

# The Concrete Collaborations of Carmen Portinho and Affonso Reidy: Structural innovation in Brazilian Modernism through public service

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**Abstract:** Over the course of a 20-year collaboration from 1942–1962, architect Affonso Reidy and engineer Carmen Portinho left a lasting impact on the urban fabric of Rio de Janeiro and helped create the Brazilian Modernist movement, all from their shared offices in the city planning department. As lifelong civil servants, their achievements have often remained unrecognized beyond Brazil. However, in Brazil, their impact as both designers and urbanists is visible from nearly any street corner of Rio de Janeiro, with housing and municipal building projects across the city still occupied today. Perhaps most notable is Portinho’s role as the driving force for this work, both as a politically savvy administrator and a highly skilled civil and structural engineer. It was her study of post-WWII reconstruction in reinforced concrete that facilitated the pair’s first large-scale concrete projects and the creation of the Department of Popular Housing in Rio, which would shape policy to this day. In this study, we survey the works of Reidy and Portinho and the innovations in reinforced concrete design that these works represented at the time of their construction. We present a novel analysis of the Museum of Modern Art Rio de Janeiro’s structural design, comparing historical construction images and drawings to a detailed finite element analysis model of the building’s exceptional suspended concrete frame structure. In addition, we compare the structural design approaches used in the Museum of Modern Art project to earlier social housing projects, considering the notable balance Portinho and Reidy struck between structural efficiency and economical fabrication through repeating concrete modules.

## Introduction

This article traces the professional history of engineer Carmen Portinho and architect Affonso Reidy contextualized within the broader movements of Brazilian Modernism, advancing reinforced concrete construction techniques and the post-WWII sociopolitical climate of South America. Connecting direct commentary from Portinho and other architects and engineers of the time with modern analysis of the structural design of several of the team’s significant works, we illustrate the remarkable impact these lifelong civil servants left on Brazilian architecture and the global Modernist movement.

## 1. Methodology

In addition to referencing and translating Brazilian research on the topic of Portinho and Reidy’s works, primary documents and schematics were acquired from the Museum of Modern Art, Rio De Janeiro, and the Universidade Federal do Rio de Janeiro Faculty of Architecture archive. Sadly, this archive burned in 2021; however, many of Reidy’s drawings had been stored digitally. Images of the projects were sourced from these archives as well as Google Arts and Culture, where historical documentation of Reidy-Portinho projects has been placed in the public domain. Interviews were conducted, and correspondence was exchanged with leading historians of Brazilian modernism, including Prof. Nabil Bonduki, who generously shared insights from his direct interviews with Carmen Portinho before she passed away.

Analysis of the structural design and innovations of the projects reviewed was conducted with the Finite Element Analysis solver Karamba3D, incorporating information on the properties of the reinforced concrete used from research by Prof. Eduardo Thomaz. The modeling and analysis of Portinho and Reidy’s work primarily demonstrate technical sophistication in terms of hand structural calculations and reinforced concrete construction on par with European structures of the 1950s.

## 2. Carmen Portinho

Carmen Portinho was fundamentally a dedicated civil servant, engineer, and urbanist with an unparalleled aptitude for leading and executing radical change in the rapidly evolving quagmire of Brazilian politics in the second half of the 20th century. In project after project, she brought and kept together the right group of skilled designers, engineers, and funding sources to realize her decidedly Brazilian version of Corbusier’s vision of the City of Tomorrow. Beyond completing each project, she leveraged her considerable political and media connections to broadcast this vision to international acclaim, receiving praise from Corbusier himself and winning numerous European design awards for Reidy’s projects.

Born in Corumbá in 1903, Portinho was the third woman to earn an engineering degree in Brazil. She was the daughter of Maria Velasco and Francisco Sertório Portinho, who moved to Rio de Janeiro in 1911, where Portinho quickly

became involved in the feminist movement led by the pioneering Brazilian biologist Bertha Lutz. Portinho grew up in this movement, which at the time was radical and critical in giving women the right to vote in 1932. Around that same period, having finished her degree in 1926, Portinho was briefly married to Lutz's brother, a doctor named Gualter Adolpho Lutz. It was during these years that the mayor of the Federal District assigned her to work as a civil engineer in the Department of Traffic and Works. There, she experienced a great deal of sexism, often assigned difficult tasks thought impossible for women to limit her chances of success. Colloquially, her first assignment was to inspect the lightning rod of City Hall. Unfazed, Portinho used her considerable mountaineering skills to complete the job efficiently. After recounting her experience of limited opportunity in public works to the then President of Brazil, Washington Luiz, in a public hearing, Portinho achieved a promotion before taking a year off from civic works to be a part of Brazil's first class of urban planning students in a new course of study established by Lucio Costa. During this course and in the ensuing two years, which she spent on a scholarship in Europe learning from British urbanists and engineers working on post-WWII reconstruction, her philosophy towards housing would be cemented. Returning from Europe, already an established voice in Brazilian politics, engineering, and urbanism, Portinho pitched a new vision of public housing to the government of Rio de Janeiro and was quickly awarded her own department and funding to create housing integrated with social services and critical infrastructure like mechanized laundry.

"The Pedregulho construction began in 1945, after my return from England, where I had collaborated with British architects and Engineers in the reconstruction of their cities at the end of the Second World War. Imbued with great enthusiasm, I had proposed to the Secretary of Road Systems and Constructions the creation of the Popular Housing Department, once there, just as in England during those terrible years, popular housing remained a problem of difficult solution. As it is up to today. The idea was so well accepted by the mayor that he ended up nominating me Director of the new Popular Housing Department.

As soon as I took office, my first project was the construction of popular housing, under the new concept of habitation, destined to low-income population and principally located near to their workplaces. With this, they would save time and money spent on transportation. In short, these would be worthy dwellings, respecting the workman, putting him within the reach of all the comforts of modern times, even including arts."

- Carmen Portinho date unknown (Bonduki 2000, 82)

It was with this project, the Pedregulho Housing Development, that Reidy and Portinho would begin their life together and launch a 20-year professional collaboration. Together, Reidy and Portinho made three significant works. The Pedregulho and Gávea housing projects and the MAM Rio Museum of Modern Art. In each project, Portinho was both project manager and lead engineer. However, she left the completion of the Pedregulho housing project to her staff as she began to focus more energy on the administration of numerous other projects for the Department of Public Housing throughout the 50's. It was also through the Pedregulho



Figure 1. Portinho inspecting the work with an unknown engineer, possibly on the roof of the MAM theatre block (NPD/ FAU/UFRJ).

project that Portinho honed her knowledge of reinforced concrete construction, qualifying her as the ideal candidate to lead the far more complex Gavea and MAM projects in the following years. Few others had as much hands-on experience with emerging concrete structural design at this time. In the case of MAM Rio, Portinho was not only the director of the Museum itself during the design and construction but also the on-site project manager and head engineer overseeing all details from concrete formulation to structural testing.

### 3. Affonso Eduardo Reidy

Affonso Eduardo Reidy was born a Brazilian citizen in Paris in 1909. His father was English, and his mother was a second-generation Brazilian of Italian descent. Reidy's grandfather on his mother's side was the notable Brazilian-Italian structural engineer Tommaso Gaudencio Bezzi, who was responsible for the design and construction of a collection of public buildings in Rio de Janeiro in the late 1800s. Raised in Rio de Janeiro, Reidy studied architecture at the National School of Fine Arts (ENBA) from 1926 to 1930, where he received the Silver Medal of the 4th Pan-American Congress of Architects

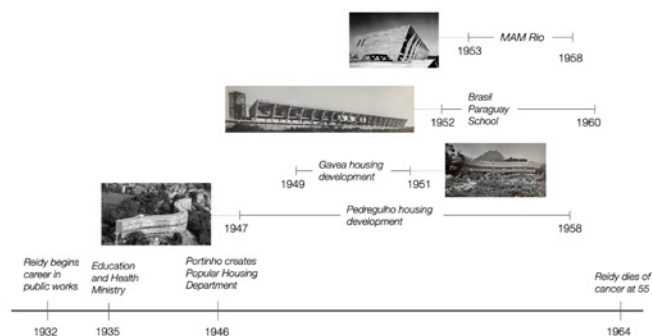


Figure 2. Social projects were slow and ongoing for Portinho and Reidy. Images: top Aertsens Michel, bottom three (NPD/FAU/UFRJ).

and the Gold Medal in the Maximum Degree contest. After completing his education, Reidy was hired by the French urbanist Alfred Agache, who was at that time contracted by the Brazilian government to complete a new master plan for Rio's two million inhabitants (Bonduki 2000, 27).

During this same period, the price of coffee fell dramatically, leading to severe discontent with the government. The ensuing armed insurrection resulted in a change of government. The Revolution of 1930 led to Getulio Vargas assuming the presidency and initiating a "national development period," which would transform the country's urban and industrial identity and pave the way for the emergence of Brazilian modernism. Just as the new regime was assuming control, Lucio Costa was appointed Director of ENBA and tasked with revitalizing the study of architecture to modern standards. Reidy was part of this educational reform as the assistant to Gregori Warchavichik, a pioneer of modernism at the time, who was contracted by Costa to reimagine the program at ENBA.

#### 4. Mayor Mendes de Morais (Pedregulho) Housing Development (1947–1958)

"I have never had the opportunity to undertake a work as complete as this one that Brazilians have achieved with Pedregulho."

- Le Corbusier (After a site visit with Portinho in 1961)

"Taking advantage of the site's rugged surface, the imposing volume of the Pedregulho Housing Development is balanced with the design's flexibility, evoking the waving forms of the local relief. The main building's curves follow the hillside's curves, greatly highlighting its lines according to a formal dialectic. It was the first large work planned by Reidy where he imposed, as the excellent architect he was, the characteristic of searching for integrated solutions that would also serve the social point of view. It was the first housing development built in Brazil with a program view and conceived to make use of reinforced concrete's possibilities".

- Carmen Portinho 1999 (Bonduki 2000, 91)

Between 1920 and 1940, the population of Rio de Janeiro doubled, creating a housing crisis of epic proportions. Portinho's proposal for a new and dedicated department to address the issue was welcomed at a time when few were proposing meaningful solutions to the problem. With Mayor Mendes de Morais's support, Portinho created her pilot project, the Pedregulho Housing Development, officially naming the project after him, an astute political move assuring his ongoing support for her department while colloquially calling the project Pedregulho (Gravel), a name seemingly loaded with a deep dedication to the hardworking civil servants the project was built for.

The project itself was a singular vision, synthesizing Portinho and Reidy's shared ideology of a Corbusian "Machine for Living." In many ways, the most impactful aspect of this project was not its architectural form but its conceptual basis, the idea that social services and critical infrastructure for education, laundry, and exercise could be made readily available to low-income civil servants. The creation of Brazil's first mechanized laundry system may well have been the greatest innovation of this project and a critical

priority for Portinho, who was keenly interested in freeing up women's time for more interesting pursuits.

"[...] this project, singular on account of not fitting in the usual way of author's planning and doing, in view of its social or artistic features and even more of the persistence necessary to guarantee its continuity—is owed to Carmen Portinho, the administrator who idealized and is carrying it out in its smallest details—inclusively teaching a way of life—and Affonso Eduardo Reidy, who conceived the development architecturally and carried it out; both of them assisted by a dedicated and capable technical board.

It might seem illogical that in a city whose popular housing problem is a pressing one, the municipality permits itself the luxury of building a housing development with the characteristics of Pedregulho. Obviously, the money spent could be diluted, altering even minimally the general picture of the situation wherein the greater part of our population lives [...].

Pedregulho is then a symbol—its own rough name (Gravel) attests to the victory of love and inventiveness in a hostile environment, and its own existence is an interpellation and a challenge, for public money was not spent in vain; instead of being diluted haphazardly, without a plan it was concentrated and had an objective, it was humanized there to show how well workers could dwell."

- Lucio Costa (Bonduki 2000, 89)

Costa's statement is affirmed by the now 70-year history of continuous occupancy of Pedregulho. However, the social services so closely tied to the development of the project did not last through the ups and downs of government during the 60's and 70's. Pedregulho is still inhabited, but the local government left much of the adjacent infrastructure to fall into disrepair until renovations in 2015 (Maddock 2016).

The structure of Pedregulho was unique for its time, consisting of a set of curving slabs sitting atop an array of elliptical piloti, which elevate the building to give each floor a sweeping view of the city. With relatively simple reinforced concrete construction, the housing block and surrounding buildings were a test bed for Reidy and Portinho's developing dedication to concrete modernist structure. While the structure itself is straightforward, its execution was not given the limited skilled labor of this time and the cost of materials. This is evidenced by the careful structural calculations for

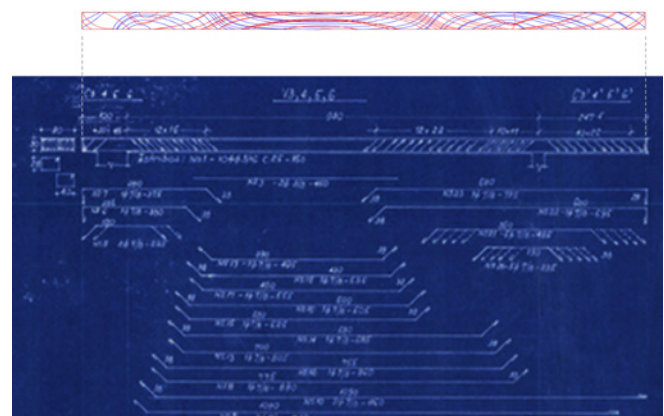


Figure 3. The precisely calculated rebar layout for this simply supported slab on the second floor of Pedregulho mirrors the principle stresses. Structural efficiency was prioritized over the fabrication of many unique parts. Image: (NPD/ FAU/UFRJ).

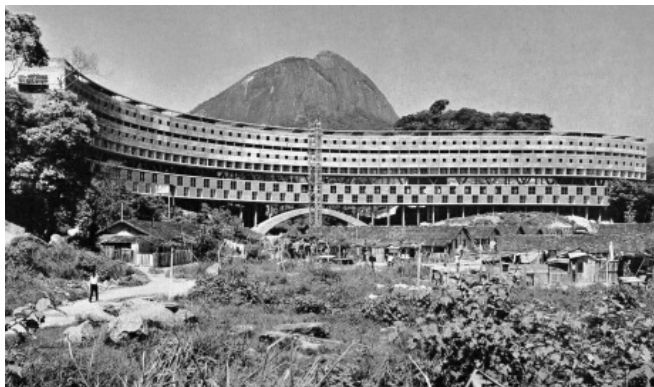


Figure 4. Gavea was, in part, situated on the hillside to avoid displacing the residents of the favelas occupying the flat portion of the site. Whether Portinho successfully housed these families in the new building before beginning the construction of accessory structures, which would destroy these homes, is unclear. Image: (NPD/ FAU/UFRJ).

the floor slabs of the housing block. Many unique pieces of rebar are cut for each element of the slab, a labor-intensive but materially efficient approach.

### 5. Marques de São Vicente (Gavea) Housing Development (1941–1951)

In Portinho's own words, Gavea was an extension of, and response to, the Pedregulho project:

“As to the project of the Marques de São Vicente Development, at Gavea, also built by the Popular Housing Department under my coordination, its construction took more time than Pedregulho, because it was to be much bigger. [...] Several blocks were to be erected on the site, but only one was built, exactly the curved one, as it is today, and even so the construction was interrupted several times. We were under the government of Carlos Lacerda, whose orientation as to popular housing I did not agree with. There was no alternative but to ask for my retirement and, right afterwards Reidy also retired. So that we no longer had anything to do with the building's progress. The other blocks were not even considered, as well as the school, the little market, all the infrastructure foreseen in the original project.

Similar to Pedregulho, the Marques de São Vicente followed the same philosophy, that is, the apartments were to be rented and not sold to the City Hall employees. Here even before the building was finished, the politicians have put aside the social assistants who were selecting the candidates, and started distributing indiscriminately the apartments, left and right. As it couldn't be otherwise, things started to tumble down.

Not long ago, I paid a visit to the place. After having made that ill-fated tunnel, I was afraid the structure would be affected. It was a quick visit, because for a deeper examination I would have needed a specialist and also the calculations which I do know where are kept. The tenants, however, complained a lot, and not without cause, of the noise and the tremors caused by the intense traffic passing under their dwellings.”

- Carmen Portinho, 1998 (Bonduki 2000, 112)

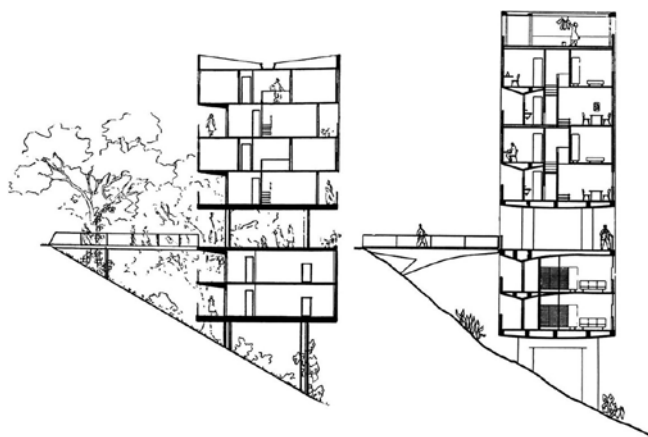


Figure 5. The development of Reidy and Portinho's grasp of reinforced concrete is evident in this comparison of the Pedregulho (left) and Gavea (right). Image: (Klaus 1960).

From a structural perspective, Gavea presented a chance to scale up the strategies employed at Pedregulho and engage with more advanced reinforced concrete construction techniques. The hollow slab design, giant supporting arch, and branching columns on the third floor were made possible by the calculations of a young engineer named Dirceu Velloso. While it is unclear how involved he was in subsequent Reidy/Portinho projects, he did go on to become a key voice in establishing the reinforced concrete code for Brazil. In particular, his name appears frequently in the 70s as the last author on papers characterizing the bearing capacity of piles in Brazilian soils (Aoki 1975). This work was conducted during his career as an engineering professor at the University of São Paulo (USP). During the Gavea project, Portinho again established herself as a leader in advanced concrete engineering, as evidenced by the team of experts she was able to assemble for the MAM project just a few years later who were willing to take on the project under her management. In the 1980's a new highway was carved through the first two floors of the Gavea complex, which was notably not demolished but carefully retrofitted as given its status in Brazilian architectural history.

### 6. Brasil-Paraguay school (1952–1960)

Built just one year before the Museum of Modern Art, it is clear from Reidy's writings on the design of the Brasil-Paraguay school that many of the ideas for MAM Rio originated in his consideration of light and structure when designing the earlier project.

“The structure was projected in a way to keep free the facade corresponding to the classrooms and to form a sunshade system. This solution allows for greater flexibility



Figure 6. The Brasil-Paraguay School designed by Reidy with structural engineer Sydney Santos. The project is a formal and structural prelude to the MAM project, which would begin the following year. Image: (Klaus 1960).

in the location of dividing walls, within the adopted module of 2m intervals between the main frame's panels, and contributes to artistic enrichment of the facade too."

- A.E. Reidy, 1952 (Bonduki 2000, 156)

This project, donated to Paraguay by the Brazilian government, was a collaboration between Reidy and the structural engineer Sydney Santos. Santos would later be credited with certain especially elegant elements of the MAM project, like the spiral stair to the main exhibit hall and adjacent structures in Flamengo Park, like the Bittencourt Bridge. The details and extent of Reidy, Portinho, and Santos's friendship and working relationship are not entirely clear beyond the shared projects that bear their names.

## 7. The Museum of Modern Art Rio de Janeiro (1953–1958)

The Museum of Modern Art Rio de Janeiro was founded on May 3, 1948, by Brazil's elite with the financial backing and vision of Nelson Rockefeller, who was just ending his tenure as Vice President of the United States, where he had been regarded as Roosevelt's key advisor on all issues pertaining to Latin and South America. Rockefeller's interest in Modern art was largely thanks to his father, John D. Rockefeller, who, along with Lillie P. Bliss, and Cornelius J. Sullivan, founded the New York Museum of Modern Art in 1929. MAM began as an exhibit space on the top floor of Oscar Niemeyer's recently finished Banco Boavista. After only a few months, the bank asked that MAM relocate and was forced to store its growing collection in the home of Paulo Bittencourt, one of the Museum's key early patrons. In 1951, Carmen Portinho was appointed deputy executive director, at which point the Museum was moved onto the first floor of the Ministry of Public Health and Education, the seminal project of Brazilian Modernism created by Lucio Costa in collaboration with many of his peers and students including Niemeyer, Reidy, Bule Marx and Le Corbusier (Hitchcock 1955). With this move and Portinho's appointment, the development of a permanent home for MAM began. It is worth noting that Oscar Niemeyer designed the 500m<sup>2</sup> temporary structure, which wove between the pilotis on the ground floor to house the MAM exhibits, of which there is very little documentation (Nobre 1999, 76).

"The construction of the Museum of Modern Art was one of the most fascinating chapters of my professional life, and the same time and adventure and achievement that involved us all. [...]"

The site was on water; the leveling of Santo Antonio hill was going on... Well, we had already done some drilling and verified that, due to the kind of ground, we would have to thrust piles 16 to 20m deep. The studies led us to adopt a system of reinforced concrete piles for the slabs, which reached a depth of over 20m. For the building of these slabs,

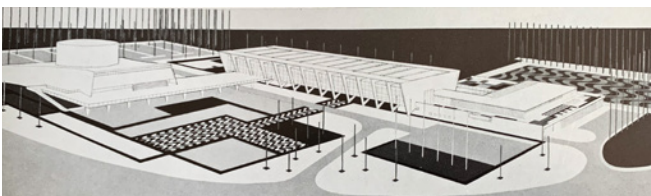


Figure 7. The site plan for MAM Rio. Image: (Klaus 1960).

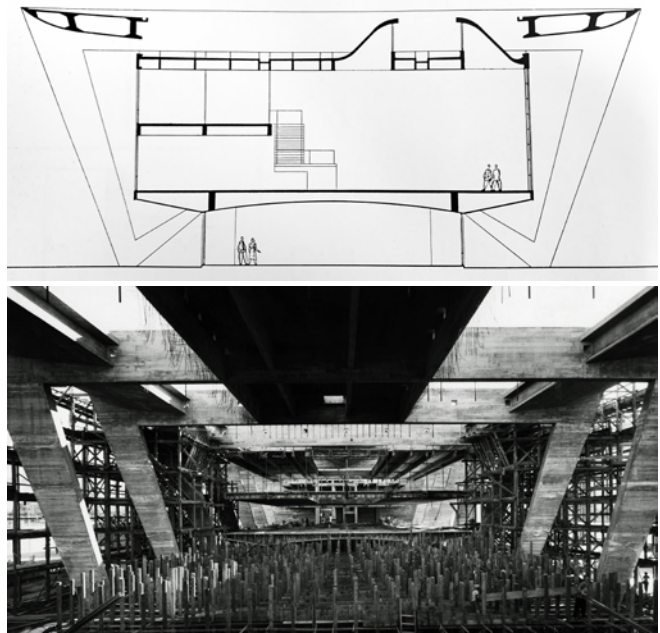


Figure 8. The hollow reinforced concrete slab design used in MAM was tested in the Gavea Housing Development. At the plane of the frames the floors have a solid section. Construction images indicated there may be vertical supports throughout the hollow portions. Top image: (Klaus 1960), bottom image: Aertsens Michel.

penetration and weight bearing tests were made. The 390 piles covered the building's three main bodies. [...] We made the most of the opportunity to prepare all the slabs, including those of the theatre block, which were not built after all, but the piles remain there.

Starting up the building works, [...] Cafe Filho, who was then the president of Brazil, symbolically thrust the first stake. This day, I remember, as the celebration went on... I was nearby in slacks and boots, thrusting piles in the ground because the work could not stop.

Just to have an idea of the kind of ground we were on, we all, engineers and technicians, went by boat to inspect work or drive piles, crossing the ocean area to be filled up with earth. In June 1955 [...] the last pile was thrust. The building works were taken up again at the beginning of August of the same year, starting with the building of the school block. Then we began the lowering of the water table on the section corresponding to the basement, and the structural work. [...] The work rhythm accelerated. Brazilian businessmen, pressured by the *Correio da Manhã* (Rio Daily), were coming forth with generous donations; Rio was on the way to have its Museum of Modern Art, whose architectural project was reported by specialized publications, having enormous repercussions in Brazil and abroad."

- Carmen Portinho 1998 (Bonduki 2000, 172)

The Rio Daily newspaper, which Portinho references, was, at that time, run by her brother. His support and media control of her projects contributed to her ability to garner local and international acclaim for the civic works she built with Reidy. This is another example of Portinho's remarkable skill in propelling an almost socialist ideology of universal access to art and arts education with largely private funding through careful politicking in Brazil's most powerful circles. This fluid balance between being a genuine public servant by

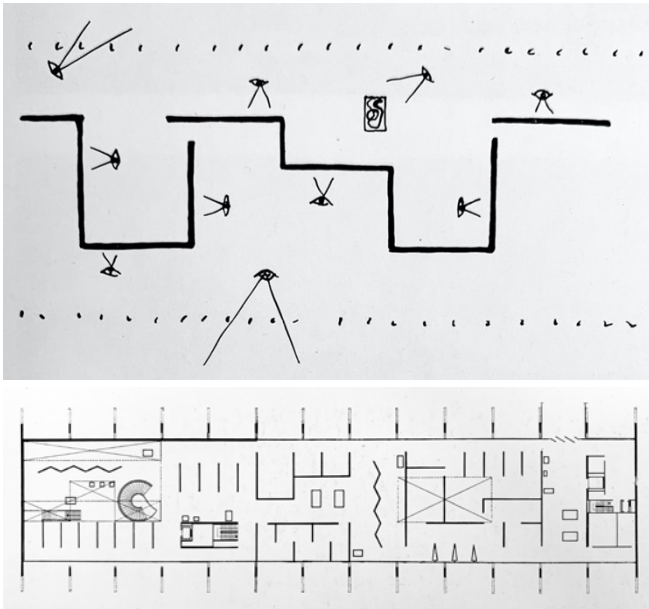


Figure 9. The innovative frame structure suspending a deck made Reidy's vision (top, sketch by Reidy) of a completely open and flexible exhibit space possible. Images: (Klaus 1960).

day and a star fundraiser and a cultural trendsetter by night seems to be unique in the history of Brazilian modernism and perhaps beyond. By all accounts, during the construction of the Museum of Modern Art Eng. Carmen Portinho was on site every day managing construction down to concrete formulation and finish details while simultaneously pitching the project to international millionaire investors, government officials, including the President of Brazil, and prominent architects from around South America, the US, and Europe.

As Nobre writes, the challenge of concrete construction in Brazil in the 1950s was "mainly of an operational nature" (Nobre 1999, 81). At that time, the number of skilled workers with experience in reinforced concrete was extremely limited, concrete was still being mixed in small batches on-site, and steel was relatively expensive and difficult to obtain. It would



Figure 10. Detail of the upper frame reinforcement and formwork. Reidy and Portinho's shared love for exposed concrete was finally manifested in MAM, requiring precise framing and custom-cut 28 cm boards (typical was 31cm at the time) to achieve their desired surface finish. Image: (NPD/ FAU/UFRJ).

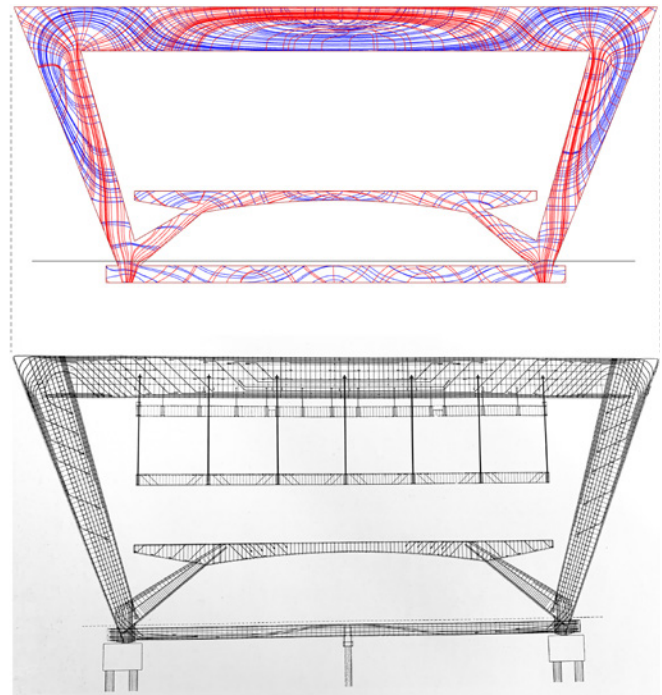


Figure 11. The hand calculated reinforcement design for the MAM frames shows remarkable alignment with the principle stresses in a modern simulation of the structure. Top image: authors simulation, bottom image: (Klaus 1960).

not be until 1957 that the first steel high-rise building would go up in Rio de Janeiro, designed by Affonso Reidy. The 22-story Headquarters of the Guanabara State Social Security would be yet another groundbreaking advance in Brazilian architecture to be finished after Reidy's untimely death in the same year, almost in parallel with the MAM Rio. Both Portinho and Reidy's concrete expertise was extensive by this time, having spent nearly 10 years designing and building concrete public works projects across Rio de Janeiro. This experience gave them access to the best engineers graduating from the National Engineering School.

The general structural plan of the MAM complex's main exhibition building was created by Reidy, Portinho, Sydney Santos, who had led the engineering of the Brasil-Paraguay School and advised on both Pedregulho and Gavea, and Fuad Kanan Matta who was the structural engineer of record on the project. Matta was an engineer at the firm Companhia Construtora Nacional, where he had also been responsible for the structural drawings of Niemeyer's National Congress of Brazil, ostensibly the centerpiece of Brasilia. Leading 450 engineers and construction workers (all men), Portinho successfully executed the stabilization of the site's foundations and the casting of massive reinforced concrete frames which would carry the 130 x 26-meter open plan exhibition space fully suspended (fig. 12). As Arthur Jermann, the engineer responsible for these calculations remarked "Carmen Portinho knows how to command" (Nobre 1999, 88).

The detailed calculation for MAM's reinforced concrete structure was conducted by engineers from Emilio Baumgart's office led by engineer Arthur Jermann. Baumgart not only did the calculations for the Ministry of Health and Education but was also responsible for South America's first skyscraper, the A Noite building designed by Joseph Gire and built in 1927 on the waterfront in Rio de Janeiro. By the

1950's, Baumgart himself had retired after a quiet but hugely influential career bringing German concrete technology into Brazilian architecture through the training provided to young engineers by his office. In the 30s and 40s in Brazil, there were no technical references in Portuguese, forcing students to learn directly from the German and French texts, which were not particularly suited to the complexities presented by Brazil's climate, limited access to cement, steel, and experienced labor, or to work on Baumgart's team. Arthur Jermann was one of the first students of Baumgart's "concrete school" in the 1930s, along with other notable Brazilian engineers of the period, including Antonio Alves de Noronha, Fernando Lobo Carneiro, Paulo Fragoso, and Tercio Souto Costa. Baumgart himself was a Brazilian of German descent trained under a German immigrant named Redlienger, who came to Brazil employed by the German engineering firm National Constructor to implement concrete technology for roads, tunnels, and other infrastructure projects. The Museum of Modern Art is, in a way, a completing moment in this history of the adoption of reinforced concrete technology by Brazilian engineers, architects, and government as it engages a level of sophistication impossible even a decade before in Rio de Janeiro.

"The structure of the museum's main body, the exhibition block, has 14 porticos of reinforced concrete, set at 10-meter intervals, with a 26m wide void between the supports. The ramps of these porticos bifurcate from the ground level so that one part holds up the second floor, and the other, going on in a divergent direction, supports the beam of the 4m void, where the slabs of the third-floor roof will be supported by binding beams. In this way, the exhibition halls will be free of columns, which will greatly facilitate the arrangements of exhibitions.

The porticos' edges will be interlocked along the building's whole extension by means of two reinforced concrete borders, about 8m wide. These borders act as structural windbreakers, as well as efficient sunshades, protecting the two opposite northern and southern facades."

- Carmen Portinho, 1958 (Bonduki 2000, 174)

The 14 frames making up the structural vertebra of the MAM exhibition hall are beautifully articulated structures. The first-floor slab sits on the interior branches of the base of the frame, while the rest of the museum gallery space and circulation hang from the upper beam. Just below grade, a prestressed beam links the two sides of the frame, equalizing an approximately 200 metric-ton horizontal thrust

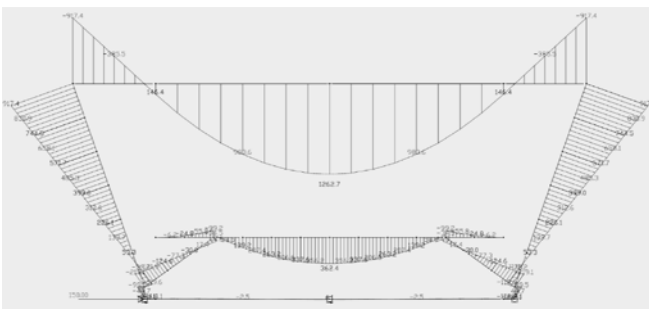


Figure 12. A moment diagram was reconstructed by Prof. Eduardo Thomaz, based on information from Matta's 1959 Technical Report on the construction of MAM, a document no longer readily available (Thomaz 2015).



Figure 13. Portinho inspecting the concrete mix on site. Image: (NPD/ FAU/UFRJ).

coming from the secondary first-floor frame. The maximum positive moment in the frame was calculated to be 2000 tm (19600 kNm). This structural scheme has no precedent in Brazilian architecture beyond the construction of the Brasil-Paraguay school, which was completed one year before MAM construction began. Despite a safety factor of two, the government's willingness to even consider approving such an untested design on precarious ground conditions speaks to the rigor with which Portinho and her team approached both the design and testing of the structural system.

## Conclusion

The complex structural details of Reidy and Portinho's projects are in themselves a commentary on the relationship between available labor and available material in 1950s Brazil. By unifying design and engineering, rebar is carefully conserved through many uniquely shaped elements, a strategy impractical in the US at the time, where the cost of labor often outweighed the cost of steel in the eyes of structural engineers, leading to simplified repeating modules. This relationship between labor and material facilitates the unique characteristics of their collaborative projects, the curving profile of Pedregulho and Gavea necessitating many unique details and the structurally complex frames of MAM. The long duration of construction for the public works they collaborated on meant collectively managing political and economic changes throughout the building process; in spite of this, their creations convey clarity of form and continue to exist as loved public buildings today. Throughout their work together, Reidy and Portinho shared a common rigor and dedication to making not only highly functional architecture but also lasting architecture, which would continue their work as public servants well after their passing.

## Acknowledgments

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