# The History of the Construction of the Cuban National Capitol

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## Introduction

In 2019, the Office of the Historian of the City of Havana (OHCH) completed the restoration of the National Capitol of Cuba. It had begun in 2010. The architectural intervention on this monument is, so far, the largest restoration project the country has ever faced, due to its size, importance and large scale. This article describes its history and construction methods, emphasising the construction and technical innovation that made it possible to complete the work in a very short time for the conditions and techniques of the time: only three years (1926 to 1929) for a building that had 13,483 m2 of construction and 26,391 m2 of parks and gardens, covering a total area of approximately 43,600 m2 [1].

The research goal is to provide information on the construction solutions and materials used to build the monument, based on the extensive graphic and photographic documentation located in the different archives in Havana, consulted by staff from the University of Alicante and the Polytechnic University of Cartagena, throughout 2010 and 2011. This made it possible to carry out a subsequent detailed study of this information. It took approximately two years to deeply understand the innovative construction of a neoclassical style building, made of reinforced concrete and iron but covered in stone, and to be able to redraw, by means of technical axonometries, the load-bearing structure of the central body. The study focuses primarily on the central body of the building, which supports the large dome, and unmasks its highly complicated internal structure.

Materials examined included:

- The original hand-drawn plans, which had never been published
- Historical photographs of the building and surroundings belonging to the Ministry of Public Works
- Photographs of the on-site visits made at the beginning of its restoration.
- Published texts and photographs from The Capitol Book, of which only two physical copies exist in Cuba and five in North American universities.

In addition, several site visits were made, which facilitated the understanding of the internal dome structure and allowed the assessment of the state of conservation of the building, in a prior phase to its architectural rehabilitation.

## Historical Context

In the first 20 years of the 20th century, Cuba's population grew, the number of immigrants increased, and the city's urban development began. The economy had grown very rapidly, but growth was based almost exclusively on sugar cane production and trade relations with the United States. However, this independence did not bring any benefits to the population, which led to numerous protests in the country.

In 1925, General Gerardo Machado y Morales became President, to reconcile the interests of the different sectors of the bourgeoisie and American capital with his economic programme, offering stability to the middle classes and new jobs to the working classes. President Machado conceived, with an almost delirious grandeur, the execution of an ambitious project whose main objective was to carry out a series of remodelling works. These aimed to creating an impressive monumental setting for the Pan-American Conference in Havana in 1928 and the possible inauguration of his second term of office, which was to take place in 1929.

The period between 1920 and the Wall Street Crash of 1929 marked an important time of economic growth for the Cuban ruling class, which promoted American investments that coincided with the creation of the large sugar mills. In addition to the public works that had already been undertaken at the end of the War of Independence (paving, public lighting networks, urban sanitation services, tram systems, etc.), this period was characterised by major public projects, reflecting the megalomania of President Machado, who wanted to turn Havana into a "tropical Paris". The works also had a social objective: to alleviate the pressure exerted by the workers and peasants' unemployment during the so-called "dead time", that is, during the greater part of the year when the sugar harvest did not take place. However, the social purpose was not the President's primary aim, but rather initiatives aimed at constructing perishable symbols representative of his power

*Figure 1: Aerial view of the front of the Capitol. Source: Archivo Secretaría de Obras Públicas. Negociado de Construcciones Civiles y Militares (Archive of Public Works Secretariat. Bureau of Civil and Military Constructions). 1938*

Among the public works that Machado set in motion as a reflection of the local oligarchy were the Master Plan for Havana. This was a reflection of the desire to adapt the urban framework to his grandiloquent aspirations in the symbolic works of the State, the National Capitol (Fig. 1), similar to the architectural model installed in Washington, and the Model

Prison of Isla de los Pinos. This prison would be the largest and most modern penitentiary establishment of its time in all of Latin America, with a capacity for 5,000 inmates. The financial investment for these constructions obviously came from American banks, "the Chase National Bank made a loan of one hundred million dollars to the Government while the concession of the Central Highway was assigned to the Warren Brothers Company of New York, a company in which Machado and the Minister of Public Works, Carlos Miguel de Céspedes, were shareholders [2]".

In this context, the National Capitol of Cuba, whose dome axis would become the starting point or 'kilometre zero' on which the country's road network was established, fulfilled the dictatorial expectations of having constructed a representative building of President Machado's political achievements, the urban apotheosis of his delusions of grandeur.

The Capitol monumentalised a mirage of benevolent authority. This false munificence soon evaporated during the next few years as, in parallel, a generalised crisis took shape, augmented by the Great Depression between 1929 and 1933. In Cuba this aggravated the existing situation by collapsing the Cuban sugar-based economy and generated a revolutionary situation, whose effects encompassed almost all factions of Cuban society. People organised to confront Machado. Students and trade union organisers staged massive public protests. Civil unrest provoked police brutality. The Capitol and public spaces built by the Machado regime changed from a stage for political theatre to one of revolution.

On 20 March 1930 a general strike was held. Two hundred thousand workers took part under the slogan "Down with Machado". This strike is considered the beginning of the anti-Machado revolution, together with the student *Tángana* (instant student protests) of September 1933, which culminated in August 1933 with another general strike. As a result of these pressures, on 12 August 1933 Machado fled the country. After his flight people destroyed his face engraved on the bas-reliefs of the Capitol gates.

From the inauguration of the building, in 1929, until 1959, year of the Cuban revolution triumph, the Capitol was the Cuban Congress. Since 1959, the building has been used for various purposes. It has been home to the Museum of Natural Sciences, the Cuban Academy of Sciences from 1962 and the Ministry of Science, Technology and Environment, adapting its facilities with each new use. In 2009 it closed its doors to the public and began to move all its workers. The building was vacated in order to begin its rehabilitation and the current unicameral parliament was moved to the building that housed the Senate and House of Representatives, as the Cuban ruler Raúl Castro stated in front of the National Assembly deputies in February 2011.

## Historical-construction context

The construction methods of the National Capitol of Cuba were a direct consequence of the success of the North American construction methods and means brought to Cuba at the beginning of the 20$^{th}$ century. After the Spanish-American War, Purdy & Henderson was one of the most pioneering New York firms in the execution ofsteel-frame and reinforced concrete structures in Cuba and New York, whose first branch was established in Manhattan in 1893. In Cuba, Purdy & Henderson also built the *Lonja del Comercio* building (1909), the *Hotel Plaza* (1909), the *Centro Gallego* (1915), the Royal Bank of Canada building (1919), the *Centro Asturiano* (1927), the *Hotel Nacional* (1930) and the *Radio Centro CMQ* building (1947).

In that sense, the structure of the building was largely tied to American construction standards. The detailed drawings show compliance with the specifications of the American Institute of Steel Construction (AISC), the first edition of which was published in 1923. The material used to construct the steel structure must also conform to the standard specifications of the American Society for Testing Materials for Structural Steel for Buildings (series designation A 9-21) and to the Standard Construction Rules for the Use of Reinforced Concrete, published in 1917 in the United States of America [3].

*Figure 2: Bas-relief of one of the main gates of the Capitol depicting its construction. Author's image.*

It is also significant to consider the importance of the first prefabricated concrete parts workshops in Havana, whose application to architectural work in the form of mouldings, column drums and decorative elements formed a language of the island's pre-industrial construction time, which left its mark on many works from the beginning of the century. Cuba was the first country to produce cement in Latin America. Workshops such as *El Arte Moderno*, founded in 1911, gave rise to the birth of the cement and plaster foundry Duque y Cia., later called *Compañía Cubana de Piedra Artificial S.A*., where all the decorative elements of the Bacardí building, completed in 1930, were made, in which the American company Purdy & Henderson also intervened. In many of these prefabricated element workshops, a variety of artificial stone elements, plaster pieces and decorative elements were built. It made it possible to construct works at high speed. In the Capitol, prefabricated elements can be found in the Corinthian capitals of the columns (Fig. 2), in its drums, some mouldings and decorative elements (Fig. 3).

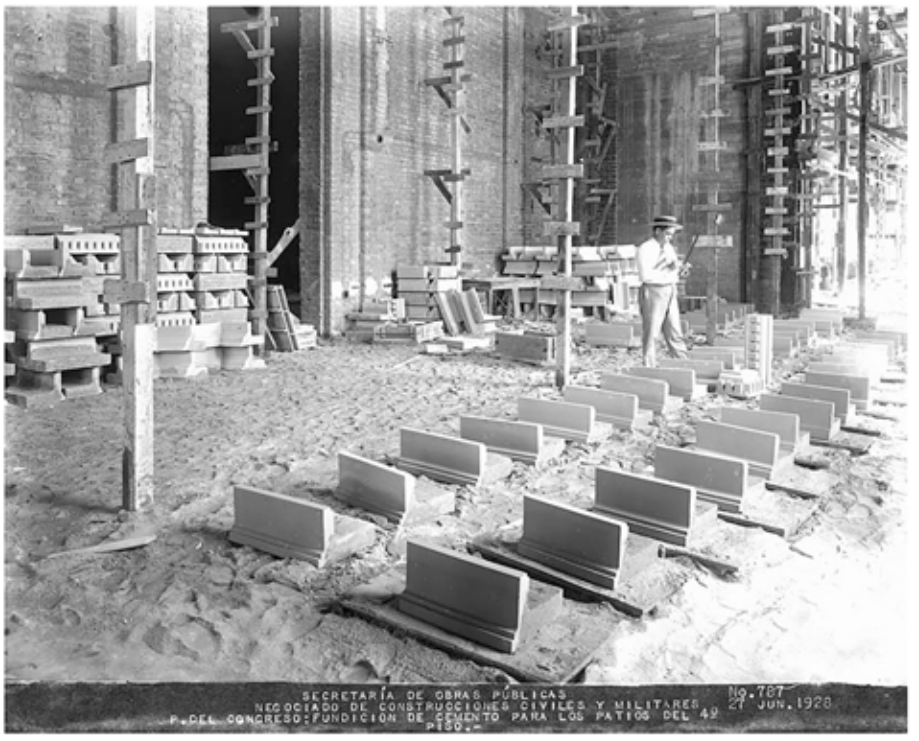


*Figure 3: Concrete casting workshop for the 4th floor courtyards, on site. Source: Archivo Secretaría de Obras Públicas. Negociado de Construcciones Civiles y Militares (Archive of Public Works Secretariat. Bureau of Civil and Military Constructions), 1928*

## The construction of the National Capitol of Cuba

The original building was the result of an international competition, held in July 1910, whose winning project, with the slogan *La República*, was developed by the Cuban architects Eugenio Rayneri Sorrentino and Eugenio Rayneri y Piedra. Construction began in 1911. Work was suspended when General Mario García Menocal assumed the presidency of the Republic in 1913. Menocal decided to build the Presidential Palace on the *Quinta de los Molinos* and to take advantage of the land and the work already begun on the former site of the Villanueva Railway Station for the future building that would house the Congress and Senate. Cuban architects Mario Romañach and Félix Cabarrocas were commissioned to modify the plans and adapt the already built part to the new capitol. Cabarrocas completely changed the original project, as well as the shape and height of the previous dome, which, although construction had already begun, seemed erroneously low.

The construction of the Capitol of the Republic was resumed in 1925 under Machado's mandate on the site of the now-disappeared Villanueva railway station, which served as a hinge between the Old Havana historic city the Centro Habana neighbourhood, as well as forming part of the axis of the Paseo del Prado. The Secretary of Public Works, Carlos Miguel de Céspedes, commissioned the architects Evelio Govantes and Félix Cabarrocas to study a new capitol project based on the one that was being executed to award the contract for the works by auction in January 1926. After several sketches, the final project was made by the architect Eugenio Rayneri Piedra with the help of Ricardo E. Franklyn, an architect from Purdy and Henderson Co. of New York, the company that was awarded the contract for the purchase.

The construction of the Capitol employed 8,000 skilled workers (Fig. 4). This great coordination was carried out by the Purdy and Henderson Co., which was responsible for thousands of workers simultaneously and more than 40 subcontractors with numerous personnel, most of whom were Cubans.


*Figure 4: General Gerardo Machado with the Capitol workers, 1929. Source: Archivo Secretaría de Obras Públicas. Negociado de Construcciones Civiles y Militares (Archive of Public Works Secretariat. Bureau of Civil and Military Constructions), 1929*

Due to the large scale of the building, many plans had to be drawn up (around 5,000), which meant that there was a large design team, mostly made up of young Cubans and headed by Luis V. Betancourt. The decoration work (woodwork, joinery, painting, etc.) was carried out by Waring and Gillow Ltd. of London, which, with more than 2,000 workers at the same time, completed the work in eight months. The design and calculation of the dome's foundations was carried out by N. A. Richards and H. V. Spurr, engineers of the construction company, in the record time of one week for the foundations and one month for the structure. French and Italian artists led by Mr. Droueker, and Cubans such as Sicre and Betancourt also participated in the design and manufacture of the metopes of the end bodies and the loggias. The marble decoration was done by two companies, Fratelli Remuzzi of Italy, which was in charge of the main floor, the main staircase at the back, the Staircases of Honour and the sides of the porticoes, and Casa Grasyma of Germany for the rest.

## The building

The neoclassical building is 207.44 m long and 91.73 m high. It is completely symmetrical with respect to the axis passing through the dome. It has a regular geometry of simple figures: the central body on which the dome rises, two semicircular

pieces on the edges corresponding to the Senate and House of Representatives hemicycles and two intermediate volumes that connect the previous ones, where the Salon des Pas Perdus (Hall of the Lost Steps) is located [4]. The central body houses the 'rotunda', the library and the main entrance or central portico, composed of 12 Doric columns and a grand granite entrance staircase with 55 steps.

On the central axis is the dome, which begins to rise above the building above the attic of the portico and consists of a square base. Below this is a cylindrical body or drum with windows that forms the base of the peristyle topped by a balustrade. Above this is the parapet, whose moulding lines coincide with the double pilasters to form wide pillars from which the ribs of the dome start, and finally the lantern.

The dome does not occupy the central place of the building: it is displaced with respect to the transversal axis of symmetry of the building. This is not the case with the longitudinal axis, which was made to coincide with the axis of the Salon des Pas Perdus, instead of rising on the longitudinal axis of the interior courtyards, which coincide with the radii of the hemicycles (Fig. 5). In other words, in a French neoclassical compositional scheme, the dome is brought forward towards the main façade, where the monumental staircase is located, ignoring the gravitational centre of the building.

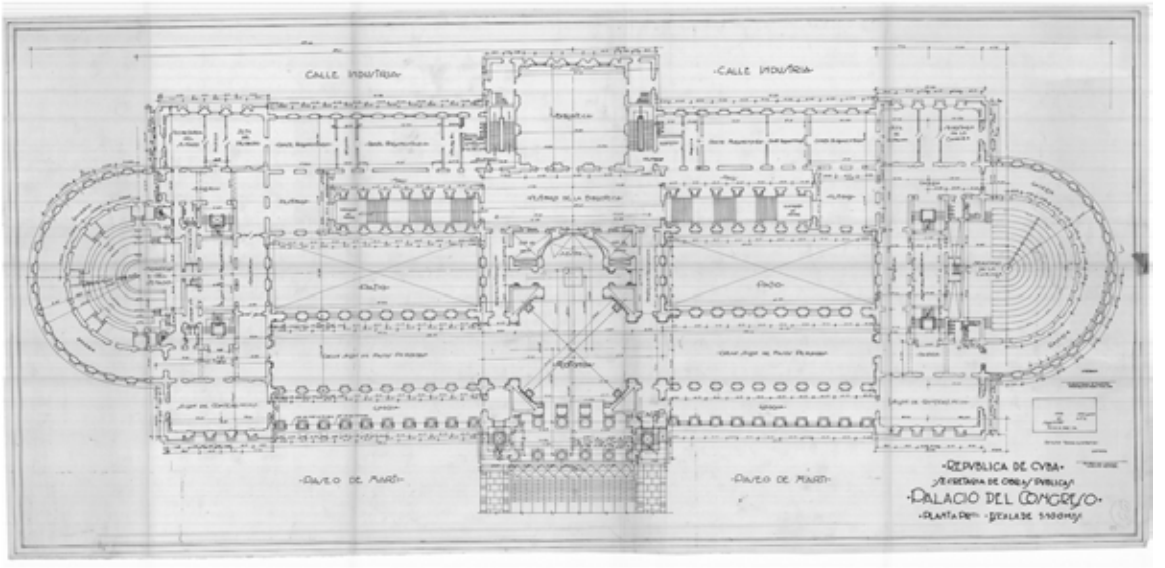


*Figure 5: Second (Main) Floor Plan. Source: Hand-drawn plans of the Capitol building.*

The construction of the Capitol was mainly reinforced concrete, steel and stone. Almost all this supporting structure consists of mixed structural elements such as columns, beams and slabs, properly braced to withstand tropical winds, clad in concrete. Only pure steel sections are used for the dome trusses and for the bracing and bracing elements, such as the cross-bracing systems (X-shaped) and the tie beams at the base of the drum.

### *The Internal Supporting Structure of the Dome*

Under the dome, on the symmetrical axis of the building and after passing through the doors of the central portico, on the main floor (first floor) is the Central Rotunda, an octagonal space, formed by the dome's supports made up of four triangular-shaped concrete bases. Each base has three steel columns, which support most of the dome's weight and contribute to its rigidity.

If we look up and around, the octagon transitions through pendentives to form a circle, where there is a decorative frieze with the coats of arms of the Republic and its six provinces. This circle is a metal ring that supports the entablature above the pendentives. From here, inside the dome void, 16 mixed steel and concrete interior columns emerge, outlining its circular shape and concealed by a stone cladding. Between these interior columns are large windows that illuminate the interior "rotunda" which houses the statue of the Republic of Cuba.

In addition, the drum has an outer ring of thirty-two Corinthian columns that form the outer peristyle of the drum of the double colonnade, which has a neoclassical appearance. The columns of the peristyle do not assume a structural role. They are made of pieces of artificial stone later assembled by steel rods.

A transverse bracing system is used in the second level of the lower drum. This system connects each inner column to two outer columns and acts as tie rods to limit the loads in the flaring pressure plane and thus to prevent deformations. They contribute to stiffening the perimeter ring with pairs of steel beams so that each inner column is connected to two outer columns (Fig. 6).

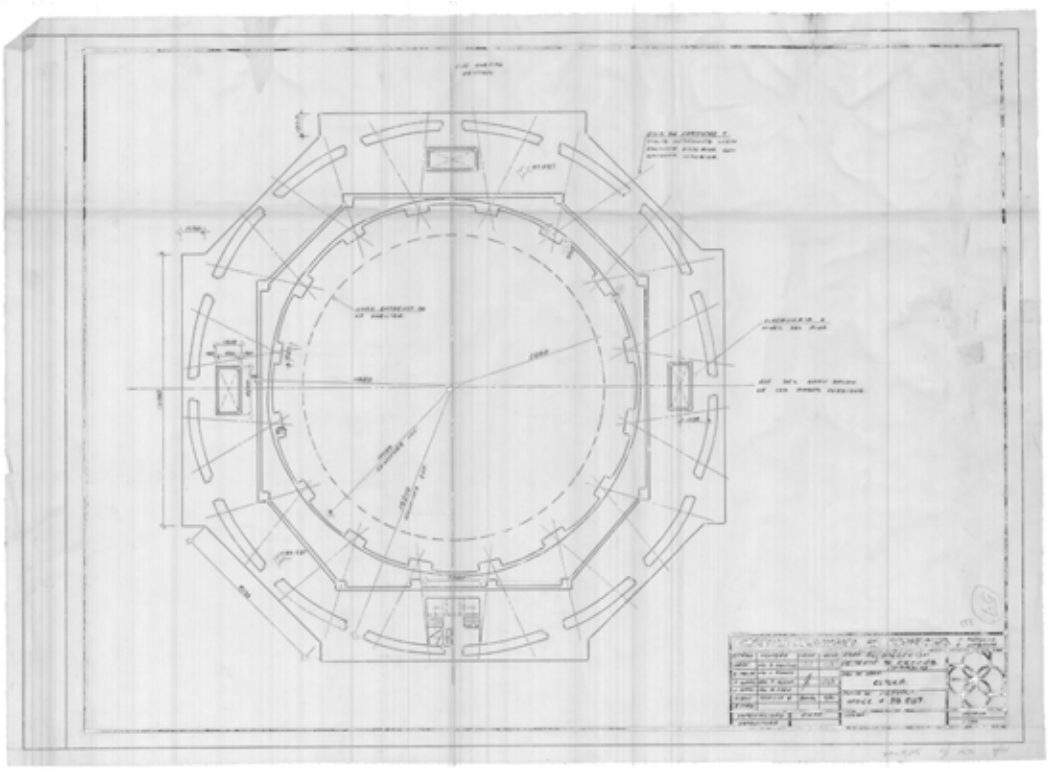

*Figure 6: Groundfloor at level +33,28m. Source: Hand-drawn plans of the Capitol building.*

The dome was the last part to be built, based on the drawing by the Cuban architect Eugenio Rayneri Piedra. The engineers of the New York firm modified and gave the final design to its load-bearing structure, respecting the proportions and shapes of the original drawings. The dome does not follow the classical load transmission scheme, whereby forces are transmitted through the outer membrane. When examining the cross-section of the dome from the point of view of structural behaviour, the ratio between the thickness of the dome and its span is very small, and the volume of the lantern is too large to be supported by this thin shell. Therefore, it is unquestionably the case that Rayneri's plan (Fig. 7) only shows formal and dimensional intentions but does not contain any information on the construction detail, nor does it include a coherent structural design, delegating the design and structural calculation to the American company.

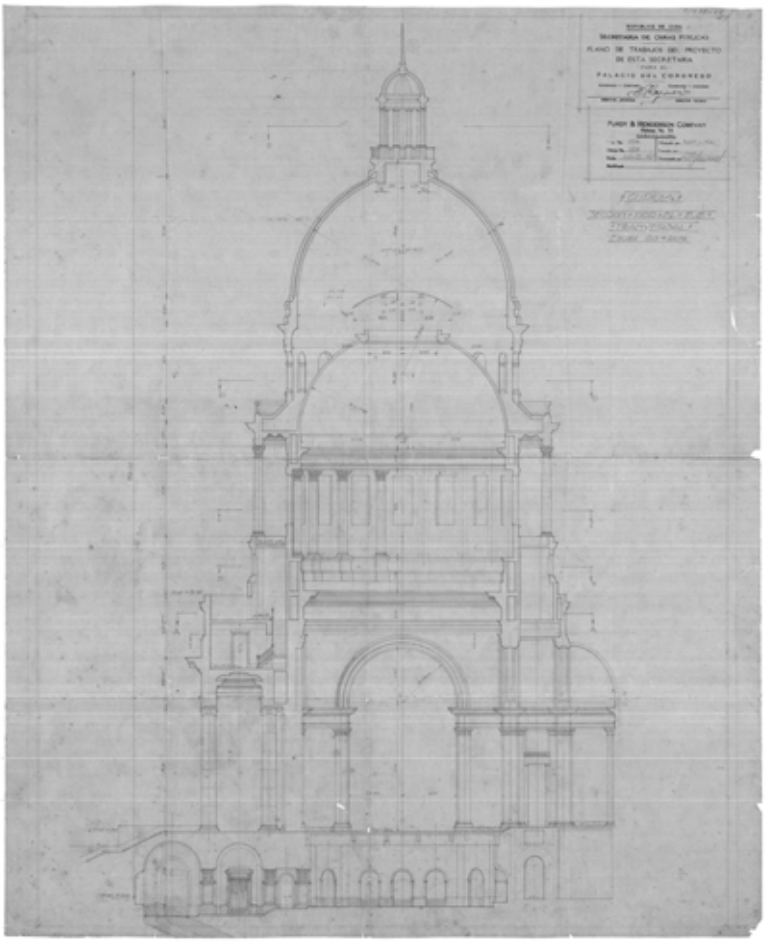

*Figure 7: Dome final drawing, by the Arch. Eugenio Rayneri Piedra. As it can be seen, only the desirable shape of the dome is specified. Internal structure does not appear, as it will be later designed by Purdy & Henderson. Source: Hand-drawn plans of the Capitol Building.*

Due to this shape limitation and the excessive slenderness of the outer membrane, the dome would have collapsed as it would not have withstood the horizontal thrusts. According to Foraboschi this would be an incoherent case of structural design that does not bring together knowledge of the material, its use and the structural solution [5]. Therefore, the choice of an internal steel bearing substructure that decreases the lateral thrusts and converts the loads of the dome into vertical point forces transmitted to the supports is understandable (Fig. 8).

The detailed drawing of the dome (Fig. 9) shows that there is a change in the cross-section and consequently also in the structural behaviour of the dome. The lower part is entirely made of in-situ reinforced concrete (reinforced concrete ribs and shell), while in the upper half, although the shell is also of reinforced concrete, the ribs become metal elements from that point onwards and are connected to the rest of the metal substructure. Geometric verifications revealed that this section change occurs near an angle of 30°. This indicates that the steel structure is used from the point of view of the possible hinge formation of a kinematic mechanism, in the case of exceeding the limit of the lower horizontal thrust. This

construction decision coincides with the later analysis of Blasi and Foraboschi on the structural behaviour of pointed domes, who stated that this value of the angle of impact (30º-35º) is independent of the thickness of the shell, the span of the dome or the specific weight and that it was already known experimentally in dome construction [6].

The internal structure of the Cuban National Capitol consists of four braced trusses (TD1, TD2 in Fig. 10 and transversally TD3, TD4) that transfer their forces to 8 of the 16 columns that make up the drum. In addition to supporting its own weight and that of the dome frame, this internal structural system must support the weight of the lantern, the access stairs to the dome, as well as the weight of the inner dome and the false ceiling. The geometry of the dome is defined by these trusses, as a total of 16 metal profiles define its curvature and act as ribs of the dome.

According to the Capitol Book, the structure of the lantern was left undefined by the engineers who drew up the project. The final solution was finally adopted as a result of decisions taken on site to reinforce it against the prevailing winds. The structure of the lantern is also made of metal and is supported by the beams of the collar.

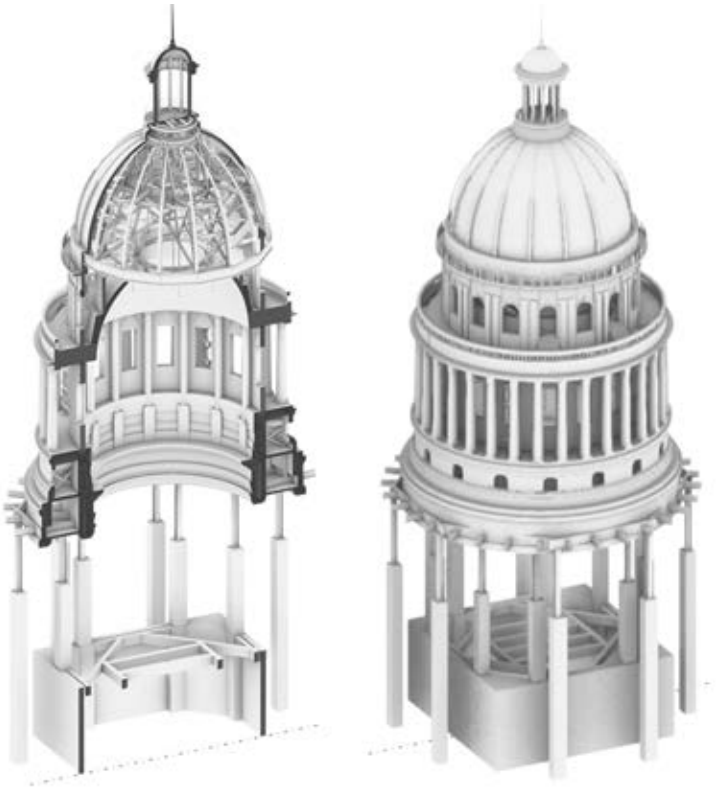

*Figure 8: Axonometry of the Capitol dome and detail of the inner structure of the cupola. Left: Metallic inner framework of the cupola. Right: exterior image of the dome. Authors' images*

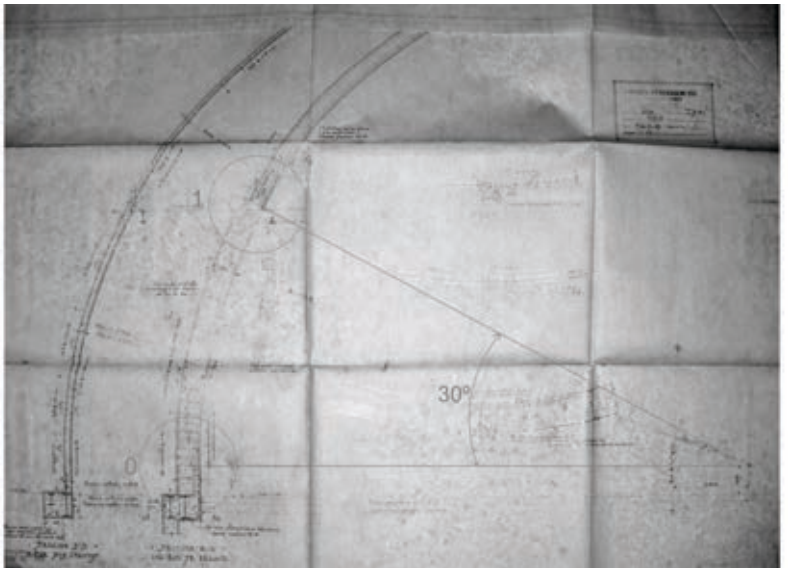


*Figure 9: Detail of the dome section, where the angle of the material transition can be distinguished. Points 0 and 1 are respectively the starting and ending points of the reinforced concrete ribs. At point 1 the steel rib (which is part of the steel truss) starts. The overlap length of bars for the connection of the ribs can be seen (Point 1). Authors' analysis based on the hand-drawn plans of the Capitol Building.*

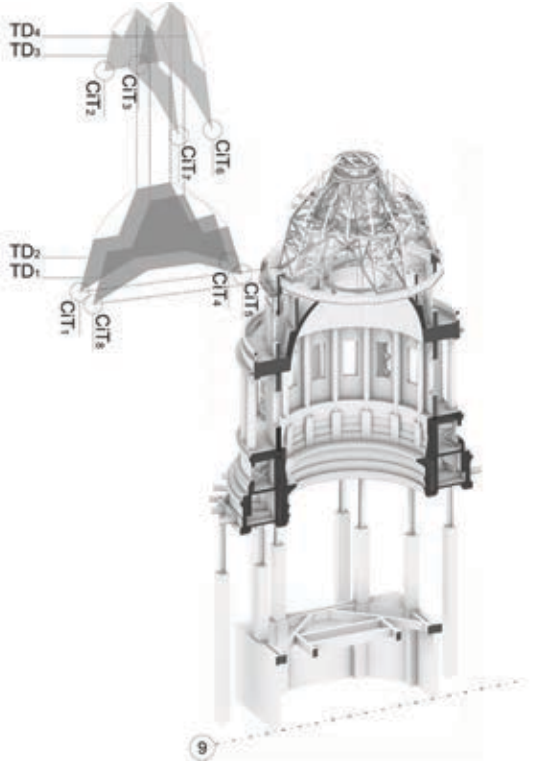


*Figure 10: Metallic inner framework of the cupola (reinforced concrete nerves and shell are not shown to visualize the internal dome's structure). Authors' image.*

## Conclusions

One of the premises that the American company and the Havana Construction Supervision had to face was the necessary adaptation of the new design of the structural system to an already partially-begun work and to a pre-designed neoclassical formal system. In addition, due to the rush to finish the building for the Pan-American Conference in 1928, the structural solutions had to be designed while the work was being carried out.

The mixed nature of the construction of the National Capitol of Cuba can be seen in three aspects. Firstly, it responds in some way to its historical and cultural moment: it is a work designed with a classical 19th century construction methodology (through the structural use of stone and brick walls, vaults, stone columns, etc.) in which some technological improvements of the time are introduced (such as reinforced concrete walls and slabs, pillars, beams and steel trusses), which gives the complex a mixed character.

Secondly, it alternates local materials from Cuba (stone from the island's quarries and jiquí wood for piles) with advanced technology and solutions imported from the United States (compressed air for stone working and carving).

Finally, the structural system itself, is composed of mixed steel and reinforced concrete solutions, because of a later structural adaptation that lacked a previous bar modelling study.

The dome was conceived as a non-self-supporting composite dome, braced and working in collaboration with a very complex internal steel structure consisting basically of four steel trusses. The steel structure functioned as a concealed support for a stone skin that served as both cladding and colossal structure.

This construction euphemism can also be seen in the structural behavior of the dome itself: the lower part differs from the upper part, as they are built differently. The upper part is an upper surface of revolution formed by metal profiles whose contour is a circular arch and a reinforced concrete cap. It transmits the loads from the lantern and the dome envelope to the trusses, which in turn transmit them to the lower supports and the lower reinforced concrete cap. The lower part is a surface of revolution formed by reinforced concrete ribs whose contour is an arch of the same circumference and a reinforced concrete shell. This part of the dome functions structurally as such, being a self-supporting shell that receives the loads from the upper part. At its base, the reinforced concrete ribs and the concrete shell are joined to the column crowning beams, transmitting uniform loads.

The absence of sturdy abutments at the base of the dome is compensated for by various bracing systems to resist the possible hurricane wind thrusts that the dome may receive, due to the climatic conditions of the Caribbean.

The desire to erect an emblematic building representative of Machado's political achievements forced the construction of a more monumental dome. To satisfy his intentions, the idea of a self-supporting dome, as it was the first design by E. Rayneri Sorrentino and his son E. Rayneri Piedra in 1911, had to be discarded in the course of the construction work. This necessitated a complex internal support system to bear the intended loads, with properly braced steel pillars, beams and trusses, and an outer dome consisting of a coated concrete shell.

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