

TQS NEWS

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Editorial

Eng. Abram Belk

In the last year and a half, we have seen civil construction grow by more than 4%, compared to an average of around 3% in the Brazilian economy. The growth has been accompanied by more than 200,000 new jobs and the spectacular increase in new construction, sales and property values, which we are witnessing *in loco* here at our headquarters in São Paulo, in the Pinheiros neighborhood. Many of these constructions are very tall, slender and bold, requiring the maximum of engineering design techniques for development. This makes us proud for several reasons. On our side, we are continuously developing, to keep up with the necessary technical improvement for these projects. And structural engineers with TQS are designing most of the most important undertakings. We are about to complete 40 years of foundation and in this period, we have already witnessed all kinds of difficulties to work and undertake in Brazil. And if, despite all the adversities, it has been possible for us and structural engineers to reach this point of development, it is because we have followed the right path of work, research and determination. To all who are and have been with us, my sincere congratulations and thank you very much!

How do we react to the emergence of new technologies over the years? As human beings, we start by distrusting (and sometimes rejecting) everything that is new, and then gradually adapt and sometimes totally change the way we work to use something that is better. This initially happened when we developed the TQS systems, automating and integrating the analysis, design, detailing and drawing in reinforced concrete. This happened with CAD systems from the 1990s onwards, which eliminated the traditional drawing boards and the designers who were true craftsmen. And with BIM, which allowed the integration of the

project model among all the projects in the construction chain, from cradle to demolition, and has become practically mandatory. The scene repeats itself with a technology that has recently matured: Artificial Intelligence (AI). To understand what it can do, let's look at the example of the biotechnology area. In this area, knowledge of the three-dimensional structure of proteins is very important for creating drugs or vaccines that fit into viruses and deactivate them, treating genetic diseases, or creating enzymes for industrial or environmental purposes. Using AI, Google's AlphaFold unveiled about 200 million proteins in one year, a thousand times more than science had accumulated in half a century. To do this, IA was trained with accumulated knowledge. Is there an equivalent in structural engineering? At least here, our young development team is actively studying the subject. We have already deployed ChatGPT within the TQSDocs search engine, our knowledge base. We are studying the application of AI in the pre-dimensioning of structural elements and in the design of structural elements. And we develop interfaces in Python, to work with structural drawings and models. These interfaces, which allow engineers to automate and personalize their model and deliverables, are also a gateway for AI to work alongside the project. We are already testing AI-generated Python programs for this purpose.

Although AI today is a revolution, it needs to be looked at carefully. The answers, which have a statistical behavior, need to be evaluated and reviewed according to the deterministic concepts of the norms. Over time, we will have one more project tool, but it will always need the hand of the engineer.

The V26 version is in the oven with a huge number of new features, shown in our development section. It will certainly be one of the most productive versions in recent years. We continue our evolution to automate repetitive tasks, collaborate seamlessly with other disciplines, and generate safer constructions, sustainable and cost-effective.

It will be a pleasure to meet you at upcoming engineering events and discuss them. We will be at the Concrete Show in August, and at ENECE and IBRACON in October. As we have commented on other occasions, it is a great opportunity to take a few days off, meet friends and see live the state of the art of engineering.

I hope you enjoy reading this newspaper. In this issue, we present an interview with RKS Structural Engineering, where father and son combine experience and technology to face the challenges of structural engineering, as well as four unpublished and unmissable articles. See you soon!

Highlights

Interview: Engs. João Alberto Kerber and João Lucas Vasconcelos Kerber, *by Mariuza Rodrigues*
Page 3

Development
Page 11

Article: Incremental analysis in columns of reinforced concrete buildings
Eng. Carlos Estevão Lúcio de Paiva
Page 30

Article: Where is engineering education going in Brazil?
Eng. Enson Portela
Page 40

Article: Shear effort, we still need to talk more about it Eng. Henrique César C. Gimenes Page 47

Article: Modal analysis and soil-structure interaction of tall buildings: conceptual and practical dilemmas
Eng. Sérgio Stolovas
Page 49

Virtual space
Page 54

News
Page 60

Dissertations and theses
Page 71

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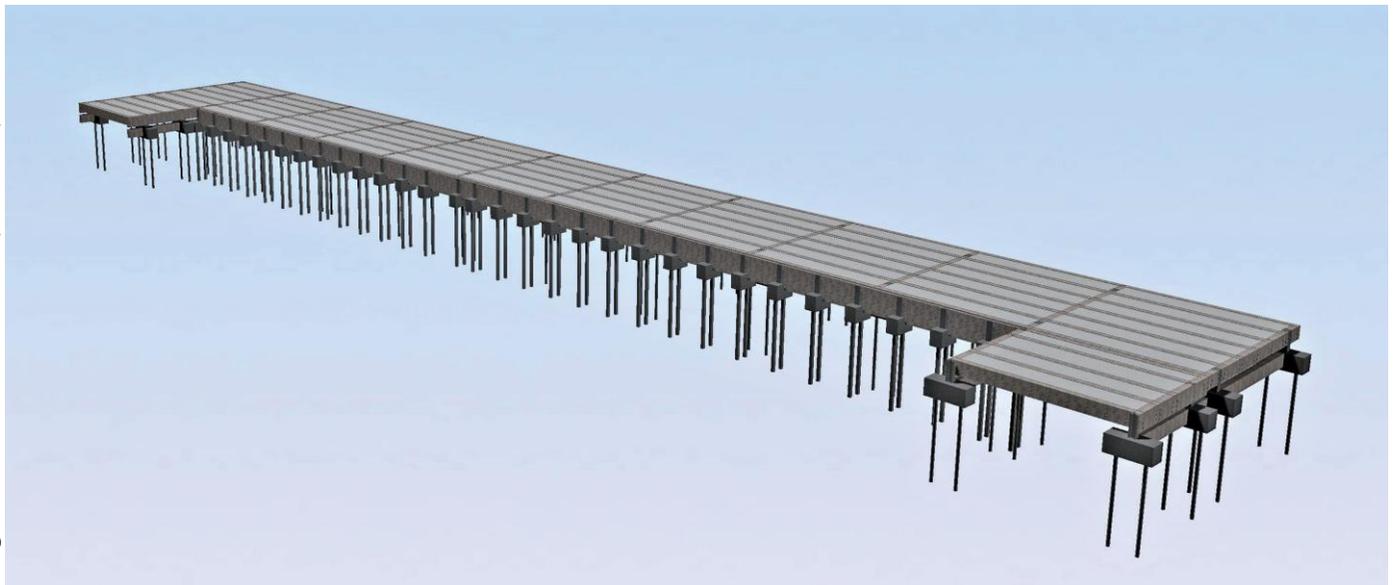
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Vocation Square

Father and son combine experience and technology to face the challenges of structural engineering

Interview with engineers João Alberto Kerber and João Lucas Vasconcelos Kerber
By Mariuza Rodrigues

It all started with the natural vocation of engineer João Alberto Kerber for the universe of mathematics and exact sciences. The option for engineering and later for the field of structures was also a logical path and favored by the series of information and experiences that Kerber recorded in his curriculum, still in the internship phase, especially in construction works. Infrastructure in the South of the country. From there came the passion for projects.

Sometime later, his son João Lucas Vasconcelos Kerber almost deviated into the legal area, his grandfather's dream. But his father's inspiration spoke louder. And engineering won. And even stronger, the vocation for structural calculation engineering.

Could you tell us about your decision to become an engineer? What was your inspiration?

João Lucas Vasconcelos Kerber: Since I was a child, I was inspired by members of my family to follow this profession. Initially, inspired by my paternal grandfather, I became interested in a legal career — I even dreamed of being a prosecutor.

As time went by, I realized that what really enchanted me was problem solving through logic and rationality, which naturally brought me closer to the exact sciences and, consequently, to the professional trajectory of my father João Alberto Kerber.

In the first semesters of the undergraduate course in Civil



Engs. João Lucas Vasconcelos Kerber and João Alberto Kerber

A perfect binomial of action was also formed, which includes João Alberto Kerber's extensive expertise in the market (more than 30 years) and his son João Lucas' technological thirst for both engineering and technology – which are inseparable today.

Engineering, I developed a special affinity for the disciplines related to structural analysis and technical drawing, which led me to start an internship at RKS Structural Engineering, an office founded by my father in the company of other colleagues.

Structural Engineering is the backbone that makes architecture possible and, consequently, makes the final product of the real estate market viable.

Today, I have many sources of inspiration, especially my partners, from whom I continually learn, a true source of almost inexhaustible knowledge.

With so many works of infrastructure in the portfolio, Kerber (father) evaluates that in the political field there is still no response to climate demands, especially in Rio Grande do Sul, and warns that other tragedies are still likely to occur.

On the other hand, João Lucas (son) highlights the great possibilities that will be generated by the integration of artificial intelligence with structural engineering. However, he warns that despite what it seems, there are no miracles. "Although technology accelerates processes, the solid theoretical knowledge and critical sense of the engineer remain irreplaceable to ensure safety, quality and innovation in each project".

Follow the following interview with father and son for TQS News.

In addition, I come from a family of teachers, and this heritage is reflected in my day-to-day professional, in the didactic tone with which I try to conduct the relationship with our clients and employees.

João Alberto Kerber: In my case, I believe it was the natural inclusion of mathematics and physics.

What college did you attend and in what year? And how did they start their professional life?

João Lucas: I started my undergraduate degree at the University of Vale do Itajaí and completed the course at the University of Southern Santa Catarina in 2015, in Florianópolis.

My professional career began during graduation, with an internship at RKS Structural Engineering — a company where I continue to work today. As soon as I finished college, I started working as an engineer in the company and, subsequently, I started my postgraduate degree in Structural Engineering, deepening my knowledge in the area.

João Alberto: I attended the Engineering School of the Federal University of Rio Grande do Sul between 1977 and 1981. I did several internships during college. When I finished the course and graduated, I started working on infrastructure construction sites such as pontoons, heavy prefabricated, airports, roads, hydraulic works.

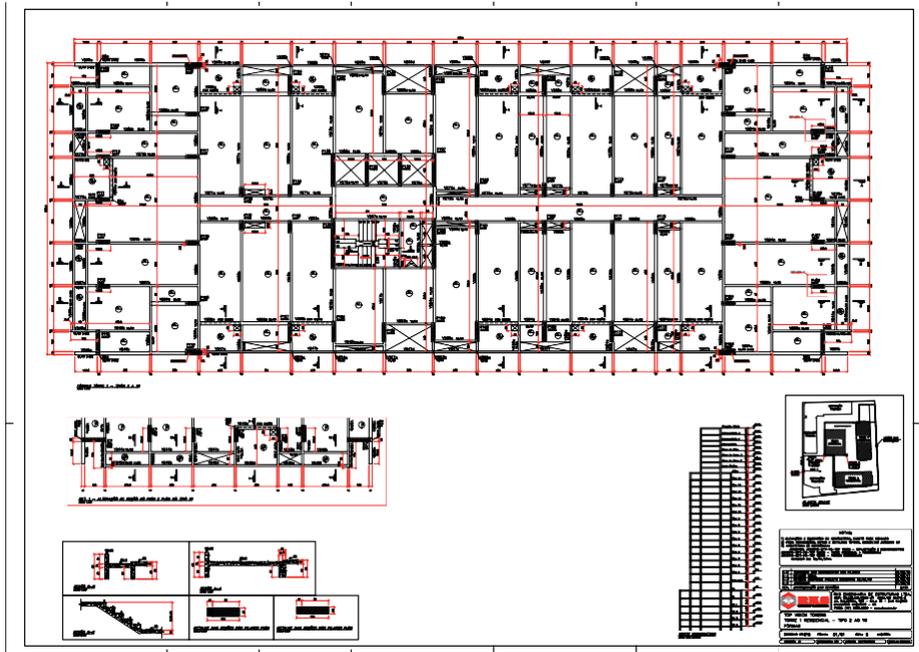
We see today that there is a redirection in the direction of railways, which should greatly increase investments for this modality

Where did you do your internship and how was this period important to consolidate your decision?

João Lucas: I did my internship at RKS Structural Engineering from the second year of college. During the holidays, I also took the opportunity to work on construction sites to understand in practice how a conventional concrete structure is built – its shapes, the assembly of the reinforcements, the concreting process and all the technical challenges that often go unnoticed in the preparation of a structural project.

These experiences were fundamental to aligning my academic expectations with the reality of the profession. I am fully convinced that, thanks to this experience, I made the right choice for my career.

João Alberto: I did an internship in the topography section of the



Forms Torre 1 - tipos 2 a 15

DemHab in Porto Alegre. I designed for several offices and did an internship at the Construction Materials Laboratory of Cientec until, finally, I worked on the works of the metropolitan train in Porto Alegre. The set of experiences only consolidated my choice.

And how did you choose Structural Engineering? What inspired you to follow this line?

João Lucas: Structural Engineering is the backbone that makes architecture possible and, consequently, makes the final product of the real estate market viable. The awareness of this responsibility and the relevance of the area was, from the beginning, what attracted me. And it is this same importance that motivates me daily to remain in this field, with enthusiasm and a sense of purpose.

João Alberto: After a few years at Jatocret, I decided to continue my career by dedicating myself to the design of structures, which has been going on for 33 years so far. In this sector, my first performance was actually my first experience in construction execution. It was a bridge over the Dilúvio stream, in Porto Alegre – a small hidden bridge with prefabricated beams supported by curtains.

Later, with projects by the Jatocret team), I worked on the execution of several interventions to reinforce, recover and change the class of bridges on BR 101 and 470 in Santa Catarina.



3D model

In this phase, the erection of the deck, at 1.785 m of a bridge over the Itajaí Mirim River in Brusque (SC) stands out.

Through RKS we have designed some extensions and reinforcements with class change in bridges on BR 470, bridge in dam spillway in São Paulo, bridge in the Metropolitan Region of Florianópolis, viaduct at the airport in Brasília, some bridges in Paraguay.

At this moment, it is very important that we take care of readapting the insertion of our cities and infrastructure in general to the environment degraded by the misuse and contempt we dedicate to environmental aspects.

And how did RKS come about?

João Alberto: It was a natural path when I finished university. RKS Structural Engineering was founded in October 1994 and completed exactly 30 years of operation in the market last year. During this period, we consolidated our expertise and strong performance in the real estate market, civil construction and water and sewage service companies. We have worked on several international projects in countries such as Venice, Paraguay, Angola, in partnership with other Brazilian companies and we have already had the opportunity to serve foreign clients with projects in Brazil. RKS's headquarters are located in the city of Florianópolis and its branch is in Balneário Camboriú, Santa Catarina. We also have a representative in Montevideo, Uruguay. And the company's trend is to grow with strong investment in technology and professional capability.

What was the infrastructure landscape at the time Compared to the current moment?

João Alberto: Those were other times, where the construction of

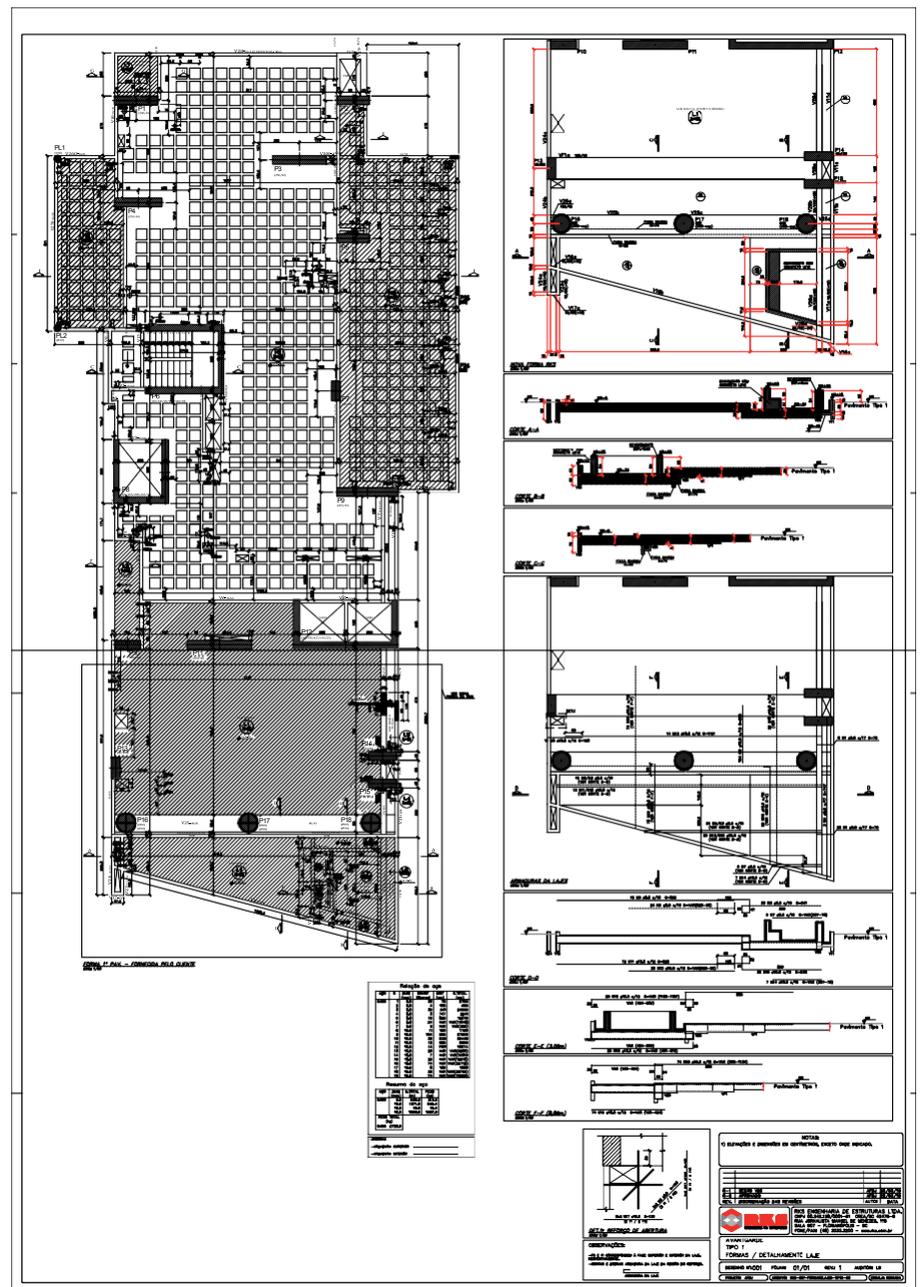
Road infrastructure was more intense, which required a lot of investment and works in this area. Today, in addition to other borders, we need to expand, maintain and improve what we already have. Today we see a redirection in the direction of railroads, which should greatly increase investments for this modality.

What are the requirements for a professional to work in this field in your opinion?

João Alberto: Brazil has always had a technical staff that is up to its needs.

The eventual lag we see today is because other economies have promoted huge investments in this area and, therefore, have made great strides in the design and execution of large crossings in challenging locations. But there is nothing that the country cannot recover quickly.

Brazil has a great demand for bridge construction. This mandate needs to be met preferably by local capacities, encouraging companies and local resources, forming and renewing an entire culture of national construction



Forms - Slab Detailing

and development.

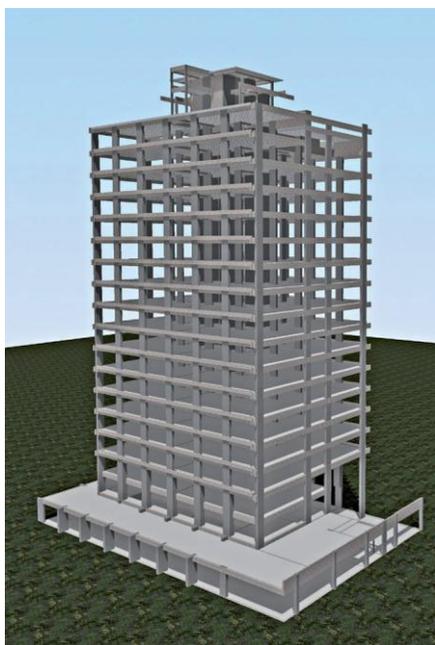
Is there a more appropriate typology due to the climate, topography and characteristics of our country?

João Alberto: Brazil is very large and diversified in its geography, geology, hydrology, and climate. This implies that we adopt the most appropriate solutions to each situation.

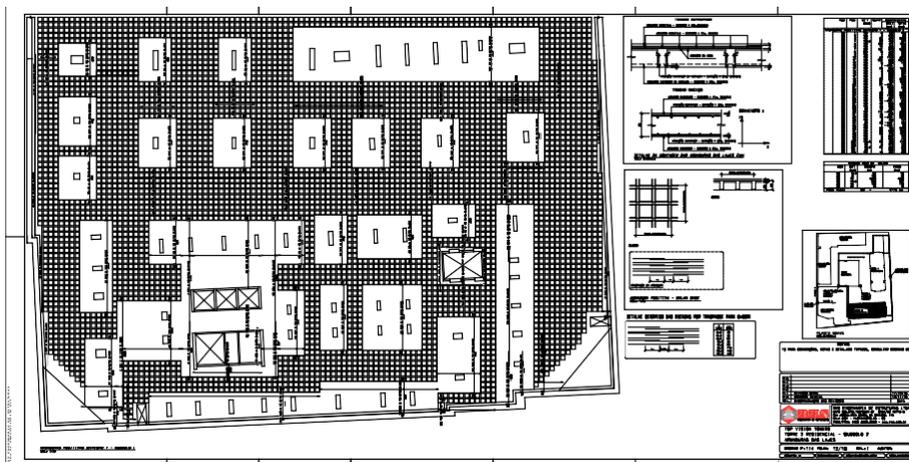
Despite the advanced features of calculation and design software — such as TQS — they are not a substitute for the critical eye and experience of a structural engineer.

The states of Santa Catarina and Rio Grande do Sul have recently suffered from several weather disasters that have affected local infrastructure. You have been working on projects to recompose this urban infrastructure?

João Alberto: We are very focused on improving the construction systems of the housing sector. In this moment, it is very important that we take care



Modelo 3D



Torre 2 - subsolo - Slab reinforcement

to readopt the insertion of our cities, industry, agribusiness and infrastructure in general to the environment degraded by the misuse and contempt we dedicate to environmental aspects.

How the great flood that occurred in Porto Alegre last year should change the perception of investments in this environmental area and infrastructure in the region?

João Alberto: Unfortunately, there is no political will to address technically, in depth, the actions in this area. I fear that we are headed for another, even greater future tragedy.

After the strong disinvestment in recent years, there are professionals prepared in the area of projects to meet an increase in demand in the field of infrastructure?

João Alberto: The time gap that has elapsed since before these "last years" was not enough to remove from the market all the technical staff with experience to at least guide those who arrived since then.

How can the structural engineering market be evaluated today for new professionals?

João Lucas: O mercado de engenharia de estruturas está bastante aquecido e oferece inúmeras oportunidades para quem está ingres-

sando. However, it is essential that these professionals do not venture out alone at the beginning of their careers. Despite the advanced features of calculation and design software, such as TQS, they are no substitute for the critical eye and experience of a structural engineer. Inexperience in designing structural solutions and interpreting results can lead to hard problems, performance failures, and even waste of materials and labor. Therefore, I strongly recommend that young engineers seek internships or mentorships in consolidated offices, where they fully understand the responsibilities involved and learn to reconcile theory, practice and security.

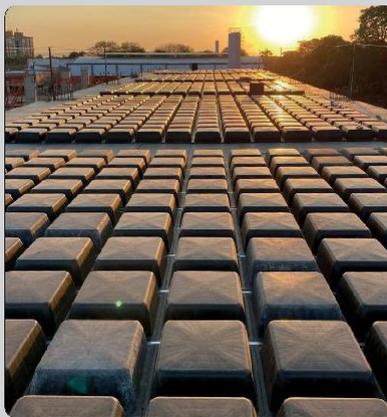
However, experience and critical insight remain essential: mastering a technology without understanding its fundamentals can limit its potential.

How are generational changes and the use of new technologies impacting structural engineering?

João Lucas: Technological transformations occur inexorably and those who use them best stand out in the market. Younger professionals, because they are not anchored in habits inherited throughout the career, absorb

NOVAS DIMENSÕES

TODO CÁLCULO ENCONTRA UMA SOLUÇÃO ATEX



Mais de 210 dimensões de fôrmas para lajes nervuradas

Fôrma Atex	Base Nerv.(cm)	Larg.(cm)	Altura (cm)																
			10	15	16	18	20	21	22,5	25	26	30	32,5	35	40	42,5	50		
600	6,0	60,0																	
600	8,0	60,0																	
610	7,0	61,0																	
610	12,5	61,0																	
650	5,0	65,0																	
660	7,0	66,0																	
680	12,0	68,0																	
700	12,0	70,0																	
740	16,0	74,0																	
800	12,5	80,0	*	*												*	*		
830	15,5	83,0	*	*												*	*		
875	20,0	87,5	*	*												*	*		
900	12,5	90,0																	
600U	12,5	60,0																	
610U	7,0	61,0																	
640U	10,0	64,0																	
655U	11,5	65,5																	
685U	14,5	68,6																	
755U	8,0	75,5	*	*												*	*		
800U	12,5	80,0	*	*												*	*		
830U	15,5	83,0	*	*												*	*		
875U	20,0	87,5	*	*												*	*		



Fôrmas Atex 610, Atex 800 com novas alturas.



Com as novas alturas, os projetistas de estruturas vão alcançar e proporcionar, em seus projetos, maior economia de concreto e aço em relação à laje maciça, desde pequenos a grandes vãos, veja demonstração nos exemplos:

Fôrma Atex	610	800	610	800	800
Eixo a eixo (cm)	61	80	61	80	80
h da fôrma (cm)	10	10	15	15	50
Capa (cm)	5	5	5	5	5
h equivalente de inércia (cm)	11,1	10,3	14,8	13,8	38,6
Concreto (m³/m²)	0,09	0,08	0,113	0,095	0,289
Economia de concreto	< 18%	< 22%	< 24%	< 31%	< 25%
Economia de aço	< 26%	< 31%	< 26%	< 31%	< 30%
	(1)	(2)	(3)	(4)	(5)

Ou seja,

- (1) Laje nervurada h = 15cm mais econômica que maciça de h = 11cm.
- (2) Laje nervurada h = 15cm mais econômica que maciça de h = 10cm.
- (3) Laje nervurada h = 20cm mais econômica que maciça de h = 15cm.
- (4) Laje nervurada h = 20cm mais econômica que maciça de h = 14cm.
- (5) Laje nervurada h = 55cm mais econômica que a maciça de h = 39cm.

Com a altura 50 cm da Fôrma Atex (eixo a eixo = 80 cm ou 83 cm ou 87,5 cm) poderão ser executadas lajes nervuradas para vãos na ordem de 18 m, sem protensão [vão = (50+10) x 30].

Com a protensão, pode-se alcançar cerca de 30 m de vão [vão = (50+10) x 50] tendo a base menor da nervura 12,5 cm, 15,5 cm e 20 cm, respectivamente.



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and apply innovative tools with greater agility and willingness to shake obsolete methods. However, experience and critical insight remain essential: mastering a technology without understanding its fundamentals can limit its potential. Today, tools such as BIM and stinking three-dimensional modeling software make it possible to anticipate conflicts between disciplines, generate rigorous quantitative, and avoid on-site rework—which increases productivity, but also requires more specialized design teams and more rigorous validation processes.

Does the extension and access to new technologies facilitate the entry of young people into the structural area?

João Lucas: Undoubtedly. Digitally native professionals reject repetitive and manual tasks, so common in the work of the structural calculator. The automations and scripting routines delivered by modern software make everyday life more dynamic and attractive, encouraging newcomers to become deeply involved with the design process. In this way, the entry barrier is reduced, as mechanical activities give way to analytical and creative challenges.

In addition to technical challenges, managing deadlines, budgets, and human resources issues in project offices is also always a balancing act

Which technologies are already well established in structural engineering, and which still have great growth potential?

João Lucas: Currently, remote communication through collaborative platforms and the structural analysis software itself have reached a high degree of maturity.



3D model

It is now possible to create computer models that faithfully simulate behaviors that are very close to real ones, both in the construction phase and already in service throughout the useful life, in addition to extracting quantities from materials with a much higher prevalence than in the past.

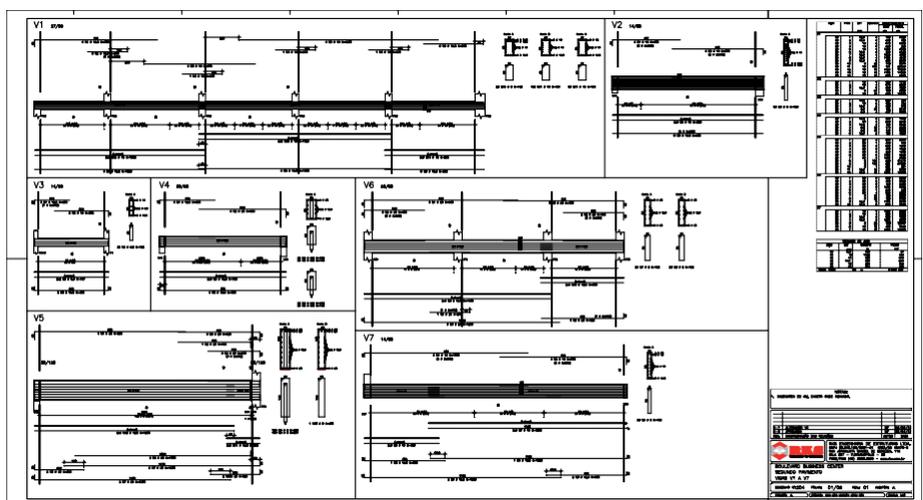
However, there is still ample room for improvement in areas such as Common Data Insights (CDE), which promote integrated information management, and in the application of artificial intelligence for geometry optimization, automated design, and verification of standards. In addition, the continuous increase in processing power opens the way for large-scale simulations and even deeper integration between design, execution and maintenance.

What requirements do you consider fundamental for a Professional who wants to work today in Structural Engineering?

João Lucas: In addition to mastering the tools of design, modeling, and calculation, CAD, BIM, TQS, and the like, I consider that solid knowledge of the strength of materials, the theory of structures, and the different materials of civil construction (concrete, steel, wood, masonry) is essential. These foundations allow us to correctly interpret computational results and to propose safe and economical solutions. On the behavioral level, soft skills stand out: clear and objective communication, teamwork, flexibility to deal with changes in scope, and critical thinking to identify risks and solve problems proactively.

Which projects most marked your trajectory and why?

João Lucas: One of them that stands out is the Quatá Residential Building, in Vila Olímpia, in São Paulo. I worked as a prototype engineer in what can be considered the tallest concrete wall building in Brazil. We use the fundamentals of rational concreteness — reinforced walls with centered screen and optimized details — generating structural efficiency and gain in construction deadlines.



Second floor - beams V1 a V7

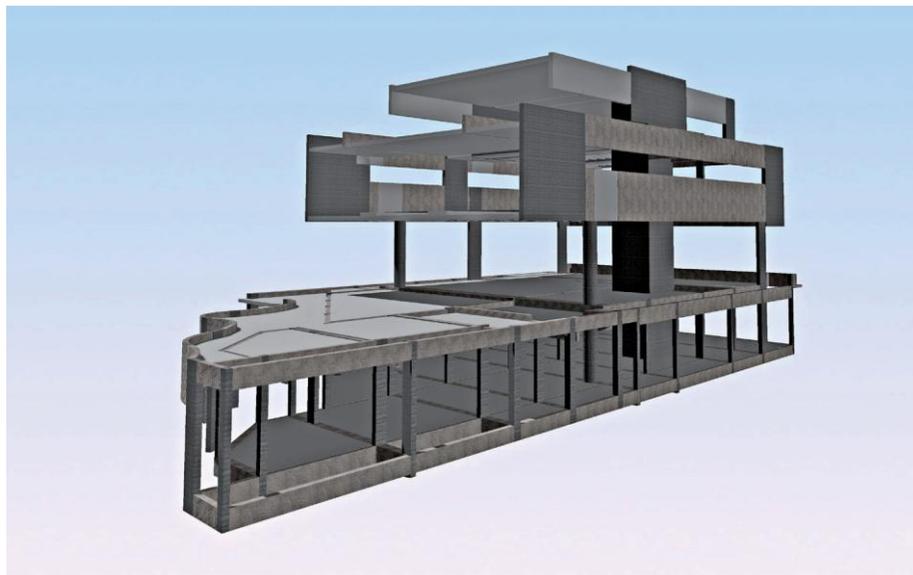
I also highlight the "Casa Wireless" Residency, in Jurerê Internacional, Santa Catarina. This project was characterized by 1,800 m² with huge free spans and a minimum number of columns, nicknamed *wireless* by the architect. As a support engineer, I was able to apply innovative pre-sizing concepts right after graduation.

I also mention the Arena Corinthians stadium, where I worked, still as an intern, participating in the structural design of the stadium that opened the 2014 World Cup. The magnitude and complexity of the undertaking were decisive in consolidating my passion for working on large works.

What were the biggest difficulties you faced in the profession.

João Lucas: One of the recent challenges involved overcoming spans of 8 to 11 meters without the use of beams with a height of more than 50 cm and without prestressing. In a small multifamily building in Florianópolis, the distribution of parking spaces in the basement did not coincide with the columns of the upper floors, requiring transition beams that, however, could not exceed 50 cm in height. The solution was to move these beams to the roof slab and replace part of the columns

3D Model



3D Model

by ties, reducing the effective gaps and preserving all parking spaces. In addition to the technical challenges, managing deadlines, budgets and human resources issues in project offices is also always an exercise in balance and negotiation.

How did the exchange of experiences with your father influence your trajectory? What is the importance of integration between generations?

João Lucas: The mentorship I receive from my father is an invaluable privilege. His background in the area provides shortcuts, systemic vision and technical repertoire. On the other hand, I contribute with a perspective focused on new technologies and market trends. This intergenerational integration is a catalyst for growth: the more experienced share wisdom, while the younger ones accelerate the adoption of innovative tools and the rethinking of traditional processes.

Does technology solve everything? What risks do you identify in this belief?

João Lucas: Definitely not. The belief that a calculation tool is enough to ensure structural safety underestimates the engineer and his critical role. This false appeal leads some professionals to disregard the

verification of the assumptions, analysis of construction details and compliance with standards. The result can be the emergence of pathologies in the building, delays in construction and, in extreme cases, risks to the integrity of people and property.

I see enormous potential for algorithms to optimize material quantities, predict design inconsistencies, and suggest innovative solutions in complex structures.

How to create a "safety cushion" that contemplates the use of technology and experience?

João Lucas: It is the joint role of the academic community, class entities (Abece, Crea) and the offices themselves to promote the culture of constant updating. At RKS, we participate in academic weeks, supervise course completion papers (TCCs) and graduate assignments, teach master classes and lectures. These initiatives keep engineers close to research and reinforce the importance of combining theoretical knowledge with good design practices and work experience.

What paths do you see, for example, with the use of AI in the sector? Is this already being studied in academies? How should firms and professionals prepare for this new moment?

João Lucas: Artificial intelligence (AI) is about to reach an impressive level of productivity. In a short time, projects that today require years can be completed in months, and projects of months, in weeks. We have already launched, in June,

our built-in knowledge management AI, which facilitates access to training, quality manuals, and best practices. We are investing in other AIs to migrate project management to these.

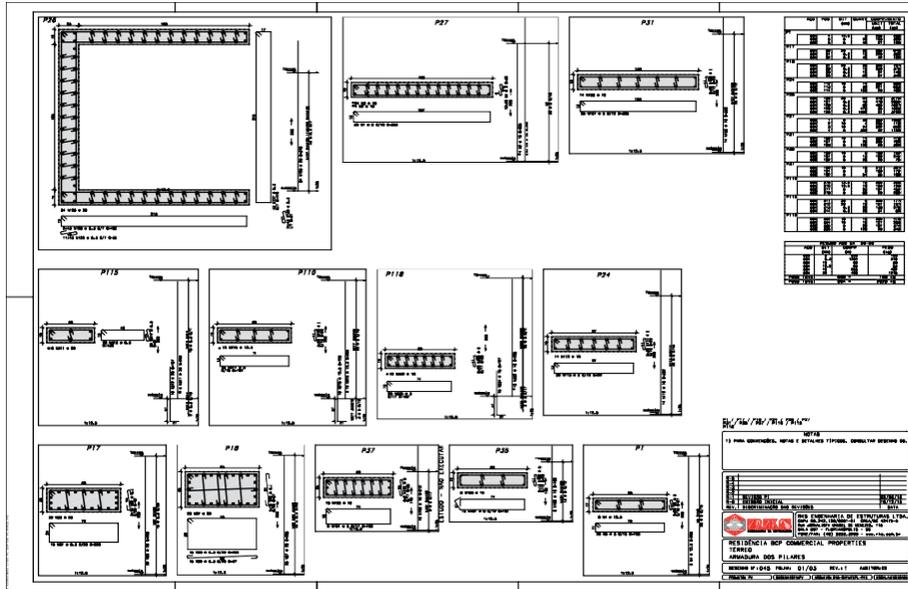
In academy we have not seen many research projects in this regard, however, we support and encourage one of our engineers to start a master's degree to develop artificial intelligence (AI) aimed at designing structures in the economic sector at the beginning of this year.

I see enormous potential for algorithms to optimize material quantities, predict design inconsistencies, and suggest innovative solutions in complex structures. To prepare, firms should invest in team training, data integration into robust platforms, and partnerships with universities that research AI applied to engineering.

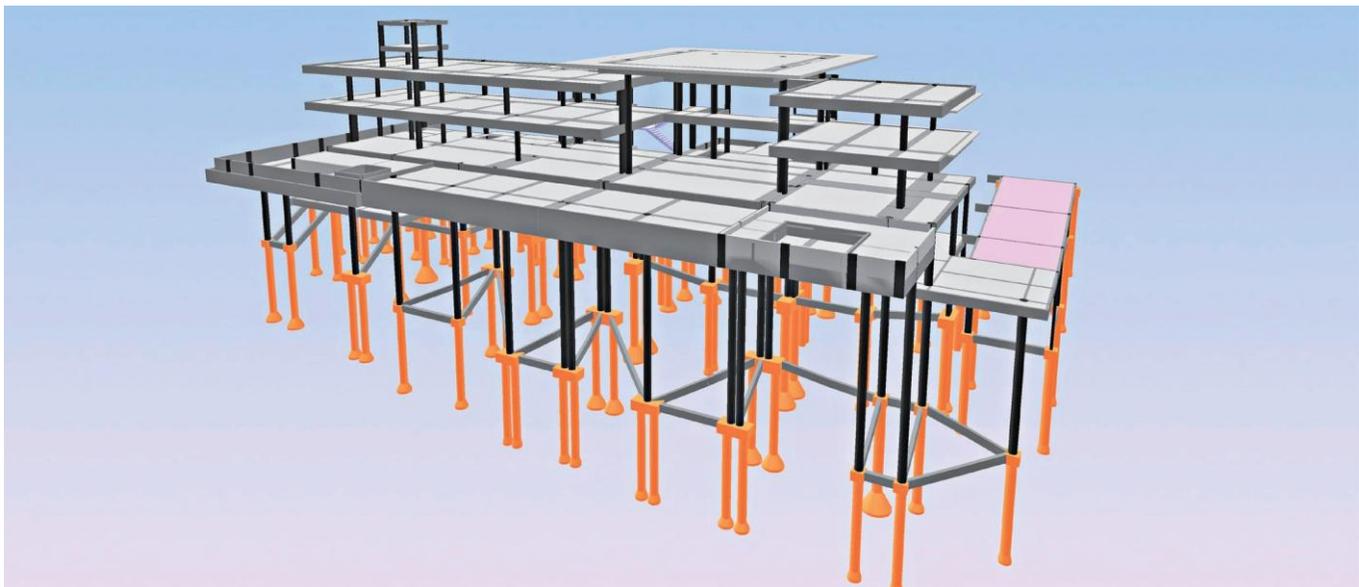
Although revolutionary, artificial intelligence (AI) still makes mistakes and requires careful oversight.

What suggestions would you give to those who are starting out, in the face of this new technological scenario?

João Lucas: Although revolutionary, artificial intelligence (AI) still makes mistakes and requires careful oversight. It is crucial to follow and master these tools, but never to give up the classical base: delve into Timoshenko, Montoya, Leonhardt, Fusco and other fundamental authors. Although technology accelerates processes, the solid theoretical knowledge and critical sense of the engineer remain irreplaceable to ensure safety, quality and innovation in each project.



Térreo - Column reinforcement



We continued our maintenance work, where the V25 continued to receive adjustments and improvements.

We've also changed versions V22, V23, and V24 to work around the keyboard and mouse issues introduced by Windows 11 24H2 KB5058499 in graphics editors.

Our young development team is taking the V26 full steam ahead. We are meeting new code requirements, such as load weights, anchoring,

puncture, in addition to items from ACI-318 and CIRSOC-201, and refinement of analysis and modeling, to meet building projects with more than 200 m in height in progress. And much more: productivity improvements in all reinforced concrete, precast, masonry and wall systems. And to top it off, more programming in Python...

V26 version

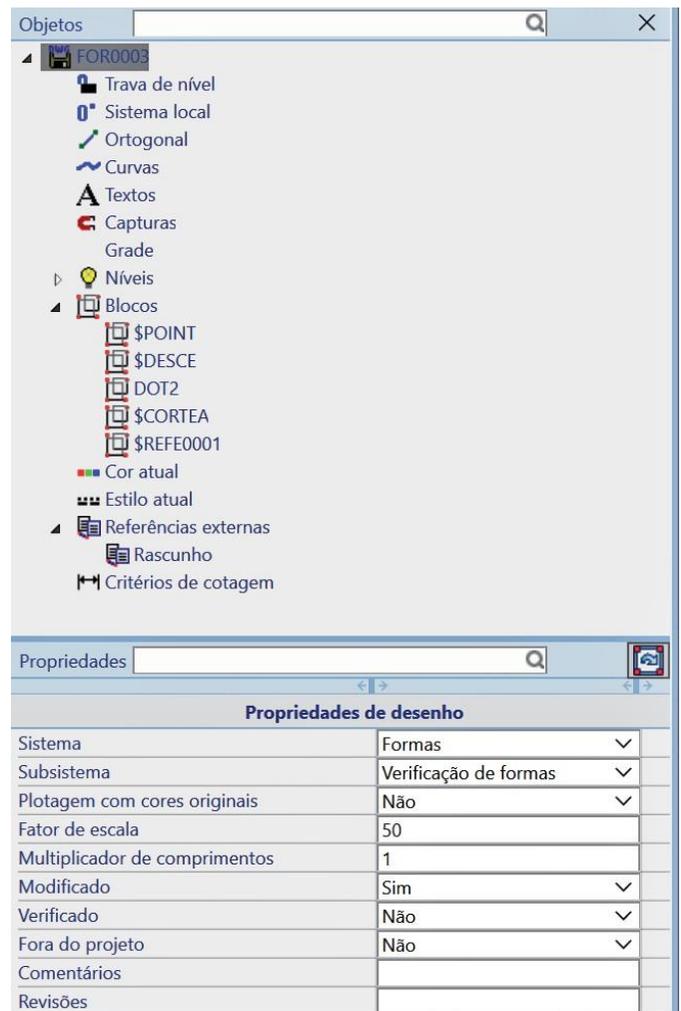
Graphic Editors

Dynamic preselection: Dynamic element lighting features have been created during preselection. In all editors, objects subject to selection are lit both in mouse movement and in the provision of the 2nd point of the selection windows:

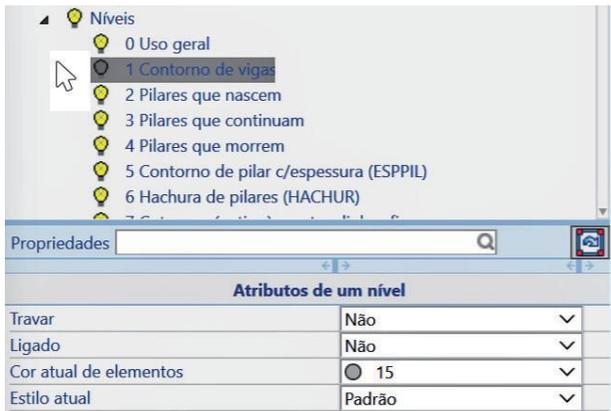


The commands started to show the possible obstacles during execution, facilitating the learning of new ways of working.

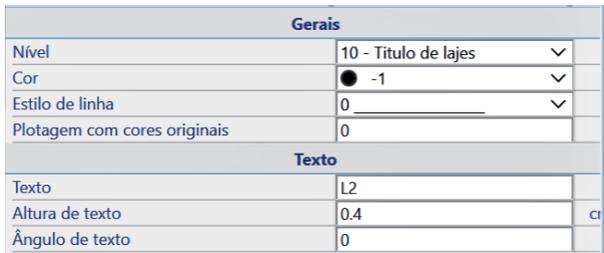
Property windows already existed in some editors, such as modeler and quick edit of beam frames. They are now available in all drawing editors. The windows are divided into two parts: a tree with global criteria, and a property area. The properties that can be edited refer to the selected object in the tree or drawing.



The level lock, level on, local system, orthogonal, slow curve, slow text, coordinate capture, and grid can be reversed by directly clicking on the corresponding tree icon:

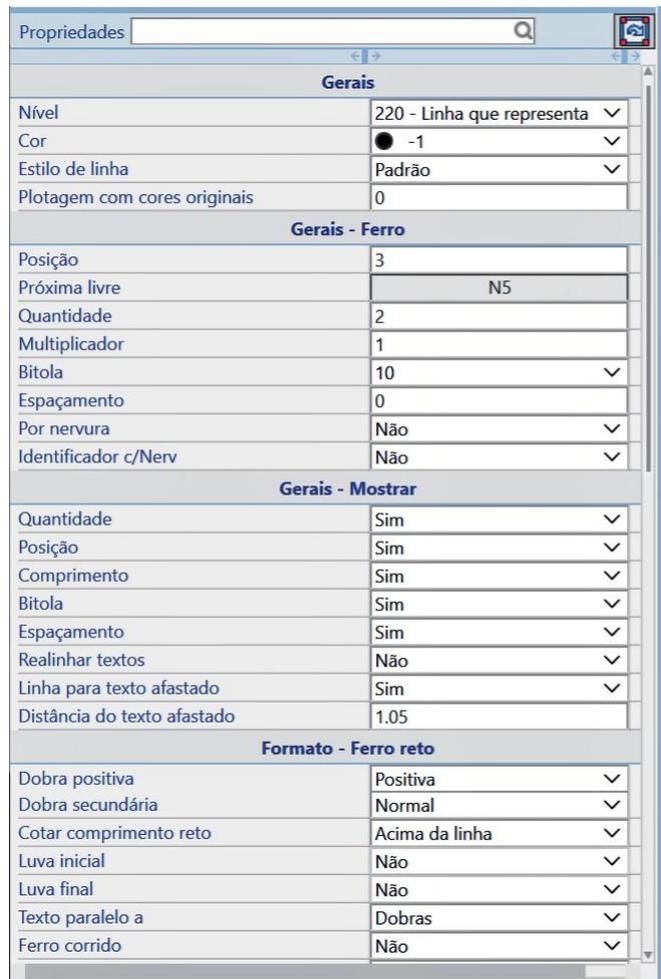


The properties panel is a handy way to make small changes to elements without calling conventional dialog windows:



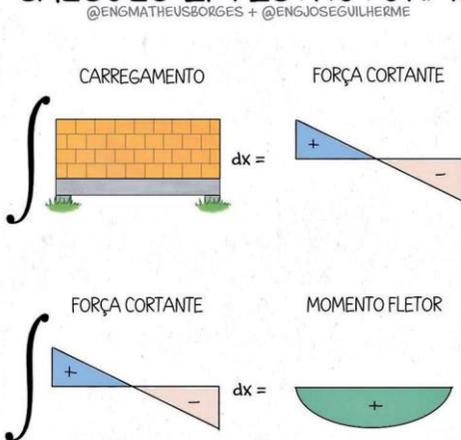
Changes can also be made with multi-selection. We can directly mess with external references and insert blocks, controlling the insertion method. In the tree, we lock levels, we rotate de coordinate

system and we control other resources. Smart objects such as dimensions and irons can also be changed from the panel:



Eng. Matheus Borges

APLICAÇÃO DO CÁLCULO EM ESTRUTURAS



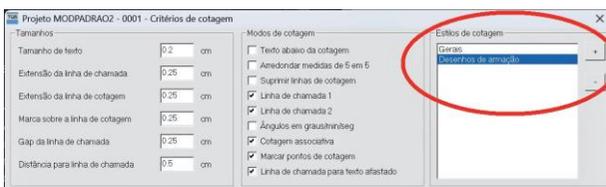
The properties panel is now used to show command modifiers. This makes it easier to understand how modifiers work. For example, when inserting a traverse, the command can be changed by the F/R/X/P/D/C/L/U/W keys, now shown in the panel:



It's easier to understand, and modifiers can be triggered directly from the dashboard. Modifiers began to appear in the commands for selecting elements, inserting blocks, partially erasing, moving, copying, rotating, entering polygons, interfering with texts, continuing to dimension, extending, cleaning intersections, creating amoebas.

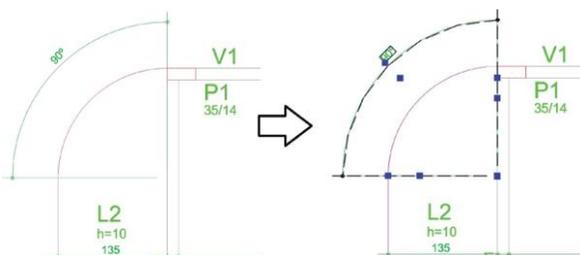
At the entrance of the 2nd point of lines, the variables with rectangular and polar displacement are opened, which can be filled in during insertion. When inserting multi-point elements, you can change properties such as level, color, and style from the panel when creating an element.

Dimensions allow for different styles named and stored in the project. For example, one style for dimensioning, another for frame drawings:



The system maintains a "current style", which can be modified as needed. The user-defined dimension text change has been centered on this tool. The listing criteria are editable in the property box. This feature has been carried over to V25 as well.

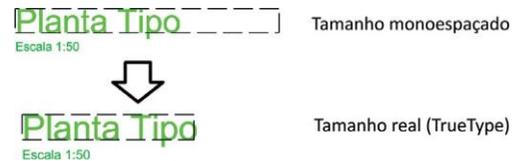
Angular dimensions are now associative and easily edited by grips:



Currently TQS allows you to view the drawings with the final plot texts, which can be Windows TrueType:



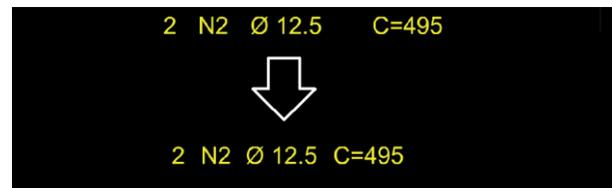
But the texts were treated as if they were from a monospaced TQS font. From now on, full-size texts are considered. This applies to all graphic, chart, and plot editors, including PDFs:



In addition to the greater ease of text manipulation, the immediate implication is the improvement of drawing quality in the use of Windows fonts, as in the alignment of all tables generated in drawing by TQS, including the reinforcement table:

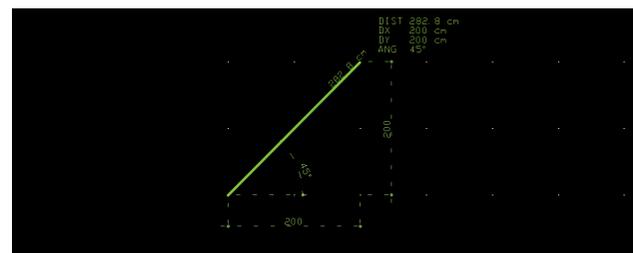
COMPRIMENTO		COMPRIMENTO	
UNIT	TOTAL	UNIT	TOTAL
cm	cm	cm	cm
590	1770 ¹	590	1770 ¹
495	990 ¹	495	990 ¹
455	455 ¹	455	455 ¹
363	5808 ¹	363	5808 ¹
427	6832 ¹	427	6832 ¹

and in programs that easily draw separate texts for editing:



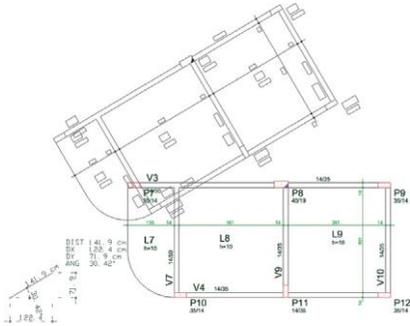
The framing of notes and multitrtexts was also affected. The location of text within the editor has been improved, with more points accepted within the text's surrounding rectangle.

The default value for the visual aid text height of the elastic line has been changed from 8 to 12 pixels (larger and more visible on large monitors). The standard color also changed from 86 to 84 (lighter on a black background).

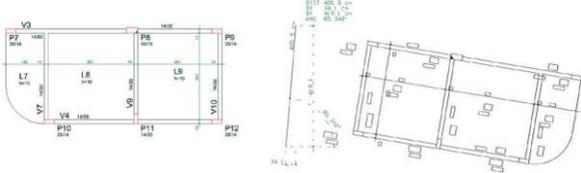


Graphics editors in 3D mode now interpret bold and italic fonts.

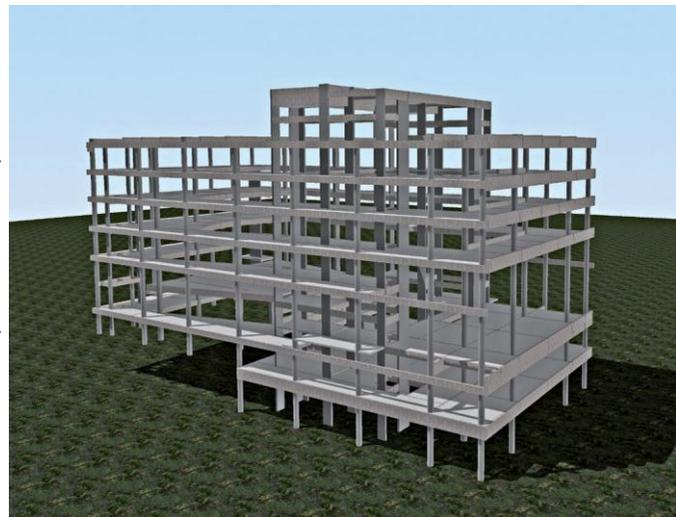
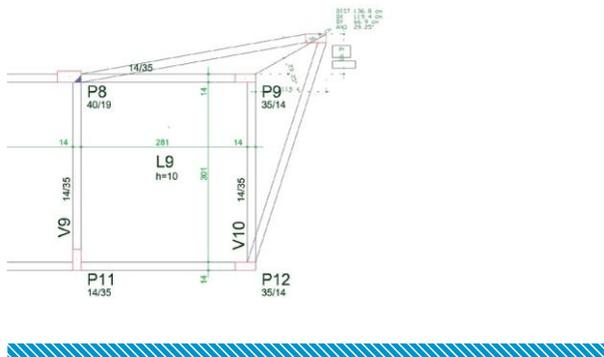
The rotation command now has a new input order. The angle is now provided last, dynamically dragging the selected objects around the rotation point. The <R> grinder allows you to define an angle reference line.



The mirror command has dynamic dragging of objects relative to the mirror line being defined:



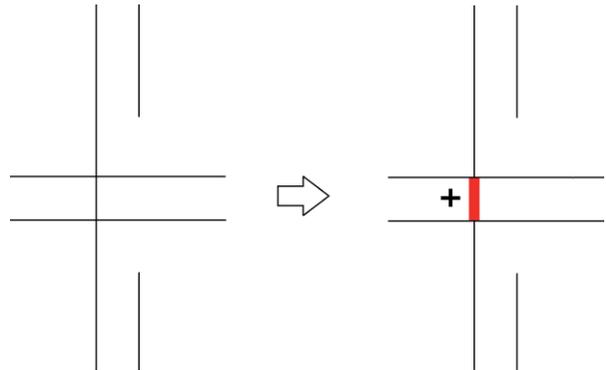
The same applies to partial moving:



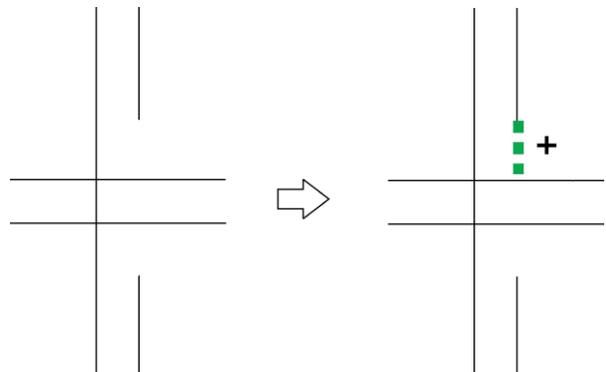
BEDE Consultoria, Belo Horizonte,

And in addition to this, several constructions for the creation of arcs, circles and regular polygons and operations with parallels gained dynamic drag during insertion.

The intersection cleaning and line extension controls were restructured and started to work in a complementary way. For example, when triggering intersection cleanup at the intersection below, we can select all elements of the drawing as "cut" through global selection <G>. Any candidate line to be cut then appears in red:



The controller repeatedly asks for the selection of lines to be cut. But at the same time, if we press and hold <Shift>, the command will instead extend selected lines:

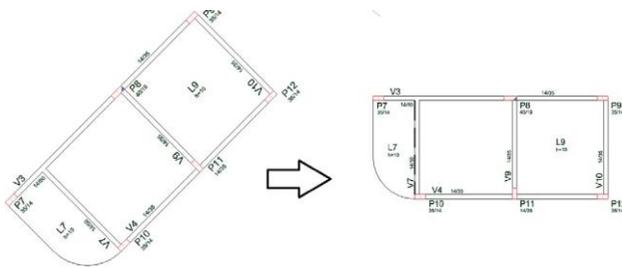


The lines to be extended appear in green. The extend command behaves similarly: when you press <Shift>, the command changes to clear intersections. These commands started to work with arcs and circles. In addition, they explode blocks and smart objects if necessary and allow *undo* from the last entry.

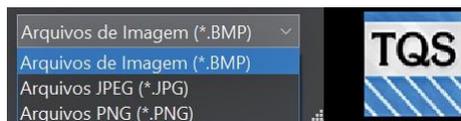
Working in plan with most lines outside the orthogonal global axes has become easier, with the possibility of rotating the local system.



For example, if you have a 45° shape plan part, define a local system of -45°, and work it as if it were orthogonal to the global axes:



The system adjusts the angle of the rotated orthogonal at the same time, so that the direction of the elastic line coincides with that of the structure in the new system. The new shortcut for this command is <Shift><F11>.

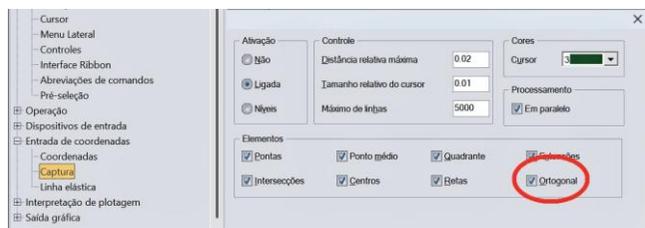


The graphic editor was adapted for reading PNG image files, which are common today.

Now, we have two formats for inserting images into the drawing: reference images (as it is today) and embedded images. Embedded images are a new graphical object, contained in DWG.

What's the difference between using reference or inline images? Images by reference are a type of block insertion with the name of the image file. This file must be distributed along with the drawing, keeping the original folder. If you forget to send the file, the recipient will not be able to see the image. The embedded image, on the other hand, goes inside and takes up space in the drawing. But there is no danger of it being distributed. Inline images are a new type of graphic object in the editor, which can be transformed like other graphic objects.

We created another type of *swap* for capturing coordination: the *orthogonal snap* :



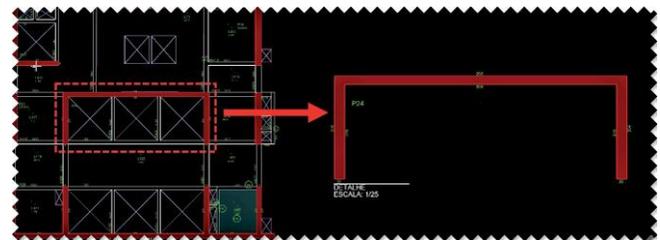
When you run commands with elastic line as the 2nd point of a line, the cursor captures important points such as point on the line, midpoint, and trembling. The orthogonal appears when the elastic line is orthogonal to a line under the cursor. The symbol showing this situation resembles an upside-down "T".

Viewport

You can now insert *viewports* into DWG drawings.

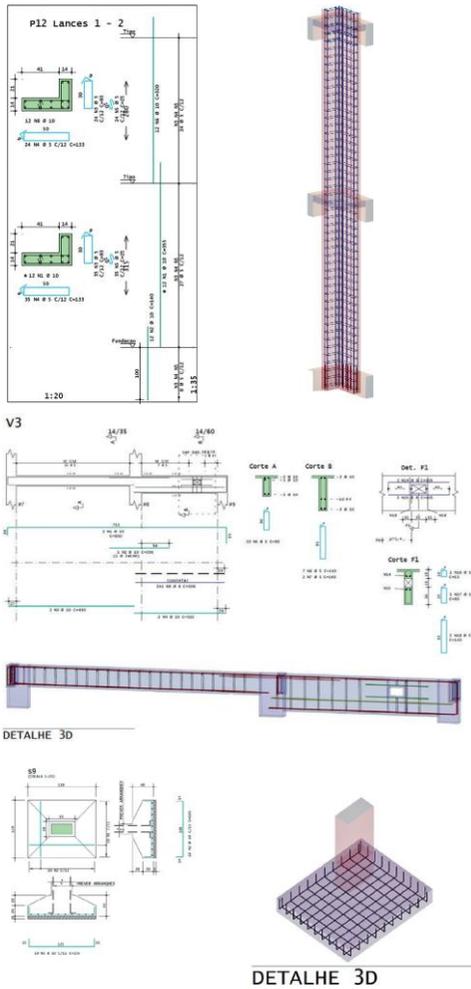
A *viewport* is a special insertion of one design within another.

Unlike the external reference, the *viewport* can crop a region of the referenced drawing and add complementary graphics without altering the original drawing. All additional entities are contained in the *viewport*, which makes it ideal for referencing details.



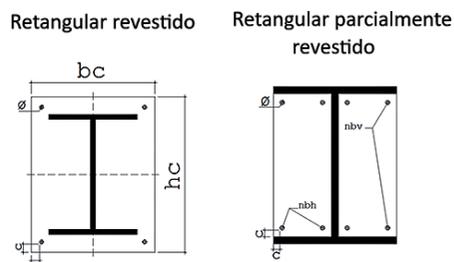
We have also implemented the *viewport* for 3D drawings. That is, in a DWG, it is now possible to incorporate 3D details using the 3D model of the building or even a custom scene, created by the 3D EAG.

We create commands to make it easier to insert *viewports*, such as automatically inserting 3D details into drawings of beams, columns, and building foundations.

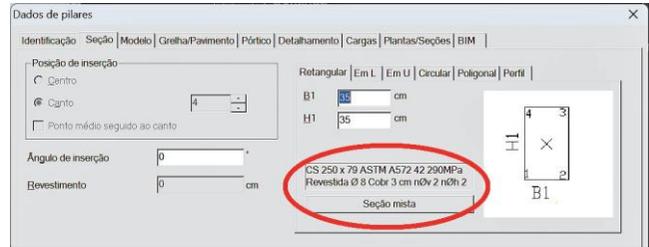


Modeler

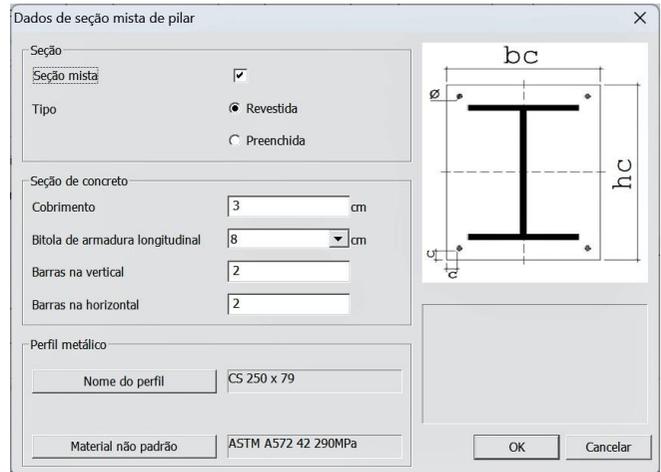
Mixed concrete columns with metal profiles were developed, integrated with MetalCheck®. Rectangular or circular columns are planned, with coated, partially coated or filled profile:



The data is edited by a button, in the column data window, tab "Sections":

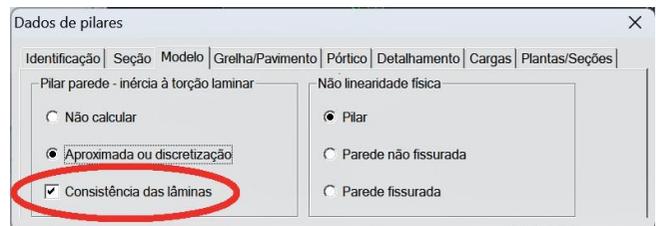


This, in turn, opens another window with the necessary data to define the mixed section:

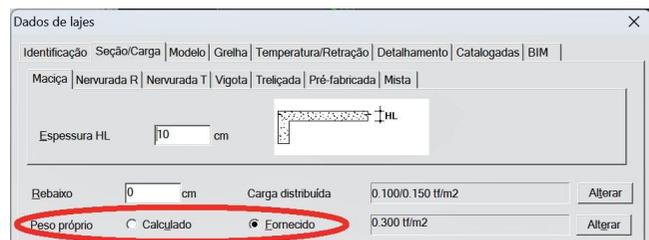


The dimensioning and detailing of these columns is done by integration with MetalCheck®. You can call MetalCheck from the Modeler, and export and import columns.

The consistency of blades for decrepitated wall columns can be switched off for the simulation of discontinuities in the column:

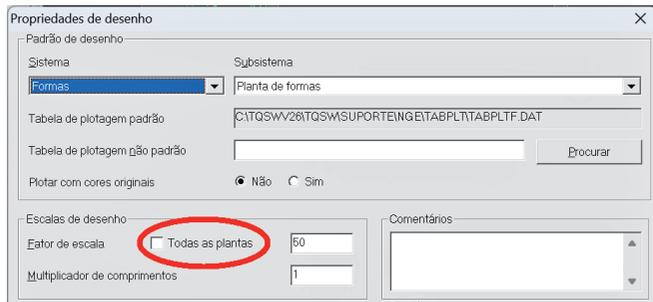


To facilitate the modeling of any type of slab, all types can have their own weight defined manually:



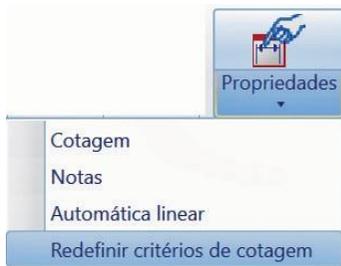
To remind the engineer that this option has been enabled, the Modeler shows in data consistency when this happens.

The Modeler's floor drawing scale, which is an independent parameter per plan, can be taken to all floor plans at once, by assigning it to the drawing properties box:



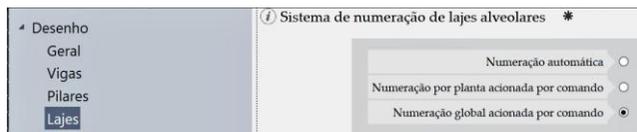
The modeler's associative dimensions are now also saved as associative dimensions in the design of shapes.

To ensure that templates are not affected by external changes to criteria, the dimension criteria are read when a new template is created and maintained to the end. To reload changed dimension criteria, use the command:



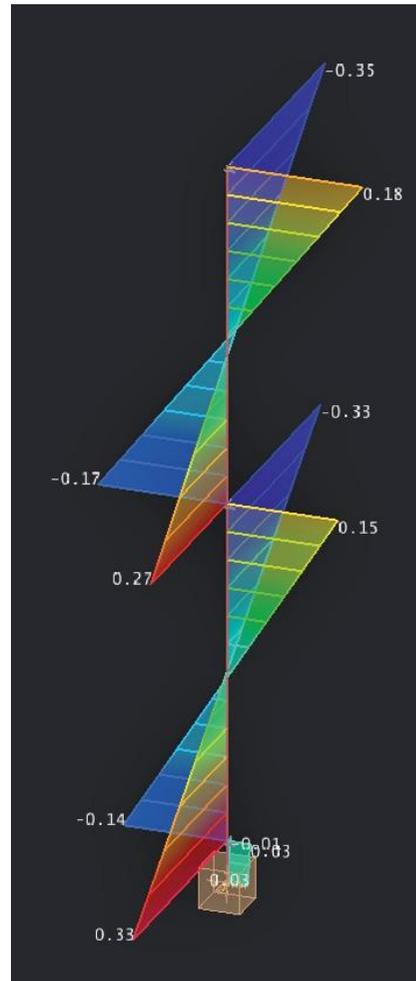
Pre-cast in Modeler

The numbering of hollow core slabs can have global control, that is, the position LA01 of one element in one plan can be equal to the LA01 of another. The type of independent control per plant or global is defined in the criteria file.

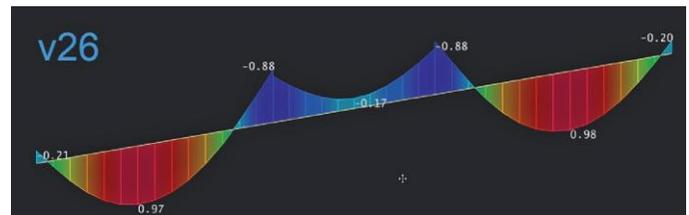


Spatial Frame and Grid Viewers

New option to view My and Mz diagrams simultaneously in spatial frame and grid viewers



Deleting text at non-significant points in diagrams



The DWG save command now includes supporting reaction tables, color gradient legends, and other elements that overlay the preview.

Improved the search node command, with display of information about the sought node.

BIM

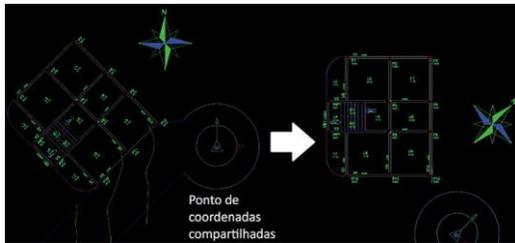
An old problem among designers of different modalities is sharing project coordinates. It is a non-standard area, and it varies from project to project. Currently, with BIM, the project coordinator, or Bim Manager, is responsible for this synchronization. The oldest way to share coordinates is the so-called "Origin to Origin". It is a matter of agreeing on a point (0.0) of the project to be used by all designers. This is still often used, with a CAD drawing as a reference.

What we did in V26 was to make it easier to use one of Revit® coordinate sharing modes: *Project base point and survey point*.

We set the "Shared Coordinate Point". It is a point common to all designers, coinciding with the topographic survey point in Revit. This point has known UTM coordinates. You define this point in the "BIM" tab of the modeler:

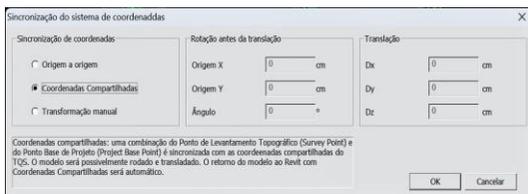


In the following example, on the left we have the model positioned in relation to the shared coordinates, with axes at 45° in relation to the horizontal, and the shared system with a Y-axis pointing to true north:



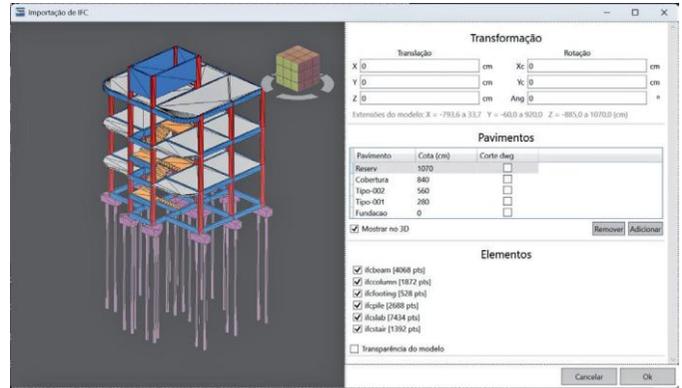
So, we can model it as right, with a local system of orthogonal axes with horizontal X, if we correctly position the point of shared coordinates. It will rotate at -45°, to maintain consistency. The important thing is that the point with known coordinates has distance and angle in relation to the coherent model.

The shared coordinate point is exported to Revit. When importing the TQS model within the Revit plugin, in order to respect the positioning of this point, it is necessary to specify what you want to import considering the base point and the survey point. Similarly, all RTQ file imports into TQS, including the structural model, walls, and pipes, may have specified the use of shared coordinates.

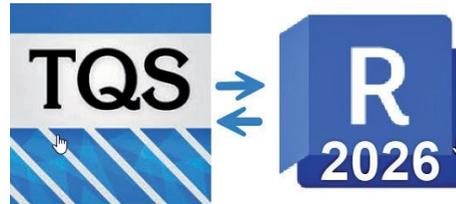


For greater flexibility, the import screens now give you the option to choose between maintaining the coordinate system (origin to origin), using shared coordinates, or specifying a manual geometric transformation to synchronize the models.

Improvements in the IFC import preview: transparent mode, graphical indication of elements of a category and number of nodes of all elements in a category.



Launch of the new TQS plugin for Revit, compatible with Revit 2026.



An additional category of beam title per span has been created to make it easier for the Revit side to identify the continuity of the beams. The title of the beams recorded in Revit is always the default title, regardless of the span.

Carbon footprint

Continuing our work of helping to collect structural project indices to compare projects and indicate the lowest carbon consumption, we started to export carbon indices in a format that will be compatible with the SIDAC (Construction Environmental Performance Information System) and BIP (Iterative Benchmark for Low Carbon Projects) systems.



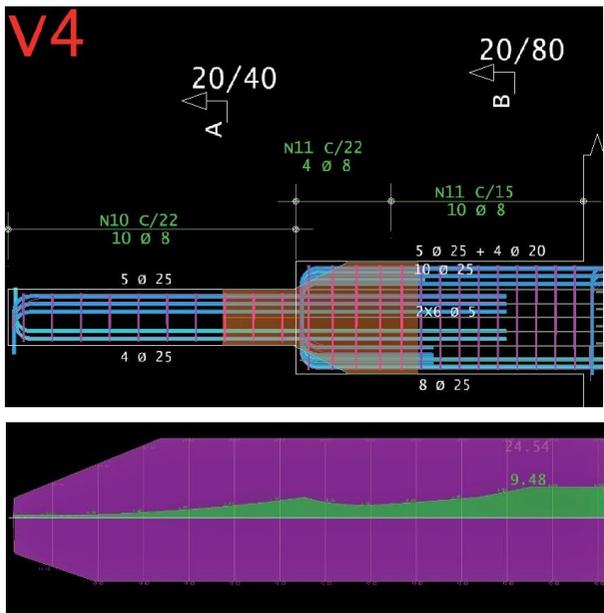
The design prerequisites for exporting this file are shown at the time of export.

Beams

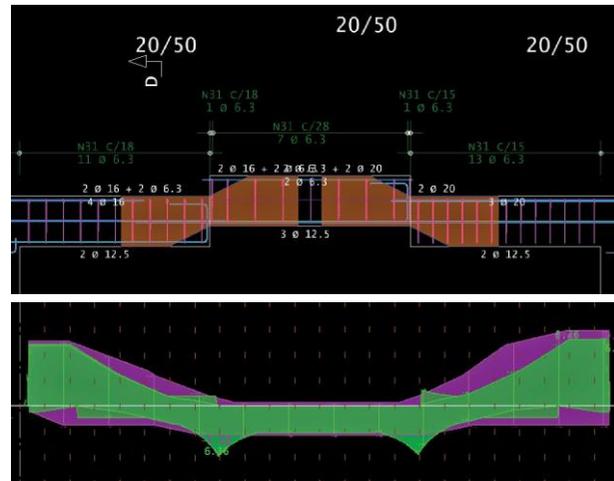
Section variation

In V26, the beam system presents the existing diagrams of A_s , required x A_s , considering the effective variation of the dimensions of the cross-section along the span. These diagrams are made for longitudinal and transverse reinforcement.

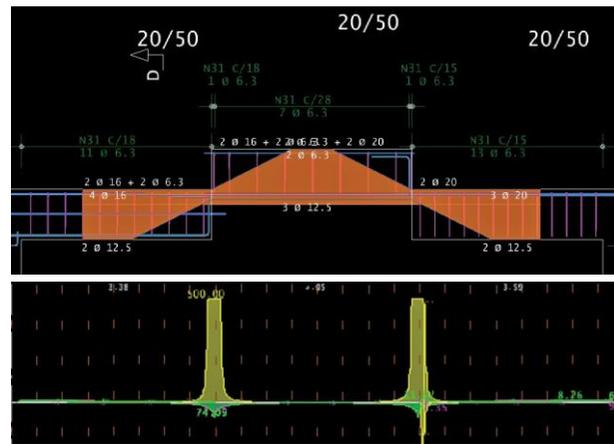
Diagram Examples: Excess detailed reinforcement



Reinforcement in need of add-on.



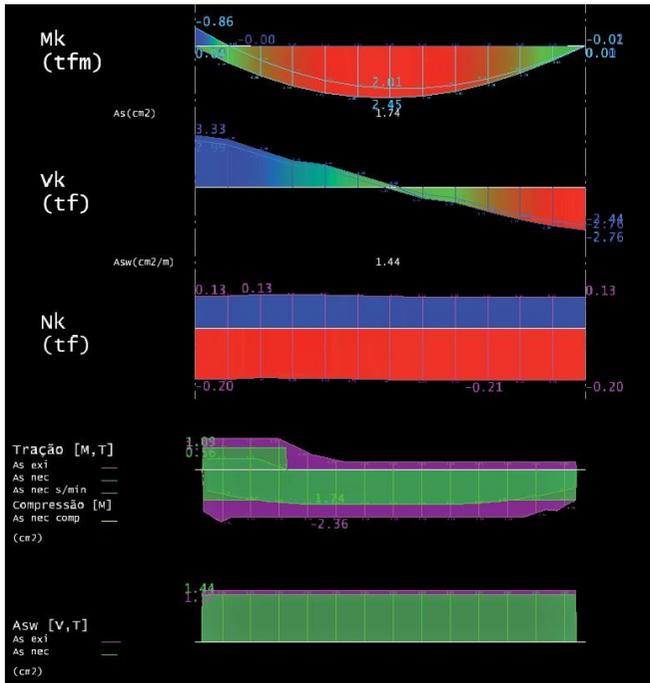
a) Section where the beam "does not pass".



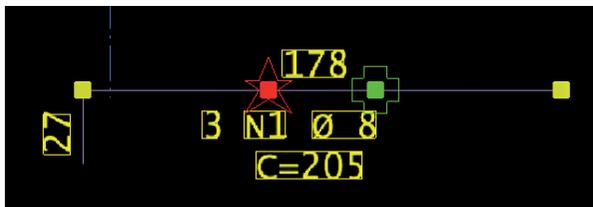
Quick Rebar Editor

Quick editor revamp with several improvements:

- Redesigned diagrams.



- Interactive editing with grips: group, join, change tip.



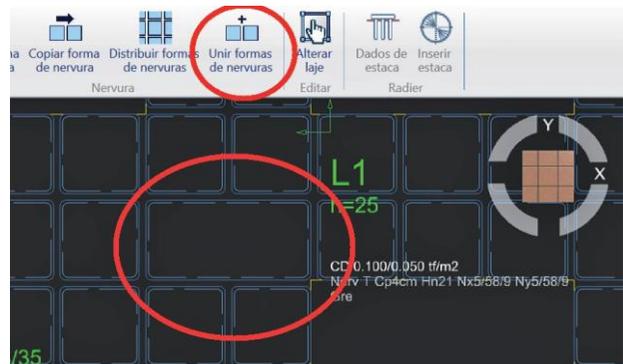
- Editing armor with double click and deleting armor with <F5>.
- Minimum moment check.
- Internal stirrup editing in 4 and 6-branch configuration.
- Adjustment in the consideration of the differentiated diameter of the internal stirrup in the beam check.

In holes in beams, some improvements were added, such as:

- New criteria for drawing the number of irons in place of the position number in cuts.
- Optimization in the design of the suspension reinforcement on the sides of the hole.

Slabs

A new control joins rib shapes using "rib canceller devices".



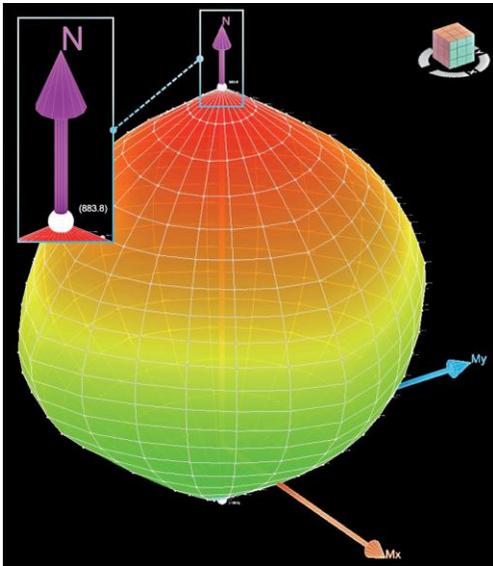
The adhesion coefficient, used to calculate the anchorage length of steel bars, was changed from 1.40 to 1.00 when the current standard is NBR-6118-2023 and CA60 steel.

Column

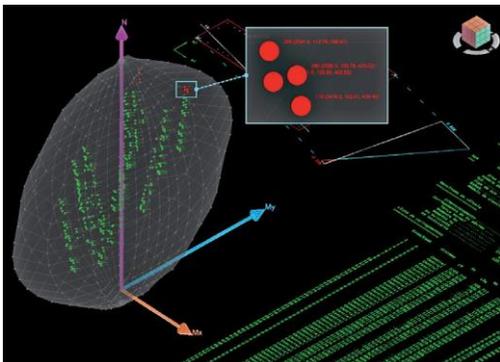
- After several tests and research, we were able to significantly reduce the processing time of discretized wall columns.



- New command that assembles 3D interaction curve in the quick reinforcement editor.



1. This new 3D interaction curve it is also available in other places, such as the quick reinforcement editor check command, the oblique compound bending calculator, the 2nd order effects viewer and the Alvest calculator.



- A new shear gauge check has been introduced.

Cisalhamento

Lance	Pavimento	Armadura transversal		V _{sa} /V _c (%)	
		Ø(mm)	c/(cm)	x	y
1	Tipo	6.3	20	0 a 25.62	0 a 27.07

- Better treatment of clamps that "tie" or not the main stirrup through new criteria.
- Increase in the maximum limit of the number of combinations.

Foundations

Block modeling

- Connecting rod check in the enlarged area of the column.

New criteria

For the design of blocks on a station, a new criterion for calculating the minimum block height has been implemented. This development follows the recommendations of the book *Structures of Reinforced Concrete, vol. 2*, published by IBRACON and ABECE, ensuring greater adherence to the best practices and technical references in the sector.



In addition, the calculation of the depth x under the column (Fusco Method A), which defines the enlarged area where the connecting rods begin, has been improved. Previously, this calculation depended on a reinforcement rate that had to be estimated and chosen via criteria by the engineer, who adopted an average value for the building. In V26, this approach has been automated: the system now has the option to read and use the actual reinforcement rate at the start and specific to the column that rests on the block.

Compressão na área ampliada [método Fusco]	
Teta 1 =	45 °
Rho =	0.96 %
X =	11.1 cm

Load plan at the base of all columns

It is now possible to obtain the load plan of the base of any columns, and it is also possible to select only the desired columns.

Pilar	Selecionado	Nasce sobre	Elemento abaixo
P1	<input checked="" type="checkbox"/>	Fundação/Solo	-
P2	<input checked="" type="checkbox"/>	Fundação/Solo	-
P3	<input checked="" type="checkbox"/>	Fundação/Solo	-
P4	<input checked="" type="checkbox"/>	Pilar/Bloco/Sapata/Tubulão	B4
P5	<input checked="" type="checkbox"/>	Viga	V4 (Pav.-Tipo)
P6	<input checked="" type="checkbox"/>	Laje	L1 (Pav.-Tipo)
P7	<input checked="" type="checkbox"/>	Pilar/Bloco/Sapata/Tubulão	B4
P8	<input checked="" type="checkbox"/>	Fundação/Solo	-
P10	<input checked="" type="checkbox"/>	Fundação/Solo	-
P11	<input checked="" type="checkbox"/>	Fundação/Solo	-
P12	<input checked="" type="checkbox"/>	Pilar/Bloco/Sapata/Tubulão	P3
P14	<input checked="" type="checkbox"/>	Fundação/Solo	-
P9	<input checked="" type="checkbox"/>	Fundação/Solo	-



3Delta Engenharia, Campinas, SP

Manager

A new command to examine the drawing block catalog is now available in the "Tools, Utilities" menu.



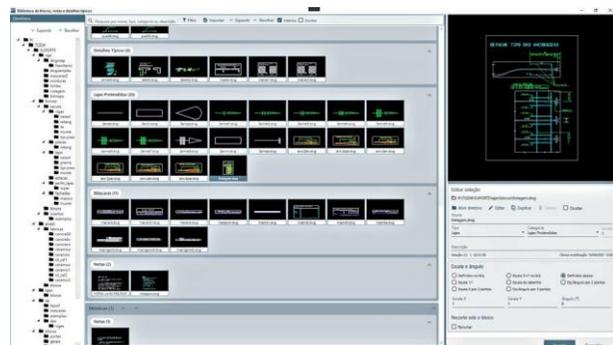
The library of typical blocks, notes, and details has been completely redesigned to make it easier to insert graphics into structural designs. Now, all drawings stored in the internal TQSW\SUPPORT folders are automatically mapped, displayed with thumbnail preview, and can be sorted and grouped by type and category. The user can easily search for files by name or description through a practical and efficient search field.

The preview of drawings with "%" markers has become more intuitive, allowing the user to check the result before insertion in the graphic editor. By inserting these drawings, the requested parameters are quickly and objectively filled.

It is possible to make simultaneous changes to several drawings with multiselecting function, speeding up general adjustments of characteristics and properties. If new drawings are added directly to the support folders, the library automatically recognizes these additions and makes them immediately available for use.

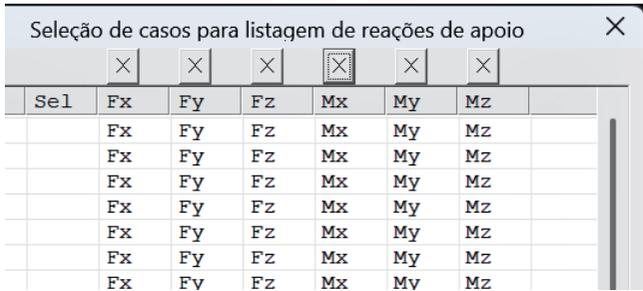
Drawings can be opened directly in the Graphics Editor (EAG) from the library, allowing for quick and simplified editing. Specific categories or files can be hidden to optimize the workflow and can be easily undisplay whenever necessary.

The library also provides several notes ready for immediate use in projects, facilitating standardization and document consistency. With these improvements, it has become easier and more efficient to view and manage masks for tables, charts, sheets, and other typical graphic elements used in the documentation of structural projects.



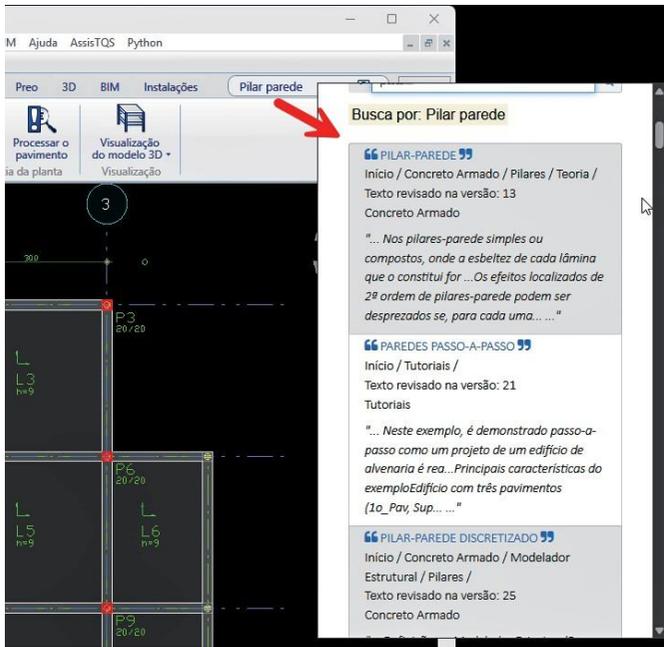
Both the modeler and the data editor of the building now warn if the manager is in global process in another window.

In load plan generation, the "X" buttons above the force columns allow you to select or deselect a force from all combinations at once:



TQSDocs

New search bar with integrated window. The results come from TQSDocs, with AI search.



Structural masonry (Alvest)

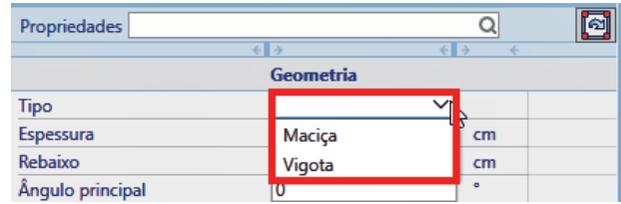
Compressed file (. TQS) now loads external references in optimized mode.

New Quoting Mode: Continuous Quoting, enter dimensions with one click.



Improvement in the block distribution algorithm at intersections, providing more precision in cases of imposed blocks close to the intersection.

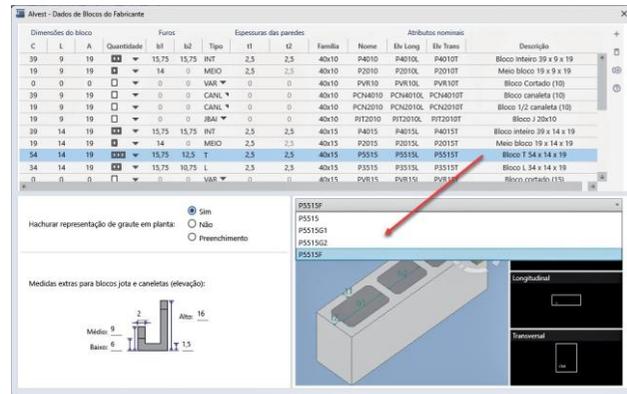
New slab type available: joist slab. It is a unidirectional slab for load distribution.



New command for mirroring grouts and copying grouts between floors.

Block Editor

Continuing the modernization of the masonry block editor, started in version v25, we implemented improvements in the application. It is now possible to view the grouted blocks directly on the edit screen, facilitating immediate visual verification and access to the respective drawings. The overall performance of the editor has also been optimized, providing a more fluid and faster user experience.



ESG – Carbon Structure

Through the "Summary and Costs of Materials" report for structural masonry, you will find the section "Carbon incorporated in the structure", with the total estimate, based on the quantities extracted from the project and related parameters, editable for control and accuracy.

Carbono incorporado na estrutura

Estimativa de Carbono incorporado				
Pisos	Insumo	Quantidade	Peso [kgf]	Carbono [kgCO2]
4 Cxdágua	Concreto Lajes	0.54 m3	1361	245.03
	Paredes	65.10 m2	-	1484.37
	Graute	0.79 m3	1980	356.33
	Aço conv.		109	325.63
3 Cobertura	Concreto Lajes	3.03 m3	7569	1362.37
	Paredes	78.25 m2	-	1784.03
	Graute	1.40 m3	3493	628.70
	Aço conv.		240	721.29
2 Tipo	Concreto Lajes	2.30 m3	5757	1036.22
	Paredes	79.87 m2	-	1821.13
	Graute	1.47 m3	3681	662.49
	Aço conv.		400	1200.37
1 Tipo	Concreto Lajes	2.30 m3	5757	1036.22
	Paredes	79.87 m2	-	1821.13
	Graute	1.47 m3	3681	662.49
	Aço conv.		400	1200.37
Total				16348.18

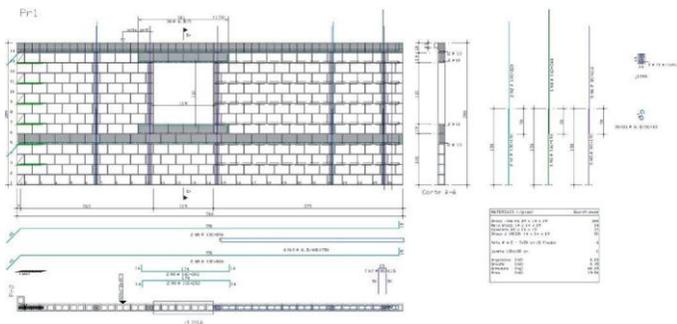
Índices de carbono cadastrados		
Insumo	Tipo	Índice kgCO2/[u]
Concreto	*	0.18 [kgf]
Aço	*	3.00 [kgf]
Graute	*	0.18 [kgf]
bl. Concreto	Alvn.Estr.	22.80 [m2]
bl. Cerâmico	Alvn.Estr.	24.50 [m2]

* Sistema utiliza valores-padrão para estimativas.

Improvements to wall elevation representations and bill of materials

Complete representation of reinforcement, grout and user-defined reinforcements, in template, plan and section/sections.

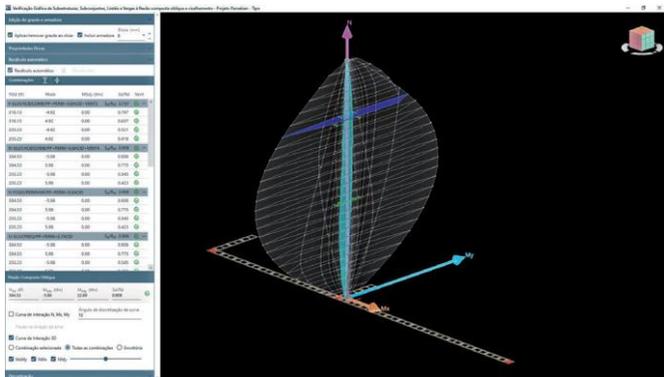
Possibility (by design criterion) of removing the resistance ratio, in command of the list of materials, by elevation. Possibility also includes new fields (wall area and reinforcement).



Graphic verification of masonry

The graphic verification of masonry has received important updates, highlighting the new 3D interaction curve, which allows the simultaneous visualization of the MxMy, NMx and NMy planes. This improvement provides a clearer understanding of the structural behavior of substructures, lintels and lintels. Now, when applying or removing grout with one click, the user can also automatically add a specific gauge reinforcement in the center of the filled hole. The recalculation of the binds and the update of the interaction curve are carried out automatically after each user interaction. However, it is possible to turn off this function to make various modifications more quickly, later validating the results by means of a specific button or by reactivating the automatic recalculation.

In addition, the discretization threshold has been expanded, allowing for more detailed analyses of larger substructures. The program has undergone a few technical optimizations, resulting in increased performance and stability during use.



Buildings on concrete walls

EGS – Carbon Structure

Through the "Material Summary and Costs" report for the Concrete Wall system, the "Embodied Carbon in the Structure" section is found with the total estimate, based on the quantities extracted from the project and related parameters, which can be edited for control and accuracy.

Carbono incorporado na estrutura

Estimativa de Carbono incorporado				
Pisos	Insumo	Volume [m3]	Peso [kgf]	Carbono [kgCO2]
4 CxDágua	Concreto paredes	4.35	10873	1957.05
	Concreto Lajes	0.56	1407	253.23
	Telas soldadas		229	685.78
	Aço conv.		38	114.21
3 Cobertura	Concreto paredes	7.53	18818	3387.15
	Concreto Lajes	3.09	7729	1391.15
	Telas soldadas		229	685.78
	Aço conv.		230	689.83
2 Tipo	Concreto paredes	7.69	19220	3459.60
	Concreto Lajes	2.36	5903	1062.52
	Telas soldadas		229	685.78
	Aço conv.		246	737.05
1 Tipo	Concreto paredes	7.69	19220	3459.60
	Concreto Lajes	2.36	5903	1062.52
	Telas soldadas		229	685.78
	Aço conv.		246	737.05
Totais			90745	21054.06

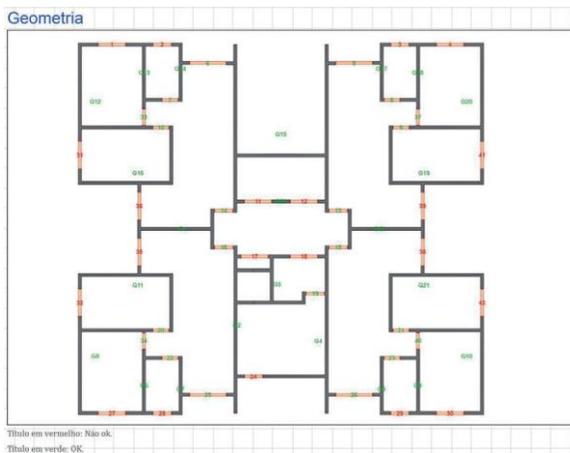
Índices de carbono cadastrados		
Insumo	Tipo	Índice kgCO2/kgf
Concreto	*	0.18
Aço	*	3.00
Concr.AA	*	0.18
Telas Soldadas	*	3.00

* Sistema utiliza valores-padrão para estimativas.

Consideration of Detailed Reinforcements for Tensile and Shear for Subassemblies

The system can now account for the user-defined reinforcement in the graphical input with the aid of editable parameters and check/compare in each subassembly whether the existing tensile and shear reinforcements are sufficient, thus enabling the automatic removal of stripes and error messages by tensile and shear regions.

Dimensioning Report



Now the report has the data and drawings of the geometries of the elements, in addition to the formulation and methodologies applied. It also has the representation of reinforcement, checks and results,

greatly facilitating the process of dimensioning and checking the subassemblies.



Flexo compressão

Piso	$\eta_{d, resist}$ (tf/m ²)	Combinação	N_k (tf)	M_k (tfm)	$\eta_{d, 1e}$	$\eta_{d, 1d}$	$\eta_{d, 2e}$	$\eta_{d, 2d}$	$\eta_{d, c/c}$	$(\eta_{d, c/c} / \eta_{d, resist})$
1	27,763	1: Todas permanentes e acidentais dos pavimentos	3,20	0,00	2,717	2,717	2,717	2,717	2,717	0,096
		6: E.U.U./ACIDCOMB/TODAS-VENT1	3,18	-6,42	2,717	2,717	20,918	-30,247	15,688	0,565
		7: E.U.U./ACIDCOMB/TODAS-VENT2	3,18	6,42	15,483	35,683	2,717	2,717	29,761	0,964
		8: E.U.U./ACIDCOMB/TODAS-VENT3	3,18	1,48	-1,477	10,314	2,717	2,717	7,735	0,279
		9: E.U.U./ACIDCOMB/TODAS-VENT4	3,18	-1,48	2,717	6,913	-4,881	5,195	0,187	

$$\eta_{d, resist} = \frac{(0,85 \cdot f_{cd} + \rho \cdot f_{scd}) \cdot t}{Div} \leq \nu_{limb} \cdot f_{cd} \cdot t$$

$\nu_{limb} = 0,4$

$$Div = k_1 [1 + 3k_2(2-k_2)] \geq 1,645$$

$$\eta_{d, c/c} = \frac{3 \cdot \eta_{d, max} + \eta_{d, min}}{4} \quad (\eta_{d, min} \geq 0)$$

$\eta_{d, resist} \geq \eta_{d, c/c}$
 * $\eta_{d, resist}$ [tf/m²m]

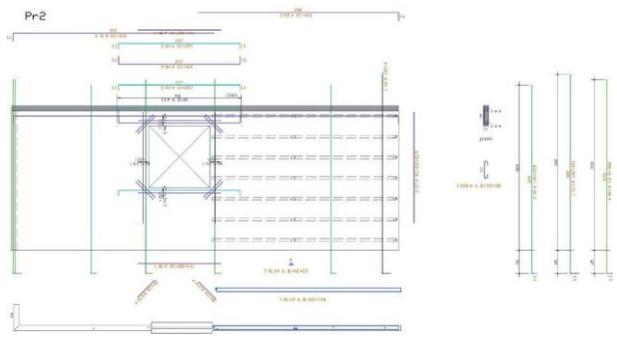
Armadura para Tração (Esp: 0,57 cm² - C=31,8 cm, f_{td}=15,483 tf/m²), existente: 0,79 cm²
 Armadura para Tração (Dir): 2,16 cm² - C=62,1 cm, f_{td}=30,247 tf/m²), existente: 3,14 cm²

Improvements to wall elevation representations and bill of materials

Complete representation of the user-defined conventional reinforcement in the template, in plan and also in the sections/sections.

Removal of necessary reinforcement stripes, for traction and shear, when sufficient reinforcements are defined, for each section of wall checked.

Possibility of adding new field, conventional reinforcement, to the bill of materials.



Other developments

On smart irons, the tex realignment option now works for multiple selection of irons.

In the center panel, the plants were ordered by the plant number.

The old backup restorer *has* been completely redesigned, with a more modern interface for the

restoration for files with extension .BAK, which are automatically generated by TQS with each save . Currently, the formats that can be retrieved through the restorer are drawing files (. DWG) and the shaper (. DAT), being useful especially in the event that there are corrupted files in these formats.



AS Estruturas, Curitiba, PR

MetalCheck

Due to the update of NBR 8800, at the end of 2024, MetalCheck was modified to implement the changes introduced by the new version of the standard. Both the metallic elements and the mixed elements of steel and concrete had their formulations revised, in addition to the implementation of new calculation methods.

For compressed metallic elements, there was a change in the calculation of the reduced slenderness index (λ_{\square}), $\omega_{\eta\chi\eta}$ no longer considered the local instability reduction factor (Q) in its formulation. As a result, the strength of the calculation to compression (N_c, R_d) is now determined based on the effective area (A_{ef}) of the cross-section, as specified in the standard.

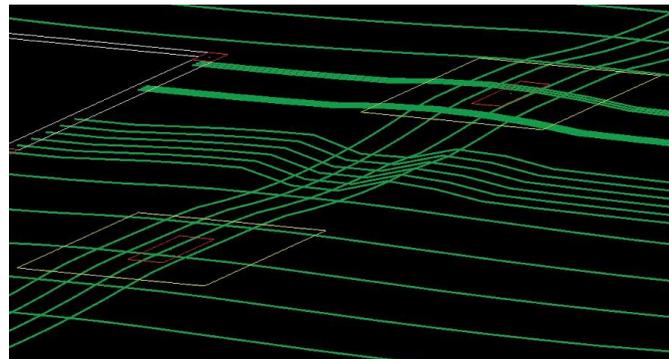
In the calculation of the calculating resistant shear force (V_{Rd}), there was a small change in the determination of the value of the k_v coefficient for webs without transverse stiffeners.

The formulations for the calculation of the calculating resisting bending moment (M_{Rd}) have undergone several changes, especially those related to the ultimate limit state of lateral torsional buckling (FLT), both in non-slender and slender web beams. The modification factor for non-uniform bending moment diagram is no longer limited to the maximum value of 3.0 in most cases.

For the composite steel and concrete columns, there were changes in the formulation of the resistant axial force and the resistant bending moment. NBR 8800 began to consider the factor for reducing the strength of concrete, introduced in the most recent version of the concrete standard, NBR 6118. Another important change was the inclusion of the concepts of compact, semi-compact and slender sections. With these distinctions, the formulations were adapted to consider each case, in addition to incorporating new parameters.

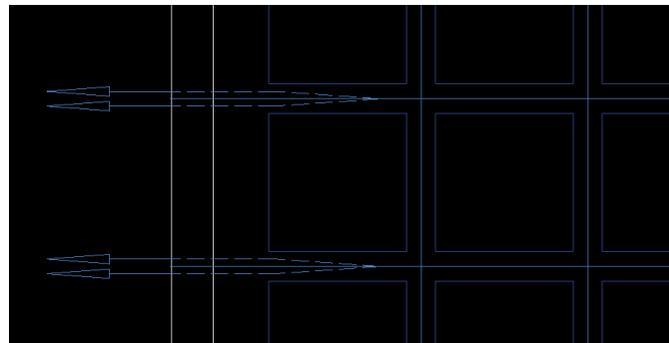
Prestressed Slabs

The prestressed slab editor has been adapted to use the 3D window. As a result, it will be possible to draw the cables of the RPU's in 3D, as well as other diagrams.

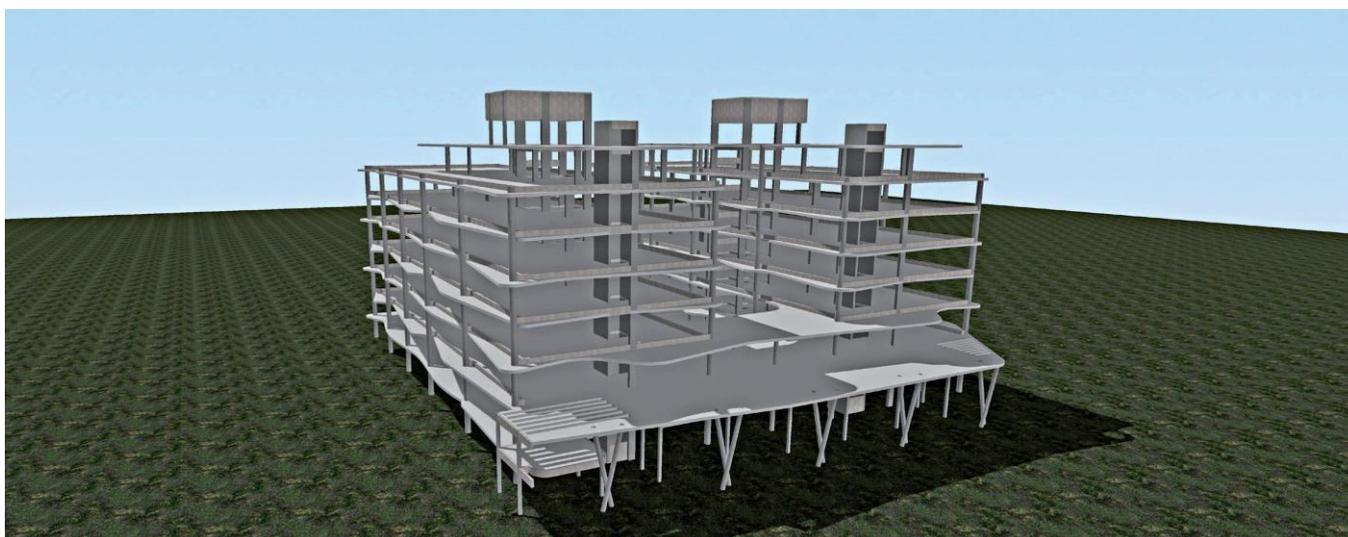


In addition, other novelties were introduced:

- New anchor blocks for the system with non-stick strands.



- New parameter that allows you to view separately the dimensions between cables and the dimensions on the additional dimension lines.
- Visualization of the minimum moment in the plan diagrams.



Python

We have evolved in the interfaces of TQS with Python, now in version 3. We introduced programming of structural models from within the modeler, created more access functions, and made minor corrections.

Module TQSEagSM

We already had a way to manipulate structural models in batch, with the `TQSMoDel`. But it was only possible to operate inside the structural modeler by triggering ready-made commands from the modeler. Although it is possible to change the DWG within the modeler, because it is an *intelligent editor*, it has a database that is not a drawing, and with each screen regeneration the DWG is regenerated and the changes lost. But the modeler is a graphical editor, so if we do a routine called a menu inside the modeler, it will receive the objects of the classes `TQSEag.Eag` e `TQSJan.Window`:

```
def aplic_cmd1 (eag, tqsjan):
```

The module `TQSEag` recognizes the use of the modeler and has a function to return the structural model. The sequence to gain access to the structure model is:

```
sm, model, floor = eag.GetTQSMoDel (tqsjan)
if (sm == None):
    TQSUtil.writef ("Não é modelo estrutural")
    quit ()
```

Where the objects `sm`, `model` e `floor` are:

Objeto	Classe	Descrição
<code>sm</code>	<code>TQSEagSM.SM</code>	Structural Modeler
<code>model</code>	<code>TQSMoDel.Model</code>	Structural Model
<code>floor</code>	<code>TQSMoDel.Floor</code>	Current floor within the model. <i>Container</i> of the structural elements of the current floor.

From these objects it is possible to make manipulations within the structural model but always considering the interaction with the modeler. The specific classes are:

- `TQSEagSM.Locate`, que faz a seleção interativa de elementos estruturais.
- `TQSEagSM.Undo` que permite que todas as operações possam ser desfeitas e refeitas.
- `TQSEagSM.View` que atualiza a geometria e a tela após operações geométricas. Ele permite também mudar a planta ou piso auxiliar atual.

As operações estão documentadas e exemplificadas através do programa `EAGME.PY` e menu `EAGME.PYMEN`.

TQSMoDel

Created virtual functions to move, rotate, mirror, and scale objects `TQSMoDel.SMObject` of the modeler. The function `Column.ColumnGetCurrentSection` Obtains the cross-section of a valid column in the current plan.

The floor class has gained the `floorName` properties (name of the current plan), `height`, `elevation`, `repetition`, `Floor-reElevation`, `auxiliaryFloors` e `AuxiliaryFloor-Recess`. The class routine `Beam.GetUserNodes` An object that allows the alteration of the original nodes of a beam

TQSEag

External programs can now execute menu commands in an open graphical editor. These commands can include Python scripts.

TQSDwg

"Modified", "out-of-project", and "checked" drawing flags can be read by class functions `TQSDwg.File`.

Created routines to change the geometry of reinforcement: `SetInsertionData`, `SetInsertionPoint` e `SetGen-RebarPoint`. Reinforcement can now be moved, rotated, scaled and mirrored by direct function.

Text with Windows TrueType font can be selected and read by iterator.

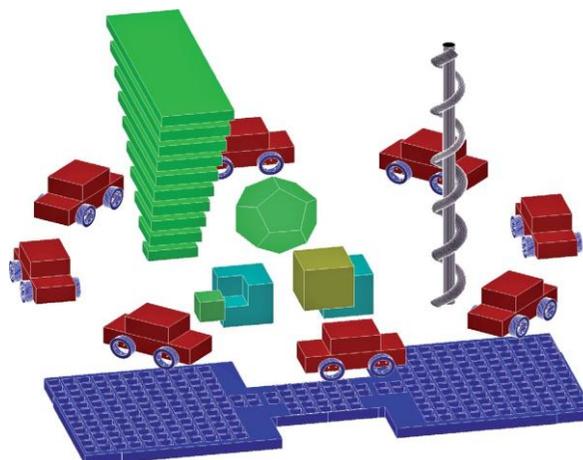
The property `TQSDwg.settings_rebarDrawing` shows whether a drawing is framed.

New module TQSLayout

This module reads and writes plans in CPL format. It allows, for example, to list and manipulate the drawings that can be traced into plans, to generate new layouts and to assemble a layout for the iron table of the entire building.

New module TQSM3d

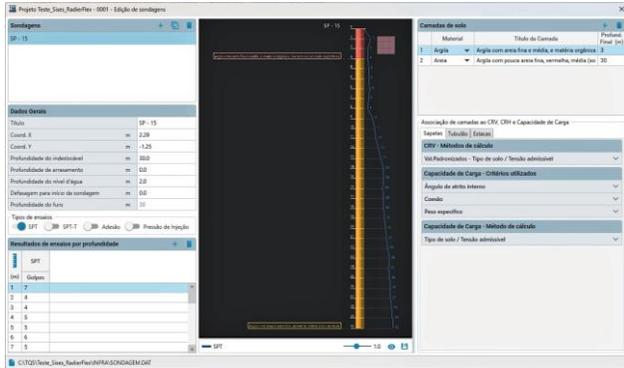
In `TQSM3d` we can generate E3D type spatial models: for visualization, external reference of the modeler and export to BIM. With it, we complete the possibility of generating concrete elements that are not analyzed in the TQS model, but that must be modified and detailed, as well as transferred to BIM. The other ways to generate these object types are through the 3D object editor and the parametric object generator. An example of the possibilities of this module is shown with the `TSTM3d.py` program, which generates the following model:



SISEs

New Soil Survey Editor

The new editor was developed to simplify the process of creating and entering data related to boreholes and soil layers, offering a more intuitive experience, without sacrificing robustness. Now it features 2D/3D representation of holes and allows simultaneous visualization of multiple holes.



Foundation Editors – SISEs

The traditional SISEs foundation editors are being completely rewritten in C#, adopting the technological standard already used in the other TQS programs. The new version brings a cleaner, more intuitive and user-friendly graphical interface. Redesigned icons make the environment more visual, offering a more fluid experience to the structural engineer.

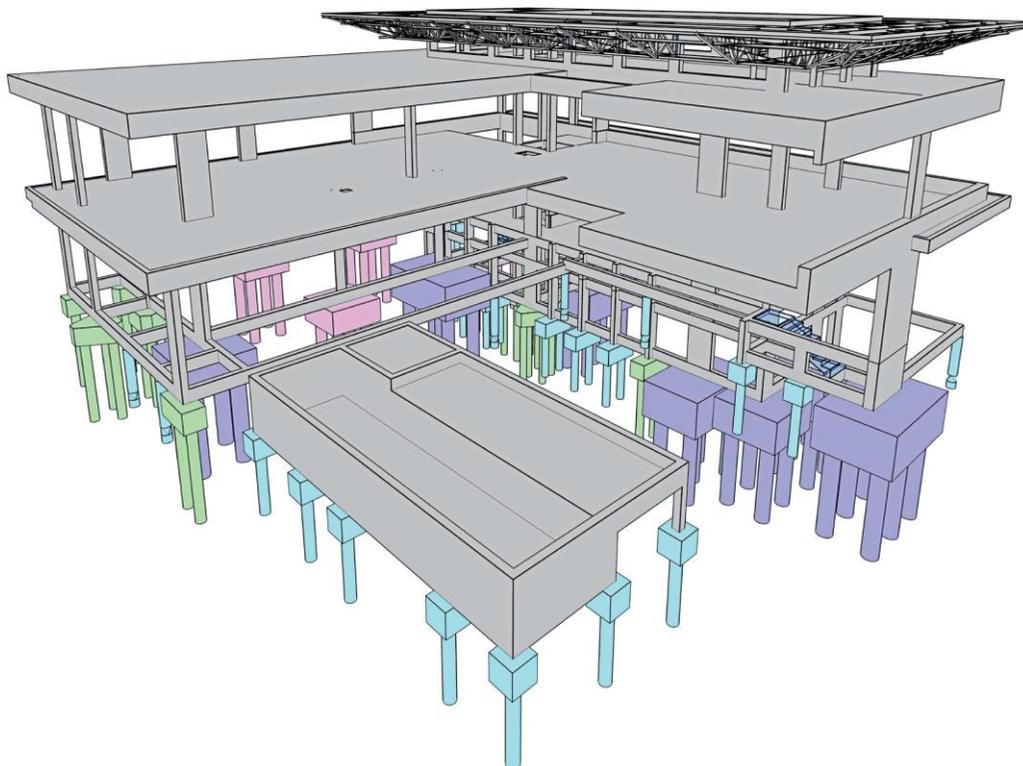
Restructuring allows the geometries of the foundations to be made and edits to be made with immediate validation. The organization by flaps facilitates access to footings, blocks, rigidity beams and criteria, bringing together all the essential functions in a single panel. With this, the structural engineer starts to lay, review and adjust foundations with greater agility and safety, reducing the number of steps necessary to complete each task.

Research in artificial intelligence

The TQS development team is keeping a close eye on rapid developments in the field of artificial intelligence (AI). In a scenario where new technologies emerge daily, we have conducted several studies and research to explore how AI can be safely and usefully integrated into our systems.

Our goal is to take advantage of this technology to bring real benefits to our users, whether in process optimization, project assistance or new analysis tools. We know this is a big challenge, but we are committed to finding the best solutions that preserve the reliability and accuracy of our systems.

In addition, the application of AI tools in our internal processes has already accelerated the delivery of new features and enabled complete solutions that were previously unlikely, and this is reflected in *even* better software for our users.



Internationalization

TQS continues to make efforts to increase the internationalization of its brand and for this it is developing examples of software validation, with comparisons with other systems and with official publications of the CIRSOC-201:2005 and ACI 318-19 Standards, in order to demonstrate the reliability of the results. Below, an example of this work that is in progress and will be available on TQSDocs.

Vigas - Flexão Simples 1
FLEXÃO SIMPLES

Este exemplo, será dimensionado a armadura longitudinal e transversal de uma viga submetida a Flexão Simples utilizando como base a Norma ACI318-19, conforme dados abaixo:

Concreto - C25 (4000 psi) / Aço - ADN420 (60 ksi)
bw: 8 in / h: 24 in

Mu: TQS = 522.15 kip.in Software B = 519.91 kip.in Software C = 511.98 kip.in

Flexão:

$$M_u = \frac{w_u L^2}{8} = \frac{522.15}{8} = 580.17 \text{ kip.in}$$

$$d = h - c_c - d_{st} = \frac{c_c}{2} = 24 - 1.57 - 0.375 - 0.25 = 21.81 \text{ in}$$

$$R_u = \frac{M_u}{b_w \cdot d^2} = \frac{580.17}{8 \cdot 21.81^2} = 0.152 \text{ ksi} = 152.46 \text{ psi}$$

$$\rho = \left(\frac{0.85 \cdot f'_c}{f_y} \right) \left[1 - \sqrt{1 - \left(\frac{2 \cdot R_u}{0.85 \cdot f'_c} \right)} \right] = \left(\frac{0.85 \cdot 4}{60} \right) \left[1 - \sqrt{1 - \left(\frac{2 \cdot 0.152}{0.85 \cdot 4} \right)} \right] = 0.0026$$

$$A_s = \rho \cdot b_w \cdot d = 0.0026 \cdot 8 \cdot 21.81 = 0.45 \text{ in}^2$$

Alumín (AO 318-19 - 9.6.1.2)

$$\left(\frac{3 \cdot \sqrt{f'_c}}{f_y} \right) \cdot b_w \cdot d = \left(\frac{3 \cdot \sqrt{4000}}{60000} \right) \cdot 8 \cdot 21.81 = 0.56 \text{ in}^2$$

$$\left(\frac{200}{f_y} \right) \cdot b_w \cdot d = \left(\frac{200}{60000} \right) \cdot 8 \cdot 21.81 = 0.58 \text{ in}^2$$

$A_{s,min} = 0.58 \text{ in}^2$

TQS = 0.58 in² Software B = 0.60 in² Software C = 0.60 in²

0.60 in² > 0.58 in² → OK!

3#4 → 0.60 in²

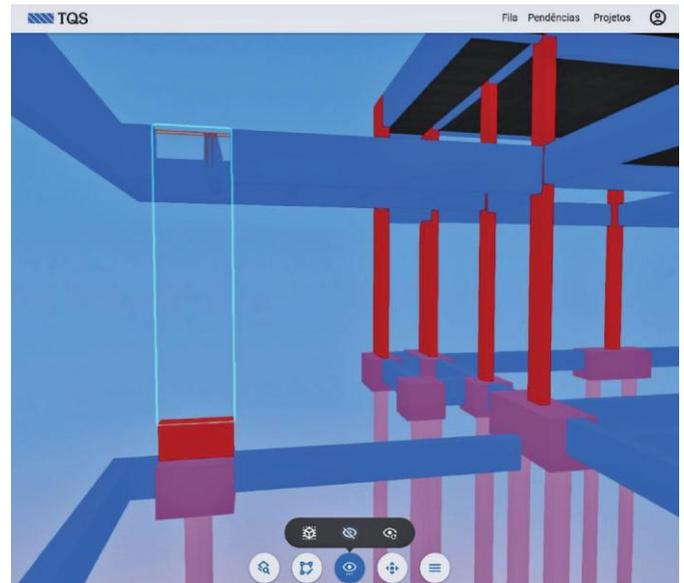
0.60 (3#4, 20 kip.in) > Mu (522.15 kip.in) → OK!

Modal analysis in the light solver

The light solver, used mainly by the student versions, free trial and EPP, was given the ability to perform the modal analysis of the gantry or pavement models.

TQS Cloud Viewer

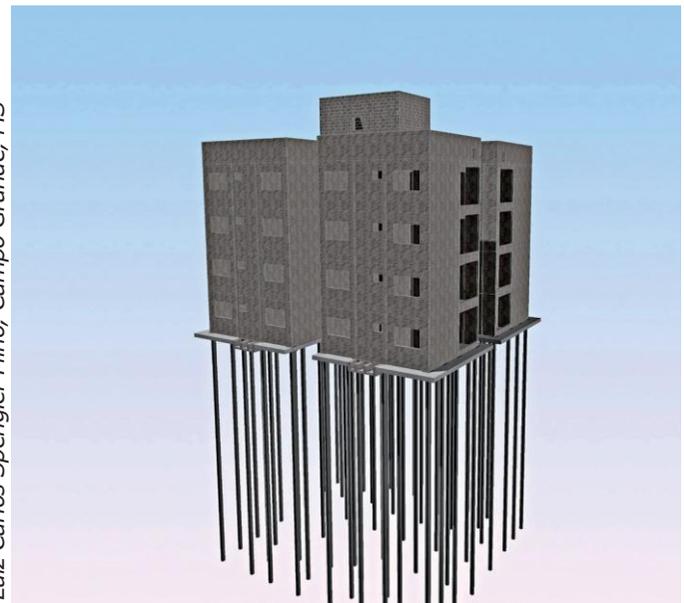
TQS Cloud Viewer is a tool that allows users of TQS Systems to view the 3D model of their buildings through the mobile app (through the TQS app available on the App Store and Google Play) or a browser (mobile or computer). The models are sent to the repository (cloud) in IFC format and may also include the reinforcements already detailed. The characteristics of each element are also exported.



Monteiro Linardi Engenheiros Associados, São Paulo, SP



Eng. Luiz Carlos Spengler Filho, Campo Grande, MS



Incremental analysis in columns of reinforced concrete buildings¹

By Carlos Estevão Lúcio de Paiva

Civil Engineer, specialist in the design of concrete structures for buildings
E-mail: carlosestevaopaiva@gmail.com

1. Introduction

Architectural projects are increasingly complex and require bold solutions to make these structures viable in order to satisfy architectural, economic and safety demands. It is essential that the models analyzed represent the structure in a reliable way.

The structural model can be conceived as the combination of basic structural elements, forming structural systems that allow a clear representation of all the paths taken by the actions, up to the supports of the structures. It must represent the geometry of the elements, the acting loads, the boundary conditions, the characteristics and responses of the materials, always according to the specific objective of the analysis, according to ABNT NBR 6118 (Brazilian Association of Technical Standards, 2023).

Structural analysis can be linear or nonlinear. In linear analysis, the effects caused by the application of load, such as displacements, for example, vary proportionally to the load. As for the non-linear analysis, it produces a response that varies disproportionately to the application of load. Kimura (2018) clarifies that, in reinforced concrete, nonlinear behavior is caused by the variation of the physical or geometric characteristics of the structure as the load is applied.

Considering that the objective of structural analyses is to simulate a building so that the response is as close as possible to reality, for this it is necessary to consider the constructive aspects, through incremental analysis. According to Medeiros (2022), incremental analysis allows the research of interim results obtained in each construction stage, in order to identify cases of excessive deformability and actions that exceed the predicted values.

A large part of the actions of a project carries the structure during the construction phase and these are the causes of the main distortions between the calculated efforts and those that act on the structure. These actions act while the structure has not yet been finalized and has a different modulus of elasticity from the end (TQS Docs, 2024). Thus, the ideal would be to develop a model that represents this sequential performance of the loads, according to the construction schedule.

TQS considers the constructive effect through the Mulaxi criterion (multiplier to increase the axial stiffness of columns), which causes the decrease in axial displacements, once the linear mode does not

represents what happens. According to Fortes (2019), during construction, the columns curve and the displacements are partially corrected in the concreting of the next floor, therefore, the final displacements of the columns are lower than those obtained in the conventional analysis.

Incremental analysis can be performed through TQS, based on knowledge of the following data:

- a) number of floors built at the same time;
- b) number of days representing a construction phase;
- c) loads history;
- d) modulus of elasticity increment curve.

Medeiros (2022) points out that a disadvantage of incremental analysis is the high computational cost, when compared to conventional analysis, in which the building is considered constructed and loaded at once. However, performing incremental analysis in TQS is relatively simple and the processing time will depend on the magnitude of the building. In tall or complex buildings, the performance of this analysis is even more important, and the time spent on it is justifiable.

Therefore, the objective of this work is to demonstrate the importance of adopting incremental analysis in the elaboration of structural projects, to provide greater structural safety in reinforced concrete buildings. To this end, a 15-storey reinforced concrete building will be modeled at TQS, which will be studied based on the results of the conventional and incremental analyses. The efforts and displacements resulting from the two analyses will be compared and the results will be discussed.

2. Diagnosis of the problem-situation

Carrying out detailed analyses to solve structures is part of the exercise of structural engineering, intensifying the increasingly challenging architectural demands. Kimura (2018) describes structural analysis as the stage in which displacements and stress are calculated using a model that will simulate the real structure.

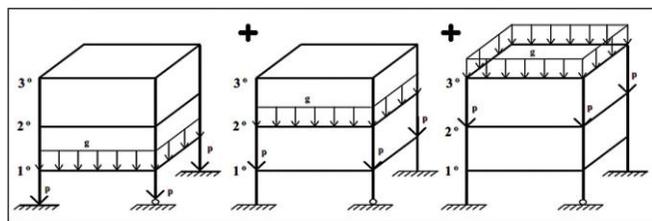
To design and analyze a complex structure, it is important to use *softwares*

1. Article presented as a partial requirement to obtain the title of specialist in Design of Concrete Structures for Buildings, School of Engineering, Mackenzie University, São Paulo, 2024.

that makes it possible to carry out these analyses in a "fast" way, and this is made possible using software. Ibracon/Abece (2022) lists some of the main national *software* that performs analysis, measurement of elements and drawings: TQS, Alto QI Eberick and Cypecad (of Spanish origin).

Structural analyses can be linear or non-linear. According to Ibracon/Abece (2022), in the linear analysis, the response of the structure varies according to the variation of loading. For the calculation model, it is considered that the structure will be loaded at once, after its construction, which can be seen in figure 1.

Figure 1: Three-storey building considering linear analysis

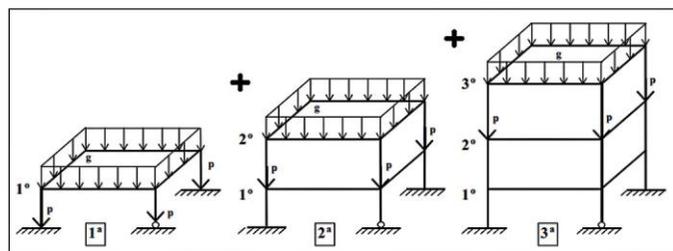


Source: Gorza (2000).

Kimura (2018) explains nonlinear analysis as a disproportionate response of the structure as a load is applied. Nonlinearity is caused by the variation of physical or geometric characteristics. Geometric nonlinearity is related to the changes that occur in the geometry of structural elements as a load is applied, while physical nonlinearity is related to the behavior of the materials that make up the structure when loaded.

According to Ibracon/Abece (2022), the constructive effect is usually neglected, as the structural analysis is usually done considering that the structure will be loaded only when it is ready, which is not consistent with reality. It is important to consider the constructive effect and the variation in the characteristics of the concrete over time. The number of analyses must correspond to the number of construction steps, as can be seen in Figure 2.

Figure 2: Building with three floors considering the "Constructive Analysis"



Source: Gorza (2000).

The choice of method is at the discretion of the engineer. According to Ibracon/Abece (2022), even if the construction of the model is done almost automatically, the person responsible for the project must have solid theoretical knowledge to define the parameters.

In 1990, Moacir Kripka published an important work on incremental analysis, which serves as a reference to this day. Kripka (1990) considered the incremental effect in the analyses of some buildings and found great differences in comparison with the conventional analysis, mainly due to the fact that, in the conventional analysis, displacements from the lower to the upper floors accumulate, and these displacements grow throughout the building, even though the upper floors have not been built, therefore, these displacements are non-existent.

According to Prado (1999), when introduced incrementally on the structures, the actions of self-weight accompany the development of the construction and there are values of requesting efforts and displacements different from those obtained conventionally with the isolated pavement. This conclusion agrees with Freitas (2004) who found, in his work, these divergences between the conventional and incremental analyses, and found in his studies that, in the first two floors, the greatest discrepancies between the deformations were found.

Much of the actions of a project loads the structure during the construction phase and these are the causes of the main distortions between calculated and calculated efforts. act, in fact, in the structure.

Ideally, the columns should have equivalent stresses, however, this is sometimes not feasible due to architectural requirements. Kripka (1990) comments that, in tall buildings, the vertical displacement between adjacent columns gains greater importance, since some of these are designed mainly as a function of lateral loading. When this occurs, these columns have a much lower normal stress than the others. Thus, the axial differential deformation between neighboring columns, when reaching significant values, generates a redistribution of normal forces, in addition to shear and bending forces in the beams that join these columns.

According to Kripka (1990), Rachinhas (2020) also verified redistribution of efforts, with incremental analysis, in addition to identifying oversized and undersized elements because of these redistributions. For Medeiros (2022), it is important to contemplate the aspects of the construction process in the analysis of multi-storey concrete buildings that, under the action of vertical loads applied throughout their construction, have their columns subjected to normal stresses that are significantly different from each other.

The results of the linear analysis vary along the height, while in the incremental analysis, the largest displacements occur in the middle. Kripka (1990) explains that in the conventional procedure of analysis, because it accumulates on the upper floors

of the building non-existent displacements, causes the differential displacement to grow along the height, reaching a maximum value at the top of it. In the incremental analysis, he states that they are verified at mid-height, or in the stretch without variation in the character of their elements.

According to Fortes (2019), part of the vertical displacements caused by shortening occur during construction and are partially corrected as the work progresses. At the time of its concretion, the first floor coincides with the absolute level, since the only displacement that occurs is that of the shoring. On the date of concrete on the upper floor, the flights of the columns have already been shortened, causing the displacement of their top, being a little below the design level. Throughout the work, the column flights are shortened, and the displacements are partially corrected in the concrete of the next floor.

According to Ibracon/Abece (2022), the constructive effect is usually neglected, as the structural analysis is usually done considering that the structure will be loaded only when it is ready, which is not consistent with reality.

A problem arising from different displacements is the occurrence of damage to non-structural elements. Fortes (2019) comments that these displacements were not included in the analysis. It is the non-structural elements such as frames, pipes and masonry that may not resist the forces arising from the deformations caused by the relative displacement between consecutive floors or total displacement of the floors, and that only the shortening that occurs after the execution of the non-structural element can cause damage to these elements.

Fortes (2019) also comments on the importance of foundation settlement, which can be important in the analysis of multiple floors, even more so when it comes to differential settlements between columns, but this consideration is not usual due to the uncertainties of soil behavior.

To calculate the incremental analysis, Medieros (2022) lists the following hypotheses:

- a) the structure of the building is shaped in stages;
- b) there is a chronology for the execution of the structure, masonry, floors and coatings;
- c) the characteristics of the modulus of elasticity of concrete as a function of time are known;
- d) the analysis of each step is performed through an isolated linear elastic structural model.

As for the list of loads active in the structure, a summary of this topic is explained by Kripka (1990):

- a) permanent loads: self-weight of the structural and non-structural elements that act throughout the building's existence, in tall buildings they can correspond to about 80% of the total vertical load;
- b) accidental Loads: gravitational loads, resulting from human actions and the weight of furniture and utensils, vary according to use. Because they act during construction, it becomes difficult to make estimates;
- c) mounting loads: loads due to the transit of workers, the storage of construction materials, to the imperfections in the pre-cast, among others;
- d) wind loads: The wind force is a load applied horizontally to the structure, and is calculated from an average speed measured over three seconds, which can be exceeded on average once every 50 years;
- e) temperature action depends on the boundary conditions of the elements. Temperature variation can lead to the occurrence of displacements, influencing their length or curvature;
- f) creep and shrinkage: Shrinkage is characterized by a decrease in the dimensions of structural elements due to the slow evaporation of unconsumed water from the chemical reaction of hardening concrete. As for creep, it depends on the load and is correlated with the following factors: concrete strength, age at which the structure is loaded, dimensions of the elements and reinforcement rate.

If special care is not taken during the construction phases, the loads to be supported by the floors that are serving as support are likely to exceed the design loads.

Regarding the action of shoring during construction, Kripka (1990, p. 8-9) emphasizes that:

In reinforced concrete buildings, props are usually used so that the newly concreted floors are supported by the lower floors. If special care is not taken during the construction phases, the loads to be supported by the supporting floors are likely to exceed the design loads. This problem aggravates the when the accidental load is small in relation to the self-weight.

According to Kimura (2018), it can be said that 100% of the projects consider aspects related to the non-linear behavior of the structure, either in a simplified way or in a more refined way. Since nonlinear behavior is characteristic of reinforced concrete structures, there is a need to consider nonlinearity in the analysis of buildings.

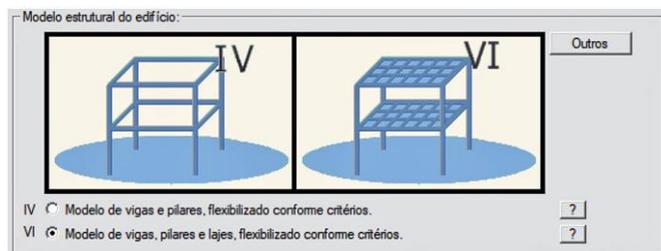
3. Methodology

In this work, a reinforced concrete building was studied for the purpose of comparing the results of the conventional and incremental analyses. This type of research will be done by modeling, from a simulation of a 15-story building subjected to vertical loading (permanent and accidental loads).

For the study, the *structural* analysis and calculation software TQS will be used to model the structure. In conventional analysis, TQS treats the constructive effect in an approximate way, while the incremental analysis is carried out from a refined model, which takes into account the action of the loads and their influence, as the structure will be built, that is, the incremental analysis is carried out from the generation of models that simulate the structure in different stages, and they give rise to an envelope, contemplating the efforts obtained in each stage.

TQS allows the analysis of the structure by two types of modeling, shown in figure 3.

Figure 3: TQS structural models



Source: Author, through the TQS software (2024).

- Model IV: From the creation of a spatial portico and grid, in which the elements are arranged in a three-dimensional way, in which the effects of the actions will be calculated with the spatial portico and the grids analyzed separately.
- Model VI: It allows you to model an integrated spatial frame, based on elements that simulate columns, beams and slabs. In this, the slabs start to collaborate with the structure, resisting horizontal actions. This model allows for more complex analyses.

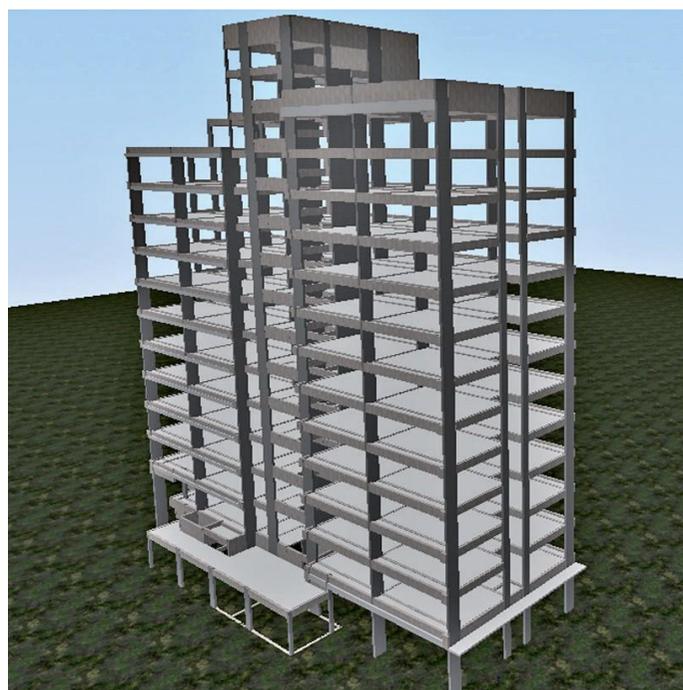
In both models, the TQS considers the constructive effect in an approximate way.

In the linear analysis, by means of the Mulaxi criterion, which measures the axial area of the columns, causing their axial deformation to be reduced in the structural analysis, therefore, the differential axial displacements between columns are reduced (TQS docs, 2024). If the value of $Mulaxi = 1$, the constructive effect would be disregarded. It is worth noting that this consideration is valid only for vertical stocks.

With incremental analysis, the value of the Mulaxi criterion is ignored in the structural analysis. Therefore, in this analysis, the columns will have gross axial area. This disregard is made for cases of loading and for combinations of the models analyzed with an incremental effect (TQS docs, 2024)

The building used in this study is a residential development, located in the city of São Paulo, is 43.16 meters high with a tower divided into the following floors: foundation, 1st floor, 2nd floor, type, 12th floor, barrel, reservoir and roof. The structural system of the enterprise is defined as a structure in conventional concrete. The building presented is by Pedreira Topázio, located in the city of São Paulo. A 3D image of the building model can be seen in figure 4.

Figure 4: 3D structural model (Pedreira Topázio) of the analyzed building



Source: Author, through the TQS software (2024).

First, the design of the structure and a first evaluation with model IV were carried out. After the conclusion of the first stage of analysis, with the structure validated, the option of model VI was checked, followed by "edit building" and the incremental effect was activated, in the "general" tab. After clicking on the option "Analyze the structure considering incremental effect" option.

The action of the wind was not considered in this work due to what was explained by Kripka (1990) that, although the wind acts on the structure from the beginning of construction, the probability that its effect will be very significant during the construction stages is greatly reduced.

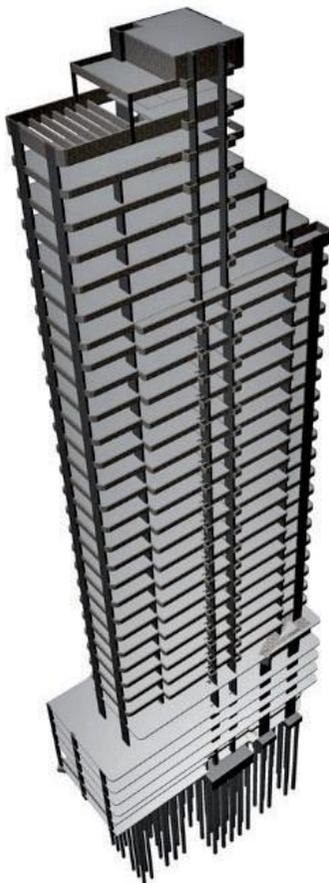
As for the calculation hypotheses, the values used by Marques (2017) were used as a reference, as the construction of a floor in seven days is in accordance with what happens in the execution of the works. The use of the values applied in the respective phases can be seen as a consideration in favor of safety, as the structure can be 100% loaded after delivery, except if there is the performance of loading, such as equipment or materials deposited during construction.

Table 1 shows the values considered in this analysis.

Table 1: Models used for analysis

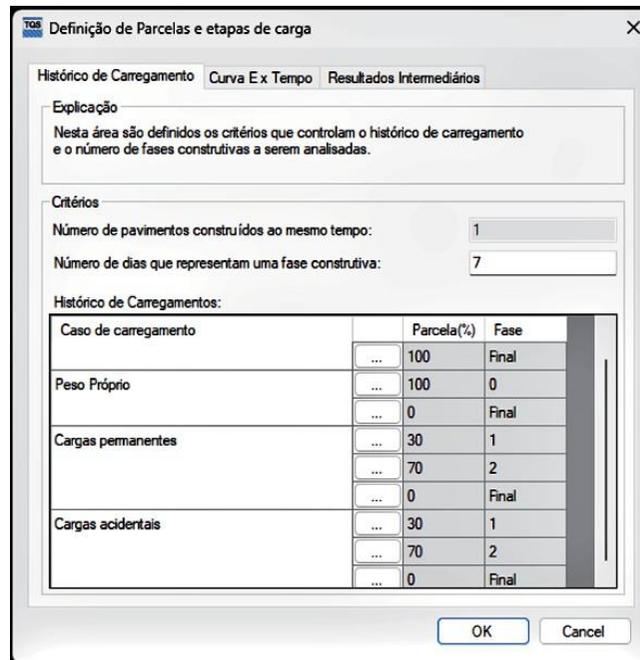
Loading history in the construction effect		
Number of floors built at the same time		1
Number of days representing a construction phase		7
Loading cases	Parcela (%)	Fase
All the permanent and accidental loads	0	0
	100	Final
Self-weight	100	0
	0	Final
Permanent Loads	0	0
	30	1
	70	2
	0	Final
Accidental Loads	0	0
	30	1
	70	2
	0	Final

Source: adapted from Marques (2017).



The loading history table was filled in according to values used by Marques (2017). It was defined that self-weight acts at the initial instant, 30% of permanent and accidental loads act in the first phase, and the remaining 70% act in the second phase, as can be seen in figure 5.

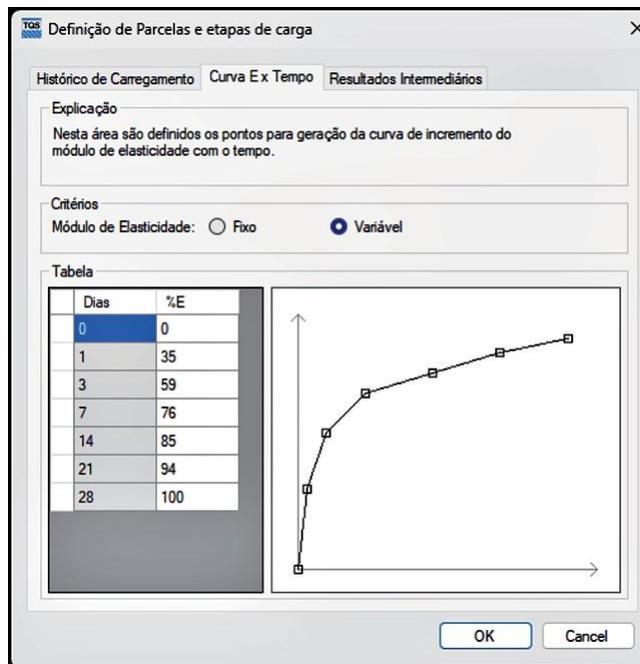
Figure 5: Upload history



Source: Author, through the TQS software (2024).

Another piece of data to be filled in is the "E x time" curve, which represents the function of the modulus of elasticity. The data were obtained from the study carried out by Marques (2017), as shown in figure 6.

Figure 6: Curve "E x Time"



Source: Author, through the TQS software, adapted from Marques (2017).

After filling in the required data, the building was processed and the forces of the columns at the base were obtained, as shown in the third column of table 2. In the second column, the forces obtained from the linear model are presented, considering $Mulaxi = 3$, the *default value* of the TQS. In the third column, the percentage difference between the efforts of the analyses is presented. It is worth mentioning that the value of the $Mulaxi$ may vary, at the discretion of the author of the structural project.

Table 2: Comparison of forces on the columns between elastic model and incremental model.
Characteristic normal stress at the base (tf)

Column	Elastic Model	Incremental Model	Dif (%)
P1	184,61	176,32	-4,5
P2	150,55	140,94	-6,4
P3	130,43	120,74	-7,4
P4	176,99	169,06	-4,5
P5	382,49	360,10	-5,9
P6	332,02	319,70	-3,7
P7	300,09	287,49	-4,2
P8	332,87	315,35	-5,3
P9	229,57	208,28	-9,3
P10	200,93	189,06	-5,9
P11	370,99	347,87	-6,2
P12	374,24	346,10	-7,5
P13	139,51	147,54	5,8
P14	299,07	289,53	-3,2
P15	7,33	7,99	9,0
P16	12,07	13,10	8,5
P17	2,63	2,68	1,8
P18	9,35	9,13	-2,4
P19	5,52	5,30	-4,1
P20	9,01	8,82	-2,1
P21	43,09	42,41	-1,6
P22	16,21	16,05	-1,0
P24	283,14	263,27	-7,0
P25	387,30	367,15	-5,2
P26	362,87	347,91	-4,1
P27	366,96	344,40	-6,1
P28	344,56	317,73	-7,8
P29	315,45	300,98	-4,6
P30	303,59	289,88	-4,5
P31	340,21	320,74	-5,7
P32	184,46	176,02	-4,6
P33	144,57	136,54	-5,6
P34	142,55	133,21	-6,5
P35	185,66	178,33	-3,9
P37	20,89	24,80	18,7

Source: Author, through the TQS software (2024).

4. Analysis of the problem-situation and proposed solution

This study compares the results of conventional and incremental analysis in a reinforced concrete building with 15 floors and foundation. For the analysis of the results, the normal forces at the bases of the columns of the building in question were evaluated. The results will be discussed based on technical literature, highlighting the importance of the analysis of concrete in multi-storey reinforced concrete buildings.

By observing the variation of forces up or down, it can be inferred that there was a redistribution of the forces of the columns, according to Kripka (1990). This is mainly due to different displacements. This redistribution directly influences the forces in adjacent elements.

The measurement of the discrepancies between the analyses should highlight the need for incremental analysis to correctly size the elements, not only because of possible savings, since there was a reduction in efforts in most of the columns analyzed. But, mainly for safety, as some columns can receive more load than estimated with conventional analysis.

It can be said that the incremental analysis demonstrated more precise calculations, by considering the nonlinearity and the constructive effect.

It can be said that the incremental analysis demonstrated more precise calculations, due to the consideration of non-linearity and constructive effect. By means of a synthesis in the TQS software, the analysis was carried out in a relatively simple and effective way, which shows methodological progress and that there is no longer any reason why this analysis should not be carried out in projects of reinforced concrete structures.

In this section, the results of the two analyses will be discussed based on the results in table 2. In the first column, the efforts refer to the linear analysis, in the second, the efforts obtained through incremental analysis, and in the third column, there are the percentage differences.

The incremental analysis showed average reductions of 5.1% in efforts in relation to the elastic model. This reduction is significant because it indicates an improvement in the accuracy of the calculations. The columns were divided into three groups: tower columns, columns up to the second floor and columns up to the third floor. From this, it can be seen that:

- Tower columns (P1-P14, P24-P35): average reductions of 5,5% in efforts.
- Columns up to the second floor (P15-P16): average reductions of 8,5%.
- Columns up to the second floor (P17-P22, P37): average reductions of 3,4%

The analyses show significant differences, as evidenced by the third column of table 2, which presents the percentage differences. It is noted that there is a great variation between the forces of the columns, which is related to the total length of the columns. The columns that present the greatest efforts are the columns that are born in the foundation and continue to the roof. As for the columns that have less effort at the base, these die up to the second floor.

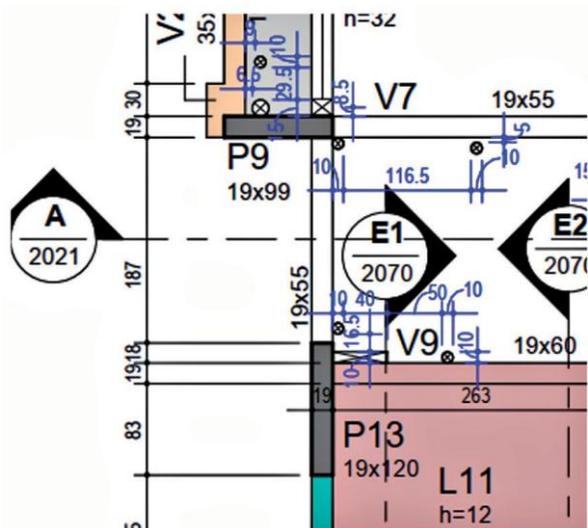
It is known that TQS considers the incremental effect by means of the Mulaxi, a majorator for the axial sections of the columns. Even so, there are differences of almost 10% in tower columns. It is worth mentioning that the study building would be classified as a medium-sized building. Therefore, this variation may be much more representative in taller buildings, due to the nonlinear behavior.

The most frequent differences are between -4% and -6%. With a minimum variation of -1.8% (P17) and a maximum of 18.7% (P37), both are columns that die on the first floor. As for the tower columns, the maximum variation was -9.3% and the minimum was -3,7%. P15 and P16 die on the second floor and showed a reduction of around 8.5%. In summary:

- a) Tower Columns: incremental analysis reduced efforts across 96% of the columns;
- b) Columns up to the second floor: significant reductions in P15 (9%) and P16 (8,5%);
- c) Columns up to the first floor: moderate reductions, except P37 (increase of 18,7%).

From now on, we will address the case of P9, which was the tower column that showed the greatest variation. It is important to observe the position of the P9 column in the structure, to understand the reason for this difference. Based on the literature, it is known that the displacements can be seen, in figure 7, that next to column P9, there is column P13.

Figure 7: Position of columns P9 and P13 on the standard floor



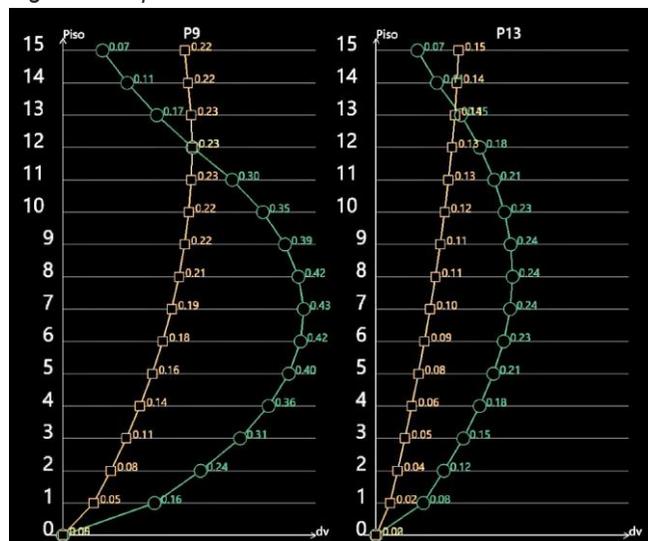
Source: Author (2024).

Column P13 presents increased load in incremental analysis. This can be explained by the fact that the

P13 be less stressed than P9. It has a load of 229.57 tf and has an axial area of 19x99, while the P13 column has an area of 19x120 and a base force of 139.51 tf, almost half the force of P9 and an axial section about 20% larger. Ideally, the columns would have had equivalent tensions, however, this was not feasible due to architectural requirements.

In this study, the results described by Kripka were found, as can be seen in the orange curve (linear analysis), in figure 8. The displacements increase proportionally to the height of the wick, while in the nonlinear analysis, the largest displacements occur in the middle of the column, as shown in the green curve in figure 8.

Figure 8: Displacements of columns P9 and P13



Source: Author, through the TQS software (2024).

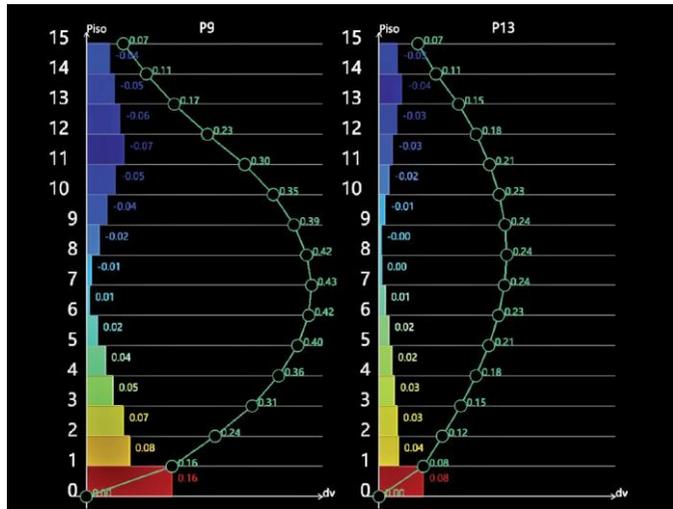
Column P9 has a displacement in the first floor, almost three times greater than the displacement calculated by the linear analysis, while in P13 the displacement is four times greater, following this approximate discrepancy up to the fourth floor. From the fifth to the ninth floor, this difference decreases and is close to two times. From the ninth floor onwards, the incremental analysis curve decreases, while the linear analysis curve increases, to an intersection point on the 12th floor (P9) and the 13th floor (P13). From then on, the displacements of the incremental analysis tend to decrease, reaching less than half, comparing them with the displacements of the linear analysis.

Note that the curves have different shapes. The displacements obtained in the incremental analysis tend to be much smaller when compared to the displacements of the first floors. This is due to the change of section from the 12th floor onwards.

Kripka (1990) states that when vertical differential displacements occur between adjacent nodes on the same floor, these displacements inform that there are great differences between the efforts provided by the two procedures studied. In figure 9, we can see a colored graph which shows the relative displacement

values of columns P9 and P13 per floor and in the green curve the values of accumulated displacements.

Figure 9: Column displacements P9 e P13



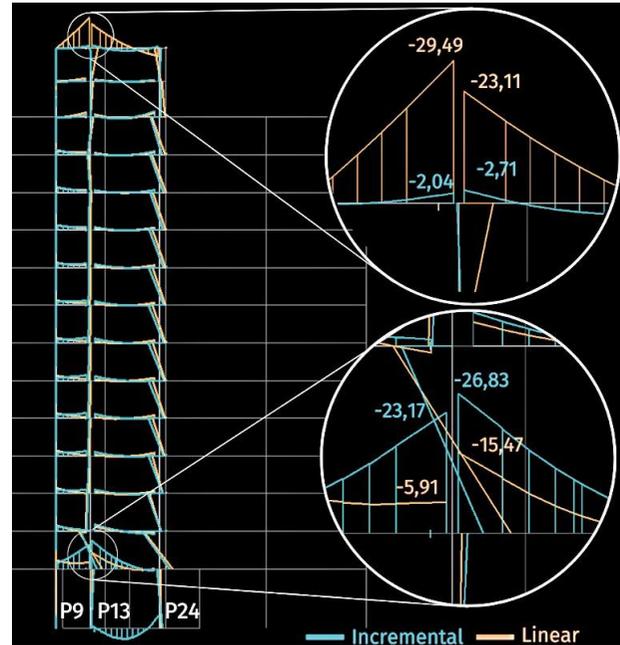
Source: Author, through the TQS software (2024).

It is verified that, on the first floor, the relative displacement of P9 is twice that of P13. This difference remains accentuated from the second to the fourth floor, smoothing from the fifth. On the seventh floor, the displacements reach 0.01 for the two columns, presenting negative values from the eighth floor of the P9 column and the ninth of the P13 column, and the P9 presents higher negative values, reaching more than double in the 12th, decreasing from then on, presenting closer values on the 14th and 15th floors.

Axial displacements between columns cause redistribution of forces between structural elements, in addition to pathologies in non-structural elements, such as masonry, frames and pipes.

The redistribution of the forces in the columns causes changes in the bending moments of the adjacent beams, especially in the beams that connect two columns subject to a large difference in stress, as can be seen in figure 10.

Figure 10: Bending moments (tf.m) in the frame composed of columns P9, P13 and P24



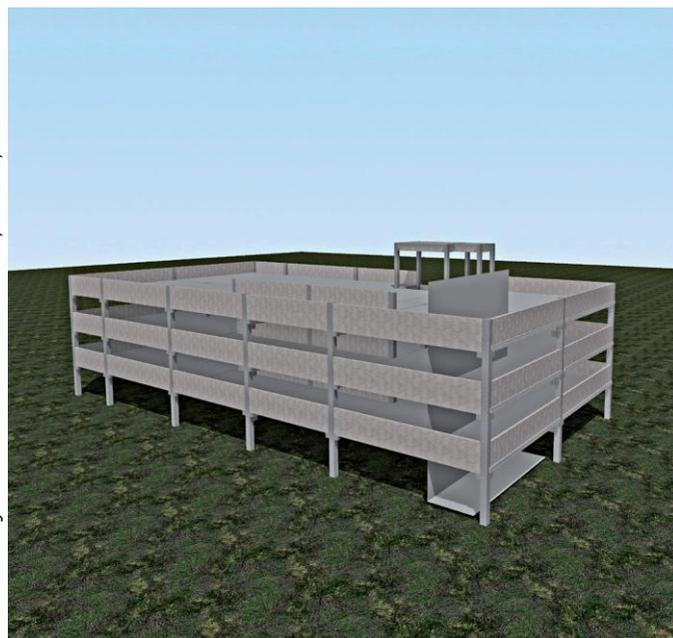
Source: Author, through the TQS software (2024).

The response of the incremental analysis shows that there are large discrepancies between the values of negative moments in P13, which does not happen. It should be noted that the greatest discrepancies occur on the first and last floors. In the first stage, the difference between the highest moments of denial, to the right of P13, is as much as 70% in the incremental analysis. While in coverage, the difference between values is even greater, the values of negative moments found in the incremental analysis represent approximately 10% of the value of the moments found in the linear analysis.

The results of this study demonstrate the importance of considering the nonlinearity of materials and the constructive effect in the design of reinforced concrete structures.

On the top floor, the high negative moment of the linear analysis is due to the great rigidity of the plat band beams, which are 172 cm high. On the first floor, the columns in question are subjected to the forces of a larger area of influence than on the upper floors and have a ceiling high of 4.44 m, being the only flight with a height greater than 2.8 m.

Although the linear analysis considers the constructive effect through Mulaxi, the discrepancies are relevant and the result is elements sized differently from their actual behavior.



In this work, a medium-sized building of moderate complexity was studied, when compared to the grandiose and daring structures that permeate the landscapes of cities such as São Paulo and Balneário Camboriú, many of the order of 150 to 200 m, with the One Tower reaching 290 m in height.

Some limitations:

- a) The tower has 34 columns in all, only 25 of which ran from the foundation to the roof, a limited sample;
- b) Creep and shrinkage were not considered;
- c) The performance of dynamic loads was not evaluated.
- d) Wind action was not considered.

5. Final Considerations

This work aimed to show the importance of incremental analysis in the design of reinforced concrete buildings, especially in columns. Then, the modeling of a 15-story reinforced concrete building was carried out using TQS *software*, simulating the consideration of the constructive effect, in order to discuss the results from the linear and incremental analyses.

In the linear analysis, the TQS considers the constructive effect, increasing the axial sections of the columns, however, it is understood that this does not lead to a response similar to the actual behavior of the structure. To contemplate the constructive effect in the incremental analysis, we used the variable parameters such as modulus of elasticity function and vertical loading were applied in stages. In the case of the present study, each stage would be built in seven days, so each phase would represent a constructive stage.

One of the main reasons for using incremental analysis is that it better reflects the actual behavior of the structure, providing more accurate results, optimization of materials, and greater structural safety. The larger and more complex the structure, the greater the need for this type of analysis.

It was found that there was a reduction in efforts in 96% of the columns, and that the shorter columns also showed significant differences in the analyses. A margin reduction of less than 10% may not seem so significant, but for the design of foundation elements it can mean one less plateau, therefore, a smaller block, resulting in resource savings.

Very discrepant axial displacement values were found on the same floors, and the redistribution of forces in the spatial frame influenced the forces of the beams that connected the columns, therefore, in the design of these elements. The results of this study demonstrate the importance of considering the non-

linearity of materials and constructive effect in the design of reinforced concrete structures. The long processing time should not be an excuse anymore, given the gains obtained with this type of analysis.

This study confirmed the importance of incremental analysis in the design of reinforced concrete buildings. The consideration of the constructive effect provided a reduction in the efforts on the columns and optimization of materials, demonstrating the need for this approach to ensure accurate and safe results in complex projects.

The consideration of the constructive effect provided a reduction in efforts on the columns and optimization of materials, demonstrating the need for this approach to ensure accurate and safe results in complex projects.

The need to consider the constructive effect in the design of structures is a fact that has been verified for many years. However, although we have Brazilian references on the subject dating back more than 30 years, this analysis is not yet very widespread. Incremental analysis is a very important topic and deserves to be explored much more. For this, I leave some suggestions for future work:

- a) simulation with shoring effect;
- b) case studies with different types of columns;
- c) incremental analysis contemplating the effects of creep and shrinkage;
- d) analysis of a building with more than 30 floors;
- e) investigation of the variation of the structural response with the variation of the percentage of loading applied per phase.

Bibliographic references

- ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 6118**: Projeto de Estruturas de Concreto. 4 ed. Rio de Janeiro: Abnt, 2023. 242 p.
- FREITAS, Alexandre Alves de. **Situações críticas no projeto de edifícios de concreto armado submetidos a ações de construção**. 2004. 103 f. Dissertação (Mestrado) - Curso de Engenharia de Estruturas, Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2004. Available at: https://producaocientifica.eesc.usp.br/producao/2004ME_AlexandreAlvesFreitas.pdf. Accessed in: 07 nov. 2024.
- FORTES, Gustavo Licht. **Encurtamento de pilares de concreto armado e a influência do processo construtivo**. 2019. 205 f. Dissertação (Mestrado) - Curso de Engenharia de Estruturas e Geotecnia, Escola Politécnica da Universidade de São Paulo,

São Paulo, 2019. Available at: https://www.teses.usp.br/teses/disponiveis/3/3144/tde-12092019-132403/pt-br.php?trk=public_post_comment-text. Accessed in: 25 nov. 2024.

IBRACON/ABECE (São Paulo) (ed.). **Estruturas de concreto armado**. São Paulo, 2022. v 1.

GORZA, Leonardo Santos. **Análise incremental construtiva de edifícios metálicos de andares múltiplos usando o método dos elementos finitos**. 2000. 328 f. Dissertation (master's degree) - Civil Engineering Course, Federal University of Espírito Santo, Vitória, 2000. Disponível em: <https://pt.scribd.com/document/373788023/Analise-Incremental-Cons-trutiva-de-Edificios-Metalicos-de-Andares-Multiplos-Usando-o-Metodo-Dos-Elementos-Finitos>. Accessed em: 05 dez. 2024.

KRIPKA, Moacir. **Análise incremental construtiva de edificações**. 1990. 129 f. Dissertação (Mestrado) - Civil Engineering Course, Federal University of Rio de Janeiro, Rio de Janeiro, 1990. Available at: <https://pantheon.ufrj.br/bitstream/11422/3962/1/172202.pdf>. Accessed in: 10 nov. 2024.

KIMURA, Alio. **Informática aplicada a estruturas de concreto armado**. 2ª ed. São Paulo: Oficina de Textos, 2018. 428 p.

MARQUES, Olivia Catelan. **Avaliação dos efeitos construtivos e interação solo-estrutura na estabilidade global de edifícios**. 2018. 157 f. Dissertação (Mestrado) - Civil Engineering Course, Structures Concentration Area, Federal University of Espírito Santo, Vitória, 2018. Available at: <https://repositorio.ufes.br/server/api/core/bitstreams/f4beae8d-f90a-48d9-bd81-732aff2069a5/content>. Accessed in: 16 nov. 2024.

PRADO, José Fernão Miranda de Almeida. **Estruturas de edifícios em concreto armado submetidas a ações de construção**. 1999. 184 f. Tese (Doutorado) - Structural Engineering Course, São Carlos School of Engineering, University of São Paulo, São Carlos, 1999. Available at: https://producaocientifica.eesc.usp.br/producao/1999DO_Jose-FernaoMirandadeAlmeidaPrado.pdf. Accessed in: 05 nov. 2024.

RACHINHAS, Bárbara Chagas. **Simulação computacional do processo construtivo da estrutura de edifícios em concreto armado**. 2020. 226 f. Dissertação (Mestrado) - Civil Engineering Course, Engineering School, Federal University of Rio Grande do Sul, Porto Alegre, 2020. Available at: <https://lume.ufrgs.br/handle/10183/212515>. Accessed in: 17 nov. 2024.

MEDEIROS, Sérgio Ricardo Medeiros (ed.). **Influência do efeito construtivo em estruturas de concreto armado**. **TQS News**, São Paulo, v. 50, n. 50, p. 38-43, mar. 2022.

TQS Docs (São Paulo) (ed.). **Efeito Incremental**. 2024. Available at: <https://docs.tqs.com.br/Docs/Details?id=3154&search=EFEITO%20INCREMENTAL&language=pt-BR>. Accessed in: 01 nov. 2024.



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Where is engineering education going in Brazil?

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1. Introduction

Engineering is, historically, one of the fundamental bases of the technical, economic and social progress of any civilization. In each phase of human development, the figure of the engineer was present as the protagonist of the material and organizational transformation of the world.

In the modern context, engineering has become indispensable for the functioning of practically all productive sectors: from civil construction, through industry, transport, telecommunications, energy, logistics, agribusiness, to emerging technologies such as artificial intelligence and renewable energies. Contemporary society depends largely on the technical competence of these professionals to sustain their way of life.

No nation that aspires to technological independence and economic sovereignty does without a robust system for the training of engineers. Countries such as Germany, South Korea, Japan, the United States and China have understood in recent decades that systematic investment in engineering education is one of the columns for sustained growth.

These countries have developed consistent public policies to ensure not only the quantity but also the quality of the training of engineers. Through the articulation between the State, universities and the productive sector, they have structured environments where technical knowledge is valued, applied and continuously renewed.

Brazil, in turn, has experienced a process of significant expansion of higher education, especially in the last two decades (2005 to 2025). Within this movement, engineering courses stood out in terms of the number of enrollments and institutions authorized to offer them. However, this quantitative expansion was not accompanied in the same proportion by quality control mechanisms and integrated public policies for professional training.

The consequence is an ambiguous scenario: while we train about 100 thousand engineers per year (2023 data), worrying indicators of dropout, low quality of training, misalignment with the demands of the labor market, and underutilization of technical labor persist.

This article aims to offer a critical analysis of engineering education in Brazil, with emphasis on undergraduate courses. The proposal is not to exhaust the theme – whose complexity requires a multidisciplinary approach – but to contribute for

the public debate based on concrete data, statistical evidence and structured reflections on the main bottlenecks of engineering education in the country. To this end, aspects such as the evolution of the course offer, regional distribution, the teaching modality (face-to-face x distance learning – DE), dropout and completion rates, in addition to institutional characteristics that directly affect the quality of training will be analyzed.

It is important to make it clear, from the outset, that any attempt to accurately diagnose the current state of engineering education in Brazil faces difficulties inherent to the complexity of the subject. Various external and internal variables interact, simultaneously and not always linearly, on the educational system. Among these variables, macroeconomic factors such as the level of construction activity, interest rates, the cost of student finance, and the Brazil risk stand out – all of which directly influence the attractiveness of the engineering course and the future employability of graduates.

In each phase of human development, the figure of the engineer was present as a protagonist of the material and organizational transformation of the world.

In addition, structural aspects internal to the educational system also play a fundamental role: the quality of the teaching staff (almost never questioned), the infrastructure of the courses, the curricula adopted, the articulation with the productive sector, the internship and scientific initiation programs, as well as the institutional policies of permanence and support for the student. In many cases, failure in the academic trajectory is not only the result of the difficulty of training in engineering – which is, by nature, demanding – but also of the absence of technical, financial and psychological support to students.

In this multifactorial scenario, it becomes even more necessary to adopt a critical and data-based approach to assess the real situation of engineering education in Brazil. This is precisely the purpose of the present work: to offer an analytical portrait of engineering education, based on the most recent data available until 2023. It is believed that only through a qualified, evidence-based and solution-focused debate will it be possible to put engineering back at the center of the country's development strategy.

II IMPACTO

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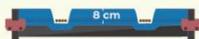


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2. Supply and demand of vacancies

2.1 Evolution of the number of engineering courses in Brazil

The trajectory of expansion of the supply of engineering courses in Brazil reflects, to a large extent, the broader movement of massification of higher education that began in the 2000s. From student financing programs (such as Fies) and access programs (such as Prouni), there was a direct stimulus to the creation of new courses, mainly by private institutions.

In 2010, the country had about 3,200 engineering courses. This number jumped to 4,500 in 2015, reaching approximately 5,800 active courses in 2020 – a level that remained until 2023.

This significant increase has a direct impact on the number of vacancies offered in engineering courses in Brazil, as can be seen in graph 1. It should be noted that in 2023, 111,605 vacancies were offered in public courses and almost 695 thousand in private institutions. Civil Engineering stands out in this scenario as the most offered modality, with about 900 courses distributed nationally.

This numerical growth, although expressive, raises serious concerns about the quality of the training offered. The rapid proliferation of courses, often without proper technical evaluation and without adequate infrastructure, compromised the consistency of training in several regions. The fragmentation of the offer – with many courses spread across small cities and newly created institutions – makes it difficult to create centres of excellence and strengthen applied research.

Chart 1: Annual offer of vacancies in engineering courses in Brazil



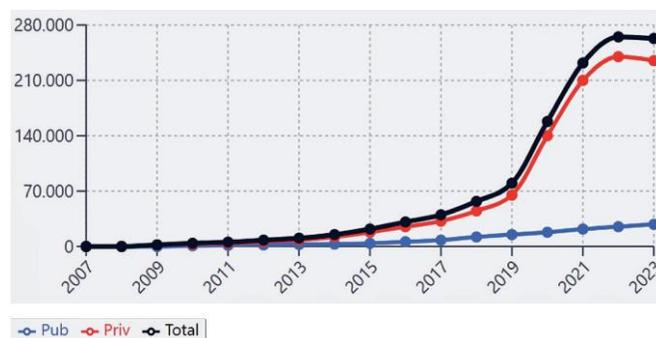
Source: Inep.

Another important point about graph 1 is that the year 2018 marks the highest point of the curve for private institutions (815,918 vacancies), coinciding with the intensification of distance engineering courses. This time frame reinforces the thesis that distance education was the main vector of the recent growth in supply – even though it is controversial in terms of effectiveness for technical and experimental areas such as engineering.

2.2. Comparative number of enrolments: Distance learning x face-to-face

In recent years, distance learning (DE) has been rapidly gaining ground in the Brazilian higher education scenario. In the case of engineering, an area traditionally associated with laboratory practice and face-to-face technical training, the advancement of distance education arouses controversial reactions. In 2010, there were practically no DE enrollments in engineering courses recognized by the MEC, as shown in graph 2. However, this number has grown significantly, reaching almost 150 thousand enrollments in 2020 and exceeding 250 thousand enrollments in 2023.

Chart 2: Enrollment in distance education in engineering courses in Brazil



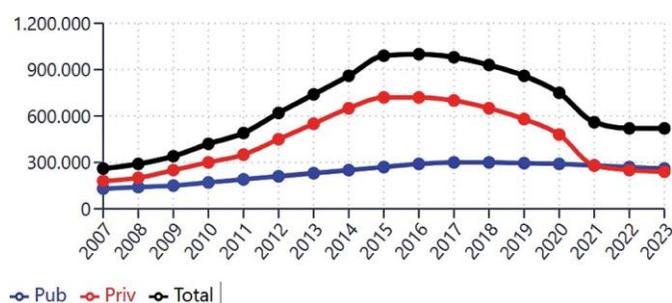
Source: Inep.

Meanwhile, as can be seen in graph 3, the total number of face-to-face enrollments reached its **peak in 2015**, with more than 1 million students. Since then, there has been a **continuous and significant drop**, with the total falling to just over 500 thousand in 2023 – a retraction of more than **50% in eight years**.

Public **institutions** showed continuous and moderate growth until 2019, when they reached around 300 thousand enrollments. Since then, the numbers have fluctuated slightly but remain at **much more stable levels** than those of the private network. This suggests greater resilience or less sensitivity to cyclical factors.

As of 2022, for the first time in many years, the number of students enrolled in public and private institutions **is significantly closer**. In 2023, this **convergence is consolidated**, which indicates a **change in the profile of face-to-face engineering teaching**, possibly due to migration to distance education or structural evasion of the area.

Chart 3: Enrollment in face-to-face engineering courses in Brazil



Source: Inep.

This phenomenon reflects two parallel forces: on the one hand, the pressure for scalability and cost reduction on the part of private institutions; on the other hand, the regulatory flexibility that allowed the expansion of courses without the requirement of robust physical infrastructure.

Engineering, unlike theoretical courses such as administration or pedagogy, requires direct contact with real materials, equipment, and simulations – factors that are not easily replaceable by digital platforms.

This quantitative expansion was not accompanied in the same proportion by quality control mechanisms and integrated public policies for professional training.

Despite advances in educational technologies and virtual laboratories, there is still no academic consensus or support from the productive sector regarding the equivalence of competencies between distance education graduates and those present in engineering. The training of engineers at a distance therefore needs to be discussed with caution.

2.3. Comparison of the number of vacancies: public x private

Another fundamental aspect concerns the distribution of vacancies between public and private institutions. In 2023, private institutions concentrated about **85% of engineering vacancies** in Brazil, while public institutions accounted for only **15%**. This asymmetry reveals a strong dependence on the private sector in the training of Brazilian engineers – which, in turn, can have implications for quality, equitable access and the ability to articulate with public policies for regional development.

In absolute numbers, private vacancies evolved from about 290 thousand in 2010 to more than 430 thousand in 2023, and in 2015 we had almost 500 thousand enrollments. Public institutions, on the other hand, maintained a more discreet growth curve, going from 160 thousand to about 280 thousand vacancies in the same period, and in 2015 they maintained the number of 240 thousand enrollments.

This difference is also observed in the indicators of infrastructure, teacher qualification, and scientific production. Public institutions generally concentrate on the courses with the best Enade evaluations and the highest employability rates.

We can assume that the rapid expansion in the private sector, without rigid mechanisms for continuous evaluation, resulted in the opening of courses in regions without an absorbing market, with a lack of master's and doctoral professors and with little articulation with the local productive sector. Therefore, discussing the sustainability of the current model implies reviewing the role of the State both as a direct provider and as a regulator and inducer of quality in the private sector.

2.4. Analysis: vacancies offered x registered x freshmen

An important fact to understand the dynamics of attraction of engineering courses is the mismatch between the number of vacancies offered, the number of candidates enrolled and those entering. As can be seen in the following image, in face-to-face courses, in 2010, about 250 thousand vacancies were offered to 680 thousand enrollees and 150 thousand entrants. In 2023, this scenario changed: there were more than 700 thousand vacancies available, but only about 640 thousand registered and about 190 thousand effective entrants.

Chart 4: Offers, enrollees and entrants (enrolled) in face-to-face engineering courses (public and private) in Brazil

Source: Inep.



This reveals two phenomena: first, the supply of vacancies grew faster than the real demand; second, a significant portion of those enrolled do not enroll. This mismatch is aggravated in private and distance education courses, where surplus vacancies often result in small classes, with low competitiveness and precarious infrastructure.

This numerical growth, although expressive, raises serious concerns about the quality of the training offered.

In addition, the drop in the number of applicants may be related to the reduction in the attractiveness of the engineering course, motivated by factors such as the high historical dropout, the perception of limited financial return, and the high academic demand.

As for distance education, the situation is even more alarming. Despite the increase in vacancies, the number of registered candidates is significantly lower. In 2023, there were more than **900 thousand vacancies**, but only about **320 thousand candidates registered**, revealing a **low occupancy rate of vacancies** and suggesting a possible over offer in relation to the real demand.

Even with the mismatch between supply and demand, the number of new entrants has grown continuously. From less than 20 thousand in 2015, the number of new entrants increased to more than **220 thousand in 2023**, indicating a greater acceptance of the distance education modality by students and a probable improvement in the institutions' recruitment mechanisms.

Chart 5: Offers, enrollees and entrants (enrolled) in distance learning engineering courses (public and private) in Brazil



Source: Inep.

The curve of new entrants almost entirely follows the private sector, showing that the public sector has a **marginal participation in distance education in engineering**. The massive expansion of distance education in Brazil has been predominantly driven by private institutions.

Another relevant point is that the number of ingredients does not revert proportionally to conclusions. With dropout rates that exceed 50% in some institutions, the system loses a large part of the investment made in expanding the offer. This reinforces the importance of not only expanding the number of vacancies, but ensuring retention mechanisms, pedagogical support and qualification of training.

Finally, Chart 6 shows the panorama of trainees by engineering modality. As can be seen, civil engineering continues to be the course that trains the most in Brazil. It was and is the modality that has the largest number of members, but it is also the most penalized in terms of reduction of interest, from 131 thousand entrants in 2015 to 62 thousand in 2023 (last census of Inep).

Chart 6: Freshmen in engineering by modalities per year in Brazil



Source: Inep.

3. Dropout, retention and completion of engineering courses

The training of engineers in Brazil is a central theme for the country's technological and industrial development. However, it is not enough just to expand the range of vacancies: it is essential to understand how students progress throughout the course, whether they complete their degree or drop out along the way. In this section, we analyze the evolution of the number of enrollments and graduates, comparing the public and private sectors, as well as discuss the dropout indicators in engineering education.

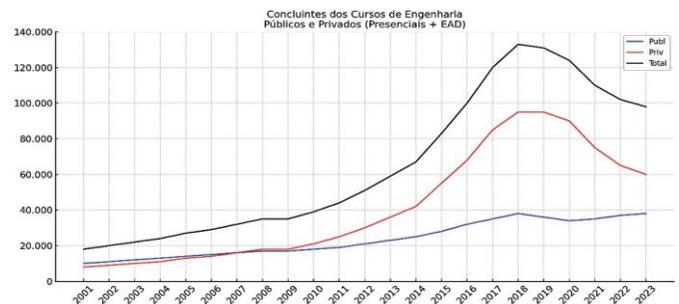
3.1. Analysis of the number of graduates: private x public sector

When we analyze the data of graduates, the differences between the sectors become even more evident. In 2010, for example, the private sector trained about 30 thousand engineers per year, while the public sector registered around 20 thousand. This number increased until 2017-18, with the peak in the private sector reaching more than 80,000 annual graduates, while in the public sector it reached just over 37,000.

The training of engineers at a distance therefore needs to be discussed with caution

However, from 2018 onwards, there was a significant drop in the number of graduates, especially in private institutions. In 2023, the private sector trained about 60 thousand engineers, a level lower than that recorded almost a decade earlier. The public sector, in turn, maintained relative stability, with about 37 thousand graduates in the same year.

Gráfico 7: Graduates of engineering courses (face-to-face and distance learning) per year in Brazil



Source: Inep.

This behavior may be indicative of the difference in the quality of training and in the mechanisms of student permanence between the two sectors. In general, public institutions have greater infrastructure, more qualified teachers and programs to support permanence, such as scholarships and grants, which contribute to higher completion rates.

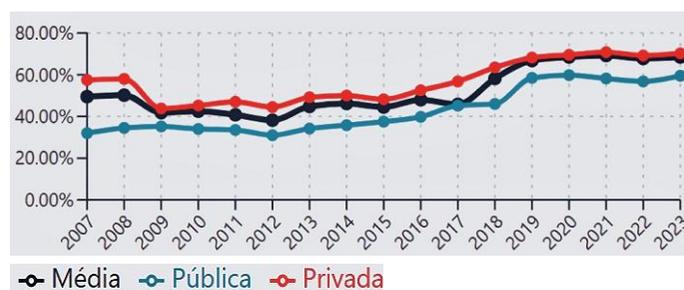
The private sector often faces difficulties in keeping students until the end of the course, especially in times of economic crisis and political instability to encourage education.

3.2. Analysis of the dropout from engineering courses

Dropout is one of the biggest challenges faced by engineering courses in Brazil. Considering the data on enrollments and graduates, we can estimate that only about 50% of the freshmen reach the end of their undergraduate studies. Studies show that, in some institutions, only about 1/3 of students complete the course in the expected time.

Professor Vanderli Oliveira in an article for the magazine *A Lanterna* (vol. 2, 2024) studied and presented graph 8 showing the variation in the dropout rate from engineering courses for each year since 1997.

Chart 8: Dropout per year from engineering courses in Brazil considering six years to complete the course



Source: Revista A Lanterna.

It should be noted that historically dropout rates in private institutions are much higher than in public institutions. This reality stems from several factors. In the opinion of the author of this article, in the first place, the engineering course requires a solid foundation in mathematics and physics, which creates difficulties for students with deficient training in high school (the filter of freshmen is greater in public universities).

In addition, the long duration, the intensive workload and the need for supervised internship are elements that put pressure on students. In the private sector, dropout is also associated with the difficulty of paying tuition fees, the low quality of some courses, and the perception that the financial return is not worth the investment.

A worrying fact in this graph is that, in the last 10 years, dropout rates in engineering courses have systematically increased, which shows a trend of disinterest in finishing the course on the part of freshmen.

To face this scenario, it is essential that institutions develop policies for welcoming, leveling and pedagogical monitoring, as well as measures to enhance their career and improve the employability of newly graduated engineers, which is known to be not easy to do.

4. Final Considerations

This article analyzed the recent evolution of engineering education in Brazil, based on official data up to 2023. Although it is not intended to exhaust a topic of such complexity, some notes stand out:

a. The expansion of distance education in engineering is significant, but raises serious doubts about quality

In recent years, the number of entrants and subjects in distance learning engineering courses has grown exponentially, surpassing the mark of 250 thousand subjects in 2023. However, this expansion occurred majorly in the private sector and without consensus on the formative equivalence between distance education and the face-to-face model. Given the practical and experimental nature of engineering, this movement requires critical reflection, especially in the face of the absence of laboratory infrastructure in many distance learning courses.

b. The total number of graduates fell after 2018, even with a high supply of vacancies

From 2018 onwards, the number of graduates began to fall, especially in private institutions. In 2023, the private sector trained fewer engineers than in 2015, even with a much higher supply of vacancies. This suggests that the simple expansion of the offer – especially via distance education – has not been reversed in greater effectiveness in the training of engineers.

This reinforces the importance of not only expanding the number of vacancies, but ensuring retention mechanisms, pedagogical support and qualification of training.

c. The number of places offered far exceeds the actual demand

The article shows that, although there are more than 1.6 million vacancies available (adding distance education and face-to-face), the number of effective enrollees is much lower – about 960 thousand. This results in a low occupancy rate and indicates a worrying oversupply, especially in distance education courses.

d. Dropout rates in engineering courses is structural and growing

Even with recent improvements in the completion rates, the data indicates that **the average national dropout rate is between 40% and 50%**. Private institutions have even higher dropout rates, exceeding 60% in certain years. The difficulty of training, the low financial attractiveness of the profession and the mismatch between high school and the requirements of the course support this dropout.

e. Civil engineering concentrated the largest number of entrants – and also the biggest drop

Civil engineering was largely responsible for the growth of engineering modalities in the years of expansion (2010 to 2015), reaching more than 130 thousand entrants in 2015. However, it was also the most affected by the retraction: in 2023, this number fell to around 62 thousand. This signals that the sector may be saturated or that there is a change in the perception of professional return in the area.

The private sector often faces difficulties in keeping students until the end of the course, especially in times of economic crisis and political instability to encourage education.

f) The private sector dominates engineering education, but faces serious quality challenges

About 85% of enrollments and graduates in engineering courses come from private institutions. This hegemony, however, does not translate into better performance: private courses face more dropout, less infrastructure, lower teacher qualifications and worse institutional evaluations. The dependence on private training, without the counterpart of a rigorous control of quality, compromises the standard of trained professionals.

g) Even in public institutions, the demand for engineering has been falling

The article shows that, contrary to what one might assume, the drop in demand is not exclusive to the

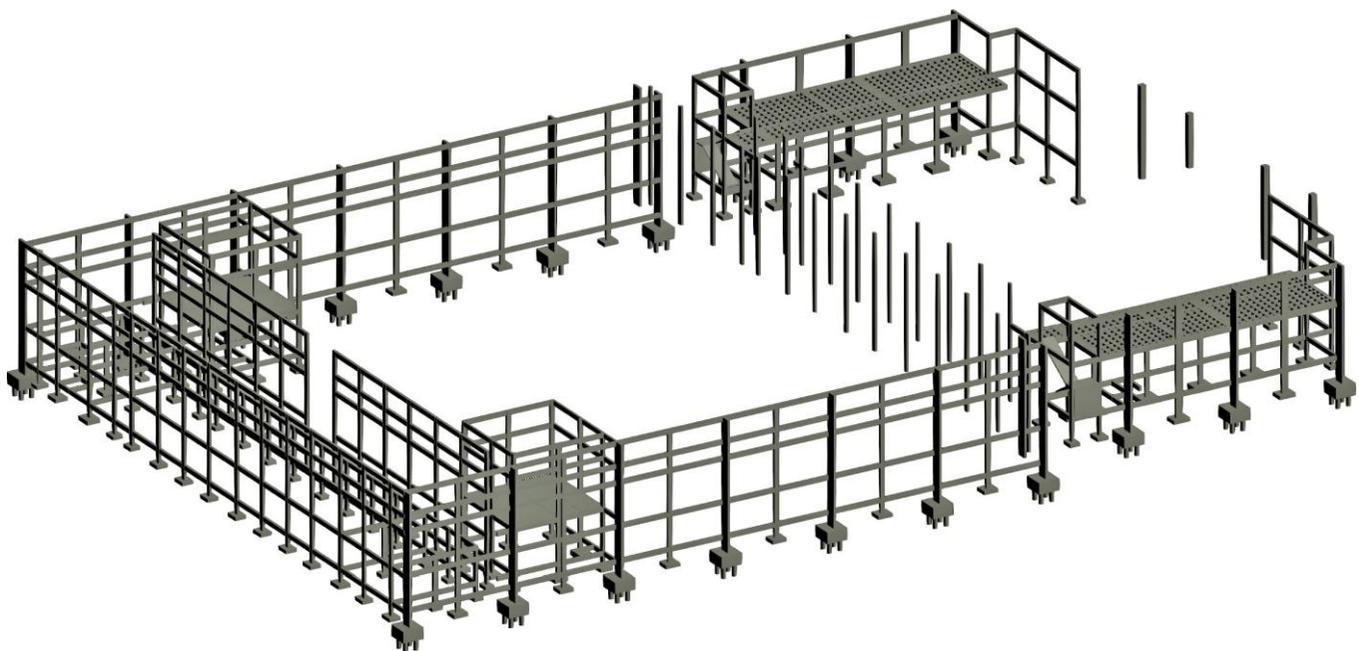
private sector. Even in public universities, which are more stable and selective, the number of face-to-face entrants decreased significantly between 2015 and 2023. This indicates a change in social perception about the attractiveness of the engineering career in Brazil, motivated by low professional appreciation, economic instability, and scarcity of public policies for technical employability.

This signals that the sector may be saturated or that there is a change in the perception of professional return in the area.

To reverse this scenario, it is proposed to:

- Strengthen regulatory and course evaluation processes, with focus on quality, not just quantity.
- Expand the integration between universities and the productive sector to give a practical character to the student's experience of engineering;
- Stimulate practical training, with modern laboratories, applied projects and supervised internships;
- Develop support and permanence policies for students, especially in more demanding courses;
- Promote teacher training and appreciation programs in engineering.

The future of engineering in Brazil will depend mostly on the ability to face these challenges with courage, planning and commitment to quality training.



Shear effort, we still need to talk more about it

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Michael P. Collins and Daniel Kuchma are the authors of *How Safe Are Our Large, Lightly Reinforced Concrete Beams, Slabs and Footings*, article written on July 4, 1999. Although it is a distant date, 17 years, they address a topic that is not yet present in the technical conversation circles of structural engineers – the decrease in the ultimate shear force in beams with large dimensions, also referred to as the scale effect.

In this article, the authors perform tests on 22 beams and discuss the changes in the ultimate shear force due to the scale factor, air reinforcement distribution, longitudinal arrangement, use of high-performance concrete¹ and minimum transverse reinforcement. In the end, they suggest correction in the procedures for calculating the shear of the ACI for structural elements without stirrups.

He also demonstrated that as the useful height of the beam increased, the resistance to ultimate shear force decreased.

The origin of all this discussion and proposals for corrections in the ACI began in 1955, in the partial collapse of a hangar of an American airline, in Shelby, Ohio. In 1957, Anderson pointed out that the collapse was caused by the insufficient shear strength of 30/91 beams that did not contain stirrups and had a longitudinal reinforcement rate of 0.45%.

In 1967, 10 years later, Kani warned about the influence of the scale effect in an article in ACI entitled *How Safe Are Our Large Concrete Beams?* – very similar to the title of Collins and Kumacha's article, right? He also demonstrated that as the useful height of the beam increased, the resistance to ultimate shear force decreased. However, in Kani's rehearsals, some unforeseen events and mistakes happened, the results did not go as expected and no changes were made.

In 1989, in Japan, Shioya conducted an experimental program on beams with low longitudinal reinforcement ratios to demonstrate the decrease in ultimate shear force as the useful height of the beam increases. At the end of the tests, it was clear that, with the increase in the height of the beam and with the decrease in the diameter of the aggregate, the ultimate shear force decreased.

In 1994, AASHTO together with the Canadian standard, CSA, introduced measures for the procedu-

res calculation of the shear force based on the modified theory in the compression fields (*Modified Compression Field Theory*). In this model, the resistance to the shear force in structural elements without stirrups occurs as a function of the width of the cracks, which, in turn, is related to the spacing of these cracks and the stress on the longitudinal reinforcement. She points out that, in large-scale structural elements, the cracks are wider and more widely spaced, thus having a predilection for collapse due to the shear stress. It also points out that the shear is related to the roughness of the cracks, which, in turn, for concretes of usual strength, is influenced by the size of the aggregates.

After all this historical rescue of the cutting effort, we arrive at the date of 1999, when Collins and Kuchma talked about the scale effect and the ultimate cutting. In the tests of the 22 beams, continuous and bisupported, with variations in formwork, longitudinal arrangements, compressive strength of concrete, skin reinforcement and transverse reinforcement, they also reach the same conclusions as the researchers who preceded them. The ultimate shear effort decreases with the increase in the useful height of the beam, with the decrease in the diameter of the aggregate. With the increase in the number of layers of longitudinal reinforcement, with the use of skin reinforcement, and minimum transverse reinforcement with minimum spacing, it has a simple improvement. Michael and Daniel also paid attention to the precepts of the modified theory of compression fields in shear calculation procedures.

She points out that, in large-scale structural elements, the cracks are wider and more widely spaced, thus having a predilection for collapse due to the shear stress.

Quantitatively, the results of the tests showed that, in beams that do not comply with the precepts indicated above, the ultimate shear force was about 60% lower than that obtained with the ICA calculation procedures.

In my view, the tests also showed that the distribution of longitudinal reinforcement, skin and the use of minimal transverse reinforcement provide the simple bending behavior, with ductile rupture in concretes with $C < 40$ MPa, distancing itself from the behavior that occurred in beams with an obtuse scale effect, where the characteristics mentioned in this same text are manifested.

1. High-performance concrete (CAD) – Concrete with $C > 40$ Mpa.

This article also addresses box structures of subway stations. In them, the scale effect is also decisive in the ultimate shear force and there is also a preference not to place transverse reinforcement, due to the difficulty of executing and implanting this reinforcement in the underground construction site. However, due to the rest carried out on a reduced slice of the box structure, it was considered more prudent to implement a minimum reinforcement.

However, due to the test carried out on a reduced slice of the box structure, the implementation of a minimum transverse reinforcement was considered more prudent.

Since the infamous event of the collapse of the beams that occurred in Ohio was in 1955, due to the difficulty of communication, I think that it is acceptable to misinform about the non-linearity of the increase in the resistance of the shear force caused by the scale effect. However, Collins and Kuchma's article is from 1999! Very close and chronologically recent to us and, even so, there are few engineers who share such information. What worries me most is not how *safe*, but who *knows*, how *safe*... I am convinced that there are few.

If we pay a visit to a work with a transition beam with a height greater than 1.00 m and if we were to say to the author of the project that for beams with such geometry the collapse is achieved with 50% of the shear effort of calculation, would we obtain a calm and friendly response? I don't think so.

At a quick glance at our standard, it is easy to see that it does not address the issues of the theory of modified compression fields in the procedure for calculating the shear for beams that suffer the scale effect.

At a glance at our standard, it is easy to see that it does not address the issues of the theory of modified compression fields in the shear calculation procedure for beams that suffer from the scale effect. There are still many gaps to be filled in the scope of the shear effort, much to be researched, rehearsed, discussed and that is why I say:

Shear effort, we still need to talk more about it.



Edatec Engenharia, São Paulo, SP

Modal analysis and soil-structure interaction of tall buildings: conceptual and practical dilemmas

By eng. Sérgio Stoloas

STO Analysis and Structural Solutions S/S

Ltda E-mail: sergiosto@gmail.com

Summary

Soil-structure interaction (ISE) modeling in tall buildings on *pile radiers* is a central theme in modern structural engineering. Although the classical modal analysis with hypotheses of non-displaceable foundation ("crimping") is widely adopted, its adequacy in the face of soil flexibility and dynamic phenomena raises technical and philosophical discussions. This article investigates central aspects of the conceptual and practical dilemmas of this modeling, analyzing the role of "static allegories", the incorporation of springs, coupled ground mass and *dashpots* (shock absorbers), the limits of Rayleigh's hypotheses and the implications for wind tunnel tests. It is concluded that the choice of analytical models should consider the rigor of the phenomenon analyzed, the nature of the requests and the limitations of the available methods, with a critical analysis of the adequacy of the model for the specific purposes of the project.

1. Introduction

The design and analysis of tall buildings require rigor in the consideration of dynamic effects and soil-structure interaction (STI). The use of deep foundations with *radiers* on piles makes the appropriate choice of the interaction model even more relevant. Conceptual errors compromise not only safety, but also adherence between numerical models and experimental test conclusions, especially in contexts where dynamic forces dominate structural behavior.

The use of deep foundations with *radiers* on piles makes the appropriate choice of the interaction model even more relevant.

It is essential to distinguish that, while the standard analytical model for the ultimate limit state aims to conservatively contemplate the structural aspects of the structure, the model used for the determination of dynamic and inertial attributes (such as natural frequencies, modal shapes, solidary mass, and damping) must, in turn, characterize the expected dynamic performance.

The way we model supports and boundary conditions is only one of the multiple uncertain parameters that influence the conclusions of a structural analysis. Other critical decisions include the selection of modulus of elasticity, the definition of solidary mass,

the consideration or not of the flexibility of the connections, the damping rate associated with the vibration modes, among many other factors.

A common practice among structural engineers is to seek safety that, although well intentioned, often becomes excessive. This can lead to wrong decisions, not always in the sense of safety, and can even make a project unfeasible. It is part of the art of structural engineering to deal with the contingency of the assumptions adopted. Especially when it comes to modal analysis, the overestimation or underestimation of parameters related to stiffness or mass does not imply, by itself, greater safety or insecurity. For example, considering a larger amount of solidary mass may lead to an underestimation of response accelerations.

2. Historical review and state of the art of foundation modeling

The hypothesis of a perfectly rigid foundation – or fixed base – derives from the desire to simplify the structural problem, ignoring deformations of the ground and treating the foundation as an in deformable support. This premise favors the use of classical modal analysis (with Rayleigh's hypotheses), allowing modal superposition, simplified calculation of natural frequencies and, generally, greater control over the design process.

The advancement of geotechnics and simulation tools has allowed the introduction of horizontal, vertical, and rotational springs to replicate the action of the soil in structures (known as the "Winkler model" and variants). Refinement also includes *dashpots* (viscous dampers) and equivalent soil masses to better capture complex dynamic effects.

Currently, computational resources enable multi-degree models of freedom, time-domain analysis, soil-structure coupled element techniques, and advanced simulations of seismic and wind response – even if, in practice, in current design, simplifications still predominate.

3. The flexibility dilemma: the use of springs in dynamic analysis

The adoption of the condition of perfect embedding of the structure in the foundation, although it provides operational simplicity and facilitates the application of the classical modal analysis, presents a crucial limitation by not reflecting the deformability of the soil.

In contrast, spring shaping represents a considerable advance over crimping, especially for high-rise or particularly sensitive structures. This approach allows the incorporation of soil deformability, pile interactions, vertical and horizontal stiffness of the foundation, rotational impedance, among other factors. In doing so, the model would apparently come much closer to the actual physical behavior of the soil-structured system.

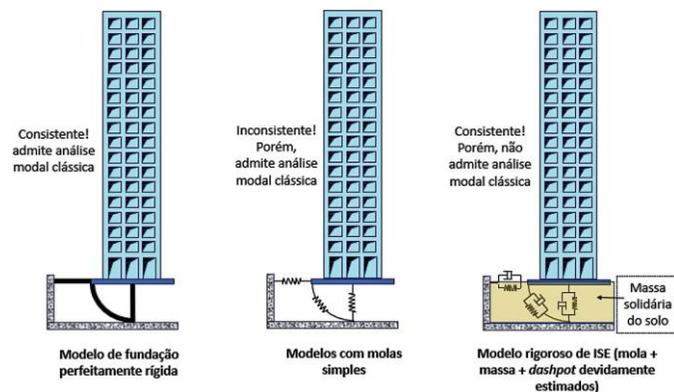
4. The inconsistency of the "pure" spring model for dynamics

However, spring modeling, when used in isolation for dynamic problems, lacks realism. If the foundation of the structure is modeled only with springs, only part of the physical system is being replicated. For spring modeling to achieve the necessary consistency in dynamic analysis, it is essential to include the solidary mass of the soil and damping elements (*dashpots*). This implies the incorporation of geotechnical parameters that are often little known and highly sensitive to local variations.

An advanced model, which incorporates the flexibility of the supports in the foundation, must necessarily include "the rest of the universe" or, at least, the solidary mass of the soil and the cushioning or dissipation of energy. Damping *dashpots* represent energy losses due to hysteresis cycles and dissipation in the ground due to wave propagation (radiation damping).

In practical projects, an "intermediate" approach is commonly employed, aiming to mitigate uncertainties, for example, by considering value ranges for frequency and displacement, balancing the accuracy of modeling with the practical feasibility of obtaining data.

Figure 1: The model that represents the soil-structure interaction with springs alone is consistent only for static analysis. For dynamic actions, it is essential to include the solidary mass of the soil and the cushioning



5. The false intuitions of static allegories

Many designers, accustomed to instantaneous equilibrium reasoning, extrapolate this understanding to dynamic problems. This intuition, synthesized as an allegorical model of reality, can lead us to falsely interpret structural dynamics as a succession of states of static equilibrium.

Traditional engineering training emphasizes static analysis, which is more straightforward and often sufficient for many common applications in civil and mechanical engineering. However, dynamics involve phenomena that have no direct parallel in statics, such as resonance, eigenmodes, inertial effects and damping, transient and sustained responses, among others.

Static intuitions can be "misleading," as they often ignore the importance of time, frequency, and dynamic couplings. An example of false intuition is the one that leads us to assume that it is enough to multiply a maximum load by a factor to "guarantee" safety in the face of tremors, impacts, or vibrations. This false intuition can lead to gross errors.

For example, considering a larger amount of solidarity mass may lead to an underestimation of response accelerations.

As structural engineers, we are exposed to falling into this conceptual trap due to the habits that stem from the equivalent static and static approaches:

- a) **Response proportional to the force applied:** In statics, displacement is always proportional to force (Hooke's Law, $\Delta = F/k$). However, in dynamics, the response depends on the load history, excitation frequency, masses, damping, and may present amplitudes much higher than the static load.
- b) **Direct superposition and independence of the parts:** In statics, the effects of the charges add up linearly. Due to dynamic coupling, the movement of one point often affects the entire system due to inertial effects. Modes of vibration can involve coordinated displacements of multiple points, making it impossible to separate a part of the structure and replace the rest of the universe by implementing suitable springs.
- c) **Time and frequency don't matter:** In statics, it is enough to know the value of the force in equilibrium. In dynamics, duration, temporal variation, and frequency of the action are crucial. A small force, but in the *range* of the natural frequency, can produce large responses.

- d) **Ignore inertia:** In statics, the solidary mass of the system is irrelevant and does not affect the results, since the acceleration is zero. In dynamics, inertia (mass) actively participates in the equation of motion ($F = ma$). Light structures may, paradoxically, be more sensitive to dynamic excitations.
1. **Static damping "does not exist":** In static, damping is not included in the analysis, since speeds are zero. In dynamics, damping can control the response, especially close to the resonance, and strongly influences the dissipation of energy (even in transient responses).
- e) **Instant balance:** In static, it is assumed that the structure responds immediately to the application of the load. In dynamics, there is a response time, and there may be oscillations and transient behavior before reaching a new state of equilibrium or never reaching a fixed state at all.
- f) **Dynamic forces are treated as equivalent static loads:** It is common practice for engineers to apply dynamic multipliers (such as "impact factor") to convert dynamic stress into an equivalent static force. In practice, this can underestimate or overestimate the structural demand, especially in cases of excitation close to the natural frequency or in systems with multiple relevant modes.

6. The impact on classical modal analysis: the breakdown of Rayleigh's hypotheses

The classical modal analysis implemented in *software* tacitly assumes a correlation between mass, rigidity, and damping called **the Rayleigh hypothesis of proportional damping**. This hypothesis assumes that the damping matrix is a linear combination of the mass and stiffness matrices. It is acceptable to assume that usual structures, in which the damping is not concentrated in a certain place or level, agree with the Rayleigh proportionality hypothesis. That is, it is assumed that they are proportional systems in which the matrices of mass and stiffness are diagonalizable together and that each classical mode will have an associated modal rate. This allows the adoption of classic modal superposition, where responses can be assumed as the sum of independent modal responses.

In the structured system with springs, masses and shock absorbers, it moves away from Rayleigh's classical hypotheses. This is because there are dissipative and inert elements coupled not only to the structure, but also to the ground, and with very different "talents" in the mechanism and magnitude of energy dissipation.

Soil-structure systems are almost never proportional. Even for pure vertical loads, the modal response becomes coupled and dependent on the overall vibratory state.

By modeling springs, masses, and *dashpots* attached to the base of the building, through any serious attempt to capture the soil-structure dynamics, the hypothesis of proportionality is lost. Because of this, the modes are coupled and depend on the excitation frequencies and characteristics of the ground and no longer on the pure structural properties.

In contrast, spring shaping represents a considerable advance over crimping, especially for structures of great height or particularly sensitive.

In practice, according to the ISE thus formulated, the problem ceases to be "classic modal" and becomes a non-proportional problem that requires complex modal analysis techniques or simulations in the time domain. This will not only make the analysis much heavier and with unintuitive results, but it will also not support the use of *standard* structural analysis software, not even the most advanced ones commonly used. In other words, the price of refining the calculation will be that the model moves away from the context of *commercial* structural analysis software and the methods established in standards, making it difficult to apply it in the engineer's daily life.

7. Analysis of wind-induced effects and the HFPI methodology

In Brazil, the modal analysis of tall building structures aims to know the attributes that govern the response to wind-induced effects. These attributes will generally be used in the integration of the motion equation using the HFPI (*High Frequency Pressure Integration*) methodology from the records of the wind tunnel scale test.

The analysis of a realistic model that deviates from Rayleigh's hypotheses should also force the abandonment of high-frequency integration algorithms, which are an essential part of the available and widely accepted response analysis procedures.

8. Synthesis of the conceptual and practical dilemma

There is, therefore, a *trade-off* between theoretical consistency, practicality of use of available tools (*software* and tests) and security in the analyses:

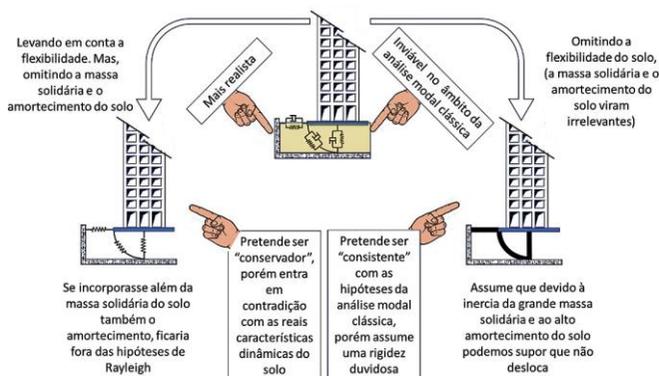
- **The perfectly rigid foundation model (crimping)** maintains compatibility with classical modal hypotheses (Rayleigh), modal integration, superposition, and experimental validation tools in wind tunnels.

- **Models with simple springs**, although they better represent (in appearance) the physical reality of deformability, when used in isolation, violate the theoretical coherence for dynamic analysis, because they ignore mass and soil damping.
- **The strict ISE model (spring + dough + dash-pot properly estimated)** it escapes Rayleigh's hypotheses, requiring specialized tools (coupled finite elements, non-proportional analysis, time domain solution), with less intuitive results and incompatible with standard commercial software.

Static intuitions can be "misleading," as they often ignore the importance of time. Frequency and dynamic couplings.

The choice should be guided by the type of load predominant, degree of precision required, and limits (normative, computational, practical) of the design context.

Figure 2: The dilemma between using springs or fixed supports for the foundation in the model of obtaining modal attributes



9. Conclusion

From the perspective of classical modal analysis—the foundation of current practice and traditional experimental resources—the only fully consistent hypothesis for tall buildings on piled *radiers* is to assume foundations to be infinitely rigid. This ensures harmony between theory, structural modeling practice, wind tunnel validation, and the methods recommended in international regulations.

It should be noted that modal analysis is the basis for HFPI integration by which the equation of motion in service state is integrated. Even if the modal analysis is performed with a model stuck in the foundation, once the equivalent static forces are obtained, they will be applied to an analytical model with flexible supports idealized by springs for the final design. This is a crucial point that often

generates confusion, because the model for *obtaining dynamic attributes* can be different from the model for structural *design*.

For situations where accuracy under wind action (especially user comfort) is critical, or in soils of exceptionally low stiffness, supplementary analysis with complete flexible models (including soil mass and damping) is recommended, aware that such an approach requires advanced numerical methods and cannot, in general, be reconciled with the standardized results obtained via classical modal analysis.

This ensures harmony between theory, structural modeling practice, wind tunnel validation, and the methods recommended in international regulations.

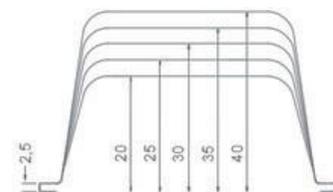
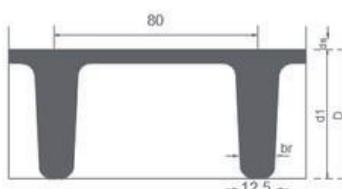
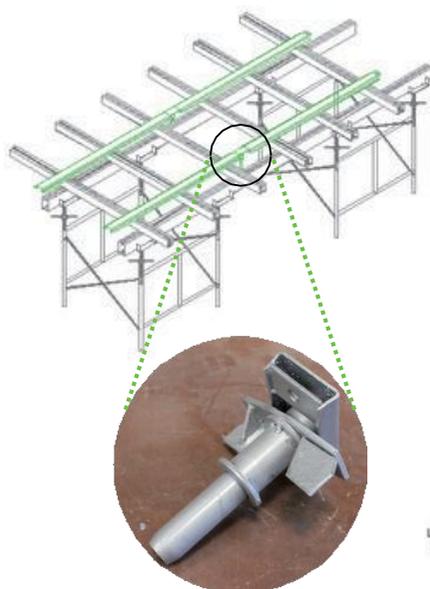
Finally, it is highlighted that developing and disseminating accessible experimental and computational models that respect the physics of the problem without neglecting practical aspects of design remains a challenge and an open path for advances in the world of structural engineering.

Bibliographic references

- MEEK, J. W. e VELETOS, A. S. 1974. Dynamic behaviour of building-foundation systems. **Earthquake Engineering & Structural Dynamics**, 3(2), p. 121-138.
- GAZETAS, G. 1983. Analysis of machine foundation vibrations: state of the art. **Soil Dynamics and Earthquake Engineering**, 2(1), p. 2-42.
- CLOUGH, R. W. e PENZIEN, J. 2003. **Dynamics of Structures**. Computers & Structures, Inc.
- WOLF, J. P. e DEEKS, A. J. 2004. Foundation vibration analysis using simple physical models. **Earthquake Engineering & Structural Dynamics**.
- EUROCODE 8: **Design of Structures for Earthquake Resistance**. EN 1998-5.
- ASCE/SEI 7-22. **Minimum Design Loads and Associated Criteria for Buildings and Other Structures**.
- ACI 318-19. **Building Code Requirements for Structural Concrete**.
- VELETOS, A. S. 1977. Dynamics of structure-soil systems. **Structural Engineering Conference**, ASCE.
- BREEZE, G. e STOLOVAS, S. 2015. The practical implementation of high frequency pressure integration (HFPI) using discrete cosine transforms (DCT). **XIV International Conference on Wind Engineering (ICWE)**, Porto Alegre.

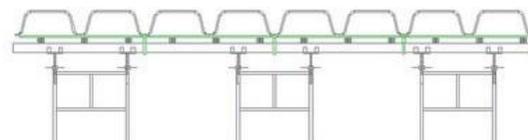
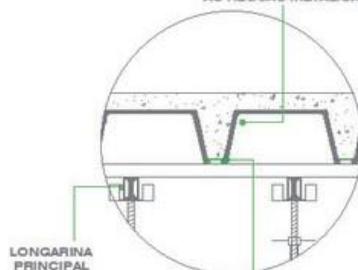


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In this section, the messages that stood out in the TQS Community and Calculators group over the last few months are published.

To register and be part of the group, just access <https://groups.io/g/comunidadeTQS/> and <https://groups.google.com/g/calculistas-ba>

Structural recovery of a solid reinforced concrete slab

Good night

Would anyone have any document with the 'basic' procedures and recommendations for structural recovery of the lower part of a solid reinforced concrete slab, knowing that the rebar of the lower part will have to be replaced, as they have a high level of corrosion?

Best regards

Eng. Bonifácio Neves de Souza, Salvador, BA

Dear Bonifacio, Good morning.

My experience says that, in the case of slabs, the fastest, safest and most economical thing is to demolish and rebuild.

If this is unfeasible, find out first if it is CHLORIDE or just CARBONATION.

If it is only carbonation, a well-designed structural mortar, after cleaning the corroded bars and replacing some, can be designed with great care to avoid shadows behind the reinforcements.

Be careful not to fall into the cleaning and preparation process!

Hugs,

Prof. Dr. Paulo Helene, São Paulo, SP

Good morning.

An alternative:

1. Shore up the slab with tight struts to relieve stresses in the positive reinforcement.
2. Clean the entire lower part of the slab, including the frames.
3. Replace the reinforcement cover with grout.
4. Use carbon fiber tapes to restore the slab's tough capacity.
5. Remove the shoring so that existing reinforcements and tapes can work.

Best regards.

*Eng. Antônio Alves Neto, Recife, PE
Engedata - Engenharia Estrutural Ltda
Projeter Serviços de Engenharia e Consultoria Ltda*

Deformation of masonry in slabs with large spans

Colleagues,

I have seen some slabs with large spans and flexibility supporting linear and long masonry (up to 8 m). I question the deformation that this masonry will suffer, as well as future pathologies that should appear. Is there any palliative solution? What is your experience?

Hugs to all,

Eng. Roberto Solano, Rio de Janeiro, RJ

Good morning, Solano,

By NBR 6118 final deflection, after installation of the wall load, it must not exceed $L/500$; 0.017 rad or 10 mm. This last limit has often been raised by colleagues.

To avoid pathologies, it is possible to resort to the arrangement of reinforcements and screens in some settlement joints, the adoption of wedging with resilient material and, better than that, to subdivide the wall into sections with the introduction of control joints.

Big hug,

Dr. Ércio Thomaz, São Paulo, SP

In time: if you make a reinforced strap on the slab and lay the masonry on this strap, wouldn't there be a reduction in the deformation of the wall?

Hugs to all,

Eng. Roberto Solano, Rio de Janeiro, RJ

Solano, there

would be.

Regards,

Dr. Ércio Thomaz, São Paulo, SP

Compartmentalization of ribbed slabs in basements – building design

Dear colleagues, good morning!

We are working on a building project with 40 floors and two basements for garages, and the basements have ramps connecting the floors.

In our project, the garage slabs were developed with the Atex system.

The doubt that arose relates to the compliance with the minimum dimensions required by the fire standard (ABNT NBR 15200) for these slabs.

With the presence of ramps, we understand that the vertical compartmentalization function of the slabs is compromised.

I would like to consult with noble colleagues on how they have addressed this issue in their projects.

Best regards,

Eng. Charly Duque, São Paulo, SP

Dear eng. Charly Duque,

This is a recurring question, whose solution is not clear in the ITs of the CBs. I try to shed a little light.

Initially, I emphasize I agree that the ramps **promise vertical compartmentalization**.

Precisely for this reason, NBR 15200:2024 is realistic and sensible when it is pointed out in the 2nd and 3rd paragraphs of subsection 8.2.3:

"The values of h indicated in tables 6, 7, 9 and 10 are the minimum to ensure the sharing functions. If there is no such requirement, only the values of c1 and b min, when applicable, must be respected for the structure to meet the resistant capacity property (R). In this case, the thickness of the slabs can be obtained by calculating the ambient temperature, according to ABNT NBR 6118.

The requirement or not of the compartmentalization function must be defined based on the legislation and regulations in force and the applicable standards."

The respectable professor Valdir Pignatta makes a point in the same sense, on page 115 of his book (*Project of concrete structures in a fire situation*, 2nd edition).

"It is not possible to guarantee vertical compartmentalization in basement garages, duplex floors and shopping mall atriums. Although it is not explicit in the instructions of the Fire Departments, this author deems it unnecessary to respect a minimum thickness for the layer of the precast slabs in these situations."

However, your project now needs to consider other IT requirements. For example, at most, when connecting three consecutive floors, the sum of the areas does not it can exceed "x" m², and other aspects.

I think you should calculate the specific TRRF for this "total-special" pavement, checking whether it is higher than the TRRF of compartmentalized pavements.

On page 114 of the book by Prof. Valdir Pignatta there are some notes on ribbed slabs in a fire situation.

I hope I have helped.

Dr. Petrus Nóbrega, Natal, RN

Dear eng. Petrus Nóbrega,

Thank you for your time in preparing the text: it brought light to this topic!

I take the opportunity, within the same context, to research with colleagues about the use **of the equivalent time method**, more specifically to reduce the TRRF of the building by 30 minutes.

The Technical Standard of the Mato Grosso Fire Department, where the work we are designing will be carried out, "seems" to say that the equivalent time method can only be used for "existing buildings", significantly increasing the cost of the structure, since the TRRF for these buildings that we do is almost always 120 min.

We did a survey in other states and, it seems to us, we did not survey all of them, but MT seems to be the only one to make this differentiation in the text.

Below is an image of the NTCB of MT:

5.3 Método de tempo equivalente para redução do TRRF

5.3.1 Admite-se, para as edificações existentes, o uso do método de tempo equivalente para redução dos TRRF (vide Anexo D desta NTCB), excetuando-se as edificações do Grupo L (Explosivos) e das divisões M-1 (Túneis), M-2 (Líquidos ou gases, inflamáveis ou combustíveis) e M-3 (Centrais de comunicação e energia), contudo, fica limitada a redução de 30 min dos valores dos TRRF constantes da Tabela A, Anexo A desta NTCB.

5.3.2 Na utilização do método de tempo equivalente, os TRRF resultantes dos cálculos não podem ter valores inferiores a:

5.3.2.1 15 minutos, para edificações com altura menor ou igual a 6 metros dos Grupos A, D, E, G e das Divisões I-1, I-2, J-1 e J-2.

5.3.2.2 30 minutos, para as demais edificações.

The most interesting thing is that, in the MS, there is no part in the text "existing buildings":

5.3 Método de tempo equivalente para redução do TRRF

5.3.1 Admite-se o uso do método de tempo equivalente para redução dos TRRF (vide Anexo D), excetuando-se as edificações do grupo L (explosivos) e das divisões M1 (túneis);

M2 (parques de tanques) e M3 (centrais de comunicação e energia), contudo, fica limitada a redução de 30 min dos valores dos TRRF constantes da Tabela A, Anexo A, desta NT.

Nota:
Para classificar as ocupações quanto ao Grupo e Divisão, consultar a Tabela 1 da Lei Estadual nº 4335 que Institui Código Segurança Contra Incêndio, Pânico e outros Riscos no âmbito do Estado de Mato Grosso do Sul.

5.3.2 Na utilização do método de tempo equivalente, os TRRF resultantes dos cálculos não podem ter valores inferiores a:

5.3.2.1 15 minutos, para edificações com altura menor ou igual a 6 metros dos Grupos A; D; E; G e Divisões I-1; I-2, J-1 e J-2;

5.3.2.2 30 minutos, para as demais edificações.

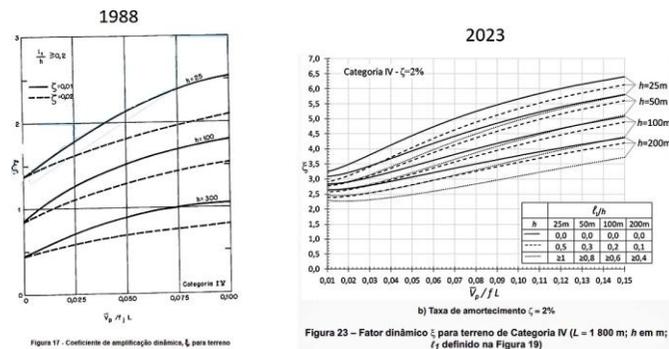
Above is the print of the NTCB of MS. Best Regards,

Eng. Charly Duque, São Paulo, SP

Dynamic Amplification Coefficient

Colleagues, good afternoon!

I hope I'm wrong, but what I'm understanding is that we sleep with a Dynamic Amplification Coefficient by NBR 6123:1988 of the order of two for buildings between 50 and 100 m in height, and we wake up with a Dynamic Factor (the same magnitude with another name) of the order of five or more for the same buildings between 50 and 100 m in height. Am I wrong?



If this is correct, process the buildings again using NBR 6123:2023 instead of NBR 6123:1988, and see the accelerations double at least. I did this (TQS) with two buildings that we are designing, and the accelerations have increased too much. I hope I'm already wrong, but very wrong indeed. If I am right, this abrupt change from one norm to another is in direct contradiction to what the late professor Fusco taught: norms cannot present changes such as provoking fear and distrust in engineers and society.

Best regards,

Eng. Luis Fernando Benvenga, Santo André, SP
Benvenga & Associados Engenharia

Bridge over the Tocantins River

Good afternoon

Below is the full three-page study on Brazilian bridges, of which part of the data Roberto Solano cited in another post, and whose event was publicized by our chief Carnaúba. <https://site.ibracon.org/wp-content/uploads/2020/07/MANIFESTO-PELA-SEGURAN-CAE-MANUTENCAO-DAS-PONTES-BRASILEIRAS.pdf>

Simply appalling. There are no words that can describe the total debacle.

Eng. Carlos Henrique Consoni

In fact, how many years, perhaps decades of neglect of our bridges and viaducts.

The truth is that the concept of Durability and Useful Life is recent. In Brazil, it is only 22 years old and only entered our parent standard, ABNT NBR 6118, in 2003.

By 2003, several articles had been published on the subject, as well as the concept in 1993, in the 1990 Model Code.

But it is taking time to become a daily concern of bridge and viaduct managers in Brazil (federal, state and municipal) and accidents continue to happen.

Prestressed bridges have complex aging and are difficult to diagnose. Just as it is complex to reinforce and intervene safely correctively.

Also, to complicate matters, they have the enormous risk of corrosion under tension that weakens the steel and can lead to sudden collapses without warning, such as what occurred on the arch bridge of Genoa, Socorro in São Paulo, Remedios in São Paulo and now on the Juscelino bridge, just to name a few.

Bridge engineering, and especially inspection, diagnosis and corrective intervention, is lagging and requires a great deal of effort and partnerships between universities, specialists, private managers and public authorities.

There is no point in throwing stones only at the public power if not even the best bridge engineer and the best specialists know how to inspect and diagnose and intervene safely.

Where are the standards, the procedures, the tests, to inspect prestressed bridges?

I hope the same does not happen with the issue of sustainability.

It took us 10 years after the CEB-FIP introduced durability and now we publish our ABNT NBR 6118 that ignores the term **sustainability**, even though the subject has been discussed for more than 25 years and the fib Model Code has already been clearly introduced in the 2023 version.

Let's **make a mea culpa** before throwing stones at managers.

Regards,

Prof. Dr. Paulo Helene, São Paulo, SP

Good morning, dear professor Paulo Helene,

Thank you for the brief historical description of the concept of durability and useful life and other concepts pertinent to the safety of structures.

I agree largely with what he wrote. The situation is extremely complex due to the numerous factors involved.

In the case of the JK bridge, the 2019 Dnit report indicated, in note 2, that the structure required attention.

And excessive vibrations were reported.

And nothing concrete has been done to improve the situation in the few more than five years between the date of the report and the date of the collapse.

According to the data published in the Ibra-con manifesto, roughly speaking, we have a bridge with serious problems in each area of 27 x 27 km² in

Brazil (proportion that may decrease or increase depending on the state of the infrastructure in the region). And a truck driver can pass through about 12 bridges with problems in a day. And what about an innocent head of a family walking around?

The situation is calamitous, involving the lives of innocent people.

In Brazil, there has been no culture of maintenance since colonial times and there are still other factors involving works of art, such as professionals without the capacity to calculate them, irregularities with the material, incorrect use of resources and, for many, simple adornments for campaigns.

I know that there are trained and goodwill people involved in these cases. But will they be enough to solve it? It seems that there is a state of catatonia.

Returning to the case of the JK bridge, Estadão published a special and long report, only for signatories, showing the fate of the amendments for the respective municipalities served by the bridge, on the banks of the Tocantins River. There was R\$ 35.6 million specifically intended to improve the infrastructure of the region, but which were used for other purposes, such as concerts and purchases of LED lamps.

Sad situation.

Greetings.

Eng. Carlos Henrique Consoni

Dear Carlos,

I appreciate your very enlightening answer and I agree with it.

We need to do something, but we cannot just wait and demand that the federal, state and municipal governments do it.

Nor can we just expect and demand that that bunch of politicians we elect from the Legislative Branch demand astonishing funds from the Executive Branch to, without accountability, use them in their electoral corrals.

I agree with you, we will charge them, we will elect better representatives, but we must do our part.

And there is a part that only depends on

us. For example:

1. How to inspect prestressing cables that are inside grout-filled sheaths... for years!!!!?
2. How to measure prestressing losses on site?
3. How to measure the risk of stress corrosion cracking non-tack (grease) or tack-bearing (grout) sheaths?
4. How to inspect an anchor head and judge whether it is fine or at risk of corrosion at the interface with the nut?

5. How to properly use equipment with corrosion potential that is not even normalized in Brazil? And a corrode current equipment? And a carbonation test? How many laboratories can identify AAR or DEF? And parameter/magnetic-type equipment? And a percussion or electric impulse test? All of these, and I will stop here, still do not have a standard in Brazil or professionals sufficiently trained to do the essay and to interpret it well!
6. How to intervene correctly or rehabilitate a prestressed bridge? How do you correct an al-kali-aggregate reaction? Or DEF?
7. It's easy and for years there has been a checklist to inspect drains, support equipment, joints, guardrails, buzinotes, abutments, walls, columns, beams and reinforced slabs. But what about prestressed beams as slabs? And the foundations? I have already received an inspection report with 65 points of anomalies and note 2 had a single transverse crack in the tensioning cables that was important but remained together in the cat's basket of other 64 anomalies and the manager, a poor manager, evidently did not know, and had no reason to know, that he had to take immediate provision...
8. We have some possibilities to intervene to correct problems, but nonconsensual. There is no standard even to say how to correct a corrosion problem of reinforcement in stirrup and main reinforcement of reinforced parts. That let alone correct stress reinforcement corrosion in prestressed... There are people who use inhibitor additives (non-standardized), others anodic tablets (non-standardized), others silica fumes, others strippers (non-standardized), and others phosphatizes (non-standardized), and so on, and they all think that their solution is the best in the world, a supper that is shocking when they use an anodic tablet or an anti-chloride additive to solve a carbonation problem!!!

So that's why I appeal to, in addition to holding the authorities accountable, to criticize the deviations of parliamentarians, we also do our part in this latifundium.

And this costs hours of voluntarism, research, meetings, a humble and flexible spirit to understand and see all sides of the coin without personal physical and moral aggression.

Ibracon has already started years ago in sustainability and durability, but it is going slowly because voluntarism is still rare in civil engineering and changing something messes with an inertial structure of large proportions.

Now Prof. Ademir has started a group of volunteers to discuss bridge health. Wonderful!

Let's go...

Let's talk... Greetings,

Prof. Dr. Paulo Helene, São Paulo, SP

Good morning, everyone,

Knowing the degree of safety of a structure is, perhaps, the most complex problem in engineering. How do you measure the commitment of concrete and steel over time? If we put the prestressing cables in this account, we will border on the impossible.

Hugs to all.

Eng. Roberto Solano, Rio de Janeiro, RJ

Dear,

Inspecting bridges is indeed a complex problem, however I don't believe that the problem is the technology available.

Bridges are inspected with precision and quality worldwide. There are sufficiently competent methods to determine the condition and diagnose each pathology of each element of each type of bridge.

Some here: <https://www.screeningeagle.com/en/industries/infrastructure/bridges>

In my view, the problem is different: mentality.

Bridge is an expensive thing. Expensive things need to be done to last. Anything other than that is a waste of (public!) money.

A bridge needs to be designed and executed to last 100 years. If it lasts 30 years, it's money thrown in the trash.

Colleagues from Finland commented a few weeks ago that some large bridges there are being designed for 200 years.

A poorly made bridge is obviously cheaper than a well-made one. A poorly done or hastily done project is cheaper than a well-done one. But none of this can be more expensive than having to build the bridge again.

There are those who think that since Brazil is not a rich country (I have my doubts), it cannot afford to do things with quality. Without realizing that doing bad things is throwing money away. It is this mentality that has to change.

It is precisely because we have no money left over that we cannot waste it. Finland has already understood.

That is why engineering and its schools need to be valued and taken seriously. Projects need to be well paid, have reasonable deadlines and it is necessary that the value of the works in the bids be reviewed. Companies do not use good expansion joints because "it is too expensive", support devices are "too expensive", equipment for large-diameter piles are "too expensive", quality formwork is "too expensive"

...

The mistake starts with the bidding.

Those who decide prices seem to have no idea what they are doing and for some reason the industry has no strength to contest it. We are already on the stage where it is thought to be so, and this is very worrying.

We need good engineering.

I have seen videos of bridges with problems where clearly the execution was poorly done. It is recurrent in cases like this that the price of the work was very low.

Quality is responsibility of public money. Our money.

Remember the three little pigs? It's about doing the right thing once. The message is there in the unconscious of each one of us. We just need to remember.

It's worth it. Saves many problems.

Greetings,

Eng. Franklin Gratton, Southbank Vitória, Australia

Calculistas Bahia

Considering the current situation of bridges in Brazil, I suggest the execution of load tests.

Theme: Proof of Load on Bridges

Structures Symposium, Julho de 1944, INT, RJ

Article: Testing and Verification of Structures

Author: Paulo Franco Rocha, IPT, SP

<http://aquarius.ime.eb.br/~webde2/prof/ethomaz/provas-decarga.pdf>

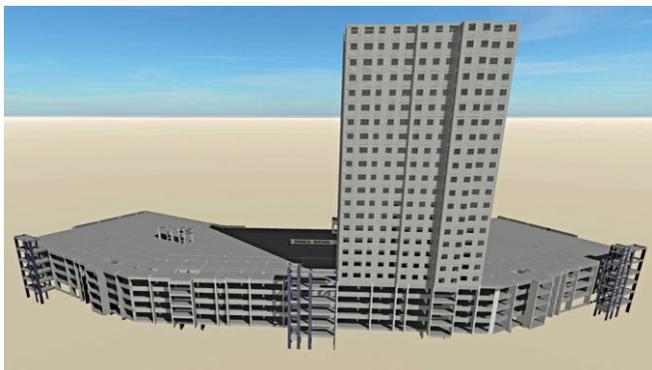
Fernando Lobo Carneiro, INT, RJ, UFRJ, view page 25.

Telemaco Van Langendonck, USP, view page 28.

Paulo Franco Rocha, IPT, SP, view page 30.

"Carry out *proof of load with the mobile load increased by 20%*".

Kreft Engenharia de Projetos,



OSMB, São Carlos, SP



Eduardo Thomaz's comments:

1. Considering the current situation of bridges in Brazil, I suggest the execution of load tests with the mobile load passing through the bridge, (Dnit must know) increased by 20%.
2. Observe:
 - cracking (maximum crack in the test must be less than 0.2 mm)
 - unwanted residual *arrow*, after completion of the load test (see page 31: "As long as the residual arrow does not exceed 20% of the total, it is concluded that there is an elastic regime of deformations. ").
3. Load tests evaluate the structure in a global way and ensure greater safety for users.
4. Load tests are relatively easy to do, and there are firms in Brazil capable of doing them.
5. Suggestions and comments are welcome.

Eng. Eduardo Thomaz, Rio de Janeiro, RJ

66th Brazilian Concrete Congress

With the banner "Concrete: the material of the Past, Present and Future", the 2025 Brazilian Concrete Congress will be held in Curitiba – Paraná, on October 28, 29, 30 and 31.



The largest national technical forum for debates on concrete technology and its construction systems. A national and international meeting of professionals and experts in the field of concrete structures.

This year there is a great novelty: the STARTUP ISLAND!

In this exclusive space, innovative startups will have a unique opportunity to present their disruptive solutions to a highly qualified audience, made up of leading experts, leading companies in the sector, investors and decision-makers.

TQS will once again be present with its own booth at FEIBRACON – Brazilian Fair of Concrete Construction.

Learn more, at: <https://concreto.org.br/66cbc/>

ENECE 2025 – 28th National Meeting of Structural Engineering and Consulting



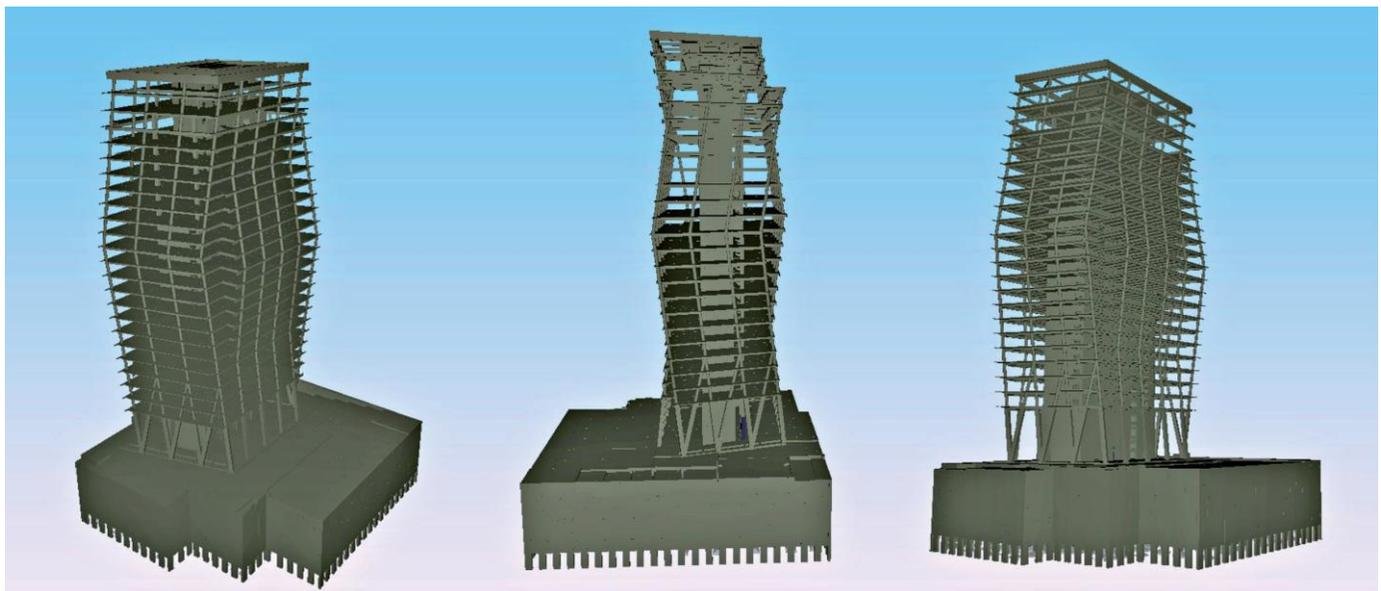
In 2025, ENECE reaches its 28th edition with a central theme that reinforces the relevance of the role of the structural designer in the search for more effective, safe and sustainable works:

Quality and Effectiveness in Structural Projects: Constructability and Productivity

The event aims to explore how design decisions directly impact the quality of the work, the rational consumption of materials, the productivity of labor and the reduction of environmental impact. The proposal is to integrate professionals in the civil construction production chain, promoting dialogue between design, planning and structural execution.

The event takes place on October 3, 2025, in São Paulo, SP.

Learn more, at: <https://enece.abece.com.br/enece-2025/>



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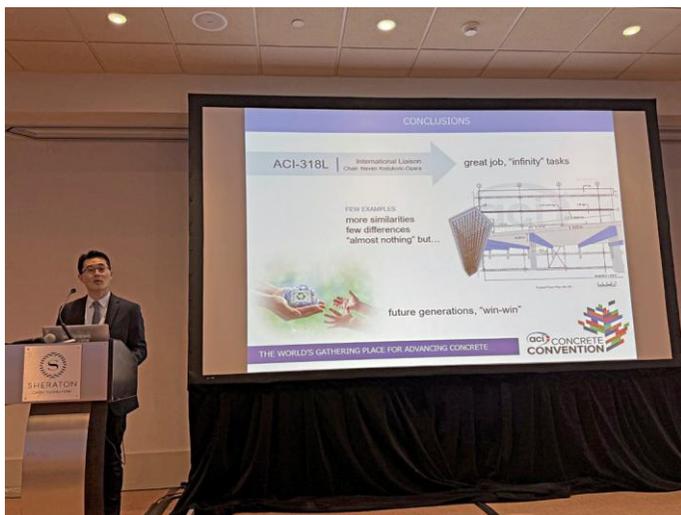
mais.gerdau.com.br



TQS Attends ACI Convention Spring 2025 in Toronto

Between March 30 and April 2, Toronto hosted the *ACI Concrete Convention Spring 2025* — one of the main international meetings in concrete engineering. The event brought together more than 2,500 participants from different parts of the world, including professionals, researchers and students in an intense program of technical sessions, committees and activities aimed at the new generation of engineers.

We had the pleasure of participating once again, contributing with technical content and strengthening ties with the international community. This was the company's second participation in the event, after the presence of Alio Kimura, managing partner of TQS, in the 2024 edition, in New Orleans. This year, our team was represented again by Alio Kimura, and by Adriana Abrahão, from the TQS development team. Both participated as speakers in the session *International Code Comparison: ACI 318, Brazilian & Eurocode*, sharing lessons learned from the work that has been developed in the ACI 318-L subcommittee.



Learnings and Conclusions from a few RC Design Code Comparison Examples no ACI Convention 2025 por Alio Kimura

Brazilian participation in the event

The Brazilian presence was modest in numbers, but relevant within a global event like this. In the same session in which Alio Kimura and Adriana Abrahão (TQS) presented, Professor Marco Carnio (PUC-Campinas) spoke about the use of fiber-reinforced concrete in Brazil. A study by the research group formed by engineers Matheus Marquesi, Fernando Stucchi, Matheus Carvalho and Carolina Silva was also presented, addressing the dimension of slab shear by the ACI 318-19 standard. IBRACON representatives, Julio Timerman and Rafael Timerman, were present and achieved an important milestone: the establishment of the *Brazil ACI Chapter*, further strengthening the ties between the Brazilian and international technical communities.

In addition, we met other colleagues and friends from TQS who were also present.



Brazilians who presented at the International Code Comparison session: ACI 318, Brazilian & Eurocode – Alio Kimura, Adriana Patricia Abrahao and Marco Carnio

Learning and collaboration on the international stage

The presentations were part of the activities of the ACI 318-L *International Liaison Subcommittee*, coordinated by engineer Neven Krstulovic-Opara from ExxonMobil. Since 2021, the group has been dedicated to the technical comparison between concrete building design standards — such as ACI 318:2019, NBR 6118:2023, Eurocode and KDS — through the resolution of practical examples.



Apresentação Code Comparison: ACI318:19 and NBR 6118:2023 no ACI Convention 2025 por Adriana Patrícia Abrahão

This technical exchange has brought together engineers from different parts of the world, fostering a space for international collaboration and proving valuable in bringing project philosophies closer together, inspiring improvements and favoring mutual learning. Discussions such as the use of hypothetical or realistic examples show that there is no single path or perfect example —

the important thing is to start and move forward. The comparison between standards allows the identification of necessary adaptations to regional contexts, in addition to supporting engineers working on international projects, where different standards are often combined. Although we are only at the beginning of the work, we have already been able to perceive differences, raise hypotheses and contribute with important reflections. More than comparing numbers, we seek to create connections between different technical cultures, promoting a broader and more collaborative understanding of the design of reinforced concrete buildings.

Featured themes: sustainability, innovation and the future of engineering

In addition to the technical sessions and committee meetings, the convention was marked by themes that reflect the transformations of the sector. The launch of ACI 318-25 and other updated standards was one of the major milestones of the event, with sessions dedicated to explaining the changes. Sustainability also played a central role, with practical discussions on the use of low-carbon concrete, implementation challenges and the evolution of regulatory standards.



ACI Convention Session 2025

Innovation was also on the agenda, with debates on new materials, construction methods and the use of digital technologies – such as artificial intelligence – in everyday engineering. Another strong point was the engagement of students and young professionals, who broke a record of participation, with interactive activities and mentoring programs that reinforce the renewal of the technical community.

Keeping the culture of collaboration alive

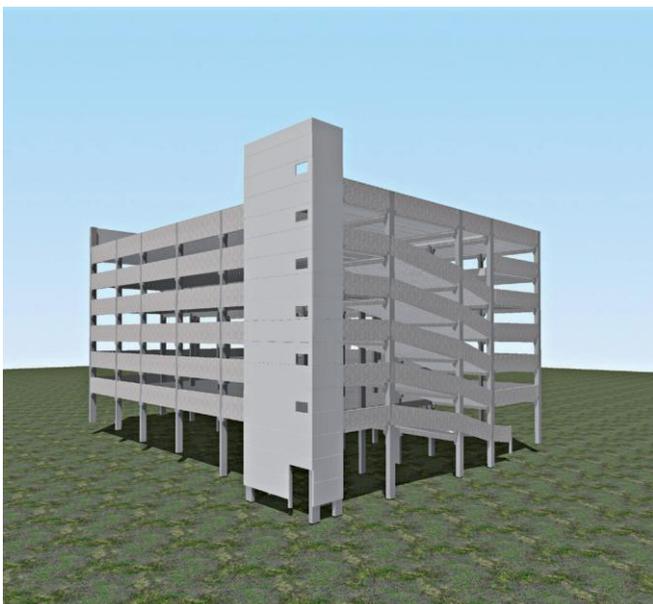
Our participation in the ACI Convention 2025 reflects the values that have always guided TQS since its foundation in 1986: the search for knowledge and the valuing of human relations. We believe that technical progress is built with dialogue, generosity and friendship between professionals.

This spirit of collaboration, so present in the history of TQS, is still alive and renewed in each event, each partnership and each contribution to the advancement of structural engineering.



Celebrating the achievement of the Brazil ACI Chapter

MARNA PRÉ-FABRICADOS, Pinhais, PR



RM Mais Projeto Estrutural, Vinhedo, SP



Launch of the book *A Protensão Não Aderente no Brasil – A História a partir do Ceará*

In this book, the engineer, professor and historian Ricardo Brígida presents the trajectory of the introduction of Non-Adherent Prestressing in Brazil, led by a group of professionals from Ceará. He took part in the first technical exchange trips to the United States, where the technique was already widely applied. The work brings together technical information, photos and boards that document the arrival and dissemination of this innovation in the country. Essential reading for engineers, architects and students interested in the evolution of construction techniques in Brazil.

The national launch of the book will take place at the Concrete Show, on 08/21, at the Impacto Protensão stand (E53), with the presence of the author, who will be available for a chat with those present.

In addition, the book is already available for pre-order on Amazon, at the link below:
<https://a.co/d/1ab8K36>



Engineer Nelson Covas and the prof. and historian Ricardo Brígida



Prof. Augusto Carlos de Vasconcelos - Registration in the CONFEA merit book

"The Medal of Merit, the inscription in the Book of Merit and the honorable mentions of the 2025 Confea/Crea Merit Award, during the 80th Official Week of Engineering and Agronomy (SOEA), already have their names defined and approved by the Confea plenary. Soea will be held from October 6 to 9, in Vitória-ES. The approval of the names indicated by the Merit Commission – CME was held this Thursday (29/5), in plenary 1711.

The Chancellor of Merit, eng. civ. Carmen Petraglia, presented the nominations. "We have made an improvement in the evaluation criteria. We asked Crea to improve the description of the curricula to be evaluated. It worked. We can say that these names will be an inspiration for future professionals". The CME is also formed by federal councilors Giucélia Figueiredo; Neemias Barbosa and Cândido Carnaúba.

Civil Engineer Augusto Carlos de Vasconcelos - Crea-SP Nomination

Death note of Eng. Antonio Carlos Reis Laranjeiras

It is with the deepest and most immense regret that we announce the death of one of the great references of Brazilian Structural Engineering: the dear engineer Antonio Carlos Reis Laranjeiras, better known as Prof. Laranjeiras.



He was president of the Engineering Club of Bahia.

In addition to the honors received by ABECE, he was awarded the Emílio Baumgart, Ibra-con, Highlight in Engineering; INT / ABCP Diploma (Rio de Janeiro), Relevant services.

He was managing partner of ACR Laranjeiras & Cia. Ltda. Structural Projects, having designed stadiums, hydraulic works, bridges, buildings, industrial works, pavements; in addition to having written theses, he is the author of theses, technical publications, translations and drafts of Standards.

He was honored with the title of "Personality of Structural Engineering" at the opening of the 11th ENECE, in 2008, during the ceremony of the VI Structural Engineering Talent Award. Very moved by the tribute, eng. Laranjeiras made a beautiful and emotional speech in gratitude for the tribute.

Civil Engineer from the Polytechnic School of UFBA (1954), with postgraduate degrees in Structures from the National School of Engineering – UFRJ, Technische Hochs – Chule – Munchen (Germany), The University of Texas at Austin (USA) and National Laboratory of Civil Engineering (Portugal), Laranjeiras was Full Professor at the Polytechnic.

He holds the titles of Professor Emeritus at UFBA, Professor of Reinforced Concrete (by competition) at UFBA and Estab Professor. Constr. and Reinforced Concrete (by competition) of UFBA. He is an retired engineer from the Department of Roads of Bahia.



MD Engenheiros, Fortaleza, CE

Tribute to engineer Godart Silveria de Sepeda



It is with great honor and admiration that we pay this tribute to the engineer Godart Silveira de Sepeda, whose trajectory is intertwined with the history of Brazilian structural engineering itself.

Over decades of dedication, Godart has built a legacy marked by technical excellence, innovation and professional integrity. Graduated in Civil Engineering from PUC-Rio, with complementary training in Mathematics from IMPA and specialization in Structural Engineering from UERJ, he has always been ahead of his time. His solid training was just the beginning of a brilliant career, which covers projects of great scope and national and international impact.

As technical director of M. Sepeda Projetos de Engenharia, he worked on some of the most important works in the country, including the Angra II and III nuclear power plants, the Recife subway and Petrobras refinery projects. His contribution transcended borders, with a remarkable performance in Iraq, where he held technical and academic functions, teaching at the University of Baghdad.

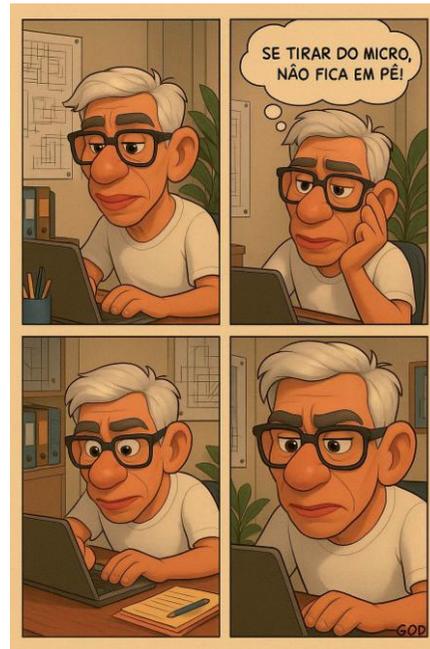
A pioneer in the development of "Method B" – a tool now present in structural calculation software – Godart demonstrated his innovative vision and his commitment to the evolution of engineering. Your capacity of

transforming theory into practice has made him an undisputed reference among professionals and academics.

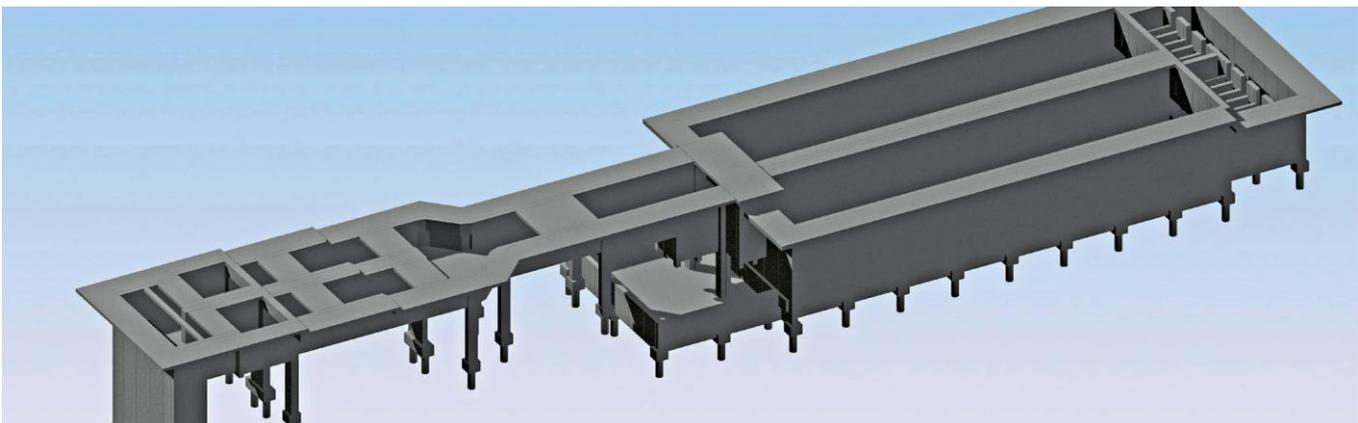
More than an engineer, Godart was a master. He was a professor at PUC-Rio, a trainer of generations of engineers, and a restless thinker, always present in debates and technical meetings. His critical and at the same time constructive look shaped paths and inspired countless professionals.

We honor, therefore, not just a name, but a living history of dedication, competence and passion for engineering. An example that will remain as an ethical and technical reference for future generations.

Our respect, our gratitude and our deepest admiration to engineer Godart Sepeda, rest in peace.



Charge Godart Sepeda





Aplicativos na TQS Store

<https://www.tqs.com.br/apps/calculators>

Além de *plug-ins* para BIM, a TQS Store conta com inúmeras ferramentas auxiliares para engenheiros, de diversos assuntos, desenvolvidos por terceiros e que não dependem do TQS para funcionar.

V-PRO | Calculadora de Vigas Protendidas
Sander David Cardoso Junior

Reservatórios | Calculadora de reservatórios
TQS Informática Ltda.

CalcLajes | Calculadora de Lajes
Valério S.A.

SECAOVIG | Mudança Brusca de Seção em Viga
Celso Jaco Faccio Júnior

GeoEst | Reações e Capacidade de carga de estacas
TQS Informática Ltda.

AlfaR | Fator de Restrição à Rotação
TQS Informática Ltda.

LPUNC | Calculadora de Punção
Celso Jaco Faccio Júnior

DETPRO | Ancoragens de Protensão
Celso Jaco Faccio Júnior

LIP | Pontes em Vigas Múltiplas
Sander David Cardoso Junior

LocBase | Locações de pilares
Guilherme Luiz Pereira Pinto

KROKI-FCR | Estabilidade de Pilares e Seção de Concreto Armado.
Lucas Chaves de Aguiar

Conten | Muros de contenção/arrimo
Sander David Cardoso Junior

CALCMOLA | Estimativa de molas de fundação
TQS Informática Ltda.

MetalCheck | Elementos metálicos
TQS Informática Ltda.

ESCP LIS | Escadas Plissadas
Celso Jaco Faccio Júnior

ProUni | Peças pré-moldadas protendidas
Augusto C. Vasconcelos e Aljo Kimura

ESCAD | Escadas Usuais
Celso Jaco Faccio Junior

QFER | Extração dos Quantitativos de Ferros TQS
TQS Planear Consultoria Ltda.

PREF | Programa de Reforço Estrutural com Fibra de carbono
Fabio Sello Prado, Pedro Henrique Cerento de Lyra

PRECALC | Vigas e lajes protendidas com armadura reta aderente
João de Oliveira Dorta Filho, Rafael Alves de Souza

HFPIBR | High Frequency Pressure Integration
Sérgio R. P. Medeiros e Sérgio Stolovas

CARAMBOLA | Calculadora de Vida Útil
Thomas Garcia Carmona

Sapforte | Sapata isolada rígida
João Pedro Aparecido Mestre Farinelli

CALCLaje | Calculadora de armadura para lajes
Murilo José Marques da Silva

P-Calc | Pilares de concreto
Sander David Cardoso Junior

FSCalc | Seções de concreto armado sujeitas a flexão normal simples e cisalhamento
Jackson Deliz Ditz

T-Rüsch | Tabelas de Rüsch para pontes
Gustavo Elias Khouri, Mariana Silva Serapião e Sander David Cardoso Junior

CalculaTimber_CLT | Calculadora de Lajes de Madeira Engenheirada (CLT)
Johnny Fontana, Maurizio Vairo, Ana Carolina Pegoraro

FlexCisTor | Dimensionamento à Flexão Normal Simples, Cisalhamento e Torção
Reginaldo Lopes Ferreira

Alvena | Resistência do prisma e bloco de alvenaria estrutural à compressão
Rangel Lage e TQS Informática Ltda.

SECC | Seções de concreto armado ou protendido
Sander David Cardoso Junior

SCAPE | Aparelhos de apoio elastoméricos
Felipe Premazzi Rego, Larissa Xavier de Melo, João Paulo Bortolazzo de Campos e Sander David Cardoso Junior

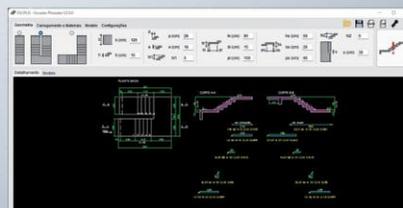
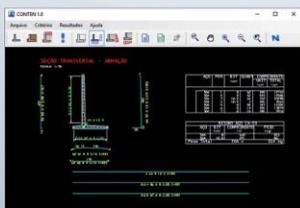
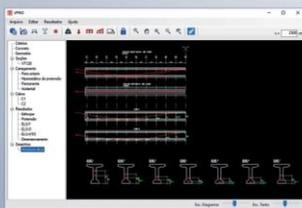
RLF SecPro | Seções Protendidas
Reginaldo Lopes Ferreira

ARMSUSP | Armadura de Suspensão de Vigas
Petrus Gorgônio B. da Nóbrega, Eduardo Marques Vieira Pereira e Ítalo Samuel da Silva Araújo

PROP GEO | Propriedades geométricas de seções arbitrárias
Ítalo Samuel da Silva Araújo, Selma Hissae Shimura da Nóbrega e Petrus Gorgônio B. da Nóbrega

LDB | Geração de Linhas de Balanço
TQS Planear Consultoria Ltda.

Se tiver interesse em publicar seu trabalho na TQS Store, acesse <https://www.tqs.com.br/developers>. Há inúmeras bibliotecas de programação disponíveis no SDK (*Standard Development Kit*) da TQS.



Death note of Eng. Antonio Oscar Cavalcanti da Fonte

It is with great regret that we announce the death of Eng. Antonio Oscar Cavalcanti da Fonte, associate of ABECE and former director of the Recife Regional.

Graduated in Civil Engineering from UFPE (Federal University of Pernambuco) in 1970, with a master's degree in civil engineering from UFRJ (Federal University of Rio de Janeiro) in 1972, and a doctorate in Civil Engineering from the same University in 1992, he was a researcher and adjunct professor IV at the Catholic University of Pernambuco.

He had experience in Civil Engineering, with emphasis on Engineering Teaching and Research, working mainly on the following topics: structural analysis, nonlinear analysis, dynamic analysis, tall buildings, civil engineering, concrete structures, soil-structure interaction, project compatibility, Simultaneous Engineering.

He was an evaluator of SINAES, Member of the Structuring Faculty of the Civil Engineering Course and of the Collegiate of the Civil Engineering Course.

He leaves an important legacy of knowledge in Structural Engineering and is greatly missed by family and friends.



Death note Eng. Claudio Renato Penteado De Luca

Is with deep regret that we announce the death of Claudio Renato Penteado De Lucca, at the age of 85, in São Paulo (SP).

Civil Engineer from EPUSP - Polytechnic School of the University of São Paulo (1962), he was director of De Luca Structural Engineering and associate of ABECE.

Our condolences to family, friends and co-workers.

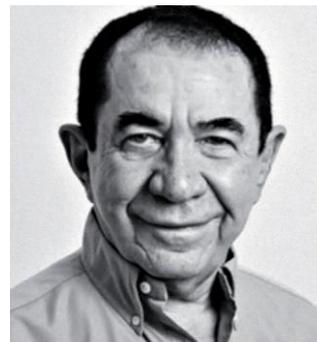


Death notes of Eng. Gerardo Santos Filho

It is with regret that we announce the death of Eng. Gerardo Santos Filho, former Regional Director of Ceará.

A civil engineer, an enthusiast of IBRACON, he never failed to participate in congresses and events, as well as imprinting a noteworthy dynamic in the Regional of Ceará.

To the family, our most sincere feelings.



Dissertations and Theses

LISBOA, Guilherme de Paula

Proposal of a methodology for computer simulation of the progressive collapse of lattice structures in reinforced concrete

Master's Thesis: Stricto Sensu Graduate Program in Geotechnics, Structures and Civil Construction of Federal University - Goiás, 2020

Advisor: Prof. Dr. Daniel de Lima Araújo

Progressive collapse is a relatively rare event associated with the spread of local damage to the structure, but which results in damage that is disproportionate to the initial cause. The most referenced standards and project recommendations on the subject, when they deal with the topic explicitly, do so in two main ways. By indirect methods, based on the provision of continuity, redundancy and ductility, using ties between structural elements with the use of current reinforcement or non-tensioned prestressing strands inside such elements, for example. The other way is based on direct methods, which, based on advanced techniques of structural analysis, seek to either dimension key elements so that they resist exceptional forces or establish alternative load paths for the redistribution of forces resulting from the loss of a vertical element, for example. The definition of the sizing forces of the lashings in indirect methods is usually done empirically. In the direct method, in order for the structure to resist local damage without collapsing in large part or in its entirety, it is necessary to verify the ultimate resistance of the structure in exceptional situations, making use of the physical and geometric non-linearities of the entire arrangement. In this work, a computational modeling methodology based on a simplified numerical model performed via the Finite Element Method, implemented in the DIANA© v.10.2 software, is developed., using finite elements in spatial frame,

rotational spring and shell. The methodology developed is based, among other considerations, on the definition of a constitutional law for rotational springs representative of beam-column connections based on modification of the behavior defined according to the Modified Compression Field Theory (MCFT). With the validated modeling methodology, parametric analyses are carried out, the results of which suggest that it is possible to predict displacements and ultimate forces in monolithic structures in reinforced concrete frames under progressive collapse based on the physical and geometric characteristics of the structure defined while still in the design phase. The developed modeling methodology is also applied to the study of complete pavement. The results obtained are compared with the design recommendations of two references: one with an approach by providing alternative load paths and the other with an approach by providing lashings between structural elements. According to the lashing method used, the longitudinal reinforcements of the beams can be considered as lashing only if these elements have a verified capacity to withstand rotations greater than 0.20 rad. The results obtained indicate that this consideration is preservative.

Link:



MIRANDA, Paulo De Souza Tavares

The influence of seismic actions on Brazilian reinforced concrete buildings

PhD Thesis: Faculty of Engineering of the University of Porto, 2021

Advisor: Prof. Dr. Humberto Salazar Amorim Varum

Co-Counselor: Prof. Dr. Nelson Saraiva Vila Pouca

As a country of considerable seismic stability, Brazil currently has small investments and few researchers linked to seismic studies. However, the constructive characteristics of Brazilian buildings point to the need for deeper studies aimed at reducing seismic vulnerability even in situations of moderate earthquakes. Within this context and driven by the standardization of technical standards in the South American continent, associated with the largest number of earthquakes in Brazil in recent years, the Brazilian Association of Technical Standards (ABNT) published in 2006 NBR 15421 – projects of earthquake-resistant structures, which deals with the obligation to consider seismic actions in the design of building structures. Due to the low seismicity in Brazil, many structural designers are unaware of the standard and are reluctant to adopt the procedures established therein, a fact proven from the responses to a questionnaire sent to engineers from all Brazilian states. To evaluate the influence of seismic actions on Brazilian buildings in reinforced concrete, several analyses were carried

in model structures that represent the building stock of Fortaleza, capital of the state of Ceará and the city with the highest seismic risk in Brazil. The results present the possible seismic actions (S) applied to the structures in the face of a seismic scenario and also relate these actions with those obtained from the wind (V), thus defining the S/V parameter. Such analyses were carried out in all 120 neighborhoods of the city and evaluated and interpreted considering characteristics of the buildings such as number of floors, period in which they were designed, characteristics of the structures, etc. The values found in the S/V parameter clearly expose doubt as to the seismic behavior of the concrete structures of the residential buildings in the city of Fortaleza, especially those lower.

Link:



PEREIRA, Nathalia Coelho

Architectural and structural conception of two works by Oscar Niemeyer: Pampulha Church and Gameleira Pavilion

Master's Thesis: University of Brasília, Faculty of Technology, Department of Civil Engineering, 2012

Advisor: Prof. Dr. Luciano Mendes Bezerra

Co-Counselor: Prof. Dr. Márcio Augusto Roma Buzar

Although the work of architect Oscar Niemeyer has great recognition in Brazil and in the world, there are still gaps with regard to the knowledge of how the structural system and the construction method of some buildings designed by him were defined. Thus, even with the vast bibliography on the architect, it is still possible to raise some points to be clarified about his work, which surprises from the beginning for the way in which the technology of the reinforced concrete was used and for its aesthetics. In this work, at first, we sought to identify and discuss relevant theoretical issues about Niemeyer's work and about the relationship between architecture and the structure of a building, of which some issues stand out, such as: When can we really consider that there was integration between architecture and the structure of a building; Why Niemeyer's works stand out in relation to aesthetics and why aesthetics and beauty are so important for a building; and in which aspects Niemeyer's works contributed to the innovation of reinforced concrete technology. In addition to the theoretical review, this research chose to present case studies of building structures

Oscar Niemeyer. Therefore, the buildings of the Igreja da Pampulha in Belo Horizonte and the Gameleira Pavilion, a building that would also be built in Belo Horizonte, were assumed as a case study. Then, after a bibliographic and documentary review research on the chosen buildings and visited one of them, three-dimensional numerical models were developed in the SAP2000 software, version 14, with the objective of describing and analyzing their structure. Software such as AutoCAD and Sketchup were also used to support modeling in the SAP2000. In the case of the Igreja da Pampulha, the case study essentially sought to investigate the functioning of the built structure. In the case of the Gameleira Pavilion, the study sought to describe the structure of the building as far as possible with the available information and bring a reflection on a case that was not successful.

Link:



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Alvest

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SISEs

System focused on geotechnical and structural design through the calculation of the stresses and settlements of the foundation and superstructure elements considering the soil-structure interaction in the integrated model. From the soundings, the soil is represented by automatically calculated spring coefficients. The load capacity of each element (soil and structure) is realized. Treated elements: isolated, associated footings, radier, circular and square piles (driven or offset), rectangular piles (caps) and pipes.

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It performs structural launching, calculation of requests (grid model), displacements, design (ELU), detailing and design of reinforcement (cables and rebar) for conventional slabs (without beams) and ribbed slabs with or without capitals. Generic slab format and any column arrangements. Calculates losses in cables, hyperstatic grid prestressing and checks voltages (ELS). Suitable for hook-and/or non-stick stranded cables.

Prestressed beams (V-Pro)

Performs analysis, dimensioning and detailing with post-traction, adherent and non-adherent. Checks: ELS-D, ELS-F, ELU- ACT, flexural design considering both active and passive reinforcement and shear design considering the effect of prestressing.

G-Bar

Storage of "positions", optimization of cutting and data management for the organization and rationalization of the planning, cutting, bending and transportation of steel bars used in civil construction. Issuance of management reports and labels in thermal printer.

GerPrE

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TQS-PREO – Pre-Cast Concrete

Software for the design, calculation, dimensioning and detailing of precast reinforced concrete structures. Automatic generation of several intermediate models (construction phases) and one of the finished structure, considering joints during assembly, partial crimping in the solidarized stages and intermediate and final loads. Consideration of corbels, gerber teeth, lifting holes, lifting handles, rainwater piping, etc.

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