Thoughts for a Contemporary Conceptual Design: Emílio Baumgart, the social history of technique and artificial intelligence.

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Summary

Through a historical analysis of Emílio Baumgart's design practice from the early 1920s onwards, this work aims to maintain the conceptual design autonomy on the human side of the relationship with digital devices, anchored in the role of the craftsman. Baumgart's design practices led to the emergence of a Brazilian School of Reinforced Concrete by spreading his knowledge. This work addresses the conceptual design operations and its subsequent development phases as unfoldings of the social history of the technique, taking as reference the workshops of medieval origins as the spatiotemporal context defined by a *modus operandi* where the transformation from explicit to tacit knowledge occurs. It also presents two case studies. Finally, it regards the challenges introduced in conceptual design and practice by the emergence of artificial intelligence to propose a contemporary posture in dealing with the possible disruptions of the Digital Revolution of our contemporaneity.

1 INTRODUCTION

This work is driven by the challenge of contemplating structural design in contemporary times, strained by the implementation and consolidation of Artificial Intelligence (AI) in everyday social and professional practices, notably in design practice. The realm of structural engineering has always been linked to technological development, which involves the study of technical processes related to various production sectors [1]. In this specific field, one can cite research on production, technological control, and the physical and mechanical properties of concrete, the resulting theories, the development of structural calculation methodologies, tools facilitating design practice, as well as the computerisation of data that supports current methodologies, among other procedures.

Structural engineering now finds itself at a turning point, requiring reflection on how to engage with AI. In the daily practice of project development, we face the real possibility that the design process—a creative endeavour resulting from subjective experiences tied to cognitive processes, inherently a human condition—may be delegated to a non-human virtual entity. In structural design practice, even when embedded in the most advanced technology available today, this marks a new moment. Although AI has been developed since the 1940s, its societal impact has indeed manifested from 2022 onwards. However, this situation is not without precedent, as the Industrial Revolution caused a similar disruption in the late 19th century when human labour was transferred to machines. Now, however, what seems poised for transfer is not only memory—which, to a certain extent, is already housed in virtual repositories beyond the human body—but also the creative capacity of the human mind.

To address this issue, this work seeks to analyse the professional practice of Emílio Baumgart, who also had to contend with the disruptive innovations of his time and proposed solutions to the problems of his historical context. The validity of this proposal lies in approaching Baumgart's history as a historical process, considering that it ceases to be merely the story of something. Instead, it is treated as a process, a history that can be brought into the present, thereby "eliminating the temporal differences it thematises" [2]. Only in this way can we speak of history lessons from which we can make choices for the future.

In 1925, precisely 100 years ago, Baumgart established the first structural design office in Brazil, a product of his academic qualification as an engineer at the *Escola Polytechnica in Rio de Janeiro* and his practical experience in structural design and construction. This began with an internship and later work at the *Companhia Construtora em Cimento Armado*, led by Lambert Riedlinger, which was later incorporated by the German company Wayss & Freitag in the second decade of the 20th century. The academic methodology of the French-rooted *Escola Polytechnica*, combined with the design and construction practices learned in the workplace, resulted in a distinctive professional formation directly related to the emergence of the historically consolidated "Brazilian School of Reinforced Concrete" [3]. It is referred to as a school because Baumgart, leveraging his academic background and, more importantly, the experience gained within the technical and social German environment established in Rio de Janeiro at the time, effectively transmitted this knowledge to the engineers who worked with him. He proposed specific work methodologies and contributed to structural engineering with creative and innovative solutions, which his disciples continued to replicate in their own offices in the years following his death. As David Billington states, creating a tradition requires more than just individual talent; it is up to successors to implement and continue the tradition rather than merely idolise their master. In this sense, Baumgart's lessons can be an impetus for the proposed reflection. Billington suggests that, like old structures, studying specific historical projects remains important because they reflect the ideas of a masterful teacher [4]. These projects incorporate ideas that may still help us rethink design practices supported by contemporary technology, given that AI seems intent on replacing the creative impulse, which is a fundamentally human condition that drives structural design.

Additionally, this reflection will require a brief historical investigation to understand how structural design and its subsequent development dynamics occur in their primary setting: the design office. This process is believed to share similarities with those developed by medieval workshops, as viewed through the lens of the social history of technology.

Two designs from Emílio H. Baumgart's *Escriptório Technico* illustrate this article. The aim here is to highlight what Billington describes as the elegant simplicity and essential correctness of solutions, demonstrating that the art of structural engineering is the interplay between education, experience, and expression [5].

2 THE SOCIAL HISTORY OF TECHNIQUE AND THE MEDIEVAL WORKSHOPS

To understand the importance of practical learning experiences within the realm of structural design — which are necessary and complementary to academic training and which were fundamental for Baumgart, becoming exemplary for future generations of Brazilian structural engineers—, it is essential to investigate the origin of the concept of training and the role of the craftsman from the perspective of the social history of technology. For this purpose, it is suggested that the case of medieval workshops be used as an example, given the significant similarity between these and design offices, where structural concepts are born, projects are developed, and the synthesis between theoretical and practical knowledge takes place.

Richard Sennett observes that in a Homeric hymn to the god of craftsmen, *Hephaestus*, the word *demioergos* (*demio* – public, *ergon* – productive) was used to refer to the craftsman. In that archaic society, the hymn honoured as civilisers those who associated the mind with the hands. From this, he proposes that the power of imagination is linked to technical skills, which begin as bodily practices. Sennett points out that in ancient times, cognitive processes, such as the reproduction of traditions, connected training to ancestors and contemporaneous peers in practice. This process was replicated over the centuries until the institutionalisation of workshops as guilds, which emerged in the Middle Ages as organisations to confront authority.The author investigates how workshops operated through direct personal interaction between master and apprentice, where training became a source of legitimacy for command. There, the transmission of skills in the master-apprentice relationship was central to the formation of new masters who, in turn, established new workshops. This learning process fundamentally involved transforming explicit knowledge (communicated information and observation of practices) into tacit knowledge (intuitive mobilisation of consolidated explicit knowledge). In this process, new practices could emerge when facing new problems—or even familiar problems for which alternative solutions could be considered—feeding back into the chain of knowledge transmission and generating new cognitive operations. Workshops had a collective identity without distinguishing the production of individual participants. Sennett highlights that this condition changed in the material culture of the Renais-

sance when a manufacturer's name became an added value to the product. This shift began to differentiate workshops not only by their manufactured products but also by the distinctive expertise of their owner, whose name became directly associated with the product—such as the famous salt cellar crafted by Cellini and the violin by Stradivari. Establishing production standards and the consequent improvement in product quality, associated with the originality of its design—characteristics embodied by the craftsmen—granted the workshop its social authority [6].
This brief aspect of the social history of technology, illustrated here by workshops and the role of the craftsman, helps us understand the dynamics of a structural design office, where design conception and development occur as problem-solving operations. The articulation between explicit and tacit knowledge, typical of operations in medieval workshops, is also continuously demanded of those working in structural design, even if we are unaware of it.
In this essay, Baumgart is associated with the role of the craftsman, and his office serves as an example of a workshop because his professional history demonstrates this condition, which, in a certain way, has been replicated in our offices ever since. The challenges faced by Baumgart in dealing with a new structural material and technology are comparable to our contemporary challenges with new artificial intelligence technology. Baumgart's development as a structural engineer intertwines with the very history of implementing reinforced concrete as a material used for constructing structures in Brazil, just as today our historical context intertwines with the implementation of AI.
Baumgart's intellectual and technical skills developed simultaneously with studies conducted in Germany to qualify reinforced concrete as a reliable structural material. Moreover, this was also the period when the reinforced concrete skeleton structure began to be used in building construction worldwide, particularly in Brazil. Here, the Modern Architecture of the European avant-garde found fertile ground in a country embarking on its modernisation process. Baumgart's design operations, driven by creativity and supported by his knowledge, occurred within this context in the theory of reinforced concrete structures' history development.

3 EMÍLIO BAUMGART AND REINFORCED CONCRETE

3.1 Baumgart and the role of the craftsman

For Adrian Forty, whether reinforced concrete was invented by Joseph Lambot, or Joseph Monier, in France, or William Wilkinson in England is of little consequence. According to the author, the significant fact is that all of them and others who conducted similar experiments during the same period were primarily builders and contractors whose expertise lay in practical construction rather than scientific or theoretical knowledge [7]. From the mid-19th century to the early 20th century, reinforced concrete construction was characterised by applying empirically derived systems. Although some research on the material existed, such as Thaddeus Hyatt's 1877 study on the structural properties and fire resistance of concrete, the scientific foundation for research on concrete was established when the German companies Freytag & Heidschuch and Martenstein & Josseaux acquired Monier's patent. This patent was later transferred to Gustav Wayss, spurring research on the material during what Karl-Eugen Kurrer describes as the Classical Phase [8] in the history of structural theories development. A significant event that intensified research was the collapse of a reinforced concrete structure built using the Hennebique System in Basel in 1901. This incident led to increased testing and load trials, eventually giving rise to the first theories that enabled the calculation and design of reinforced concrete structures [9]. Only in 1915, with the expansion of reinforced concrete construction, was a framework theory for the material developed, followed by a theory of shell structures in 1930, during what Kurrer identifies as the Consolidation Period in the history of structural theory development. Among the German engineers who led the research to develop these foundational theories in reinforced concrete structural design were Matthias Koenen, Gustav Adolf Wayss, and Emil Mörsch.
Baumgart, born in Blumenau, Santa Catarina, arrived in Rio de Janeiro in 1911 when he enrolled at the Polytechnic School of Rio de Janeiro. He got married in 1915, interrupting his studies, and during this period he taught at Ginásio São Bento and interned at Lambert Riedlinger's Reinforced Concrete Construction Company, later acquired by the German firm Wayss & Freitag. He graduated as a civil engineer in 1918. Baumgart worked at the company until he briefly operated his own construction firm before opening his office in 1925, dedicating himself exclusively to structural design. These dates reveal the parallel trajectory of his career with the development of reinforced concrete itself. His academic training

was complemented by exchanging ideas with professionals from the German technical and social community in Rio de Janeiro during the 1910s and 1920s, an interaction unlikely to have occurred solely at the Polytechnic School.

Baumgart's unique education likely explains his distinguished career. His exposure to the theories developed by Koenen, Wayss, and Mörsch, combined with the construction knowledge acquired from Lambert Riedlinger in the German work environment he engaged with during his formative years, enabled the young engineer to synthesise practical experience with the French-influenced theoretical framework, philosophically grounded in aesthetics as a technical foundation, embraced by the Polytechnic School.

As Augusto Carlos de Vasconcelos notes, Baumgart was undoubtedly not the first engineer to design concrete structures in Brazil [10], but his legacy was perhaps the most impactful of his generation. His office became an authentic workshop for structural design, where engineers were trained in Baumgart's methodology, which fostered creativity and autonomous thinking grounded in theory derived from technique, ethics, and aesthetics. This approach aligned with Brazil's rapid modernisation from the 1920s onwards. Among his notable disciples were Antônio Alves Noronha, Paulo Rodrigues Fragoso, Sérgio Marques de Souza, Fernando Lobo Carneiro, and Arthur Eugênio Jermann, among others. Many later became mentors in their own right, spreading Baumgart's methodology. Jermann, in particular, closely followed Baumgart's footsteps, founding *SEEBLA (Serviços de Engenharia Emílio Baumgart Ltda)* after Baumgart's untimely death in 1943.

3.2 Designs as tools for reflection

3.2.1 *A Noite* Building

In 1928, justifying his winning design in the competition proposed by the newspaper *A Noite* for constructing its headquarters at Praça Mauá, Rio de Janeiro, French architect Joseph Gire highlighted what he considered the supreme demands of his contemporaneity. These included the desire to make the framework of large buildings visible internally and externally. He referenced the law of adaptation of decorative forms to skeletal forms, which had emerged from the law of equilibrium, rendering decorative complexities superfluous. Additionally, he emphasised the significant progress in reinforced concrete construction, which indicated the widespread adoption of that system. He also noted "the growing collaboration between the architect and the constructor, which will enable the realisation of the harmony of architectural forms from which the style will emerge" [11]. In this interview for the newspaper *O Paiz*, Gire encapsulated the context of modernity that influenced his architectural design and a new approach to its development. This process involved collaboration with the "constructor," who, in this context, was actually the project's structural engineer, Emílio Baumgart.

The building, standing 102.80 metres tall, was completed in 1929 and was acknowledged as the tallest structure in the world, built with a reinforced concrete frame. Some of the innovative structural features that facilitated this achievement included a rectangular floor plan measuring 65.00 m x 18.20 m, resolved with only three lines of columns in the transverse direction; slabs just 7.00 cm thick spanning 5.00 m x 6.70 m and 5.00 m x 9.50 m, supported by corbels on beams; and an unprecedented bracing system developed later, as it appears that wind effects had not been ideally considered in the original design. The 1920s saw the rise of skyscrapers, especially in Chicago (USA), designed with the premise that the combination of steel structures and masonry walls provided resistance to wind-induced forces. This concept was likely brought to Baumgart's attention after site supervision by engineer Otávio Carneiro, who, concerned with the building's great height, requested that he consult American companies to verify the effectiveness of their solutions applied for the Brazilian skyscraper. Carneiro doubted that this transfer of forces would occur in the same manner as in American skyscrapers, given the use of reinforced concrete. Baumgart responded to Carneiro's concerns by devising a novel bracing system. This system involved constructing two central concrete walls with door openings from the floor plan up to the 20th floor. It was assumed that the slabs, acting as rigid plates against horizontal forces, would transfer the wind loads to these walls [12]. Thus, Baumgart initiated what would later become known as the rigid core bracing system for tall buildings constructed with reinforced concrete frames (Fig. 1, Fig. 2).

Fig. 1: *A Noite* Building aerial view, 1930.
Source: https://diariodorio.com/historia-do-edifcio-a-noite/. Acessed January 25.

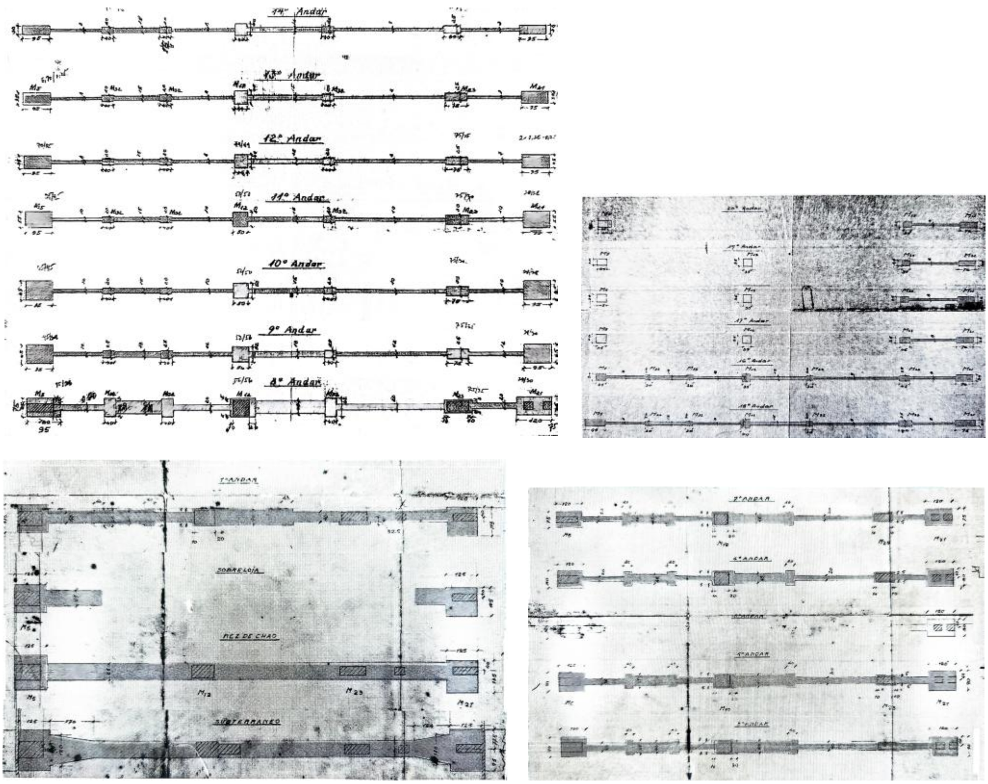
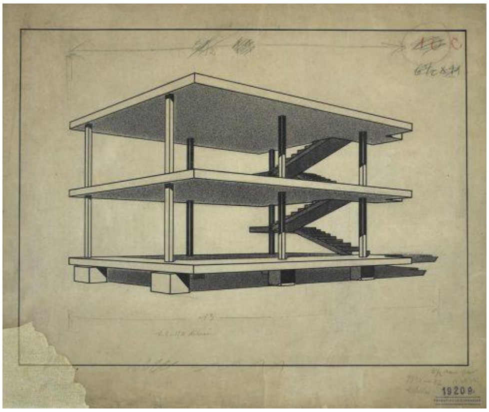


Fig. 2: Bracing formwork plans. Top: left. 8th to 14th floors; right, 15th to 20th floors. Bottom: left, basement to 1st floor; right, 2nd to 7th floors. Source: SEEBLA Archive in Fonseca (2016) [3].

3.2.2 *Ministério da Educação e Saúde Pública (MESP)* Building

The structural design for the *Ministério da Educação e Saúde Pública (MES)* building in Rio de Janeiro (1937) enabled the realisation of a structure now considered a global icon of Modern Architecture's built heritage. Based on the architectural design led by Lúcio Costa's team—which included talents from Brazil's first generation of modern architects, such as Affonso Eduardo Reidy and Oscar Niemeyer—and with consultancy from Le Corbusier himself, a key figure in modern architecture, the structural design was developed following contemporary international parameters for reinforced concrete engineering, once around 1908, Swiss engineer Robert Maillart had already begun transforming the Hennebique System by proposing direct slab support on columns through capitals, thus eliminating beams.The structural innovation in the MES building stemmed from the architectural design's requirement for smooth-bottom slabs directly supported on columns, without using capitals, in line with Le Corbusier's famous Domino system. This iconic modern architectural and structural system synthesised principles around a skeletal structure that enabled free floor plans, free facades, pilotis, rooftop gardens, and ribbon windows. To resolve this challenge, Baumgart proposed the execution of inverted capitals—an innovation for the time (Fig. 3).



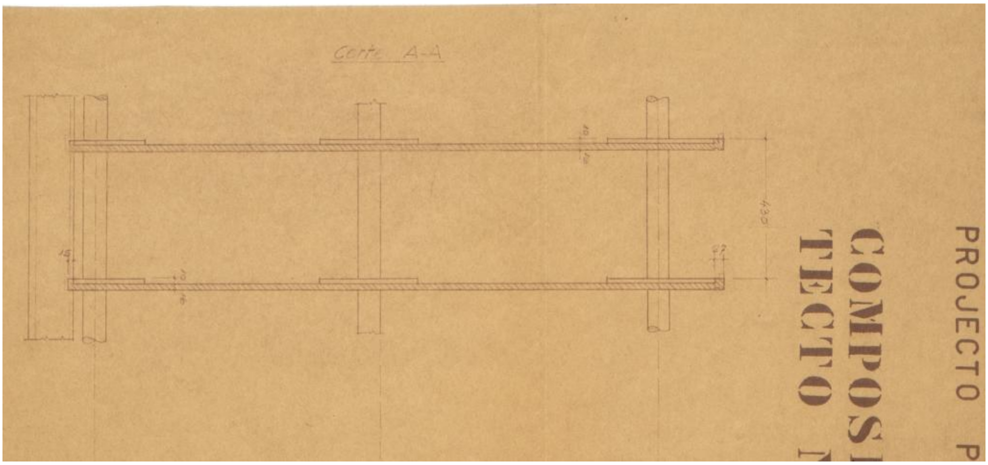


Fig. 3: top left, *Ministério da Educação e Saúde Pública* Building; top right, *Domino* System; bottom, cross-section of the normal roof *(MESP).* Sources: Costa [13]; Le Corbusier Foundation. Accessed January 25. https://www.fondationlecorbusier.fr/; NPD FAU UFRJ *SEEBLA* Archive.

Baumgart's innovative solutions continued to enable the construction of buildings that embodied the country's modernisation. Architect Lúcio Costa once said, "Baumgart pioneered the new reinforced concrete technology here when these concepts were still very embryonic at the Polytechnic School...

and Baumgart was a creator. His office in the *A Noite* building occupied half a floor and was a true postgraduate college, with graduates like Fragoso, Noronha, Holmes, and many others regularly attending his atelier" [14].

4 ARTIFICIAL INTELLIGENCE AND CONTEMPORARY CHALLENGES

Until the 1960s, the debate on the relationship between structural engineering and technology remained within the analogue world of design strategies that linked prevailing theories, materials, production techniques, and construction processes. By the mid-1960s, the use of computers as tools to assist in project development began to spread, becoming significantly more widespread by the 1980s. During this period, one might question to what extent these tools impacted structural design, as they were initially used solely for calculus and drafting, with decision-making entirely under the engineer's control. However, with the emergence of parametric tools in the 1990s, software gradually gained autonomy. In this sense, the fascination with digital technology and the structural engineering community's subsequent adoption of computerised processes transformed the *modus operandi* of design offices, accelerating analytical processes and significantly increasing production capacity.

Since the 2010s, software available for structural design has progressively gained more autonomy and has recently begun influencing decisions in conceptual design. This development results from significant advancements in digital culture, particularly the evolution of neural networks, which led to more sophisticated algorithms and the rise of Artificial Intelligence (AI). It is highly probable that, in the near future, AI will actively contribute to structural design by leveraging data stored in project repositories—an increasingly inescapable reality.

In this context, it is argued that the responsibility to validate, modify, or request new solutions from AI must remain in the hands of the designer through continuous interactions until the structural engineer in charge achieves the desired outcome. This new *modus operandi* could shift paradigms in structural design, as the creative act will increasingly involve organising parameters—previously a product of individual creativity—now articulated by AI through existing project data instead as a product of the imagination of human intelligence, which will ultimately serve only to validate the results at the end of the interactive process.

The current reality of working alongside supercomputers powered by algorithms simulating human intelligence reveals that a paradigm shift has already occurred in numerous fields where digital technology is employed, often unnoticed. AI in the digital realm shares similarities with human intelligence in the biological world, particularly in data collection, processing, and decision-making. Aside from subjective reasoning, the primary difference between biological and digital intelligence, as Neil Leach classifies them [15], lies in the speed and capacity for data processing. Existing software and computers can aggregate, relate, and process immense amounts of accumulated knowledge at speeds far beyond human capability, making increasingly accurate decisions through self-learning processes. There is little doubt that AI could influence structural theory and countless design solutions, provided these are present and updated in stored databases. This reality demands a new posture regarding structural design and its validation from the structural engineering community.

At this point, it is essential to consider Hannah Arendt's reflections on the human condition [16]. She highlights the unsettling military and political circumstances often generated by technological advancements that initially amaze us. For Arendt, our relationship with technology reflects a desire to escape our human condition. In this sense, in its fascination with technology, human intelligence appears willing to yield to AI, wanting to embody the concept of a controllable second nature. But is this control genuinely possible?

5 CONCLUSIONS

By its very nature, engineering is an extension of humanity's attempt to control nature, where ingenuity—as the inventive faculty and productive force of the human mind—contends with reason and its demonstrative capacity. In structural engineering specifically, this struggle is ongoing and further intensified by the challenge of proposing the best solution among many possible ones, all of which must be understood as historical productions within their specific contexts. Only by acknowledging this can History fulfil its role of encompassing both the past and the future as a regulatory agent of experience, as Reinhart Koselleck affirms—thus, we can learn from history. In this sense, revisiting Emílio Baumgart's design practice within the context of the social history of technology, using the figure of the craftsman and the practices developed in medieval workshops as a reference, is relevant. Baumgart is an emblematic figure whose work in Brazil is closely linked to the early application of reinforced concrete as a structural material, domestically and globally. His work exemplifies the ongoing struggle between ingenuity and reason, a characteristic dynamic of engineering itself, still very much present in our design practices today.

Humans have always used tools to assist with various aspects of daily life, to the point where tools have become extensions of the body. It is still too early to assess the implications of our relationship with AI to the extent that it might be considered an extension of our minds. It seems urgent to discuss this relationship regarding both digital and biological sides. Billington suggests that the art of structural engineering stems from human imagination, which can only function after a solid academic foundation and practical experience. For him, and indeed for all structural engineers who deal with conceptual design challenges in their everyday professional lives, structural engineering is not merely the application of science.This essay aims to emphasise that, be it in the most trivial tasks of our ordinary lives or in the practice of structural design, we are already engaging with AI—probably in an insufficiently conscious and critical manner. In the professional field of structural design, perhaps now is the moment to evaluate each role in this dialogue between the biological and the artificial to maintain human control over the conception process. This will demand increasingly solid, consistent and profound education from our academic system to sustain balance in this dialogue and ensure that we, as structural engineers, retain control over decision-making so that we can continue to operate in our workshops as masters, engaging with our apprentices, using AI as an extension—not a replacement—of our minds. The role of the craftsman should not be delegated to AI.

Additionally, this essay proposes an imaginative exercise by envisioning a symposium like this in the not-so-distant future. In our field of expertise, what—or instead, who—will we be discussing? Will we be reflecting on the lessons left by structural engineers and their creative, elegant, and technically innovative proposals for the challenges of their time, or will we be discussing the works of people like Bill Gates, Elon Musk, Mark Zuckerberg, Sam Altman, and other AI controllers? Our chosen path to engage with AI today will likely provide the answers.

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