Fearless Forms: The Fluid Creations of Joaquim Cardozo

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André Tavares (Porto, 1976) is an architect. Since 2006, he has been running Dafne Editora, exploring publishing as a form of cultural and architectural practice. With Diogo Seixas Lopes he was editor-in-chief of the magazine *Jornal Arquitectos (2013-2015)* and co-curator of the Lisbon Architecture Triennale 2016, *The Form of Form*. At Serralves Museum he curated the exhibitions *Serralves Villa: the client as architect and Raw-Material: a view on the archive of Álvaro Siza*. He has published several books addressing the international circulation of knowledge among Portuguese-speaking architects, including *Arquitectura Antituberculose* (Faup-publicações, 2005), *Os fantasmas de Serralves* (Dafne, 2007), *Novela Bufa do Ufanismo em Concreto* (Dafne, 2009), and *Duas obras de Januário Godinho* (Dafne, 2012). His book *The Anatomy of the Architectural Book* (Lars Müller/Canadian Centre for Architecture, 2016), addresses the crossovers between book culture and building culture.

ABSTRACT

Joaquim Cardozo – the structural engineer for Oscar Niemeyer's most audacious concrete buildings – is better known for his contribution to Brazilian literature than for his works as an engineer. His poetry reveals the ambiguous relation between "misunderstood" European models and regionalist convictions. In fact, if we look closer at his constructive solutions for the technical problems presented by Niemeyer's designs, we will see instead of "reason," a large measure of improvisation, cunning tricks and intuitive solutions. While engineers were learning how to mix steel and cement to build reinforced concrete, in the world of literature, Franco-Swiss poet and writer Blaise Cendrars turned out to be fundamental to Brazilian modernist poets and showed them how to become tourists in their own country. For them, through this new foreigner condition, it was possible to rediscover Brazil and be delighted with the «genuine» and virile expressions of nature and popular culture. Meanwhile Ricardo Severo developed a strategy to adopt neo-colonial architectural forms which inspired different modern reinventions of popular culture, drawing from Lucio Costa's revision of Modern Architecture and Monteiro Lobato's *Sacy Pêrêre*. These debates were finally orchestrated in a peculiar architectural synthesis in 1943's *Brazil Builds* exhibition. Joaquim Cardozo approach to concrete technology engages the cultural debates of the period, ensuring coherence between cultural ideas and building forms. In his early works, technical solutions were the guidelines to create architectural forms that later he considered "too much European". Cardozo tried to place himself in a complex set of social practices that defined a new Brazil. To do so, and following his literary interests, he progressively abandoned the strictness of technical knowledge adopting more intuitive building solutions. Arguing that technological advances could explain his creations, Cardozo used its peculiar way to conceive structures less due to technical solutions than to cultural ambitions. By looking at incoherencies in building practices, I reveal how architectural strategies are related to the social and the cultural debate in which they are immersed.

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Concrete, as a material, has no form of its own. The form it is given is substantially dependent on the cultural field in which engineers and architects work. And that is not at all a technical field. It depends on personal convictions and on the belief in certain intuitions rather than on mathematical rules or technical achievements. Based on this hypothesis, this paper aims to challenge the usual argument that conceives Brazilian modern architecture as a perfect synthesis between poetry and reason. To do so, it points out several misunderstandings and erroneous appropriations of various arguments by architects and engineers. Joaquim Cardozo (1897-1978), structural engineer for Oscar Niemeyer (1907-2012) most audacious buildings, is a symptomatic figure of these dynamics.

In São Paulo, in the late 1920s, skyscrapers were achieving Olympian performances, and concrete was becoming an increasingly well-mastered technology.[1] As a system that is very easy to build and does not need high-tech labor skills, concrete was increasingly being studied and engineers such as Emílio Baumgart (1889-1943) and major institutions such as São Paulo's Polytechnic School, brought a high level of knowledge in structural design and dimensioning from European companies such as the German company Weiss & Freitag (using the Monnier system) and the Danish company Christiani & Nielsen (using the Hennebique system).

The gap between the knowledge of concrete among professional elites and the rough conditions on the building site was huge. The high-tech concrete argument corresponded to a low-tech concrete practice. For example, to build a dam in concrete, in Minas Gerais, steel and cement had to be transported by cows.[2] It was precisely this concrete technology that Lucio Costa (1902-1998) advocated as the element, along with the reinvention of colonial heritage, on which the new modern culture should be based.

There was great ambiguity in the cultural debate, developed in a social context where nationalism, emancipation from the colonial past and eugenic conceptions became fused with tradition (through ethnology), progress (through technology), and social control (through hygiene and urbanism). That already ambiguous social field (in which everyday language arose) became fused with the major ideas of art and literature whose arguments attempted to address the contemporary cultural debate. Architects, trying to find the right place to present their theoretical responses (concerning what the built forms of a growing country should be based on), needed to choose one possible way from within a system of contradictions that was far too complicated.

The originality of Brazil's modern architecture has been established in architectural history as the development of a specific language, within a particular culture, as the result of the evolution of concrete technology.[3]

1. A.C. Vasconcelos, *O concreto no Brasil, Recordes-Realizações-História*, São Paulo, Pini, 1992, (1985).

2. H. Broe, *Construction of two power plants in Brazil*, in Christiani & Nielsen, *Twenty-five years of civil engineering: 1904-1929*, Copenhagen, Krohns bogtrykkeri, 1929.

3. Y. Bruand, *Arquitetura Contemporânea no Brasil*, São Paulo, Perspectiva, 2003, originally published as *L'architecture contemporaine au Brésil*, Lille, Srtul, 1973.

This argument was put forward principally by Lucio Costa, who proposed a useful synthesis of the Brazilian architectural debate during the 1930s. His text *Razões da nova arquitetura*, not only focused on the fundamental link between architectural space and the plastic strength of concrete construction, but also created a genetic tie between Le Corbusier's presence in Brazil and the Portuguese colonial heritage of the late 18th century.[4]

Lucio Costa attempted to demonstrate this genetic link between colonial tradition and modern architecture in a sketch, closer to a caricature, where the evolution of the Brazilian façades couldn't be more explicit. The *fenêtre en longueur* is presented as being the result of a progressive adaptation of the house major constructive elements to the technical conditions of construction.[5] [Fig. 1]

His so-called progressive way of dealing with concrete construction techniques and architectural culture set up an intense conflict with other arguments, mostly Eclectic and conservative, that soon became opponents. It was a similar quarrel to that of European Modernism versus Regionalism.[6] Perhaps understanding the unfounded basis (mainly a symbolic disagreement) of this quarrel, Costa suggests an original «true Brazilian» synthesis, being neither neo-colonial nor absolutely modern, but gathering architectural tradition, popular spatial structures, concrete building techniques and modernist plastic grammar. If we took away the grammar, we wouldn't be far from neocolonial arguments, but that detail made all the difference.

Costa's major argument was a pledging for reason and rationality. Something it is hard to find in Oscar Niemeyer's buildings, considered worldwide as the major achievement of the Brazilian modern architecture. But knowing that Niemeyer would be much more useful as an ally, Costa subsequently enlarged his notion of reason. After all, Niemeyer's curves could evoke colonial Baroque architecture, the natural topography of Rio de Janeiro or seductive tropical vegetation. Who would care?

Costa considered Oscar Niemeyer as a kind of miracle, hard to explain or sustain, but whose personal freedom together with the audacious forms of his buildings allowed his work to be looked on favourably within theoretical discourse. This flowing vision of a distinctive Brazilian architectural originality has prevailed and is still very present today.[7] This paper aims to present an alternative hypothesis to that argument, considering that a lot of what was said – from the cultural roots to the building techniques – was due to rhetorical strategies rather than architectural practices. Even though the use of ideological arguments inspired by technical solutions had conditioned the emergence both of new theoretical approaches and new building forms, we suggest that it was neither the technological development of reinforced concrete structures nor the autonomy of the structural system in regard to the

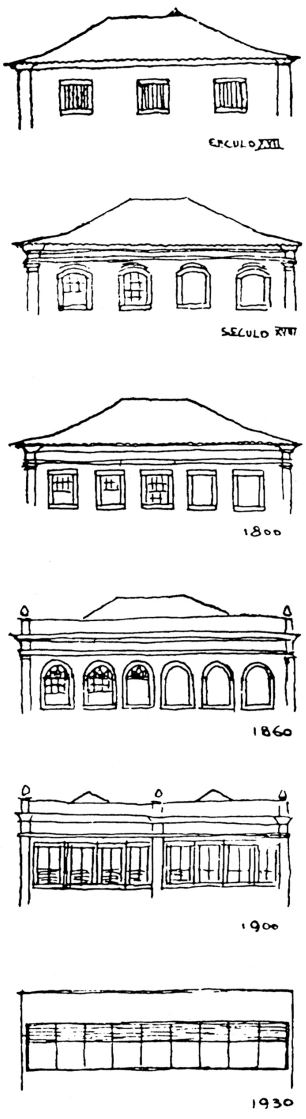


FIG. 1 Lucio Costa, the evolution of the Brazilian house, 1937.

4. L. Costa, *Razões da nova arquitetura*, in A. Xavier (ed.), *Depoimento de uma geração, arquitetura moderna brasileira*, São Paulo, Cosac & Naify, 2003, pp. 39-52 (1936).

5. L. Costa, *Documentação Necessária*, in *Sobre arquitetura*, Porto Alegre, Centro dos Estudantes Universitários de Arquitetura, 1962 (1937).

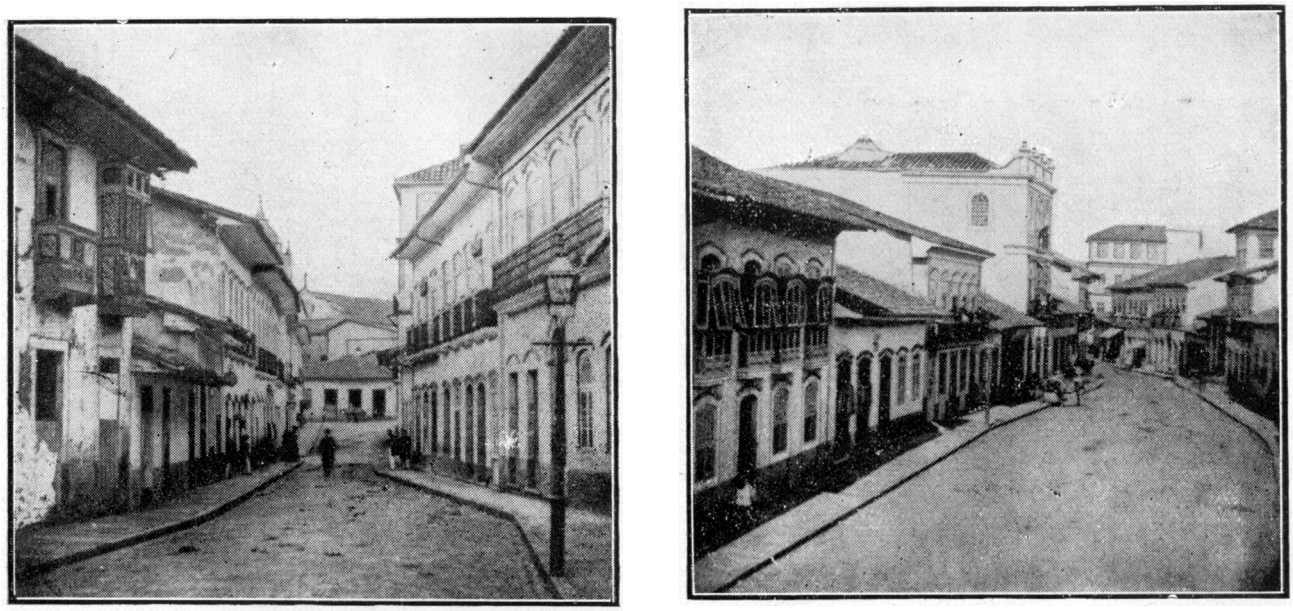
6. J.-C. Vigato, *L'architecture régionaliste*, France 1890-1945, Paris, Norma-Institut Français d'Architecture, 1994. A. Amaral (ed.), *Arquitectura Neocolonial,* São Paulo, Memorial-Fondo de Cultura Económica, 1994. E. Andreoli, A. Forty (eds.), *Brazil's Modern Architecture*, London, Phaidon, 2004.

symbolic apparatus of the constructions (ideas put forward by Lucio Costa and other historians), that led to new architectural practices.

FIG. 2 Luiz Nunes, Joaquim Cardozo, Olinda Water-tower, 1937.

Joaquim Cardozo activity was precisely at this point of tension, between arguments and practices. Being engaged with modern literary movements he dealt both technically and culturally with architectural forms and he understood too well the major quarrel where Brazilian architecture was being discussed in the public sphere. To approach this subject we will need to follow diverging paths, constantly shifting the terms of reference. Although the argument might seem difficult to follow, it his precisely whitin the ambiguitys arising from these shifts that some architecture took place.

Everyday language, the way people talk casually about things in the routines of everyday life, plays a big role in legitimating



FIGS. 3-4 Santos, 1860, photography used by Severo to illustrate his conference in 1915.

the presence of this kind of reasoning. Architects need to find arguments to anchor their buildings in people's minds. For Brazil's modern architecture the perfect relation between architectural forms and the mathematics which were supposed to generate them was the key to guide that transfer between architectural theory and popular reasoning. As everyday language plays a role in legitimating certain narratives of historical discourse, if we try to demystify some canonical historical arguments of Brazil's architecture, we need to be cautious and play double attention to the way language covers some tricks of architectural practice. Aside from the architectural debate, if we pick up again the evolutionary sequence

proposed by Lucio Costa connecting Le Corbusier and colonial heritage, we can trace several slippages showing us how fragile the connection between Brazilian tradition and modern architecture was.

FIG. 5 Ricardo Severo, Casa Lusa, São Paulo, 1920-1924.

We can trace the hidden sources of Lucio Costa outline back to a very famous lecture in 1914.[8] Ricardo Severo (1868-1940), a Portuguese engineer well established among São Paulo's elite, presented and published a genealogical sequence of the roots of Brazilian architecture in a bid to demonstrate that Portuguese blood would be the best to breed a great Brazil.[9] He called this lecture and argument, almost a crusade, *Traditional art*. Looking at the pictures he presented, we find exactly the same sequence of façades presented in Lucio Costa's outline. But Severo's few architectural achievements were precisely the neo-colonial examples that Costa despised. [Figs. 2-4]

A member of the audience at Severo's lecture was Monteiro Lobato. He was a prolific and eccentric journalist, farmer, editor, writer, diplomat and Henry Ford fan.[10] Excited by the idea of a *traditional art*, instead of retracing the white Portuguese origins of Brazil, he promoted the invention of Sacy Pêrêrê, a tiny devil from folk tradition. With black skin, only one leg (some said he had 3 legs), and wearing a red hat and red shorts and smelling unpleasantly of sulphur, this character was wont to laugh loudly and go about making stupid and careless mischief.[11] [Fig. 5]

In the opposite direction to Lucio Costa's appropriation of Severo's arguments, and in a even more opposite direction to Severo himself, Lobato shows us how the same theoretical argument (the "true" origin of tradition) can be used in several contradictory directions. This possibility not only undermines the argument for a genuine and pure Brazilian national identity, but also demonstrates the blurred boundaries where the use of language interacts with architectural ideas. Both the argument of "true tradition" and the idea of "rational freedom" were simplified and drowned in the powerful strengths of everyday language, and that strength allowed the buildings defined by these terms to perform a powerful symbolic task. It is precisely this kind of simplifications that allowed the coherence of the canonical promotion of Brazilian architecture as a new synthesis between plastic forms and concrete technical reason. Cardozo major achievement was an acute way to address this issue. [Fig. 6]

FIG. 6 Sacy-pêrêrê, drawing by Monteiro Lobato.

Making an X-ray through the white surfaces of Niemeyer

8. R. Severo, *A arte tradicional no Brasil, a Casa e o Templo*, Separata das conferências 1914-1915 da Sociedade de Cultura Artística de São Paulo, São Paulo, Tipographia Levi, 1916.

9. J. Mello, *Ricardo Severo, da Lusitânia ao Piratininga*, Porto, Dafne, 2008.

10. C.L. de Azevedo, M. Camargos, V. Sacchetta, *Monteiro Lobato, Furacão na Botocúndia*, São Paulo, Senac, 1997.

11. He was not very hard to catch but if caught he would cry so plaintively that people took pity on him and let him go. [M. Lobato], *O Saci-Pererê: resultado de um inquérito*, Rio de Janeiro, Gráfica jb, 1998 (1917).

buildings, trough Cardozo's structural conceptions, we can discover some structural conceptions that create the potential for drawing out a different historical narrative.

FIG. 7 Minas Gerais, cows pulling construction materials to build a dam in concrete, 1923.

Joaquim Cardozo was born in 1897 in a modest neighborhood of Recife, in north-eastern Brazil, he spent his life simultaneously working and studying. As a topographer, he spent long periods of his youth reading and working in distant natural areas, allowing him to experience an intense relationship with nature. He was greatly interested in mathematics and astrophysics, and also had a broad knowledge of languages, including Portuguese, German and Chinese. This knowledge allowed him to make a significant contribution to Brazilian modernist poetry, bringing together regionalist and popular themes with a modernist freedom in formal compositions and, for the most part, an extreme metric and phonetic discipline in his creations. Later, he will use these literary skills in metric rigor to conceive his engineering solutions.[12]

Although he is today better known for his contribution to Brazilian literature than for his virtues as an engineer, he earned his living as an engineer, not as a poet. In Recife, he first worked with Luiz Nunes (1909-1937), a promising young Brazilian architect who died too early. Together, in 1937, they created the Olinda Water-tower, which produced one of the strongest images in *Brazil Builds* (the exhibition that in 1943 brought Brazilian architecture a worldwide reputation).[13] Later in is life, Cardozo referred to this work as reproducing "much too" European models learned through the *Handbuch* of Fritz von Emperger (1862-1942).[14] Why where they "much too" European? Perhaps because they were conceived rationally, and their forms followed the technical prescriptions of the European manuals. Commenting on is own youthful "European" sins, he felt that works such as this one already represented, «in their power, a possibility of a Brazilian language, a slightly coarse, national expression of architectural practices of European origin, transferred to local technical and industrial possibilities».[15] Strength and power of rationality were the pathway to supersede the colonial architectural past. [Fig. 7]

Due to political problems, in 1939 Cardozo left Recife for Rio de Janeiro where, through his modernist poet friends, he met Lucio Costa. Costa found him a job with the team that was designing the Ministério da Educação e Saúde (for which Le Corbusier had made an initial sketch)[16] where he met Oscar Niemeyer and began a fruitful collaboration.

When Cardozo, after a long career, was asked to explain his own work, he did not hesitate to use the same arguments used by Lucio Costa to

12. M. da Paz Ribeiro Dantas, *Joaquim Cardozo, ensaio biográfico*, Recife. Fundação de Cultura da Cidade do Recife, 1985.

13. P. Goodwin, *Brazil Builds. Architecture New and Old, 1652-1942*, New York, Museum of Modern Art, 1943.

14. J. Cardozo, *Uma homenagem simples e sincera dos arquitetos de Brasília*, in "Cadernos de Arquitetura", 1973, No. 6, pp. 28-34. Cardozo is probalbly quoting the 12 volumes from F. von Emperger, Handbuch für Eisenbetonbau, Berlin, W. Ernst & Sohn, 1911.

15. J. Cardozo, *Dois episódios da história da arquitetura moderna brasileira*, in "Módulo", vol. II, March 1956, No. 4, pp. 32-35.

16. M. Lissovsky, P.S. Moraes de Sá, *Colunas da Educação, a construção do Ministério da Educação e Saúde 1935-1945*, Rio de Janeiro, minc/iphan-Fundação Getúlio Vargas-cpdoc, 1996.

demonstrate how poetic and creative the forms they conceived were. The general idea he presented was the capacity to conceal an abstract consciousness under a poetic form. Geometry was the science that could help architectural composition and, through a sophisticated algebraic conception it was possible to abandon the old formal limitations, always keeping a linear relation between form and constructive reason. As he put it, to «get back to the intuition of a natural geometry, useful for its own inherent qualities and not for conceptions built upon them».[17] In physics, he was very interested in the science of viscous and formless materials, and he believed in the possibility of a "true" and vigorous balance between human poetic creations and the physical properties of materials. On the building site, he saw reinforced concrete as the technology that allowed those forms to be built, leading the way for people to think that it was possible that intuition and science, together, could create spontaneous and liberated forms, expressions of a new era and also of a new Brazil.

17. J. Cardozo, *Algumas idéias novas sôbre arquitetura*, in "Módulo", vol. VIII, June 1963, No. 33, p. 2. «Speech given […] at the formal degree ceremony for those completing their studies at the Faculdade de Arquitetura at the Universidade do Recife, a ceremony held in the open air in the churchyard of the former Jesuit College in Olinda, on 20 December 1962».

He himself was not lucky. By the end of his life, in 1971, one of his buildings, designed by Oscar Niemeyer, had collapsed during construction. It was a tragedy in which 54 people died. He was charged with negligence and then acquitted.[18] The Gameleira Pavilion disaster was clearly due to careless construction. Miscalculated after a bad soil sample, several columns began to sink. The concrete was neither well poured nor vibrated and compacted, so it did not adhere to the steel at several points. The formwork was removed too early and suddenly, and crudely. It is easy to understand that the construction collapsed due to the contractor's negligence. But the engineer was put on trial because his calculations were way outside the norm. He paid no heed to the legal restrictions or to several safety standards. It was therefore easy to charge him with responsibility for the collapse.

18. A file containing copies of the court procedures is available on the Biblioteca Joaquim Cardozo, Universidade Federal do Recife (BJC-UFR).

During his defense Cardozo clearly explained his design strategies. He quoted several engineers, arguing that a structure, if well-conceived, never falls down due to dimensioning errors, but always due to the combination of a number of different errors. Cardozo's opening defense statement starts with an explicit epigraph:

> A structure does not fall because of a calculation error, because the calculation is just an approximation of reality; generally buildings fall as a result of the imperfect understanding between those working on their construction.[19]

19. *Ibid.* Cardozo was quoting professor Rudolf Saliger, from Wien.

One of the apparent reasons for the sudden tragedy was the way the formwork was removed from the slab which, along with the contractor not leaving props in place, was not carried out slowly using wedges or jacks and was carried out «using saws and axes», which subjected the

structure to blows and violent jolts (one of the reports even noted that, «a tractor was used to remove the formwork».[20] Another reason was the beams poor concreting which failed to encase all the reinforcement bars with concrete. «The steels appeared clean inside showing that they had had no contact with the concrete, no fragment of concrete had adhered to them».[21] As if these two errors were not enough, sinking was visible in several pillars, which totaled 10 cm at one pillar caused by soil shifts and by the foundations defective behavior (this is why the pillars fell when the beams collapsed).

20. BJC-UFRE, *Laudo desempatador*, 4.

21. *Ibid.*

The precision and rigor which was lacking in the concreting work was as necessary, or even more, because of the substantially higher density of the steel in the beams. One of the issues not dealt with in the defense, but mentioned in several expert reports, was that the beam section did not meet the national standard. The beam, which collapsed due to a lack of resistance to the compression forces it was subjected to because of the sinking pillars, had a 59x50 cm rectangular section that included 100 CA-50 ø 1⅛ steel bars. Thus, around 60 percent of the area of the beam's section was filled with steel reinforcements, which required a more liquid mix and additional vibration of the concrete. One of the reports is unhesitating noting that, «as a result, the free space between two neighboring bars was around 17 mm, which was much less than the diameter of those bars (29 mm) which makes transferring loads from the concrete to the reinforcements precarious».[22]

22. BJC-UFRE, Aluizio Klein Dutra, *Laudo Pericial 905/74*.

The sink of the foundations (which subjected the structure to unforeseen stresses), the deficient concrete pouring (which made the beams incapable of withstanding compression stresses) and the aggressive removal of formwork led to the system's breakdown and the structure to collapse. As the defense stated:

> the structure obeys an easy calculation. The difficult part of it is precisely construction, whose defects are mainly increased in the concreting of the steels which would ensure absorption, by adhering to the steel, of the reaction on the supports.[23]

23. *Ibid.*

It was the fact that the calculation did not meet the standard that allowed the court to effortlessly blame the engineer. The poor execution of the foundations, the deficient concrete work on the beams, the savage removal of the formwork did not stray from the standards and only the calculation, despite being safe, did not comply with the law, and thus the engineer was convicted. We are not interested in working through the tragedy and its reasons, but rather to keep hold of the non-standard aspect of the work of Joaquim Cardozo. At a later date Cardozo himself said:

> That is why my work, more than once, led to conflict with those that think that architecture should obey balance structures that have been previously tested by use and unanimously accepted by engineers, with those who confuse the norm with the law and certainly suppose that the physics of solids, on which the structural engineer's science is based, is a normative science.[24]

24. Joaquim Cardoso quoted by M. da Paz Ribeiro Dantas, *Joaquim Cardozo...*, cit., pp. 58-59.

An analysis of some reinforced concrete structures in the buildings in Brasilia carried out by Augusto Vasconcelos makes apparent not only the experimental and innovative logic of some of Cardozo's designs, but also the importance of the moment of construction itself and the empirical nature of calculations. Searching how the inverse dome of the National Congress Hall was built, Vasconcelos has collected a curious testimony by an engineer responsible for its execution:

> at the last moment before the concrete work was carried out, Cardozo decided to increase the reinforcement of the dome's uppermost ring. As there had been no time to introduce this modification into the blueprints, it was authorized via a note in the construction site log.[25]

25. A.C. Vasconcelos, *O concreto no Brasil...*, cit., p. 99.

Also known as "fear coefficient", boosting the size of reinforcements beyond the calculations is a common strategy. In fact, looking at some photographs of the work, which show the incredible density of steels in the dome, allows us to imagine that this over-sizing had been foreseen. The most striking information is that the change was made on site, without design. In fact, Vasconcelos bemoans, particularly for Cardozo's work, that, «all the reinforced concrete designs […] mysteriously disappeared… […] And there's no fixing this, as we don't know what is inside those pieces of concrete!».[26]

FIG. 8 Gameleira pavilion, Belo-Horizonte, construction collapse February 4, 1971.

26. *Ibid.*, p. 86.

Another singular example of the works of Brasilia is the *Planalto* and Supreme Federal Court palaces, at *Três Poderes* Plaza, in which a formal/structural solution is repeated in two buildings. It consists in the two

pillars that actually do not support the construction but lend form to the building. The slabs used for the covering have spans of 37,5 meters and are just 30 cm thick, and are made as ribbed slabs, designed with the ribs in balance to avoid having beams between the sculpturally-shaped pillars and the constructed volume. However, the pillars still absorb some of the reaction stresses of the covering slab, but substantially fewer than the internal pillars. In relation to the external pillars Vasconcelos explains that «only the steel withstands the applied load».[27] It was already the strategy later used at Gameleira, the sections where so reduced that «the concrete has the exclusive function of protecting the reinforcement and keeping it in place».[28] [Fig. 8]

27. *Ibid.*, p. 92.

28. *Ibid.*

Under the eyes of the Brazilian norm these pillars cannot be considered "reinforced concrete" as they greatly exceed the limit of 6 percent of reinforcements, a percentage required to ensure cohesion of the concrete and steel. Skirting around the normative instruction, Cardozo enveloped each main bar with a helicoidal wire to ensure that the concrete continued to be reinforced. The expedient worked but did not prevent fissuring when the formwork was removed. «The load applied to the steel caused transverse expansion […] with a propensity to expel the concrete. It did not split apart, as the concrete work was well executed […] and the thin helical wire provided greater adherence».[29] The improvised solution to prevent the rapid degradation of the structure consisted in removing the coating of the structure up to a height of 1,0 meters and entirely wrap it with wire which, under tension, soldered itself to the structure's external bars. The result was the execution of a 'tube of steel' binding the pillar up, which was later covered with 2 cm of mortar, such that the pillar, which bears a reduced load, lightly touches the floor and is just 20 cm wide.

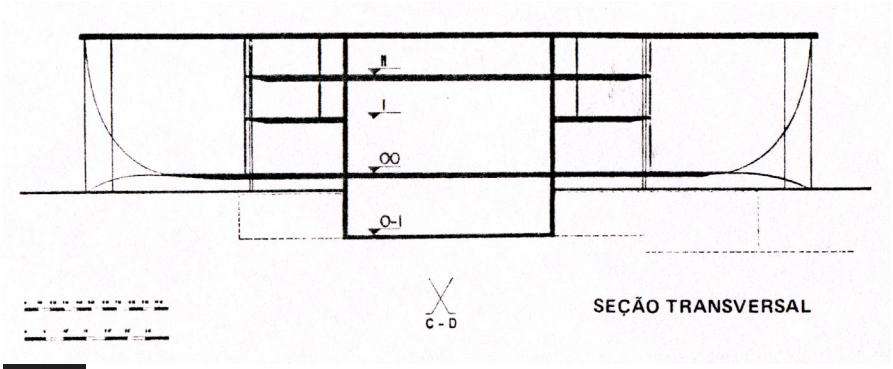


FIG. 9 Palácio do Planalto, Brasília, cross section.

29. *Ibid.*

At the Alvorada Palace, the façade pillars of which have a great formal freedom and very elegant measurements, the principle of shifting loads to the interior structure of the building was also adopted. As can been seen in the transverse section of the building, the curved slab, which is not a continuation of the covering slab, is supported in balance on a large longitudinal beam upon a line of pillars along the internal façade. That slab is 40 cm thick in the embedding zone and 20 cm in the line to support the external pillars. In its turn the support point, which is of almost no size, supports a sub-structure which was buried by the embankment, therefore looking like a floating pillar. Despite the artifices, the execution of the reinforcements required overlaps and significant amounts of steel,

which complicated the execution of the work. An engineer recalls he was surprised to see on the designs a note to, «as much as possible, place the steels in such and such positions…».[30] The note on the vanished drawing is indicative of the awareness of the fallibility of the design in relation to the construction work and the prioritization of execution rather than rigorously complying with the abstract concept. [Fig. 9]

30. *Ibid.*, p. 89.

In epic tone, Cardozo voluntarily ignores the shortcuts to mathematical perfection of his work and sang out visible geometric harmony:

> Now resounds the vast canticle of surfaces that accompany the supporting points, and in it is highlighted tall and clear and dominant, the voice of the surfaces of Liouville, in the splendor of fundamental tonality appropriate to its intrinsic metrics:
>
> $ds^2 = [o(\mu)+t(v)] \bullet (d\mu^2 + dv^2)$ [31]

31. *Ibid.*, p. 97.

A major question lay without answer: what connection can we find in the use of mathematics on his poetry and on his engineering? In his arguments he makes no distinction between different forms of rationality. Reality has his on laws, independent from standard norms and other conventions, the seconds being useful to those ignoring reality. When Cardozo states «calculation is just an approximation of reality» he is stressing exactly this distance, praising the human effort for knowledge when it his obvious this knowledge can not be accurate.

Looking to these few descriptions of Cardozo's building strategies some hints on his practice become evident:

- Hybridization of solutions, which became autonomous from the concrete structural principles using empirical logic of construction reasoning, a strategy only possible due to the independence from the normative standards;

- Focus on the execution and the construction site, both in the in loco supervision and the possibility, through improvisation, of solving problems resulting from the unexpected reactions of the structure;

- Possibility of 'hiding' the logic of the construction under a few centimeters of covering mortar, valuing geometry and form of the object over its structural peculiarities or methods of construction.

We focus on these three points to shift subject again and regain the useful contribution of Cardozo to the Brazilian debate on modern architecture. As a columnist noted at the time of Cardozo's acquittal of Gameleira disaster:

> We are far from the Portuguese master builder, who calculated his own work, and also knew how to show his apprentices the way bricks should be laid in a wall.[32]

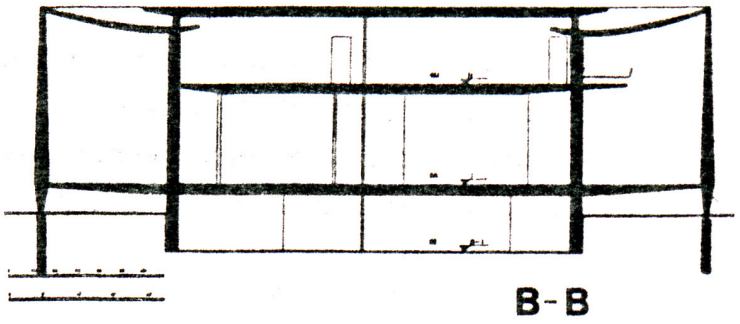


FIG. 10 Palácio da Alvorada, Brasília, cross section.

This sentence, wrote in the 1970s, still echoes the 1930s debate on the evolution of Brazils modern architecture, from which we quoted the Severo's shift to Lobato's arguments. It reminds us that Cardozo's structural conceptions still addressed this conflict between the colonial past and the future of the country, precisely the one Lucio Costa tried to solve with concrete reason and then was solved with Niemeyer's freedom. So, as the natural physic laws where more relevant than norms and standards to keep the buildings up, Cardozo also understood that, to create social meaning, the way we speak was more relevant than the way we build.

32. Barbosa Lima Sobrinho, *Uma situação de desafogo*, in "Jornal do Brasil", 18 May 1975.

Cardozo and Niemeyer's major structural achievement was the inverse dome of the National Congress Hall. Cardozo made a famous phone call to Niemeyer in which he said joyfully: «I just found the perfect tangent curve that will allow the form to float in the air».[33] In their euphoria, they thought they were able to appeal, simultaneously, to the poetry of plastic intentions and the utilitarian aesthetics of the engineer which, in a spiritual unity, would produce the only true expression of the beauty inherent in contemporary life. That legendary phone call summed up the virility of modern Brazilian architecture. Looking at the pictures of the building site, there is an amazing quantity of steel. Apparently, a kind of last-minute "fear coefficient" was added to the structure in order to ensure the safety of construction. The fearless forms advocated as rational and the result of the union between poetry and reason seem, rather than the result of a simple and linear progression of a genuine national culture, to be the result of a peculiar set of circumstances and an incredibly tense practice. [Fig. 10]

33. M. da Paz Ribeiro Dantas, *Joaquim Cardozo...*, cit., p. 77. A.C. Vasconcelos, *O concreto no Brasil...*, cit., p. 97.

We might consider Cardozo way of dealing with adversities as closely connected with his literary convictions, since they are hard to understand as rational engineering strategies. Far from his first "much too" European structural conceptions, he felt free to conceive the structures as he wanted to, knowing that they would not fall down. A huge tension is visible, from the unconventional and even reckless approach to engineering (confirming the conventional view of Brazil's Modern Architecture as audacious, virile and fearless) to the paradoxically overly cautious and fearful experimental practice. [Figs. 11-12]

FIG. 11 Palácio do Planalto, Brasília, construction site, 1958. Photo Marcel Gautherot.

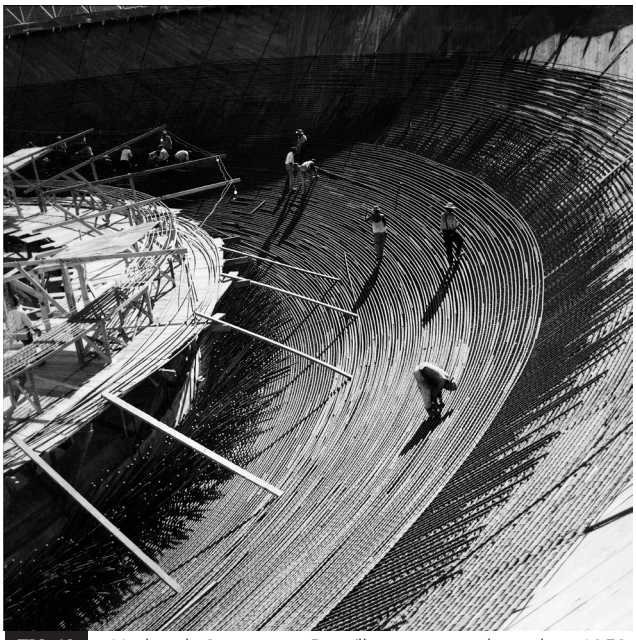


FIG. 12 National Congress, Brasília, construction site, 1958. Photo Marcel Gautherot.

For the sake of its own success, architectural history tends to underline coherencies and organized systems of thought, as is evident in the way Brazilian modern architecture has been celebrated. Joaquim Cardozo's structures, simultaneously engaged with literary and architectural debates, contributed to establishing a coherent discourse about so-called "true Brazilian architecture". But the coherence of the discourse does not match the incoherence of practice. Looking at those incoherencies we find not only the tricks that allow the coherence to remain, but also some clues to an incredibly rich, and ambiguous, everyday life.