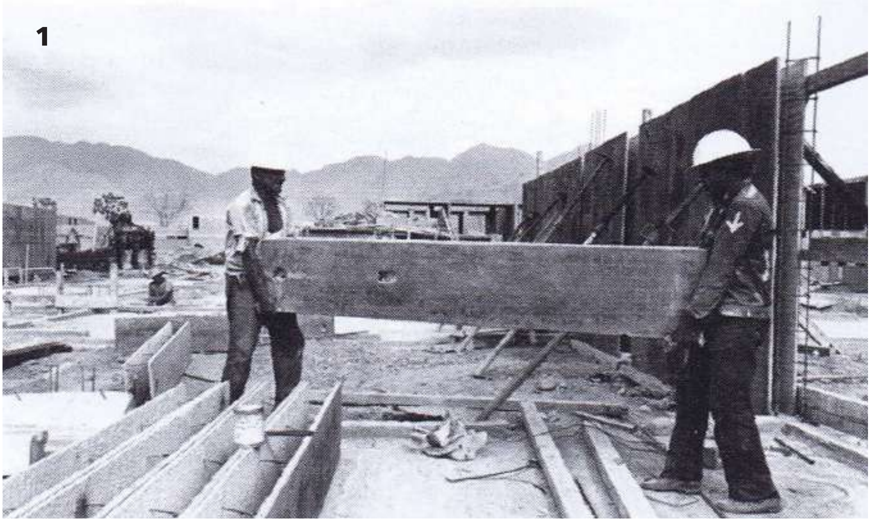

Fig. 1: Workers carrying prefabricated ferrocement elements for walls, to be later filled with concrete. PREVI building site, houses designed by swiss studio Atelier 5, 1971.

uruguayan cooperatives and prefabrication

One of the most important examples in Latin America of self-built experiments making use of technical assistance, that often included partial prefabrication processes, is found in FUCVAM. Since the 1960s, FUCVAM has organised this model of activity in Uruguay, more specifically one that benefits from the country's 1968 National Housing Law (*Ley Nacional de Vivienda*) which created and regulated the 'National Housing Fund,' which financed homes built by cooperatives.

FUCVAM came into being due to a 'group of technicians committed to the popular movement who saw the importance of thinking and developing a tool that would make it possible for workers to make use of the Housing Fund Law that would undoubtedly be approved' (González, 2013, p.47). González gives an account of mutual aid and self-organised cooperatives in Uruguay that have roots in the rural people's '*gaucho*' culture, and he also highlights the role of the Uruguayan Cooperative Center (CCU). Founded in 1961, the CCU centralized its research on the topic in other countries, including visits to Chile by architects to research the Housing Institute of Chile (INVICA), mentioned by John Turner in his studies. The CCU was created due to the initiative of progressive sectors of the Catholic Church, and was later transformed into an Institute of Technical Assistance(IAT), a non-profit entity whose role was to 'provide, at cost, technical services in the following fields to cooperatives and other non-profit entities: legal, cooperative education, financial, economic, social, project, and coordination of architectural builds' (Art. 170, Housing Law apud Baravelli, 2007, p. 127), at a maximum cost equivalent to 7% of the project's overall value.

From a technological point of view, built projects self-organised by these cooperatives were characterized by the use of solid bricks, a uruguayan construction staple, and also by extensive experience in the production of prefabricated elements. From the 1970s onward, this kind of donations from European institutions fostered technological development and successfully allowed for the installation of plants that produced prefab ferrocement, concrete, and prefabricated elements with ceramic bricks. Important to take notice of two aspects: the constructive elements built with prefab ferrocement technology - frames and window sills, used in an open cycle along with conventional construction components; and the curing of the elements with steam, a relatively sophisticated feature for this kind of industrial plant.

Hit by commercial and political instability, the circumstances that made large-scale prefabrication production possible came to an end, reducing the ongoing construction processes to a culture of light manufacturing on the building site, positively responding to the temporal demands of the self-organised process, thus helping to improve productivity during work hours.

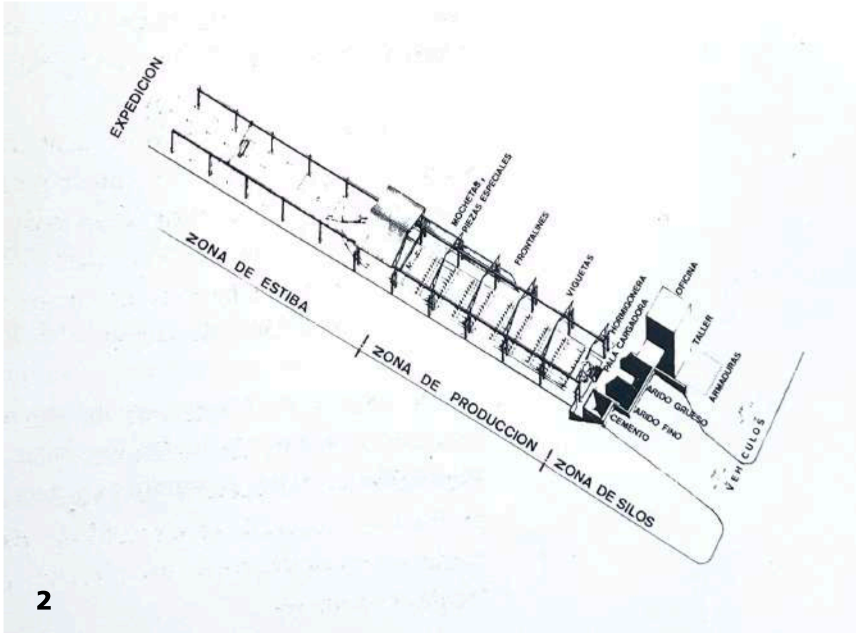

Fig. 2: Drawing representing the operation of the prefabricated ferrocement plants of the Technical Assistance Institutes (IAT) 'Cedas' and 'CCU'.

prefabricated ceramic bricks panels

The Uruguayan example of light-weight prefabricated buildings erected with clay bricks also served as technical inspiration for the activities carried out by architects Joan Villà, João Marcos Lopes, Nabil Bonduki, and engineer Yopanan Rebello, among others, at the Housing Laboratory of the Architecture and Urbanism course at the Faculty of Fine Arts of São Paulo (FEBASP), between 1982 and 1985. Villà coordinated the laboratory, which, from its creation, aimed to consolidate pedagogies in teaching design, construction, and building in conjunction with housing movements in São Paulo, working to promote access to technical assistance in self-build projects executed with group participation. While initially building projects were carried out using conventional artisanal techniques, from 1984, the laboratory began testing prefabricated panels composed of perforated ceramic bricks and concrete. Among other activities, the laboratory implemented the urbanization and house building project for the Joyous Corner ('*Recanto da Alegria*') shanty town as well as providing technical assistance for the Nucleus for Securing Housing in Vila Remo and Cidade Dutra (*'Núcleos para a Conquista de Moradia da Vila Remo e Cidade Dutra'),* also in São Paulo.

After the FEBASP Laboratory experiments came to an en end, due to conflicts between the group of teachers and the organizers of the private college, other similar laboratories were set up as a result of the first. The most noteworthy of these was the State University of Campinas's Housing Laboratory (LabHab-Unicamp), where Joan Villà and João Marcos Lopes worked, among others. In this new venture, professionals found institutional support from this public university and started a project that aimed to 'counter expensive, individualized self-building made without technical support; the new proposal for 'mutual aid' collective construction should bring constructive forces together, organizing them into a single set – given the 'collective scope in which they operate, intervening favourably in the concentration of human, organizational, institutional, economic, technical, etc. resources' (Pompéia, 2006, p. 47).

The proposed construction system developed by the Laboratory had a clear focus on prefabrication. Its goal was to train a specialized workforce in order to obtain a better product, reduce waste, and minimize physical effort expended during construction. In addition to the Laboratory's celebrated production in which it perfected the manufacture of ceramic prefabs inside Unicamp itself (Student Housing, 1986; Lake Restaurant, 1987, among others), LabHab also worked for the Association for the support of housing in the South Zone(*Associação Pró-Moradia da Zona Sul*) and for the Vila Arco-Íris Residents Association, (*Associação dos Moradores a Vila Arco-Íris*) among others in São Paulo, and entered into an agreement with the United Nations/ United Nations Development Programme (UN/UNDP) for technical cooperation and prototype development for Brazilian municipalities in the northeast, while it carried out various other activities until 1989.

Fig. 3: Prefabricated ceramic brick panels. Joan Villà and Lab Hab-Unicamp team, 1985

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self-organised collective building projects at usina ctah

In 1989, architects João Marcos de Almeida Lopes, Mário Luis Attab Braga, and Sérgio Manccini left LabHab-Unicamp and founded Usina – Centre for Work on the Inhabited Environment (*Centro de Trabalhos para o Ambiente Habitado*), a multidisciplinary collective specializing in advising self-organised social housing projects self-built with mutual aid.

Usina CTAH constitutes an important political experience combining social organisation, architecture, construction, and urban planning. It advocates the use of prefabrication technology in the building site in contrast with the idea of industrialization as a tool for the domination of financial capital over production systems. Usina CTAH aligns itself with the idea of technological development as a tool of respect towards the joint effort of workers, as guaranteeing greater safety and more accurate results, less waste, and better use of available economic resources. In contrast with deeper industrialization processes, s it is possible to observe in these case the setting up of factories within the building site and the resultant training of the involved workforce, similar to what Ian Terner proposed in *Freedom to Build.* For example, while building the COPROMO complex in *Jardim Piratininga*, in the city of São Paulo's municipality of Osasco (1990-1998), prefabricated steel stair towers were used and installed right after the foundations were completed in order to improve circulation within the vertical building site, to give the project's dimensional definition greater precision and to give collective builders more advanced technical means (Vilaça; Constante, 2015, p. 238). Almost simultaneously, the same solution was successfully used by Usina in the self-organised building collectives at *União da Juta* (1992-1998) and *Juta Nova Esperança* (1993-1999), on the outskirts of São Paulo.

Resulting from a long process of observation of self-organised building sites and of painful experiences related to the construction of the stairs by its users, the solution to use prefabricated steel staircases designed by Usina sought to create 'a work directed and managed from another production relationship' (Lopes, 2006, p. 340). Sergio Ferro, when commenting on the work of the Usina group, highlights:

> When it comes to Usina, the mixture of advanced technology (various levels of steel structure) with, at times, quite primitive procedures, breaks with common associations made between such building sites and technical impoverishment. The underlying prejudice associated with

this thinking may be to consider that the poor have to 'figure it out' themselves with leftovers and elementary things when taking care of themselves, as the system forces them to – leaving serious production to serious people. Misery-making is a rich person's thing. If it is possible, there is no reason to avoid using advanced technological solutions in building sites operated by self-building collectives (Ferro, 2004, p.2).

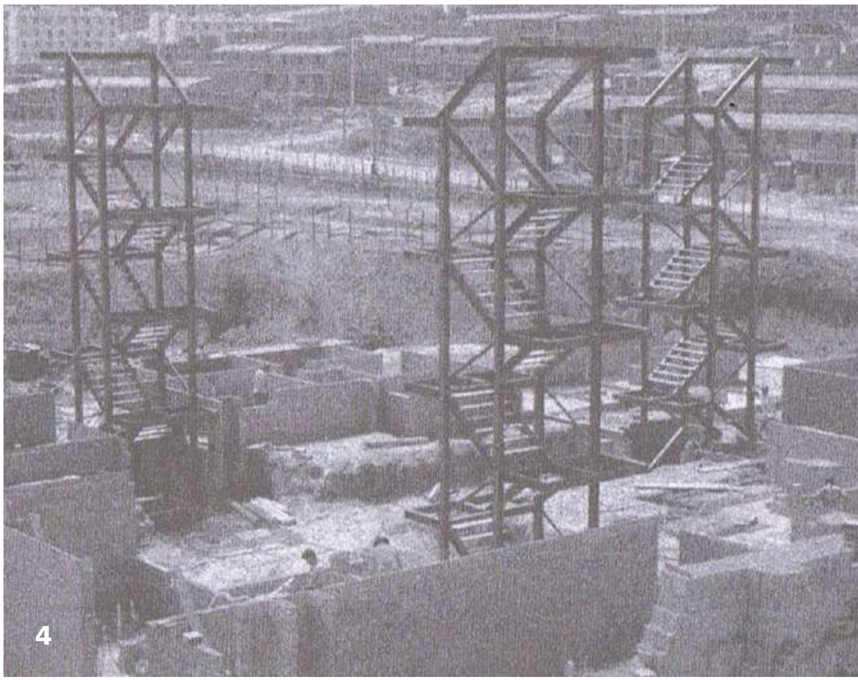

Fig. 4: Construction of the União da Juta Residential Complex, showing the prefabricated steel stairs already set up at the onset of the work. USINA CTAH, União da Juta Construction Association, affiliated with the Landless Workers Movement for East São Paulo 1 (Movimento Sem Terra Leste 1), linked to the Union for Housing Movement (União dos Movimentos de Moradia). São Mateus, SP, 1992-1998.

the vila nova cachoeirinha case in são paulo

Another relevant chapter in collective self-building with mutual aid and technical assistance in Brazil began in 1981, when a young engineer called Guilherme Coelho visited Uruguay while he was still a postgraduate student at the Polytechnic School of USP. Impressed by the work of FUCVAM, Coelho returned to São Paulo armed with a film made with a Super 8 camera, and decided to travel, showing his film to 'people who lived in favelas and in informal settlements, neighbourhood associations, students, left-wing politicians, and technicians who were beginning to advocate for alternatives to the National Housing Bank (*Banco Nacional da Habitação*-BNH) programs' (Baravelli, 2007, p. 114). This process resulted in the organization of the first mutual aid collective self-build group in São Paulo, on municipal land in *Vila Nova Cachoeirinha*, set up by families that had been pressuring the city hall to be included in existing BNH programs. This political action led to the implementation of one of the first mutual aid construction processes in Brazil, which then continued throughout the 80s and early 90s, with the implementation of two more phases, that absorbed the demands of new families in the region, and benefitted from the support of different financing programs.

In its third phase, which began in 1992, the collective buidling project called '*Cachoeirinha Leste*' was part of the mutual help program to support collective builds implemented by Luiza Erundina's municipal government (1989-1992), through FUNAPS, the Fund for Assistance to the Population Living in Subnormal Housing (created in 1979). The project was managed by architect Paulo Sérgio de Souza e Silva with technical assistance from Peabiru - Community and Environmental Work (Peabiru - *Trabalhos Comunitários e Ambientais,*) through architect Alexander Yamaguti. The collective builders decided to take advantage of the '*argamassa armada*' technology being used by the Centre for Development of Urban and Community Equipment (CEDEC), a factory coordinated by architect Mayumi Souza Watanabe and directed by architect Paulo Fonseca de Campos. CEDEC took the '*argamassa armada*' that Lelé had developed in Salvador to São Paulo, aided by professors from the USP School of Engineering in São Carlos. It thus worked on the creation of schools and other community facilities in low-income neighbourhoods, in addition to executing drainage canals and assisting in building projects taking place in other communities.

The work in Vila Nova Cachoeirinha is a vibrant example of technology exchange between official institutions and self-organised social movements, representing an experience in which the '*argamassa armada*' technology served the purpose of rationalizing construction, while also fulfilling a pedagogical and economic mission, by generating developments beyond construction. According to Yamaguti, 'within this context, the issue of introducing a pre-industrialized system instigates evolution, and, from the houses production, instigates the community's interest in setting up cooperatives for the production of components and constructive elements aimed at the formal market' (Yamaguti, 2006, p.49).

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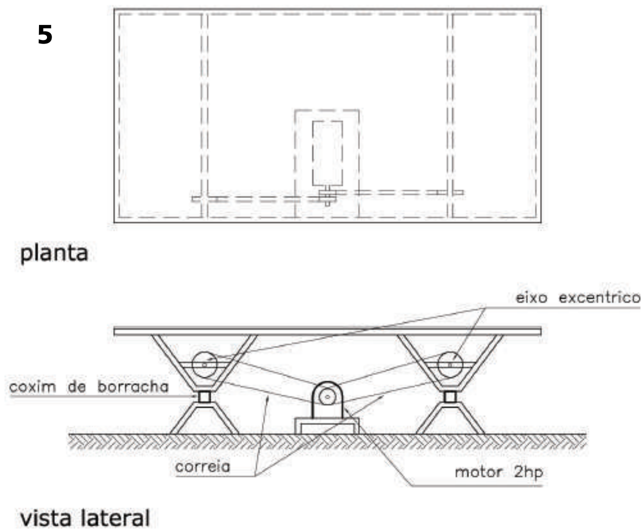

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Figs. 5-12: Self-organised collective building projects executed with technical assistance using moulds of 'argamassa armada' in the Vila Nova Cachoeirinha neighbourhood, outskirts of São Paulo, 1992. The 'argamassa armada' elements were produced in a partially industrialized process, in a plant set up with rudimentary equipment on the building site.


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factories for lightweight prefabrication
salvador urban renewal company (renurb)

Lelé's experience with '*argamassa armada*' began in the late 1960s. It aimed to find alternatives to heavy prefabrication, with which he had worked going back to the construction of several buildings at the University of Brasília. In isolated elements such as the sheds of the Taguatinga Hospital (1968), Lelé found space to conduct tests and prototypes. Later, invited to complete the delayed construction of Bahia's Administrative Centre in the second half of the 1970s, Lelé began his relationship with the city of Salvador, Bahia, where, from 1978 onwards, he initiated the development of a unique experience in the industrialization of ferrocement.

Originally envisioned by Mayor Mário Kertész to implement the Public Transport Improvement Plan (TRANSCOL), the Salvador Urban Renewal Company's (RENURB) factory highlighted its role in sanitation and urban furniture, especially in the scope of the Camurujipe Valley Program, one of the largest urban upgrade programs executed in Brazil to date. RENURB also played a crucial role in other significant interventions in Salvador, such as the Lapa Transfer Station (*Estação de Transbordo da Lapa*) (1981), Liberdade-Calçada funicular elevator (*Plano Inclinado Liberdade-Calçada*) (1980), and the Barris Police Complex (*Complexo de Delegacias dos Barris*) (1980), all designed and built by Lelé.

RENURB consisted of a design studio and a precast concrete plant working together to develop its projects. According to data from the Salvador Municipal Government, more than 60 settlements in the Camurujipe Basin received new drainage staircases, with a direct or indirect impact on the lives of over 60,000 people at the time (Salvador Municipality, 1981, p. XXVII).

Considering that RENURB was the first case of the industrial production of '*argamassa armada*' in the country, we can say it pioneered the specific processes of mould design for the casting of these elements. Some moulds consisted of two, or even three, parts, with movable mechanisms and unique complexity. According to Lelé, 'the design of the mould was based on the techniques of bending sheet metal and the operations of casting and mould removal' (Lima, J., 2012, p. 48).

In an interview with architect José Fernando Minho, who collaborated with Lelé for over thirty years, it's easy to see the effort and constantly evolving research on topics like formwork sealing, for example, which was something that had to be efficient in all the various phases of the process. Sealing had to be tight enough to prevent mortar leakage during concreting and, as we will see later, practical enough for the easy removal of the mould.

Another important phase of the production flow, the curing process of the recently fabricated elements had at RENURB the starting point of an ongoing technological development throughout Lelé's career[11], reaching its peak during the the years the Sarah Kubitschek Network Technology Centre (CTRS) was in operation. It was RENURB, nonetheless, that served as a model for Lelé's working methodology, within a format that was replicated in subsequent factories: integrated project experiences, industrialization in the plant, and 'in situ' construction.

The first precast 'argamassa armada' elements executed by Lelé at RENURB were lateral staves of drainage culverts, designed under Professor Frederico Schiel's direct supervision. These designs were based on experiments that had been under development in previous decades at the School of Engineering in São Carlos, as evidenced by drawings from the archives at the 'Urban Development Company of Salvador' (DESAL).[12] The drawings date back to February 1980 and refer to lines laid on *Direita do Bom Juá* Street, a location in the *Camurujipe* Basin in the *Acesso Norte* neighborhood of Salvador. The canal at *Vale das Pedrinhas* dates back to the same period and received a similar solution. Later drawings, dating to 1983, show more sophisticated versions of the same mould, in steel, consolidating concreting and mould removal technologies that would be crucial to the success of this industrial undertaking. These evolutionary drawings demonstrate how the process of industrializing '*argamassa armada*' in Bahia worked, which was pioneering even at the international level, with its use of solid wood and plywood moulds as prototypes for more developed metal moulds.

Between 1979 and 1982, RENURB produced four basic elements: the precast shelter (made of reinforced concrete), drainage channels, drainage staircases, and retaining walls (made of 'argamassa armada'). Schools and other facilities also stood out.

RENURB's plant produced, in 1980 alone, 1,800 pieces for *Vale das Pedrinhas* and *Bom Juá's* drainage canals, in addition to 4,000 meters of draining stairs for the *Camurujipe* slope, with a view to containment.

RENURB's design Studio also included management for projects financed with resources from the Brazilian Urban Transportation Company (EBTU) and the Inter-American Development Bank (BID), as well as resources from the National Housing Bank'(BNH), National Bank for Economic and Social Development (BNDES), EMBRATUR, and Brazil's Federal Savings Bank, *Caixa Econômica Federal*. Within the TRANSCOL, several interventions occurred to consolidate and improve low-income neighbourhoods, at the intersection of transportation programs and settlements, notably the project for 50 bus terminals, paving 11.81 km of streets in low-income neighbourhoods, and various constructions in Amaralina's northeast, including the renovation or opening of 100 pedestrian streets and 30 main transport corridors (SalvadorMunicipality, 1981, p.18).

Fig. 13: RENURB factory in Salvador, 1980 - First industrialized ‘argamassa armada’ factory in Brazil.

Fig. 14: Abadiânia Factory, Goiás, 1984.

Figs. 17-20: RENURB Factory, Salvador, 1981. Drainage channel stave reinforcement.

Fig. 15: Rio de Janeiro Factory, that occupied two plots of land on the banks of Av. Presidente Vargas, 1986.

Fig. 16: FAEC Factory, Salvador, 1988.

the rio de janeiro schools factory

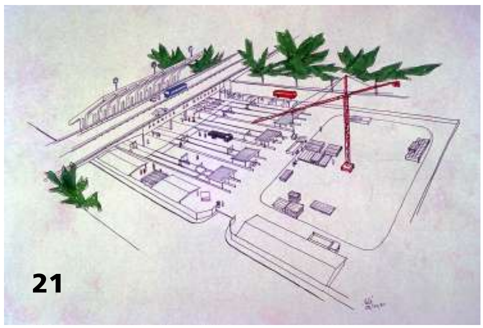
The Rio de Janeiro Schools Factory was inaugurated in November 1984, during the Leonel Brizola's government, when anthropologist Darcy Ribeiro was vice-governor. The government's strong emphasis on education found in Oscar Niemeyer and Lelé's designs the architectural components it was seeking for the building of new schools. The 'Integrated Centres of Public Education' (*Centros Integrados de Educação Pública*-CIEP) with their emphasis on heavy prefabrication and the '*argamassa armada*' schools designated for smaller and difficult-to-access plots, the 'Essential Schools,' originally nicknamed Children's Houses, were all remarkable achievements built in Rio at that time. In both cases, prefabrication and the industrialization of construction were used to increase the speed, quality, and quantity of works being built. Lelé's effectively executed '*argamassa armada*' schools were part of a broader urban policy that finally abandoned favela removal practices.

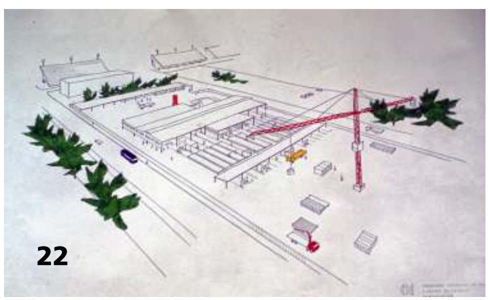
In contrast to the CIEPs, which were reinforced concrete buildings installed in flat, easily accessible large areas, with a minimum of 5,000m2 (Ribeiro, 1986), the '*argamassa armada*' schools occupied residual plots in areas of spontaneous urbanization and acted as a tool for the public sector to penetrate and socially upskill the more vulnerable population, as carried out in Salvador a few years earlier. According to Michel Chauí, the experience gained in Rio was also 'a massive leap in production and urban application' (Do Vale, 2016, p. 212), which was once again anchored in multidisciplinary action on urban territory. The Rio factory, located in the city centre, was later duplicated. It was set up to produce 40m3 per day, at least twice the production capacity of RENURB, which is tantamount to being able to manufacture up to 600m2 of schools per day (approximately two complete buildings).

Lelé designed the entire industrial plant, specifying the machines and accessories for producing the elements, the process, and the production flow within the warehouses and curing tanks. In his drawings he outlined the dimensions of hoists and their supporting structure, as well as the design of warehouses and the structure of the work areas, where one can see the carefully designed closings and structure elements. In Rio, 'Bambozzi'- style electric hoists were incorporated, designed for loads up to two tons, servicing different curing tanks with varying lengths (26 to 38m) and depths (0.70 to 2.70m). The factory had a stockyard serviced by a crane with a 50m radius, designed to quickly load trucks transporting the pieces to the sites where buildings would be assembled.

Although larger, more equipped, and mechanized than previous factories, the Rio de Janeiro factory continued to focus on producing buildings that were easier to assemble and used lightweight prefabricated modules, compared with CIPES and other construction sites that used pre-fabricated elements.

Drawings and photographs from the João Filgueiras Lima Institute Archives and Rio de Janeiro's Public Archive show the factory being implemented in two phases, as well as the inauguration of a new production unit in Belford Roxo in April 1986, as part of an expansion plan for '*argamassa armada*' constructions, especially canals and basic sanitation works on the city's outskirts.





Figs. 21, 22: Studies for the occupation of two plots of land on the banks of Av. Presidente Vargas, in Rio de Janeiro's city centre, where the School-building Factory would be implemented, Rio de Janeiro, 1984 Lelé.

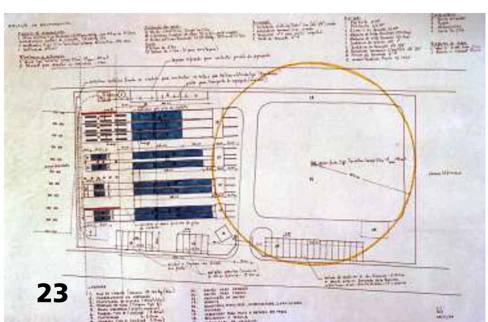


Fig. 23: Detail of the first implementation phase of the School-building Factory, Rio de Janeiro, 1984, Lelé.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Figs. 24-29: Views of production processes at the School-building Factory, Rio de Janeiro, 1984, Lelé. A more sophisticated sector was built for the 'argamassa armada' elements, as well as curing tanks dedicated to specific pieces, a crane in the storage yard and metallurgy sector for the production of moulds and other metal elements.

community equipment factory in salvador

When mayor Mário Kertész was democratically elected for a new term (1985-1989) and political-administrative conditions were once again favourable to Lelé's work, he returned from Rio de Janeiro to Salvador for a more comprehensive project than the first. The Community Equipment Factory (FAEC) or 'city factory' as it is commonly known (Risério, 2010) was active from 1985 to 1988, and it left important marks in the city, especially in certain neighbourhoods, due to an extensive catalogue of urban elements made with '*argamassa armada*'. Schools, daycare centres, footbridges, bus stop shelters, public restrooms, various bench models, and unique projects such as the headquarters for Salvador's City Hall in Praça Municipal, are all examples of its undertakings. In territories where RENURB had implemented the drainage system, respect was paid to the planning carried out by the Central Urban Planning Agency of Salvador (OCEPLAN), the city's planning body, to implement schools in such places as the *Pau Miúdo* neighborhood. According to Kertész, 'using resources from National Savings Bank - *Caixa Econômica Federal*, the City invested heavily in infrastructure and basic sanitation works in peripheral neighbourhoods. By December 1988, 865 public works had been completed in various parts of the city through programs like "Celebrate your neighbourhood" (*'Viva o Bairro'*) in addition to macro-drainage work – dredging, straightening, and lining – carried out on the Camurujipe River, the city's main drainage canal' (Kertész, 1988).

FAEC also made a significant contribution to the project of the historic centre intervention led by Lina Bo Bardi, which produced important examples of intervention in pre-existing structures, such as Benin House (1988) and *Ladeira da Misericórdia* (1988). For the latter, the development of special sections for concrete flooring and stabilization elements for existing walls were part of the construction repertoire from which a unique collaboration in the history of Brazilian architecture was consolidated, which to this day attracts international attention. The second Kertész administration focused on public transport, as occurred in the past, and introduced the project of the so-called 'modern tram', for which pedestrian walkways made of steel and '*argamassa armada*' were installed.

The diversity and complexity of the constructed elements made FAEC a more complete factory than previous ones, though similar in size and organization to the ones tested in Rio de Janeiro. The schematic design for the factory's layout outlines a production capacity similar to that of Rio de Janeiro – 40m3/day – and a suggests similar idea of using a crane for handling the stockyard, though it seems this idea never came into fruition.

In addition to the core nucleus that produced '*argamassa armada*' elements, carpentry and metallurgy sectors were developed not only for the of metal moulds, but also for the fabrication of buildings and footbridges structures. It was a pioneering experiment in the joint use of steel and '*argamassa armada*' . The carpentry workshops produced doors, lintels, and other wooden pieces that were used mainly in schools and daycare centres. In comparison to those produced by RENURB, FAEC moulds constituted a remarkable advance in terms of dimension and mechanical operation. FAEC applied the experience from Rio de Janeiro with fixed molds to specific curing tanks, to working with mould joints and stabilizers of flat bars, as well as metal hinges that allowed the opening and closing of the mould without having to completely disassemble it, and this also integrated, more efficiently, ways to assemble the internal casing. The mould's position, which was fixed in relation to the worker who assembled and concreted it, is always under development, which allows for ergonomic relationships and increased productivity.

The emergence of projects that were more diverse than the schools, which were originally the main focus of the Rio de Janeiro factory, also resulted in a greater variety of curing tanks, some of which were outdoors while others were protected inside the warehouse and reached depths of up to 3.0m, in order to, for example, manufacture specific pieces like sections for the footbridge roofs.

The reinforcements, in turn, received metal templates for their assembly, optimizing the entire production flow and also integrating structural connection devices, drainage pipes, and embedded elements, solutions that underwent continuous development in previous years and are still used today in Salvador's Urban Development Company (DESAL).

FAEC project archives at DESAL also reveal the methodology used in the preparation of construction site drawings in light of these industrialized construction methods, dispensing with specific details about each of the buildings. Although meticulously drawn, FAEC buildings had variations that reflected the site and the program implemented. The project for each of these variations was translated into assembly maps of the modular elements, which greatly simplified the customized project drawings in each case to meet the deadlines set by the administration[13].

FAEC operated in an area of approximately 70,000.00 m2, significantly expanding Salvador City Hall's scope of action, in comparison to RENURB. After its activities ended in 1989, FAEC bequeathed its assets to Salvador's Urban Development Company (DESAL), which is responsible to this day for the installation and maintenance of the city's footbridges, for example.

Fig. 30: Manual assembly of a FAEC school in Salvador, 1987. Unspecified location.

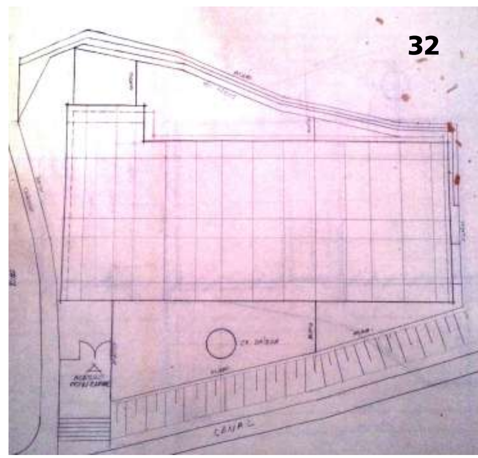
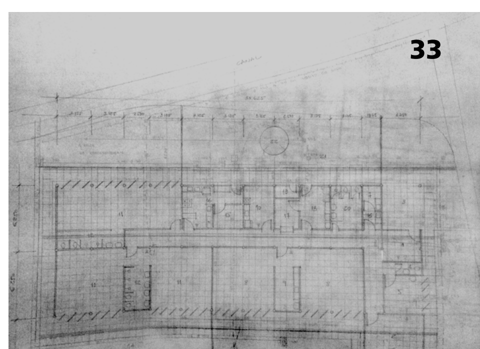


Fig. 31: Assembly maps of Bom Juá's nursery's vaults, which make clear the construction process using prefabricated elements.

Figs. 32-33: Bom Juá's nursery's site plan and floor plan, which are only auxiliary drawings to the maps that help with the effective execution



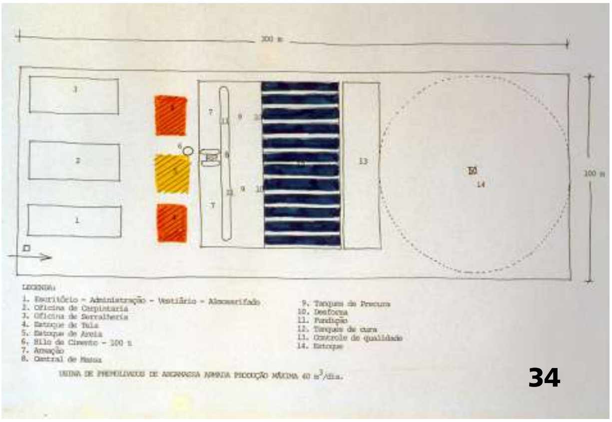


Fig. 34: Study for the implementation of the Community Equipment Factory in Salvador, 1985, Lelé.

Figs. 35, 36: Two different phases of the FAEC Factory in Salvador. On the left, when the factory started its activities (1985) and on the right when it was fully operational (1987). It is interesting to note the transformation of the Camurujipe River canal, at the bottom of each photo.

the abadiânia factory in goiás

After Lélé's experiences in Salvador, and before the construction of the factory in Rio de Janeiro, he proceeded to work in Abadiânia (1982-1983), a small town in the interior of Goiás state (population 17,000 in 1982). Lelé was taken there by architect Edgard Graeff, then a professor at the Federal University of Goiás, and Frei Mateus Rocha, close friends from the days of the University of Brasília (UnB). In Abadiânia, Lelé 'did not limit himself to elaborating social projects and small urban infrastructure work – instead, his central role at the municipal planning level was evident when developing a draft Master Plan for the city, based on a meticulous reading of the environment, its regional insertion, and its socio-economic characterization' (Do Vale, 2016, p.192). In this context, he developed this phase's most prominent project in Goiás, the Rural Model Transitional School, where he reinterpreted and moved the school projects forward compared to the ones developed with RENURB in Salvador, laying the foundation for one of his most important creations, the buildings for basic education. These unfolded in subsequent experiences in Rio de Janeiro and Salvador and later nationally. In addition to schools, Lelé also built infrastructural elements for urban mobility, such as '*argamassa armada*' prefab ferrocement footbridges, and designed health and community association facilities.

The rural conditions of Abadiânia resulted in the assembly of an '*argamassa armada*' plant that was simpler, less mechanized and on a smaller scale than RENURB's. Still with differentiated production lines, the goal was to produce, in '*argamassa armada*' , a more definitive version of a wooden school prototype previously executed For this, Lelé relied on the site's proximity to Brasília and the support of the '*Irmãos Gravia*' metalworking company, with whom he worked from the seventies until one of his last projects, the Darcy Ribeiro Institute Headquarter at the University of Bahia, Darcy Ribeiro Institute's headquarters. Abadiânia thus became a place for the development and precision cutting and bending processes of the sheets used for making moulds. Delicate recessed pieces, such as the transitional school's column or the 'economic' reduced core beam, emerged from this refined process. The moulds also needed to produce better finished pieces, undergoing a transition from being elements installed in urban space to becoming part of a building, and therefore it was expected they would be of a higher quality in terms of appearance and functionality within the interior classroom spaces.

In archival photos, we see a relatively simple warehouse in the factory and only two curing tanks, watched over by a small hoist for lifting pieces, a production unit clearly more rudimentary than the previous factory in Salvador and incomparable to later experiences in Rio de Janeiro and Bahia, including CTRS.

However, precisely because of its unpretentious, communal nature, the Abadiânia factory can be seen as a reference for autonomy and self-management when it comes to a a plant producing equipment for a community. The image of workers inside the curing tanks not wearing uniforms helps to understand the interrelation between industrial production and mutual aid. In this sense, the work in Abadiânia comes into alignment with the experience of the Vila Nova Cachoeirinha collective endeavour, ten years later, a building site where interested users were involved in both production and assembly of pieces and buildings.

Abadiânia safeguards a kind of technological paradox, set against the backdrop of prefabrication. Although one of the simplest factories Lelé built in his entire career, it is the place where sophisticated forms produced by the Gravia metalworking company were perfected and would be later refined in both the Rio de Janeiro factory and in FAEC in Salvador. It is in Abadiânia that Y-profile beams emerged, that required moulds featuring great ingenuity of production, symbols of the huge investment made in the design *of* their production, in contrast to the design *for* their production. This is change of stance illustrated by the booklet 'Transitional School: Rural Model,' in which Lelé translates into easy-to-understand drawings, the entire assembly process of a single-storey school he invented to address the seasonal demands of rural communities in Goiás.

Factories like the one built by Lelé in Abadiânia and the type of architectural production that they proliferated, symbolized by the proposal contained in the rural transitional school booklet, align with the idea of 'Simple Developed Cooperation,' proposed by Sérgio Ferro in his book *Construction of Classical Design*. The training of a collective and autonomous worker, who was once upon a time immersed in pre-capitalist production in medieval building sites, and who is observed and analyzed by Ferro, was to some extent experimented by Lelé in the 1980s, and such a worker indicates a path that can be taken to address some of Brazilian society's challenges as they are manifest in architecture and urbanism. This was a moment that materialized dissonant forms of making and producing. It was a moment that sought, through technology, different relationships on how to organize and produce work and to conceive of prefabrication in this context.

Fig. 37: Study for the Abadiânia factory, 1983.

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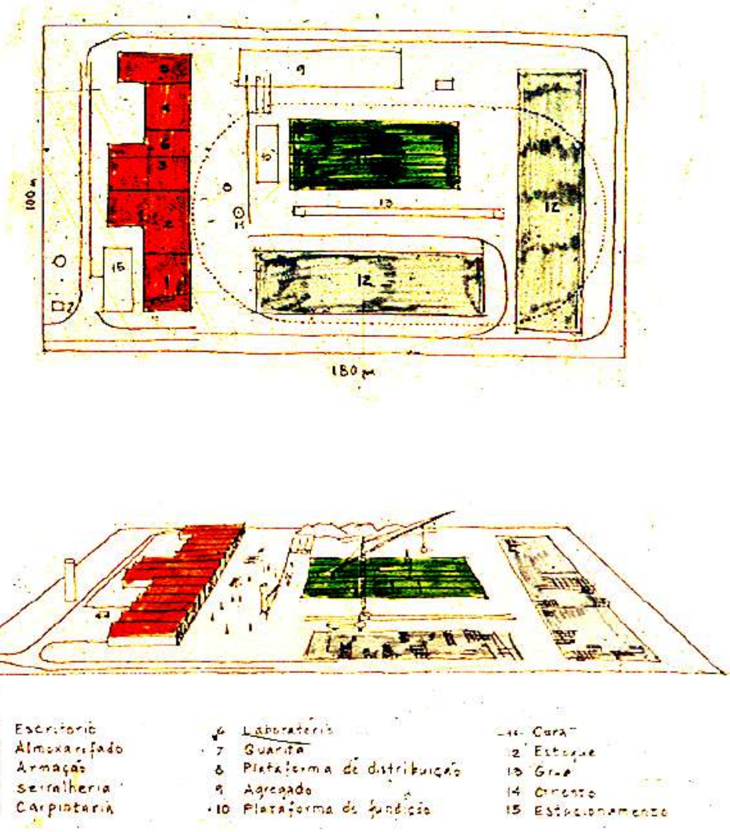

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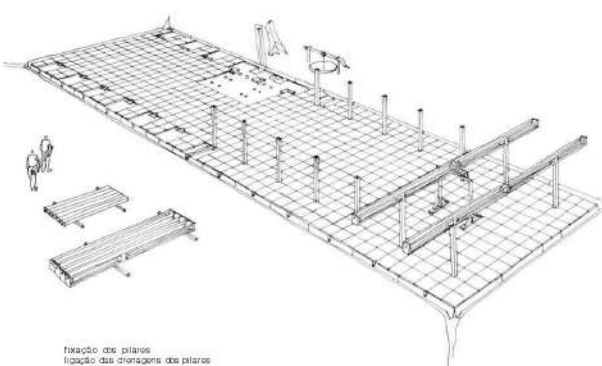

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Figs. 38, 39: Instruction booklet for the construction of the Rural Transitory School.


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Figs. 40-43: Aspects of the production flow at the Abadiânia factory: framing, mortar production, filling and curing, all within a relatively 'rudimentary' infra-structure, 1983.

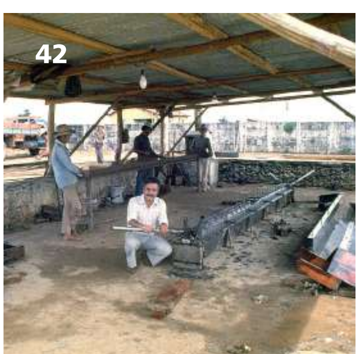
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Fig. 44: Curing tanks at the Abadiânia factory, 1983.

Fig. 45: Curing tank at the joint effort factory Vila Nova Cachoeirinha, SP, 1993. The Abadiânia and Vila Nova Cachoeirinha plants share many similarities in terms of infrastructure and means of operation, although they were built ten years apart. See the workers handling the sections inside the curing tanks.

sarah kubitschek network technology centre (ctrs)

In contrast to the Abadiânia Factory, Lelé's most complex technological experience is the Sarah Kubitschek Network Technology Centre (CTRS)[14], inaugurated in Salvador in 1994, after the successful construction of the first hospital in the network, specialized in the locomotor system. Built due to the decision to expand the hospital network envisioned by Lelé and Dr. Aloysio Campos da Paz to other cities in Brazil, CTRS emerged as a complex capable of industrially producing all the necessary components of these hospitals's building models. Occupying an area adjacent to the Salvador hospital, covering approximately 131,000 m², CTRS featured five workshops, administrative sectors, and a technical office laid out over 16,000 m² of constructed area. The workshops (heavy metalworking, light metalworking, prefabrication of '*argamassa armada*', carpentry, and plastics) occupied rectangular buildings with double-height ceilings, allowing for the creation of mezzanines for administrative and technical structures that overlooked the work areas. This large circulation on two levels integrated this space with the workshops, allowing for traffic, including that of vehicles, on the lower level. The construction system was the same as the one adopted for the hospitals: a mixed prefabricated system of metallic elements and reinforced cementitious grout components (Minho, 2022). Even special hospital-use equipment, such as stretchers and beds, were produced in the light metalworking nucleus, with exclusive designs made by Lelé that aimed to integrate the built space, equipment and its users.

At CTRS we find one of the most successful prefabrication experiences ever carried out in Brazil, even though it was characterized by closed-cycle production. As a public initiative, it incorporated, beyond its technical dimension, an intrinsic human dimension with regards to the integration between the building being constructed and the design, as well as between the conceptual, manufacturing, and construction teams. The CTRS created a significant reference for the notion of the industrialization of construction in Brazil, taking the prospects for the development of national prefabrication to unprecedented levels. Limited by the Federal Court of Accounts (TCU) in 2003,[15] the CTRS was prevented from continuing to support other public initiatives lead by Federal Government agencies, which planted the seed of its closure a few years later.

mini-factory

At the intersection between Abadiânia and CTRS, Lelé came upon one of the most interesting ideas about prefabrication's role in Brazil's social housing field.

In 2010, Lelé was involved in the creation of the Brazilian Institute of Habitat Technology (IBTH) after CTRS was dismantled due to political and bureaucratic obstacles that prevented him from continuing to work on different things in order to maintain the Sarah Network, resulting from the TCU's constant vetoes of the factory continuing to carry out work for the public authorities.

The Institute's objective was to create a new factory for buildings that would also be an educational hub, operating with a certain autonomy to execute State commissions. One of its initial motivations came from the studies carried out by Lelé for social housing within the scope of the 'My House, My Life' program (*Minha Casa, Minha Vida* - MCMV), commissioned directly by the Presidency of the Republic under Dilma Rouseff's administration. Such initiatives also ended up facing a series of bureaucratic and economic obstacles, until they were finally shelved in 2012, something that Lelé discussed at public events as being a major source of frustration.

The 'My House, My Life' program, implemented by the Federal Government in 2009, aimed to build 3.4 million housing units by 2014, at a cost of almost 244 billion reais (Brasil, 2015). This brought the discussion about addressing the country's housing deficit to the fore, forty years after the National Housing Bank's (BNH) inaugural initial experiences.

The PMCMV's massive numbers, along with the vastness of the Brazilian housing problem, thrust the program to the top of the pile of discussions on the topic in Brazil, especially in light of the fragile nature of the building projects and designs that were being carried out. Additionally, as José Eduardo Baravelli elucidates in his doctoral thesis (Baravelli, 2014), the technical and technological mechanism applied to production and prefabrication quality control for the 'My House, My Life: Program' and its built projects, in São Paulo, for example, actually contributed to exacerbating the social and urban problems facing new housing, rather than the other way around.

Lelé executed several projects with his team at IBTH, one in the Pernambués neighbourhood (which had a sloping site) and another in Cajazeiras (flat site), and these were supposed to serve as prototypes for the implementation of a new architectural and urban production logic within the auspices of the 'My House, My Life' program. The focus was on industrialization with lightweight prefabricated elements for the production of social housing, in the vicinity of to self-built areas.

> There was never an opportunity for us, within Sarah's industrialization process, to achieve an economy of scale that matched projections for 'My Home, My Life'. At that time I think we offered a proposal that, if it had been adopted, would have achieved a very reasonable economy of scale, and it would cost half the amount and provided much better quality, and more comfort.
>
> But this opportunity to create an economy of scale, was never afforded me in architecture. Even when you come in with a massive amount of prefabrication it isn't enough to provide such an opportunity, and I think that to achieve and develop an economy of scale, it really has to be a housing program in order to justify it (Lima, J., apud Cordiviola; Olmos, 2013, p.62).

Lelé's project was remarkable from an urbanistic perspective, as it affected land close to major centres, and provided for the construction of leisure facilities, improved accessibility, and support for resident families (childcare centres and schools), even if it did not specify the best mechanisms for financing these more central sites.

Lelé's project proposed two types of housing for Pernambués: the first consisting of 240 flats conforming to the Federal Savings Banks' (*Caixa Econômica Federal*) program, with 4-storey buildings without lifts and 39.60m2 units. The second, 'semi-detached houses' for the sloping sites, offered an 'alternative inspired on the city's existing *favela* occupation culture, where each unit expands vertically to adapt to possible changes in the respective family program' (IBTH, 2012, p. 2). The proposal made provisions for vertically extending homes up to four floors high, rising up from a minimum 32.80m2 ground floor module, which included a laundry area. The proposal also adopted as a general pattern an occupancy of ground floor + 1 floor with stairs that were 'external' to the unit and a total area of 67.20 m2, allowing for a maximum per unit area of 136.00 m2, a total population of 1,644 inhabitants and density of 548 inhabitants per hectare (Ibid., p.2). Access to the units located on the hillside would be via two funicular elevators, which Lelé illustrates as something along the same lines as the one he designed and built for the connection between CTRS and the Sarah Hospital, in Salvador.

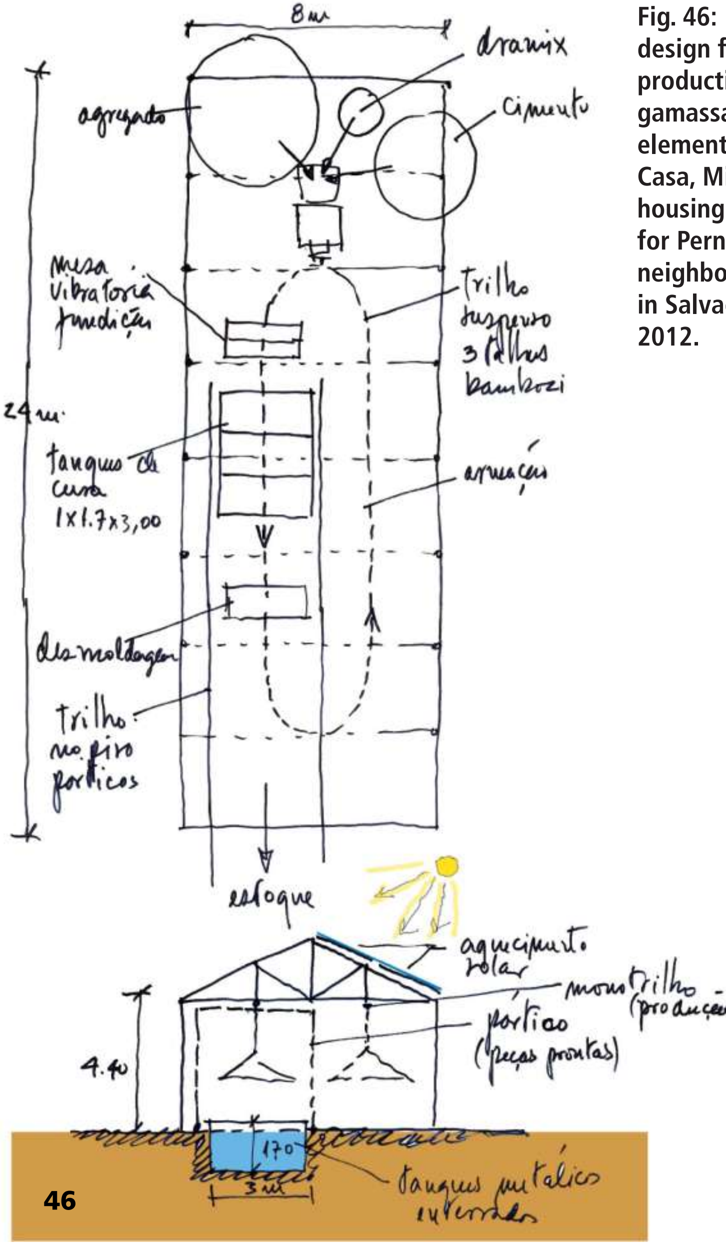
With an eye on the construction and extension of houses, Lelé envisioned the use of '*argamassa armada*' in the walls and flooring, produced in a mini plant measuring 24.0x8.0 with a 4.40m high ceiling, located close to the building site, in a drive to reduce transport costs for the elements being produced, which would have to weigh up to 70kg.

The proposal was also defeated by bureaucracy, resistance from the financial system and the construction sector as well as the government's inability to support the initiative, so that it remained merely 'on paper'.

In our view, one of the greatest contributions of Lelé's proposal for the PMCMV consists precisely in the idea of a mini '*argamassa armada*' production plant , something that we can associate with his experience in Abadiânia, in terms of scale and production methodology, at the same time as it envisions a manufacturing plant that offers a 'synthesis' of later experiences in Rio de Janeiro and Salvador (FAEC and CTRS), contemplating a minimal but effective structure for the production of such prefab elements.

The mini-factory designed by Lelé was supposed to allow for a continuous flow of moulds, hanging from hoists and metal gantries, from the framing sector through to the area that produces the '*argamassa armada*' and then the filling/vibration station, then through to the curing tanks (3 units measuring 3.00 x 1.00m and 1.70 m deep) and flowing through to the mould removal table, all inside a 200m2 warehouse. The way it is laid out is as if the structure is intended to provide interaction with the community. It even allows us to imagine building projects carried out within a collective self-build regime that benefits from technical assistance (although this was not foreseen by Lelé), which would, as we have seen, have an incremental character, setting forth a gradual increase of housing.

Beyond the bounds of a closed-cycle proposal, as originally envisaged, the mini-factory would potentially serve as auxiliary equipment for the production of open-cycle structural elements, as well as fulfilling the role of incorporating the kind of pedagogical potential that was present in experiences like Abadiânia. Lelé considered this to be of great importance, and in our opinion the mini-factory could be a piece of equipment which offers a wide gamut of possibilities in the field of state-supported self-built housing. It could also be completely autonomous, giving rise to the potential of 'argamassa armada' as a tool for technical assistance, whether for housing initiatives or for urban upgrade programs. It would be exemplary of what we perceive as being a 'possible industrialization' for the context of countries like Brazil, and the synthesis of elements expounded upon by Lelé in his work since the end of the 1970s.



46

Fig. 46: Mini-factory design for the production of ‘argamassa armada’ elements at “Minha Casa, Minha Vida’ housing project for Pernambués neighbourhood in Salvador, Lelé, 2012.

metal moulds and production design

A fundamental aspect of the development of prefabricated '*argamassa armada*' elements is the mould design used in the manufacture of the pieces. This required great intellectual effort and technological development knowhow from Lelé and his collaborators, in terms of both at RENURB and at the later factories they worked at. Among the many other initiatives linked to his work, it summarizes Lelé's proposal for a design 'of' production, rather than a design 'for' production, as in Ferro's provocation.

To achieve the goal of prefabricating architectural components with characteristics such as reduced weight and thickness, and the presence of 'folds,' flanges, and recesses dedicated to interconnecting and joining different building systems invented by Lelé, the moulds underwent an unusual development method. This often started with a wood and plywood prototype, and later developed into metal pieces, made with folded sheets of steel, with various degree of thickness.

When ready, the moulds had to withstand a constant work routine, with 2 or 3 daily moulding/demoulding cycles. They had to cure at high temperatures, undergo significant dynamic efforts during both moulding and demoulding, and finally deliver pieces with an excellent finish. Many of these moulds were made up of elements articulated at multiple points in order to cope with the formal complexity of the '*argamassa armada*' structures.

Lelé's architecture is more a result of this process than the other way around. Therefore, factories like RENURB, FAEC, and CTRS always had a sophisticated metallurgical production centre and very high calibre specialized designers, the likes of Mariano Casañas and Waldir Silveira. Part of their their work consisted in creating drawings at 1:1 scale with details at at millimetere precision. Developed together with Lelé, the molds embrace tradition and know-how from the heavy prefabrication industry, but absorb Lelé's internationally recognized creative ingenuity and establish a very characteristic production design.

According to a report by architect Fernando Minho, analyzing a collection of drawings donated by him to the UFBA Faculty of Architecture (FAUFBA) and currently the subject of his academic research:

> The mould designs always commandeered Lelé's full attention and were constantly evaluated on the basis of the pieces' finish and the casting and demoulding processes, with a special emphasis on production speed. The clamps and movable parts of the moulds have changed over time. In the beginning, screws and nuts were used to close the moulds that got stuck

> during dismantling procedures due to mortar residues adhering to them during the pouring process. The solution adopted used pins and keys as shown in the drawings presented here. The use of metal forms made a great contribution to the development of 'argamassa armada' technology in Brazil, which had previously used wooden moulds and stucco techniques in the production process (Ekerman et al., 2022).

We will now analyze the moulds used to produce well-known elements and systems in Lelé's work, such as the columns, beams and tiles of the two-storey school in Salvador, however, they are rarely analyzed from the point of view of their 'design' and the role they played in the materialization of this architecture.

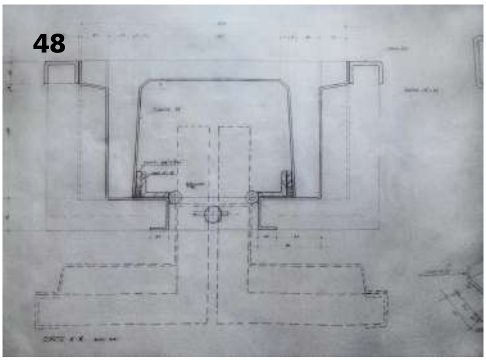
macro-drainage canal, 1979-1982

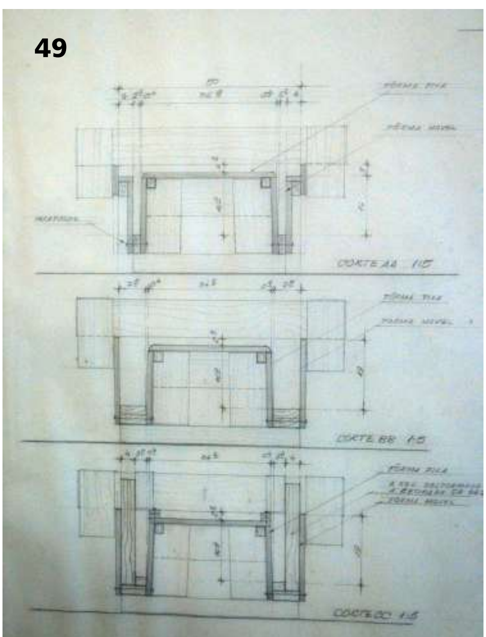
One of the first elements in '*argamassa armada*' produced by RENURB was the modular wall component of the drainage canals designed for the valleys in zones of precarious urbanization in the Camurujipe Valley, as previously discussed by this author in other texts (Ekerman, 2018). Research carried out at DESAL in 2016 and 2017 shows that the process of creating prototypes for these pieces with moulds made of solid wood and naval plywood, headed by Engineer Frederico Schiel, literally represented the first steps of an industrial production that would later be consolidated with the metal moulds.

The consistency of the transition from prototype to final piece is remarkable, so that a series of specificities become defined almost immediately and remain almost unaltered in the transition from the wooden mould to the metal mould, especially with regard to the form and the definition of reinforcement locations and/or constructive importance to the mould.

These first examples illustrate, when compared to what would later be machined at FAEC, a greater number of elements – 'L' shaped angle-brackets, flat bars and folded plates, sometimes with thicknesses that are generally more robust than those of second-generation moulds, with a thickness of up to 3/8' (10mm) in some pieces. Despite differences in relation to the later generation of moulds, the ones from RENURB set the groundwork for everything carried out throughout the 1980s, so that its basic 'design' is recognizable in all the elements later produced later at FAEC.

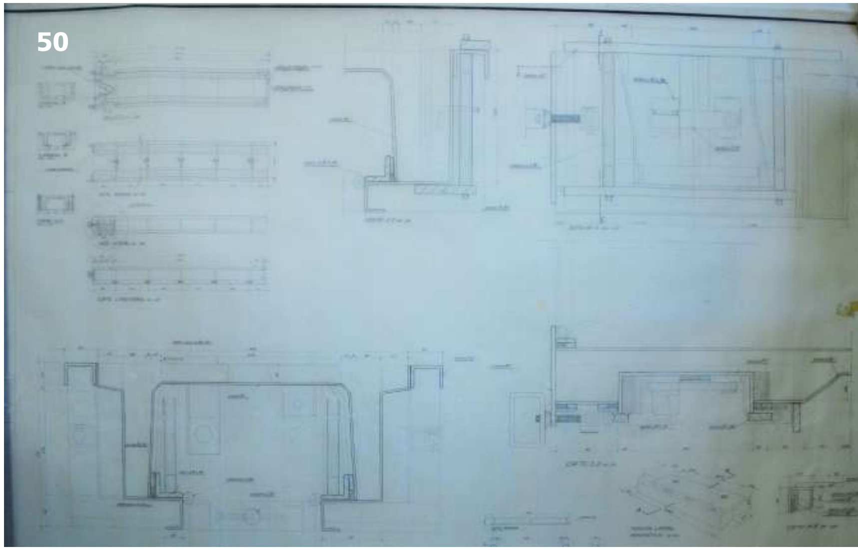
Fig. 47: Mould design for the 'argamassa armada' stave for the micro-drainage canal, RENURB, 1983.





Figs. 48, 49: Design for the wooden moulds and the prototype voussoir frame for the drainage canal, which will be built in the borough of Juá. The moulds and the structural design of the piece were carried out under the direct supervision of Engineer Frederico Schiel, in February 1980, according to the stamp.

Fig. 50: Design of the metal formwork for the same part, dated 1983.



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the drainage staircase

The drainage staircase was part of the set of devices cast in '*argamassa armada*', alongside devices used for macro-drainage canals which were integral to the Basic Sanitation Program at RENURB. It was made up of small voussoirs arranged in sequence on the slopes of low-income collectively-owned land, forming drainage channels that adapted to the steep topography in small terraces, covered by '*argamassa armada*' platforms that formed steps. Rainwater was collected through openings on the sides of the small channels and directed to the macro-drainage canals. More complex in some measure than the drainage canal sections in terms of dimension and geometry, the components of the staircase system required moulds of corresponding delicacy. One of the noteworthy elements of the mould for each step is a funnel that will be recurring and a subject of constant development in other moulds. The funnel serves the singular role of regulating the mortar — an extremely important aspect in the industrialized process to prevent waste and better contain the cementitious mix, which, in the ideal 'slump,' is still quite hard to control. It is also important to note the auxiliary structure, essential to withstand the internal pressures of the mix and ensure the necessary tightness of the mould. Along with the locking system that uses a 'pin and wedge/key,' it optimizes the mould's reuse.

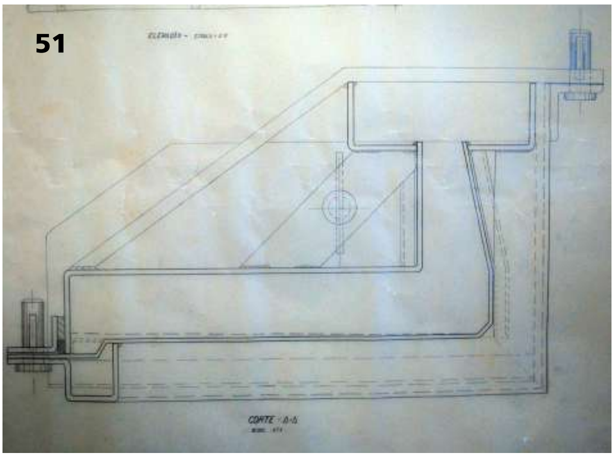


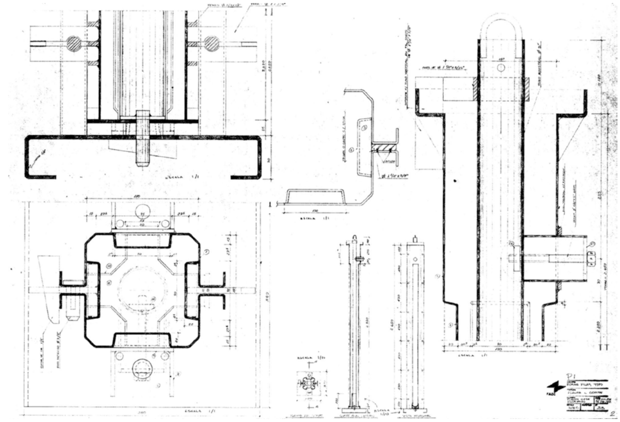
Fig. 51: Detail of the mould for a step of the draining staircase, revealing the trough for filling and details of the pin/wedge mechanism for locking/unlocking the two-part mould. The trough allowed for the levelling of the cementitious grout at the desired elevation through scraping with a mason's 'trowel.' RENURB, 1980-82.

the faec column, 1985-1989

Most of Lelé's metal moulds are made of thin sheets of SAE type carbon steel, hot-rolled, with a thickness of 1/8'. However, there are many variations and circumstances that lead to remarkable inventiveness in mould design and, consequently, in the types of pieces and widths the mould is composed of. The large scale usually characteristic of the elements forming the building systems under analysis, will also give such molds a distinctive 'DNA.'

In the case of the two-storey school's supporting columns, at least three properties stand out: first, the mould's elongated shape; second, the protrusions present in the piece, where partition pieces are fitted during the building assembly; finally, rainwater drainage built into the body of the piece through a void of tubular shape, made possible by placing an internal tube into the mould, which is removed a few hours after moulding, during the curing process, so that the surface tensions of the hardened mortar was not yet sufficient to jam it. A thicker 1/4' sheet was used for the base of the mould that was filled vertically and needed the factory floor's rigid support.

Fig. 52: Details of the metal mould used for the school column. Plant and main sections. Original drawings at 1:1 scale.

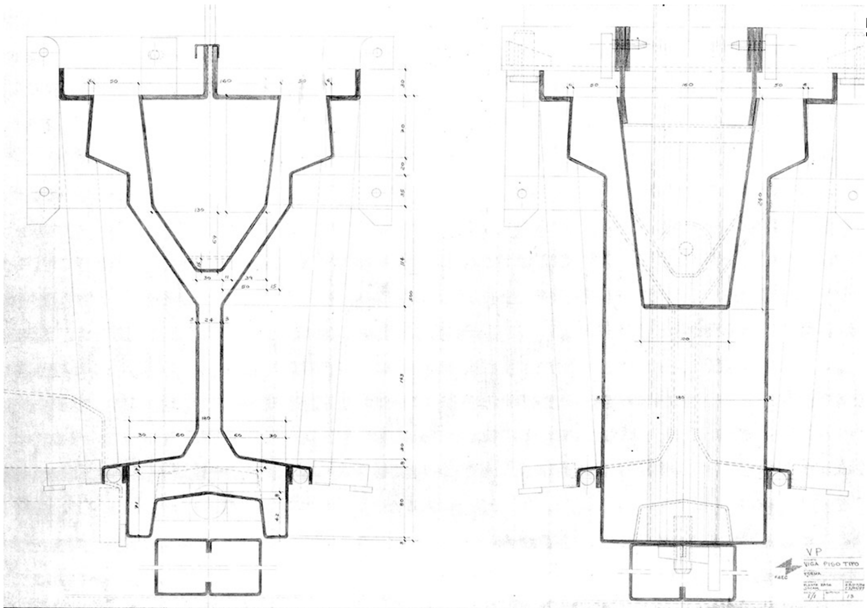


52

beams

One of the most significant advances in the transition between Rio de Janeiro's and Salvador's factories in the latter 1980s was the production of two-storey schools. As a further development of the model that originated in Abadiânia, they attempted to respond to the strong demand for schools in Salvador, in contrast to the limited available land for these built projects.

This movement led to the design of two types of beams: one for the floor plate and another for the roof, which supports the roof tiles and at the same time serves as a drainage channel leading to the column's internal void, which uses a design reminiscent of Abadiânia. Both of them are 5,621mm long, and when they are assembled in pairs, joined together through a screw and nut in the traction area, they allow distances between columns that span 6.25m with overhangs of 2.50m. They demonstrate the characteristic cuts, bends, and protrusions of Lelé's work in '*argamassa armada*', challenging the limits of precast concrete construction, achieving structural performance and aesthetic results with their 'Y' shape. As can be seen in both the operational photographs and drawings presented here, the moulds use a refined system of hinges and joints, delicate yet robust, that allow for the clamping shut and releasing operation to be carried out at the necessary speed, as an integral part of the assembly and sealing process. Also noteworthy are the 'funnels' dedicated to the mortar pouring, that ensure reduced wastage of the mix as it reaches the mould's narrow opening. The close-fitting quality of the different systems is another important attribute worth observing. It is often achieved without the need for gaskets or rubber fixtures, solely through the precision of the moulds' design and execution.



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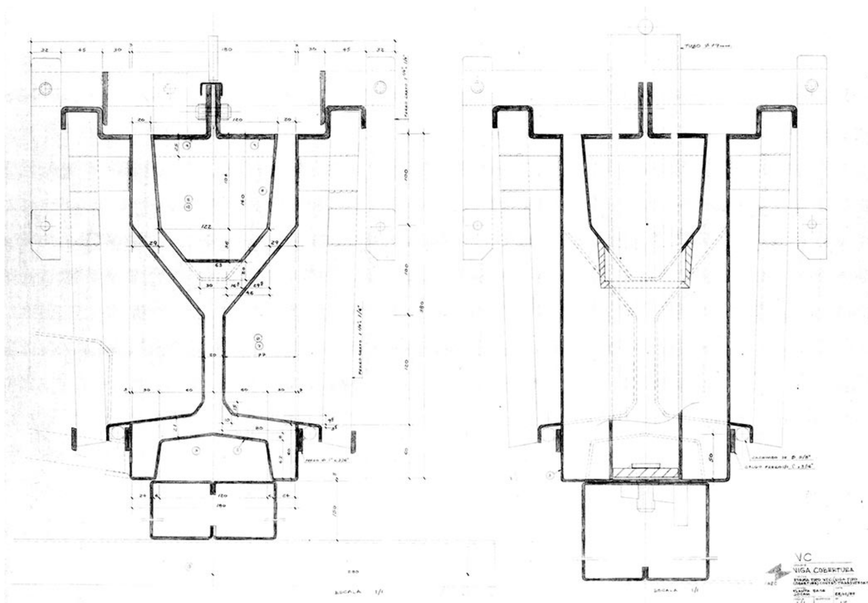

54

Fig. 53: Detail of the metal mould for the school's roof or 'floor beam'. Section. Drawings originally scaled 1:1.

Fig. 54: Detail of the metal mould for the school's roof or 'Canopy beam'. Section. Drawings originally scaled 1:1.

Figs. 55, 56: Function of the metal mould for the school awning, characterized by the more sophisticated metal joints and the bespoke curing tank.

tiles and roof system of the two-storey school

The roof system of the two-storey school is comprised of three basic pieces, which show variations in specific places, linked to the building's eaves and the location of the sheds. They are: the roof cover, responsible for collecting rain-water from the beam-gutter; the cover roof-tile, which seals the junction between the tiles, and solidify them; and the thermal insulation, which creates an air cushion between itself and the tile, resting on the cover roof-tile. The edge tile has a specific shape that includes an overhang.

The small variations between cast pieces, basically comprised of elements with a U-shaped cross-section, with specific geometries and dimensions, show another merit of Lelé's metal moulds, which is the ability to easily adapt to the design of new pieces, based on an already tried and tested technology. The successful repetition or reiteration of details such as the pin and wedge lock, sheet thicknesses, drag angles for disassembly, joints, hinges, and flat bar 'ribs' can be seen. Thus, the factory was able to absorb, with relative ease and adaptability, the challenge of creating different pieces. In this sense, the choice of lightweight prefabrication, with relatively smaller and more compact pieces compared to those commonly used in heavy prefabrication construction, also allowed for greater variability and compatibility of '*argamassa armada*' design with the architectural challenges it sought to address when it came to these buildings.

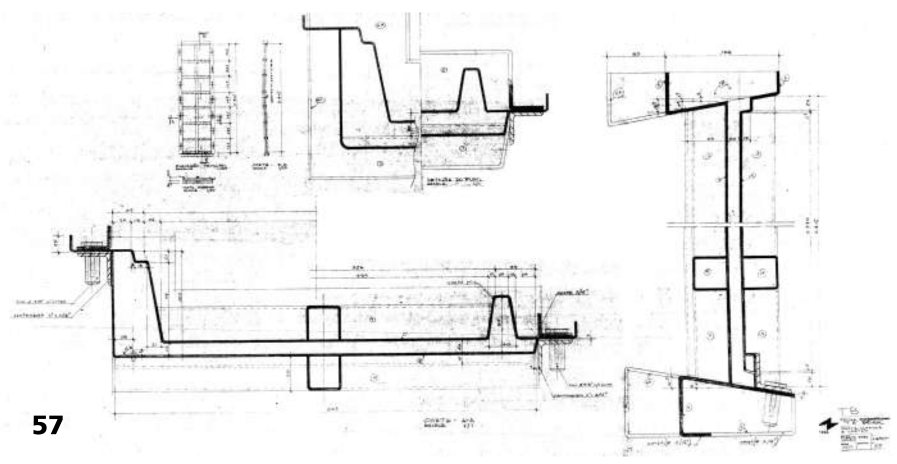

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Fig. 57: Project for the mould of the 'argamassa armada' tile for the 'two-storey school', FAEC, 1988.

stairs

The two-storey school gave rise to a new design for an architectural element that had been previously worked on at RENURB, for the staircase and prefabricated steps. At least two staircase moulds were produced for the two-storey school, one of them with two flights of stairs, with a semi-circular landing, and another in a single ‘shot,’ similar to the one built using the *Iansã* Module (*Iansã* is the Africa-Brazilian goddess of thunderstorms) at UFBA’s Faculty of Architecture. Both staircase models ~~moulds~~ were used at the time, depending on program and available space.

The mould for the single-flight staircase’s step stands out because of the ingenious positioning of the step’s geometry on the main base, which optimizes gravity by filling the mould’s Z-shape, while simultaneously using a system of articulated flat bars similar to that used for the moulds for the beam, responsible for structuring the movable pieces without the need to detach them completely, which would greatly hinder the process. In all drawings, we see the pin and wedge lock system mentioned earlier, which though it is very simple it is proven to be effective through constant use.

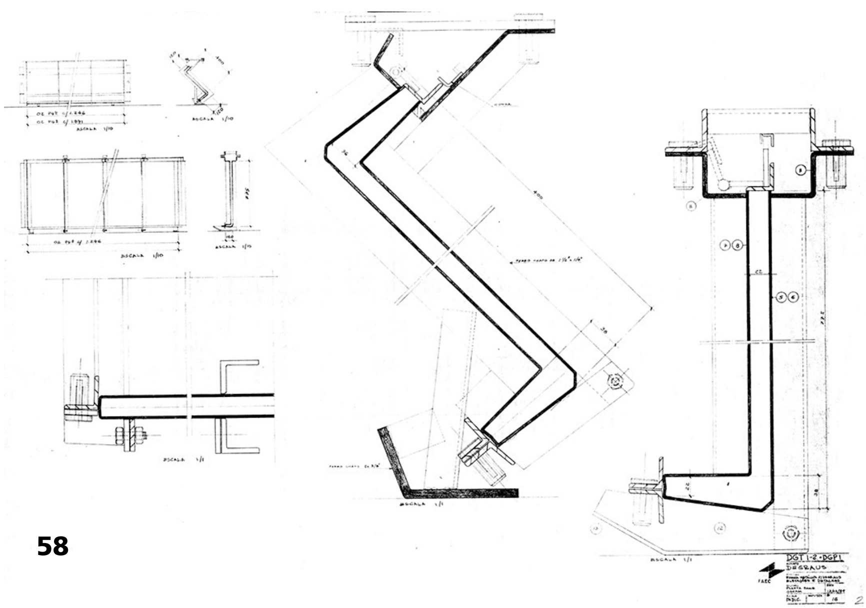

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Fig. 58: Project for the stair step-mould in reinforced cementitious grout for the ‘two-storey school’, FAEC, 1988.

conclusion

This reconstruction of Lelé's long and continuous professional involvement with prefabrication in Brazilian architecture and urban planning, in different scales, is justified in light of Lelé's creativity with technologies and methods of production and his ability to operate within the scope of various public policies. In fact, Lelé was able to lead in the creation of a set of tools which transformed urban and rural areas without losing sight of the social dimension of the multiple challenges he faced, whether in housing, urbanization, sanitation, transportation, education, health or through construction.

In the specific cases of Salvador, Abadiânia, and Rio de Janeiro throughout the 1980s and also in his later proposal for the 'My House, My Life' Program, Lelé's work is a result of the intersection between a keen reading of the geographical, social, economic, and political conditions of these cities and the technological challenges involved in each situation. In these experiences, he was able to combine aspects of urban planning with public policies that supported the consolidation of low-income areas, themselves made possible thanks to the development of architectural and engineering technological alternatives. The metal moulds for prefabricated lightweight '*argamassa armada*' pieces, and the production plants he developed, stand out in this context as being symbolic of the role of architecture and fabrication as agents of transformation.

The moulds and the industrialization of lightweight prefabrication also represent the meeting point between industrial and artisanal production in Lelé's work. He was able to imbue rationalized repetition with an important appreciation for constructive detail and the technical performance of designed systems and finished buildings. He thus manages to synthesize his approach to making designs **of** production, as opposed to designing **for** production, as advocated by Sérgio Ferro, who never hid his admiration for Lelé and the propositions he managed to execute in his factories.

Lelé thus made a significant contribution to the development of a dissonant vision with regards to industrialization in civil construction, by testing and proving in practice, rather than in theory, the ability to adapt and understand technology in the context of countries like Brazil, on the sidelines of capitalism, and offering a solid perspective on a *possible industrialization*, to use the Julián Salas term.

Especially in the Abadiânia factory and in the design and execution of the short-term rural school, which though less 'totalizing' than the Salvador or Rio de Janeiro experiments, nevertheless yielded an exemplary juncture in Brazil's architecture and engineering history, providing unequivocal meanings and notable lessons.

Lelé functioned like a 'dissonant' architect when he subverted conventional heavy prefabrication to operate specifically in favelas and other vulnerable areas, while viewing technology, as few others did, , through a social and humanistic prism.

The social aspect of Lelé's work also holds potential for shaping mutual aid ventures and similar initiatives, allowing us to speculate about the possibilities of opting for '*argamassa armada*' as technology for technical assistance. In this sense, the proposal for the mini-factory outlined in the last years of his life provides an example adapted to values that we consider essential here. Accessible to unskilled labour, it consists of a potential environment for exchange and mutual technological learning, where the most income-deprived population can indeed adopt prefabrication techniques as tools for empowerment and the creation of more equitable relationships of production, from social and economic perspectives.

Based on the Abadiânia factory, the mini-factory designed by Lelé for the 'My House, My Life' Program opened up possibilities for the creation of semi-industrialized building sites, aligned with the discourse out forward by the population it aimed to serve, where the real stakeholders do not exclusively serve as a labour force; rather together with other professionals, they can actually be agents of transformation and understanding regarding the importance of technology and autonomy in the fields of architecture and urban planning, sounding dissonant chords.

notes

1 This text is based on a doctoral thesis defended in 2018 in the Postgraduate Program in Architecture and Urbanism at UFBA (PPG-AU), located at the Faculty of Architecture at UFBA (FAUFBA), entitled 'Technology and Transformation: prefabrication for the restructuring of popular neighbourhoods and technical assistance for self building' ('*Tecnologia e Transformação: pré-fabricação para reestruturação de bairros populares e assistência técnica à autoconstrução*', in Portuguese) reviewed here in a synthesis that also aims to come closer to the writings of Sérgio Ferro, who was the protagonist of the 'Translating Ferro, Transforming

Knowledge' research project, which we were involved with as an affiliated researcher. His viewpoints on architecture as a field of production and on the process of construction act like a prism that help to reveal 'dis-sonant' experiences in the field of prefabrication, such as in the *Lelé* case.

2 '*Argamassa Armada*' is the portuguese term used to identify the prefabricated ferrocement developed at the Engineering School of São Carlos, São Paulo, Brazil, after Pier Luigi Nervi's visit to the country, in the 1950's. Lelé would develop '*argamassa armada*' as an industrialized system, in the 1980s. For this work we will referring to the material in its original portuguese terminology.

3 Lelé was invited by architect Aldary Toledo to join the staff of the Bank Workers' Retirement and Pension Institute (IAPB), which at the time designed and built financed housing for its members, within the scope of the Brazilian social security system. From this venture, begun in Rio de Janeiro, he was assigned to supervise the construction of 11 residential blocks in Superquadra Sul 108 at Brasília.

4 Lelé recounts in an interview that he only used to have a few hours of contact via amateur radio, once a week, in which to contact Oscar Niemeyer's architectural office which was responsible for the projects he was in charge of building (see https://www.ele-lele .com.br/).

5 Light prefabrication usually involves the use of parts that can be loaded manually, up to 80 or 100 kg, thus eliminating the need for heavy mechanization.

6 Lelé visited the Soviet Union, Poland, Czechoslovakia and East Germany in 1962, countries that he considered a reference in large-scale experiments with concrete prefabrication, a technology that he thought was more coherent in light of the challenges of the Brazilian reality, when compared to steel technology omnipresent in North American construction, for example (EKERMAN, 2018, p.174)

7 In addition to the four factories mentioned, Lelé also directed the Urban Equipment Factory in Rio de Janeiro in the same period (1984-89), which stemmed from the Schools Factory, (*Fábrica de Escolas*) and the Urban

Equipment Factory (*Fábrica de Equipamentos Urbanos*) in Brasília (1985-90) (MARQUES, 2012).

8 The CTRS operated officially between 1994 and 2018, and only until 2009 under Lelé's supervision.

9 Bruna's text, developed as a doctoral thesis at the University of São Paulo, was completed at the beginning of 1973 and later published by Editora Perspectiva in 1976, then reissued in 2002.

10 In a statement made during a visit in April 2023 to the FAU-USP archives as part of the 'Translating Ferro, Transforming Knowledges' research activity, Ferro reported, when comparing the built projects of houses named after their owners, 'Boris Fausto' and 'Bernardo Isler', that the *Arquitetura Nova* group felt it, 'was not a high-level scientific experiment, but it proved that heterogeneous manufacturing was still very difficult in Brazil in the fifties and sixties' - Sérgio Ferro, statement, April 3, 2023, FAU USP Library (Video – MP4 file)

11 The average curing time for 'argamassa elements' elements at RENURB could reach up to 24 hours, compared to 8 hours at CTRS which was made possible by heating water in tanks, using solar energy in a coil system and dispensing with photovoltaic cells.

12 The Companhia de Desenvolvimento Urbano de Salvador - DESAL is a mixed economy company, created by Municipal Law no. 4343/91 of July 23, 1991, according to information on its institutional website, that is, in the process of closing down the City Factory (*Fábrica de Cidades*). The company has a land area of 20,000m2 and an important installed industrial capacity. Heir to the experiments carried out by Lelé, between 1979 and 1989, DESAL is the guardian of the technologies developed in Salvador by RENURB and FAEC.

13 According to Fernando Minho: the process with the schools was fantastic. We received the topography in the morning, and by the afternoon we already had the scheme. Sixty days later, the school had already been built. At one point, between the factory and assembly line, we almost had 5,000 people working at FAEC - Interview given by MINHO, Fernando. Interview I [Aug.

2016]. Interviewer: Sergio Kopinski Ekerman. Salvador, 2016. 1 m4a file (73 min.)

14 For more information about production at the Sarah Kubitschek Network Technology Center, see Fábio Mosaner's doctoral thesis - 'The design and production process of architecture: João Filgueiras Lima (Lelé) and the Sarah Network Technology Center (CTRS)' (MOSANER, 2021).

15 In response to the consultation of the Minister of Culture, Gilberto Gil, in 2003, to the Federal Court of Auditors about the possibility of signing an agreement between the Federal Government and the Association of Social Pioneers, who oversaw the Sarah Network Technology Center, for the construction of its 'Bases for Cultural Support', Minister Lincoln Magalhães da Rocha, rapporteur, wrote that 'Surely, the CTRS does not have any technology that could justify, in terms of intrinsic economy and speed, the hypotheses of removing the need for this bid (...)' (COURT OF ACCOUNTS OF THE UNIÃO, 2003).

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Figure 2: Baravelli, 2007;
Figure 3: AU 126 Magazine;
Figure 4: Vilaça; Constante, 2015;
Figures 5-12: Yamaguti, 2006, and Baravelli, 2007;
Figures 13-30, 34-37, 40-44, 55, 56 : João Filgueiras Lima Institute Collection – Lelé;
Figures 31-33, 47-51: DESAL Collection;
Figures 38, 39 : Lima, 1984 ;
Figure 45: Yamaguti, 2006;
Figure 46: IBTH Collection;
Figures 52-54, 57, 58: Fernando Minho Collection/FAUFBA.

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