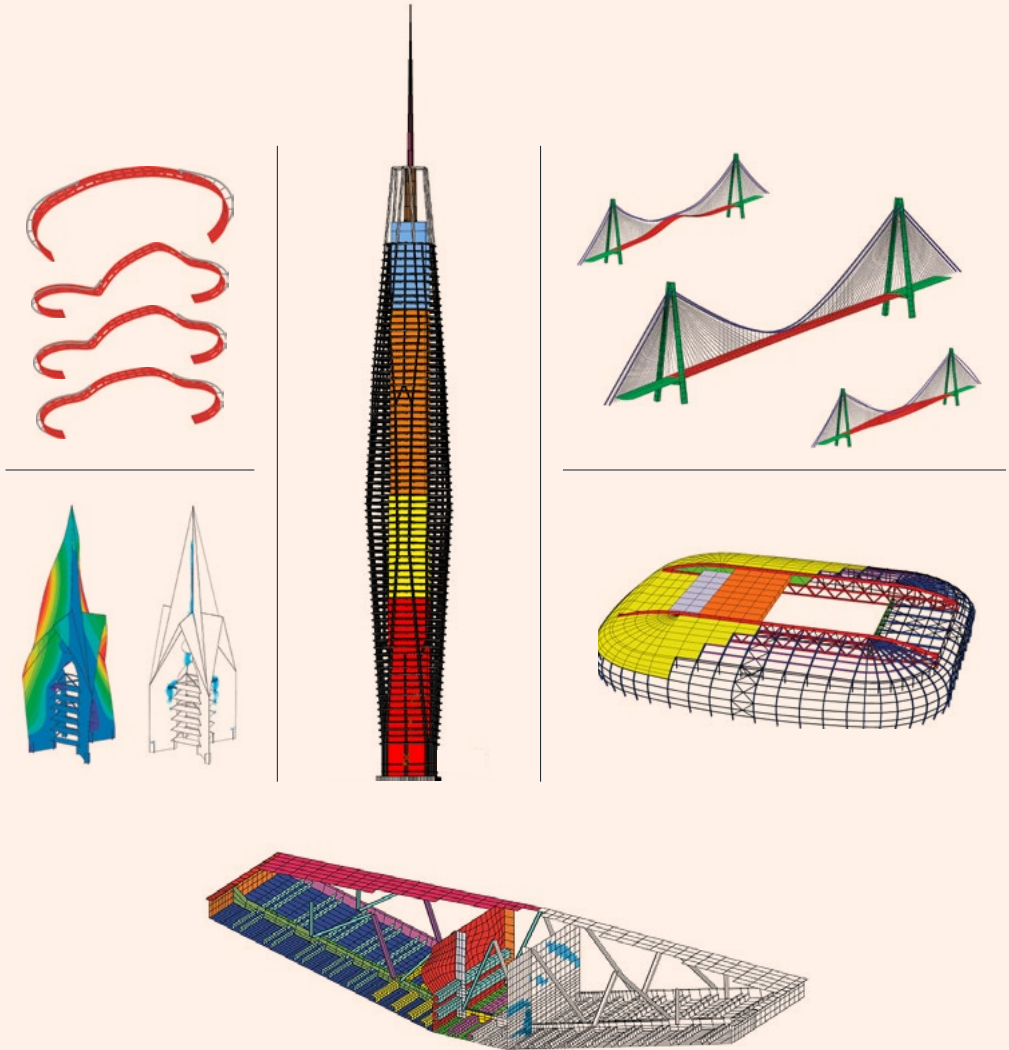


50 YEARS

DESIGN WITH FINELG



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Greisch was founded in 1960 by René Greisch, who was both an engineer and an architect. Greisch is originally based in Liège (Belgium). In 2006 a second office opened in Brussels, and a third one was established in Capellen (Luxembourg) in 2019.

Altogether, Greisch counts more than two hundred collaborators including engineers, architects, technical and administrative staff. Every day our team addresses challenging problems in various fields of civil engineering and is always open to new joint ventures.

One of Greisch's great assets is to have established a close working relationship with the University of Liège (ULiège) at a very early stage. Both the company and the university benefit from this cooperation which facilitates the exchange between the academia and the industry and allows to propose original solutions to construction companies, based on the most recent research advances. Several engineers, at Greisch, are themselves part of the teaching staff of the ULiège School of Engineering, devoting energy to train new generations of engineers and inspiring research. Furthermore, our team includes a number of young engineers who also carry out research into new fields.

This is how Greisch's R&D department has been able to stay at the forefront of research in numerical simulation. Our R&D department develops its own numerical software which contributes, on a daily basis, to the success of the various projects Greisch is involved in.

A profound knowledge of the construction companies we collaborate with, and of their potential in different fields, is another important asset. This enables us to work on challenging and highly innovative designs, by taking advantage of already available techniques but, at the same time, by constantly exploring new ways to improve them or to simplify their implementation, in the purpose of reducing costs.

The organic and smart integration of construction techniques, implementation constraints, and innovative theoretical research is the key to Greisch's unique approach.

René Greisch's deep belief in the correctness of a design in relation to efficiency, economy and functionality has translated into a series of projects (buildings, stadium roofs, bridges, ...) which have established Greisch's reputation at an international level.

The interest of René Greisch in architecture, just as much as in the dimensioning of structures, has instilled a spirit of research and innovation in his collaborators. By this fact, Greisch's reputation has grown with time, also within the architects' community, leading to many joint ventures with some of the most renowned names of our time.

Greisch counts architects amongst its own staff as well. This contributes to the creation of a stimulating environment where engineers are constantly questioning and searching for new solutions, both formal and technical.



A strong team spirit and the attitude for quest, the determination to work through collaboration and synergy, constant innovation and dynamism, invention combined with imagination have become the principles that define our working method and underpin Greisch's accomplishments.

The research culture that has flourished within Greisch, and the availability of sophisticated computer equipment, allow Greisch R&D team to explore new territories, and to devote time to develop original solutions in the most varied fields: stadium roofs, ultra-light canopy, telecommunications towers,... where innovation is driven by the pursuit for the greatest structural economy.

The discretion of our work, the absence of pretentiousness, the economic use of resources, the search for a kind of self-evident simplicity in the structures we design form the basic principles of Greisch's attitude when addressing new projects, and also form part of the team's culture.

We are convinced that the art of the engineer lies in being careful not to display all the amazing feats of which he/she is capable of and in containing the desire to demonstrate how clever a solution is, so that even a non-expert should find it almost obvious as long as it fulfils its function.



FINELG is a nonlinear solver based on the finite element method. The software supports structural design in a wide range of scenarios. For a given structure, **FINELG** allows to predict:

- its linear behaviour ;
- its eigenfrequencies and associated vibration modes, including the presence of internal stresses ;
- its critical buckling loads and associated instability modes, also accounting for geometric nonlinearities ;
- its fully nonlinear response until and after collapse ;
- its behaviour during the different stages of construction by taking into account the evolution of the structure.

For instance, the construction of a bridge by the cantilever method, or by launching can be simulated

To be able to reproduce the actual behaviour of the structure, different nonlinear effects can be included in the analysis:

- large displacements and instabilities (local buckling of shells and buckling, bending and torsional buckling, and lateral torsional buckling of beams) ;
- elasto-plastic constitutive models for steel ;
- nonlinear constitutive models for concrete, including cracks, creep and shrinkage, and related time effects ;
- residual stresses ;
- semi-rigid joints ;
- initial deformations.

FINELG provides a comprehensive library of finite elements for the analysis of civil engineering structures: truss bars, cables, plane beams, spatial beams, plates, shells, nonlinear springs, nonlinear supports, linear or nonlinear constraints, and many other.

The available elasto-plastic constitutive models cover typical engineering needs when dealing with steel, concrete, or composite structures.

Different kinds of analysis can be performed with **FINELG**:

- static ;
- dynamic by modal or nodal analysis ;
- spectral or step-by-step analysis for:
 - > seismic solicitations
 - > turbulent wind loading

Alongside its daily use by Greisch engineers in the context of real-life projects, **FINELG** is also employed:

- to undertake academic research in the domain of nonlinear analysis ;
- to simulate laboratory tests, allowing a better understanding of the experimental results ;
- to perform parametrical studies to define or to complete design rules ;
- to verify the stability and/or strength of complex structures for which simple calculation methods do not exist.

FINELG is also the hearth of a new software, called **MyFin**. **MyFin** is a fully interactive computational suite, providing a unique workflow for pre-processing, simulation, and post-processing.

The numerical model can be created interactively in 3D using the GiD¹ pre-processor. Additional tools have been integrated in GiD to access **FINELG** specific features, while retaining a great level of user-friendliness.

A catalogue of predefined profiles for steel beams is available to the user so that static cross-section properties can be assigned to beam elements simply by selecting the desired profile name.

For non-standard profiles, in particular in presence of any transversal shape, the user can draw the desired cross-section using two other interactive tools, called CALPRO and CINELU. CALPRO allows the definition of thin-walled cross-sections and it is especially employed for steel beams or bridges cross-sections, while CINELU is used for composite cross-sections without geometrical constraints.

All the cross-section mechanical properties (centroid, shear centre, orientation of the reference axes, area, bending and torsional inertia, ...) are then automatically computed, either by CALPRO or CINELU, and can be readily integrated in the numerical model.

Once the **FINELG** model is ready, the computation can be run, and the results post-processed for their interpretation.

The available results include:

- The initial structure ;
- The deformed structure for each load case ;
- The deformed structure for the different load levels, in the case of a nonlinear simulation ;
- Internal forces diagrams ;
- Reactions.

These are just some of the results that can be obtained. Furthermore, animations can be generated to get a better interpretation of the overall behaviour of the structure.

Several other computational tools are available for the interpretation of the results. For instance, it is possible to combine different load cases, or to compute the envelop of the internal forces for several load cases.

The first developments of **FINELG** date back to the 70s and were performed by researchers of the University of Liège (today ULiège) in Belgium. Since the 90s, the code has been further developed by Greisch R&D team in full collaboration with ULiège.

Without interruption, **FINELG** has been the subject of research projects funded by the European Community and by the Belgian government. Currently, a new research project, funded by the Walloon region, brings Greisch and three different universities (ULiège and UHasselt in Belgium, and INSA Rennes in France) together, for a period of four years (2019-2023). The areas that will be covered by the project are fast dynamics, probabilistic design, and stochastic solicitations.

It is Greisch R&D team's firm intention to maintain close relations with the academia to ensure that all the new developments introduced in **FINELG** are at the forefront of technology and lie on solid theoretical bases.

1 <https://www.gidsimulation.com/>

Every day, technological advances lead to new possibilities in civil engineering. Architects exercise their imagination to exploit them at their best when conceiving new structures such as buildings, bridges, footbridges, or canopies. As a result, new structures are often characterised by complex geometries.

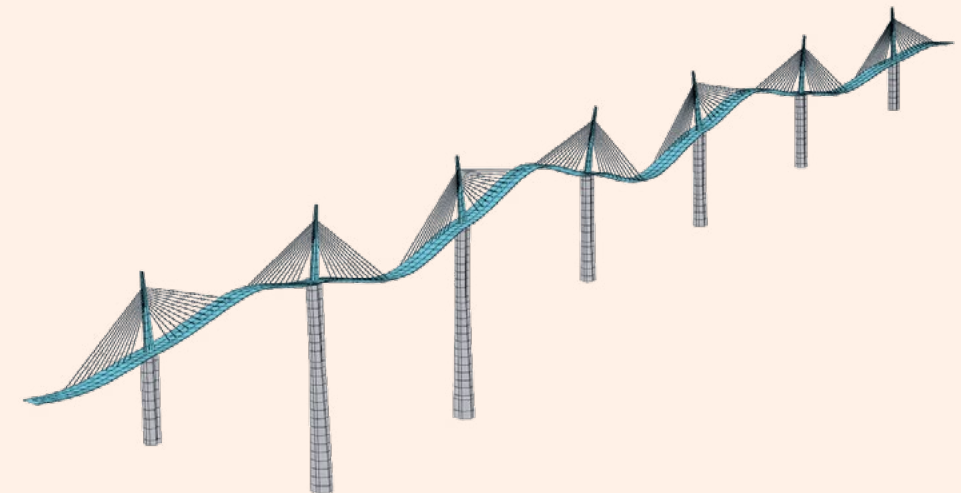
For such structures, although it is still possible to perform simple computations by hand to get a preliminary design, the use of some Finite Element software is unavoidable to achieve the final design, which demands extensive analyses and requires a deep understanding of the behaviour of the structure.

The interest of a Finite Element solver, such as **FINELG**, is to allow the detailed modelling of any structure whatever its geometry.

Even if **FINELG** represents a fantastic tool, the understanding of the underlying physics and the mastering of structural mechanics remains of capital importance. Engineers must know what to expect, even before using a Finite Element code.

FINELG has been employed in many projects, in particular :

- For the design of buildings, roofs, canopies, road bridges, high-speed rails (HSR) bridges, water bridges, footbridges, works of art drawn by artists, water tanks ;
- For the renovation of Historical structures, such as churches ;
- For scientific research including simulations of experimental tests and simulations of parts of one structure to define ad-hoc design rules, when not available in the standard ;
- For expertise concerning the collapse of a structure.



Vibration eigen mode of Millau viaduct

Millau Viaduct (France)



An eight-span multi-cable-stayed viaduct of overall length of 2,460 metres, in a site presenting severe geographical and climatic conditions: a steep-sided valley, and strong winds with high speeds and turbulence.

The superstructure is entirely made of steel – an orthotropic deck (28 m wide and 4.20 m high) and 7 pylons (90 m high). Total weight of steel: 50,000 tons.

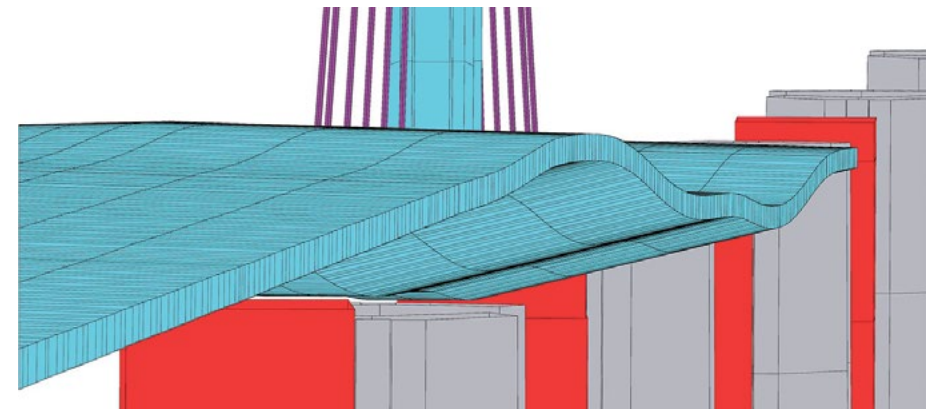
The bridge was built by launching the deck from the two sides of the valley, earning a triple world record – launched in spans of 171 m, to a maximum height of 280 m (junction over the river Tarn) and with a total weight of 20,000 tons on the last launch. The highest temporary pier stood at 175 m.

Greisch introduced the steel variant and carried out all the working calculations for the deck-pylon-cable structures for :

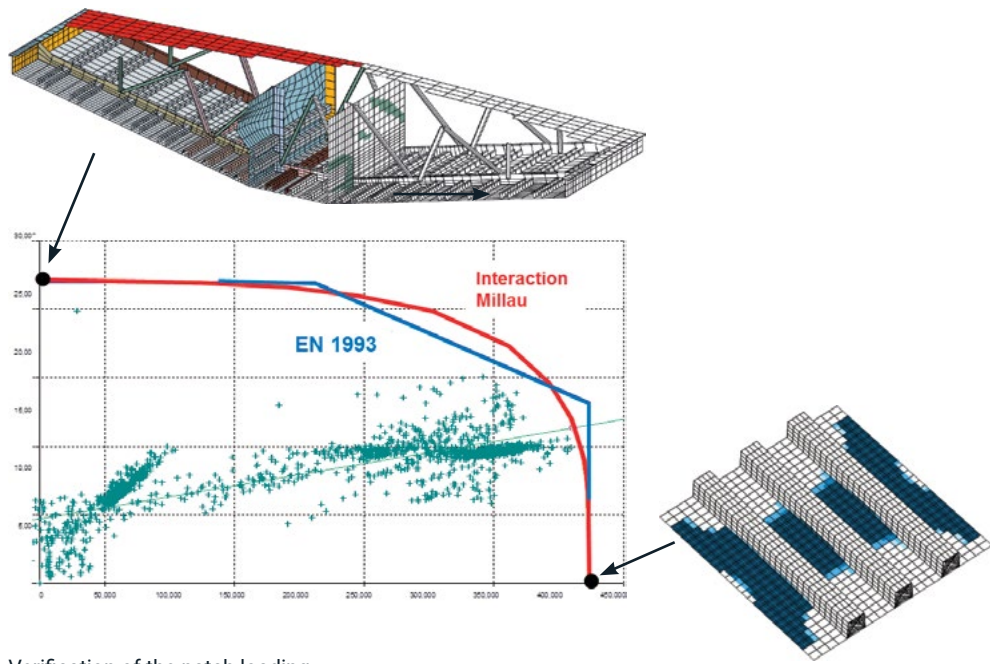
- the service life ;
- each construction stage ;
- under static and turbulent wind.



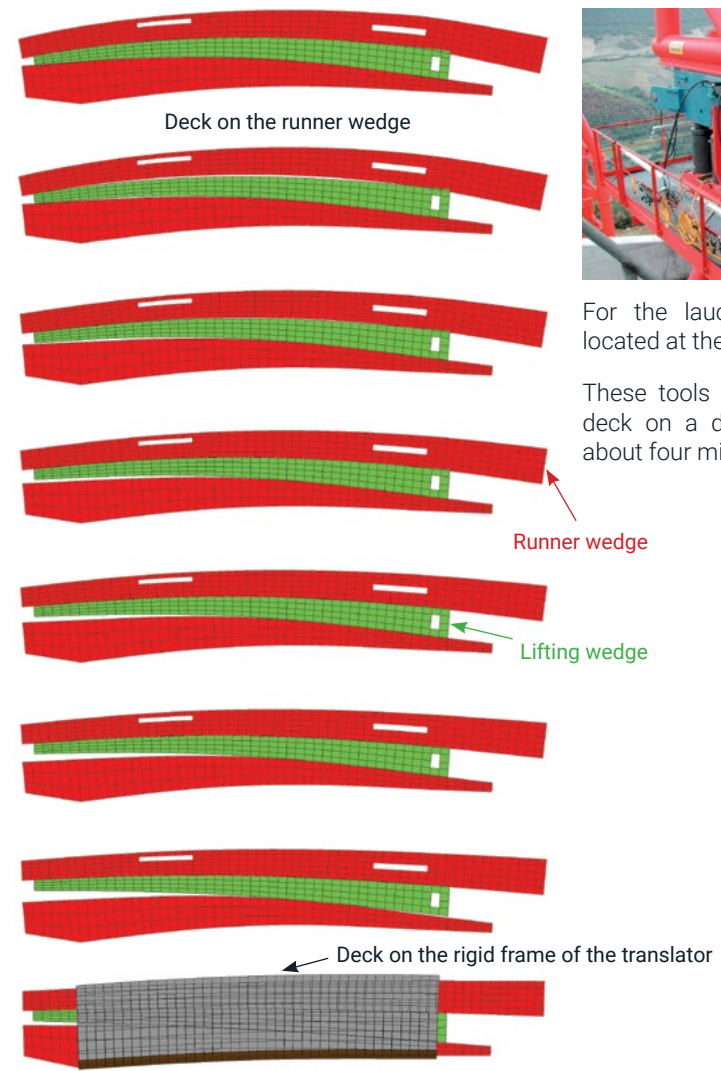
Deformed shape of deck during launching



Deformed shape simulation



Verification of the patch loading

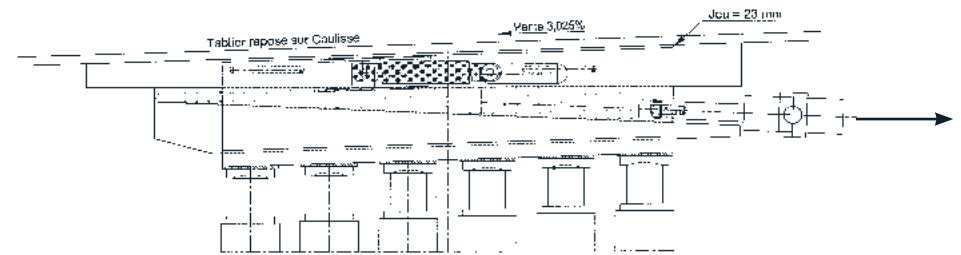


Simulation of the wedge deformations during a launching step

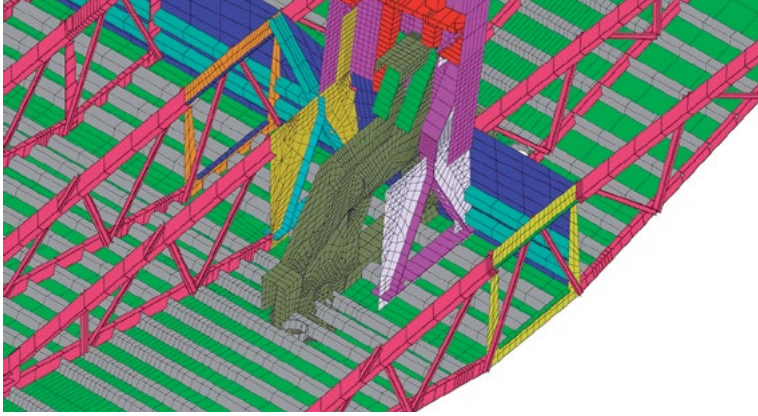


For the launching, translators were located at the top of the piers.

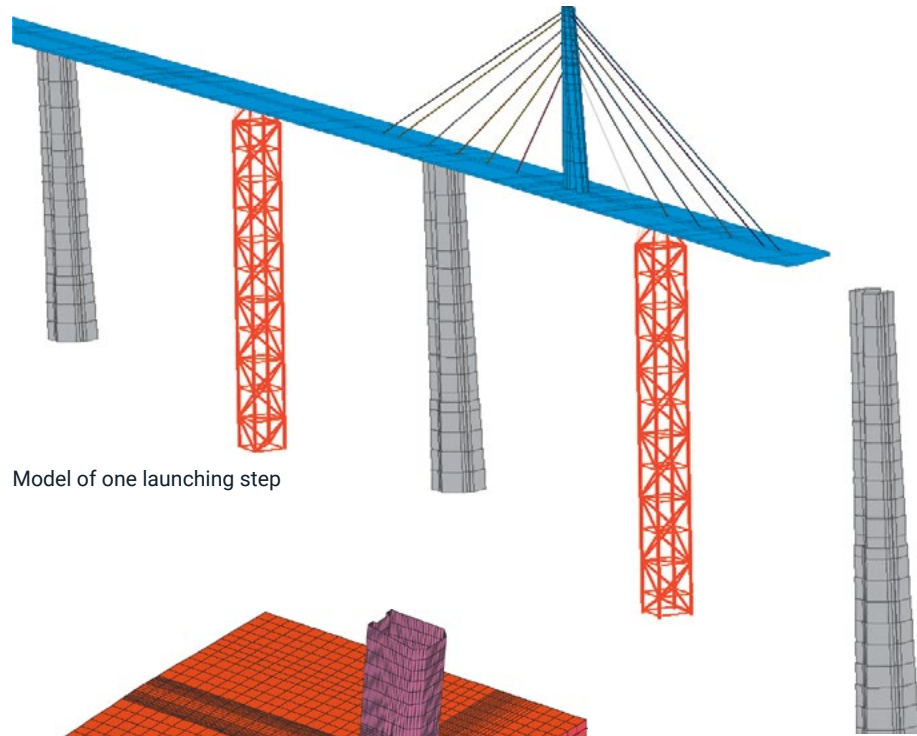
These tools were able to move the deck on a distance of 600 mm in about four minutes.



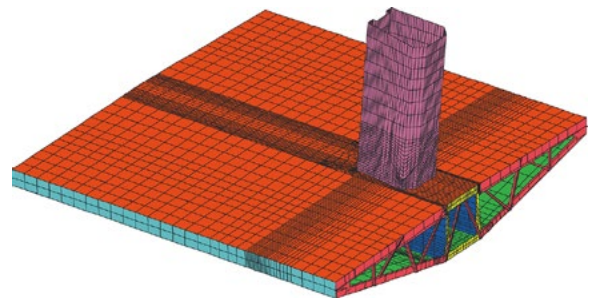
View of the translator



Study of the local stresses distribution in the node deck / pylon / pier.



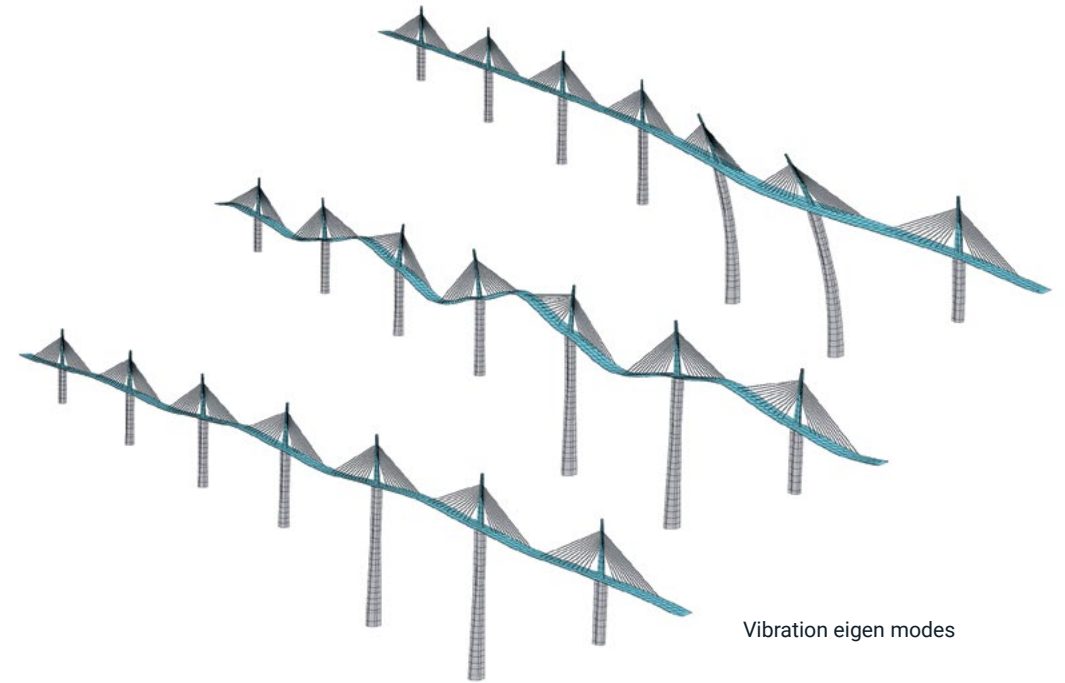
Model of one launching step



3D model of the connection deck / pylon / pier



© Daniel Jamme



Vibration eigen modes

Nonlinear simulations of the launching steps.



3rd Bosphorus Bridge (Turkey)

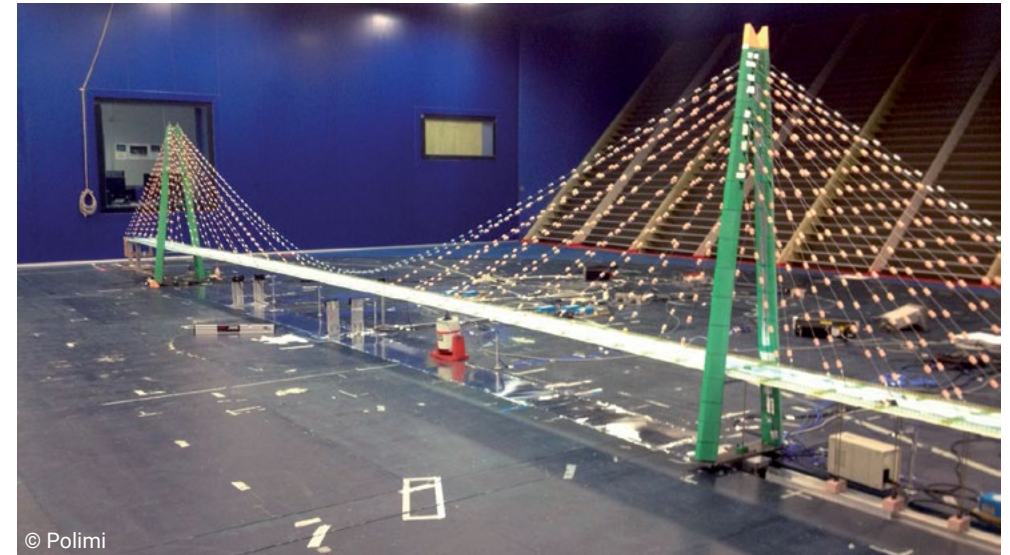


Suspension bridge with a 1408 m-long main span and a total length of 2 408 m, located north of Istanbul near the Black Sea.

As the Brooklyn bridge, the main span is partially suspended at the towers by stiffening cables and at the main cables with vertical hangers. The top of the towers, composed of 2 concrete shafts, is 320 m above sea level. The deck is 5,50 m high and 58 m wide with 4 road lanes in each direction, 2 railways tracks and 2 sidewalks.

In the central span, the steel deck is made of an orthotropic plate (total steel weight : 45 000 tons). The side spans are made of post-tensioned concrete.

The preliminary design is the result of a competition won by Michel Virlogeux (France) and Jean-François Klein (Switzerland). The final design is by T-Ingénierie (Switzerland), Greisch (Belgium) and Michel Virlogeux on behalf of the joint venture Içtas and Astaldi S.P.A.

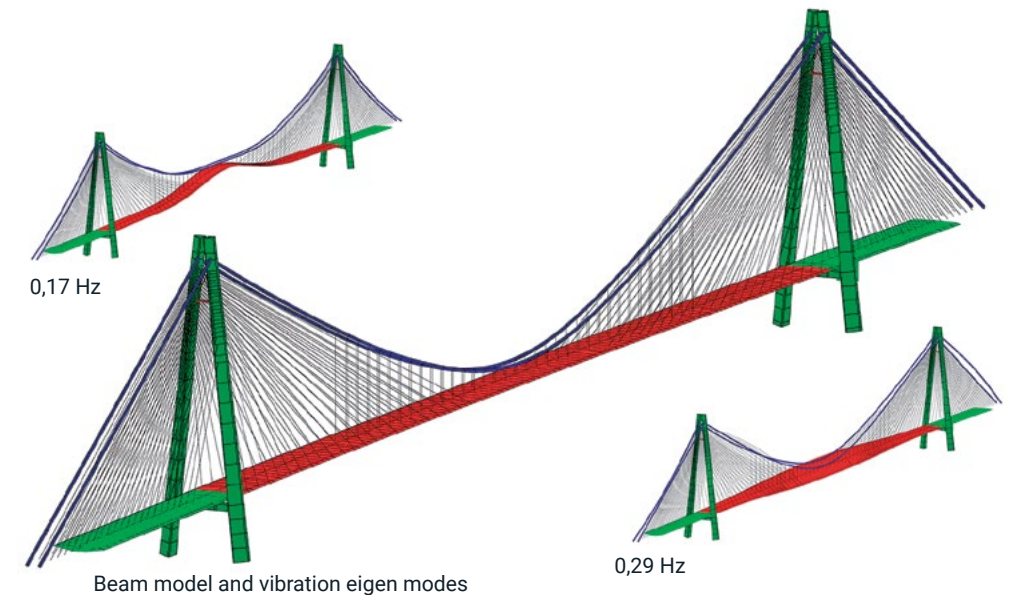


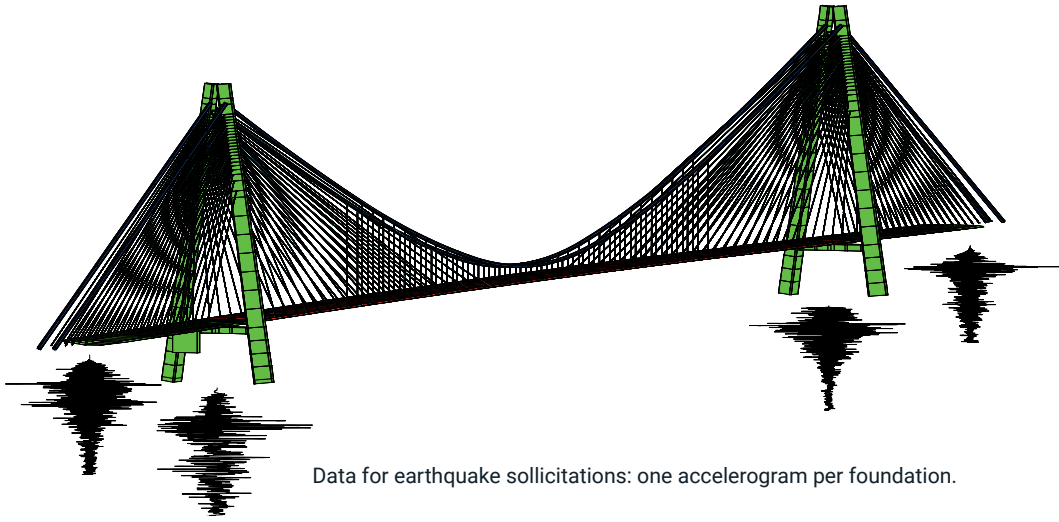
© Polimi

Wind tunnel tests

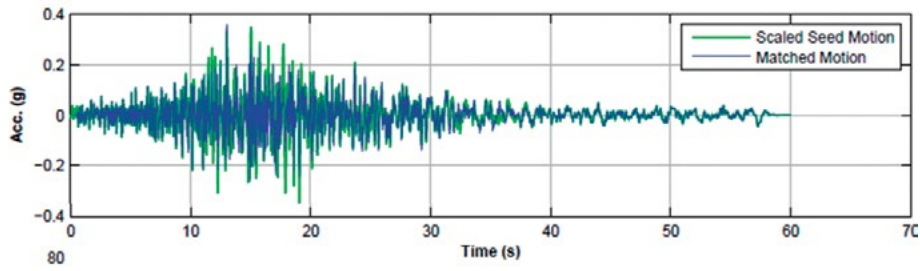
Greisch mission :

- calculations of the structure global behaviour during its service life ;
- proposals for construction methods ;
- design of the main-span steel deck ;
- dynamic studies necessary to verify the behaviour of the global structure :
- under the action of wind (during service life and construction stages - verifications made by numerical simulations and by tests in wind tunnel laboratory),
- in case of earthquake and/or passage of trains.





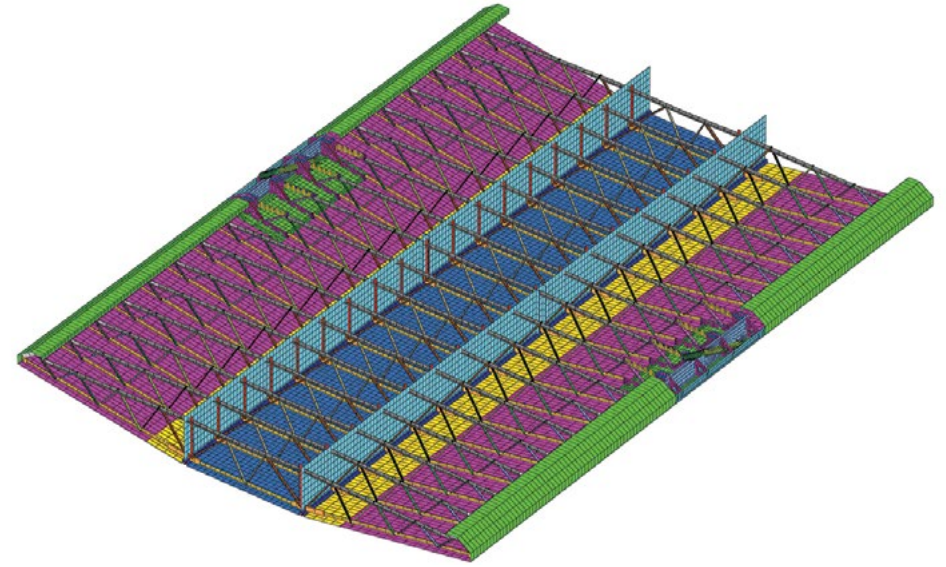
Data for earthquake solicitations: one accelerogram per foundation.



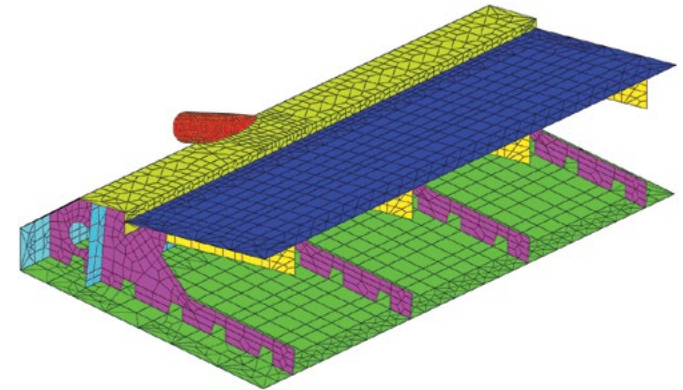
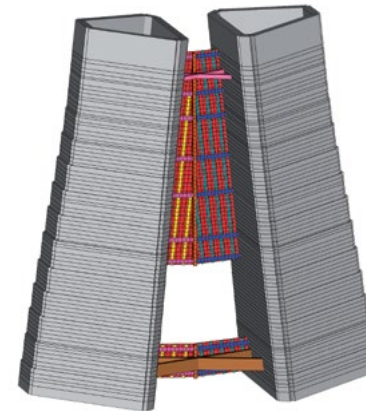
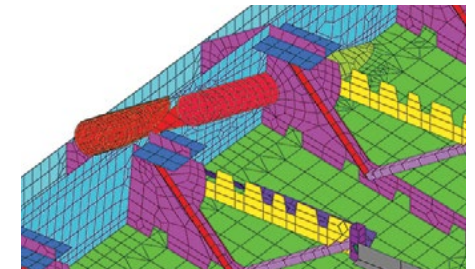
Accelerogram for seismic simulation.



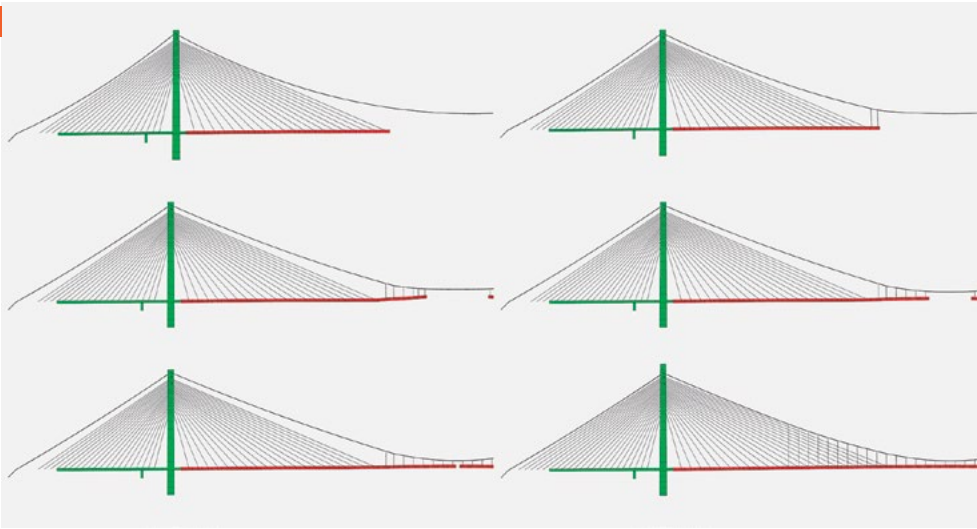
Deformed shapes during earthquake.



Model of the deck for the design of the stay cables anchorage.



Model of the connection of the pylon legs at the top.

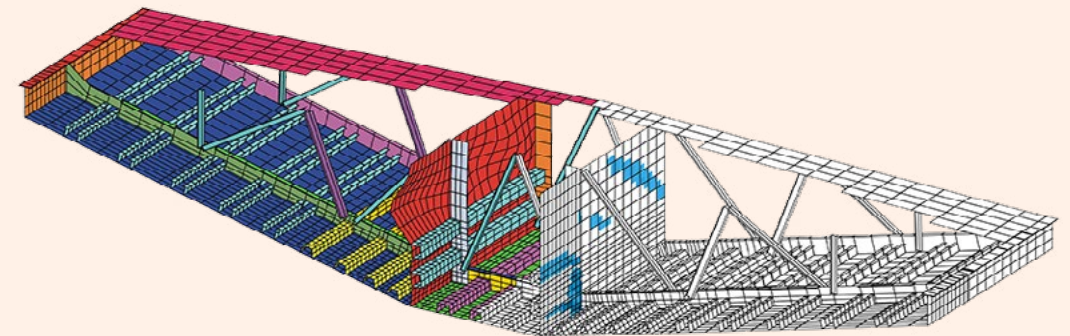


Some steps of the main span construction.



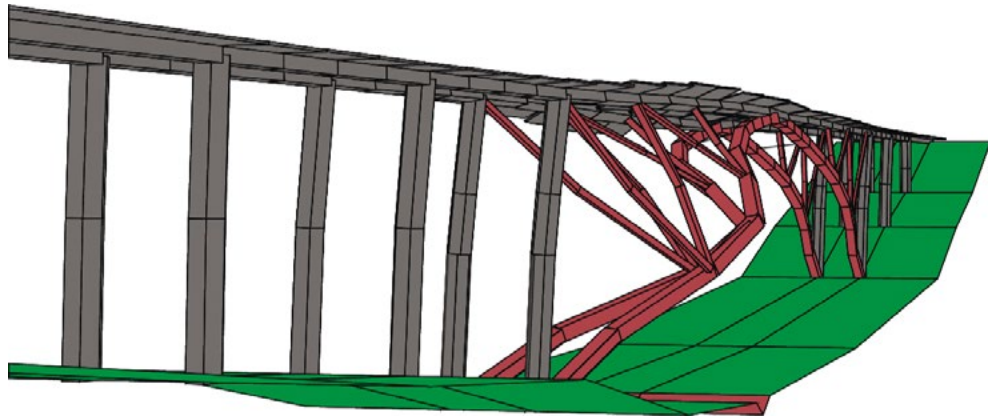
A classical method for designing a structure in which instability phenomena can arise is to add stiffeners and/or bracings. However these structural elements are costly and complicate the construction works. To avoid them, more advanced analyses have to be performed. This can be achieved either based on the rules proposed by the Standards, or by means of finite element simulation, to predict the instability loads and/or the nonlinear behaviour of the structure, possibly taking into account the elasto-plastic constitutive law of the material.

The final goal is to verify the safety of the design. Examples are the launching of bridge decks or the suppression of stiffeners, even if, in this case, it is usually necessary to increase the compression plates thickness. In the case of bowstring bridges, the suppression of external bracings would increase the slenderness of the structure. Nonetheless, removing external bracings between arches results in a simplified construction process.



Patch Loading during the launching of the Millau Viaduct.

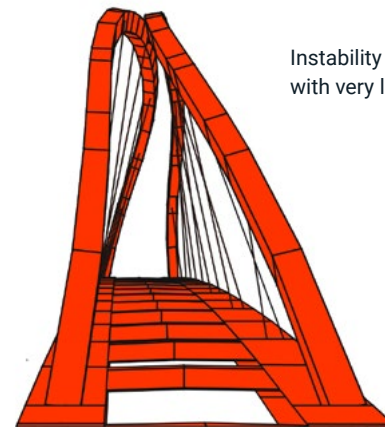
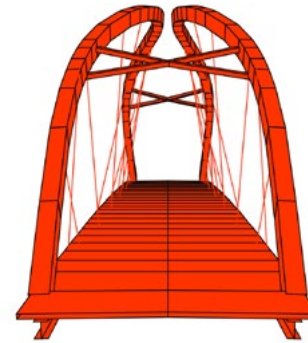
Eau-Rouge Viaduct (Belgium)



Instability verification without bracing between both arches.



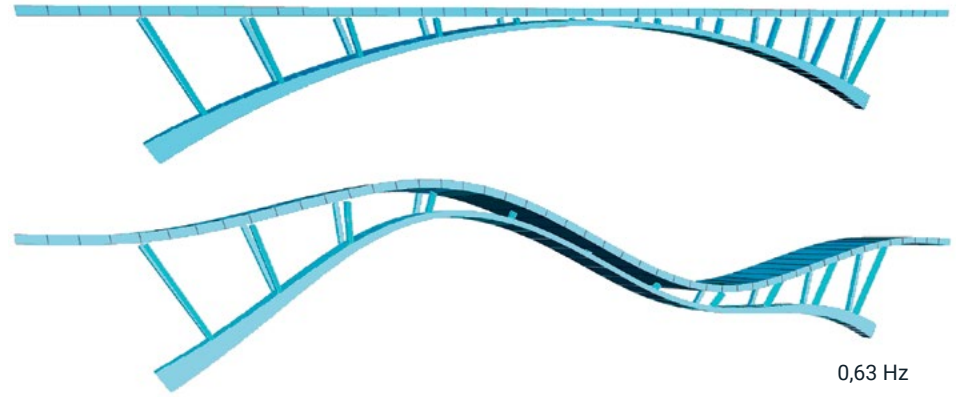
Milsaucy Bridge (Belgium)



Instability verification without or with very light bracings.

Hermalle Bridge (Belgium)

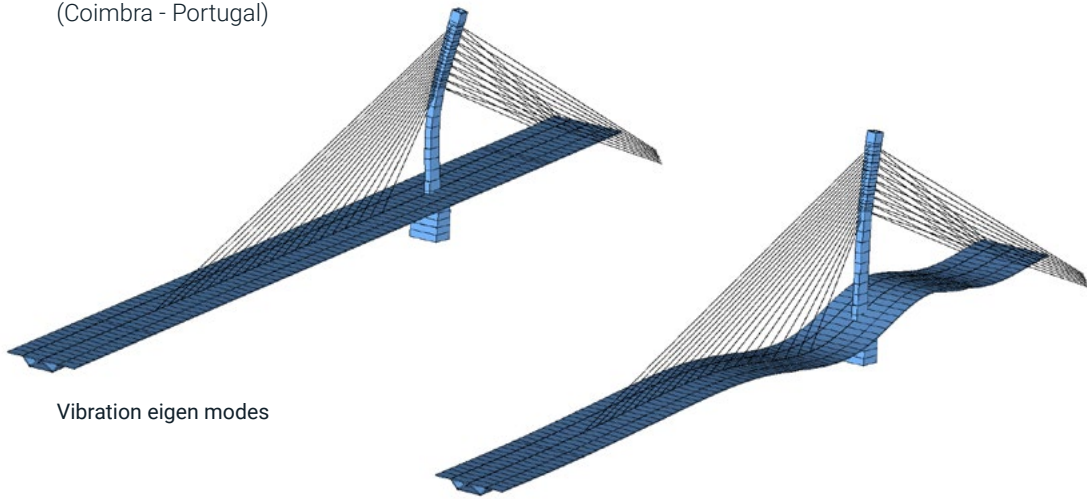




Vibration eigen modes

0,63 Hz

European bridge
(Coimbra - Portugal)



Vibration eigen modes

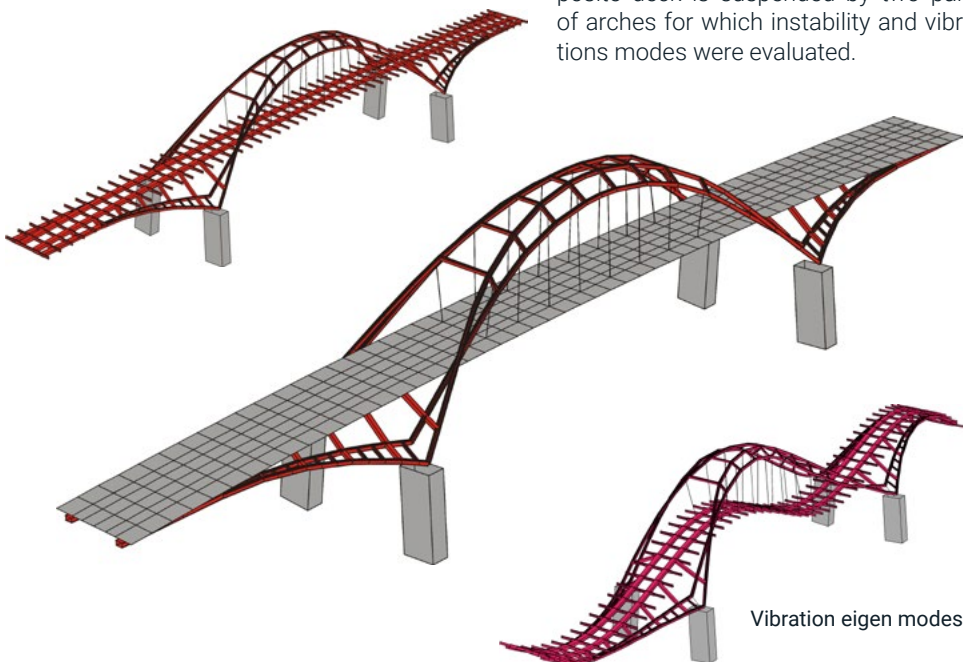


Analysis of the behaviour during the construction : cantilever method / composite deck

(with creep, shrinkage, cracking of concrete)

Arch Bridge (Chooz - France)

Bridge over the Meuse river. The composite deck is suspended by two pairs of arches for which instability and vibrations modes were evaluated.



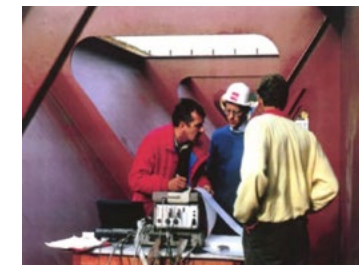
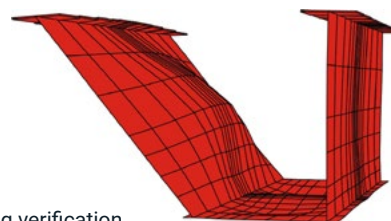
Vibration eigen modes



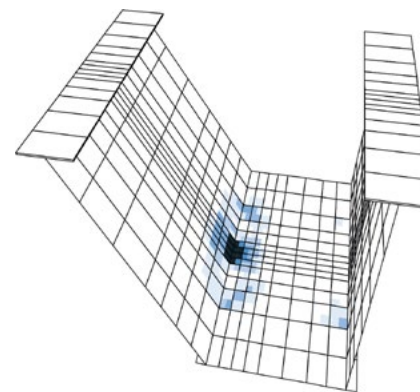
Alzette Bridge (Luxembourg)



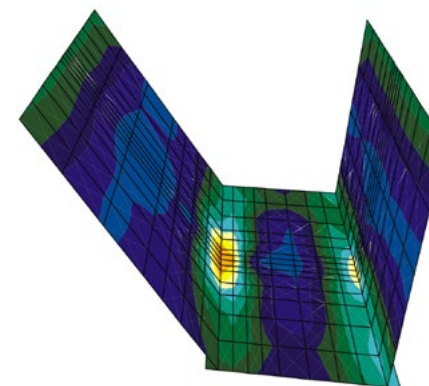
Patch Loading verification



Measurements on work site

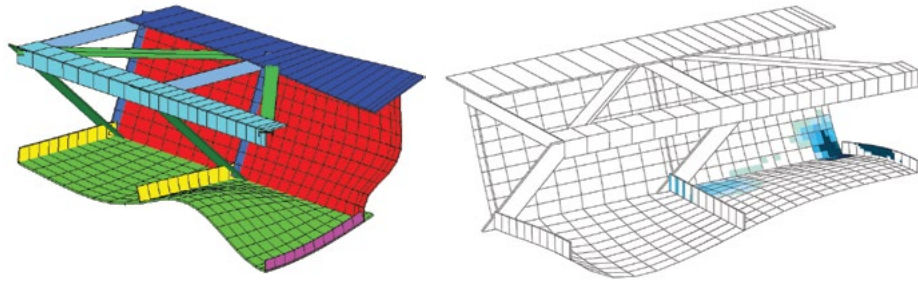


Plastification pattern

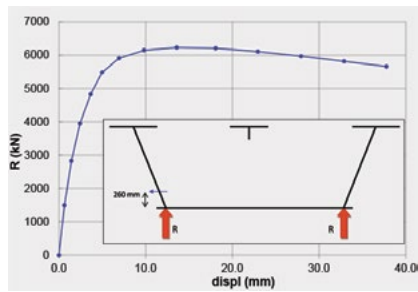


Stresses distribution

Sado Viaduct
(Portugal)

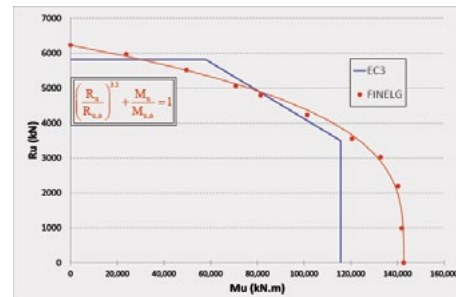


Patch Loading verification

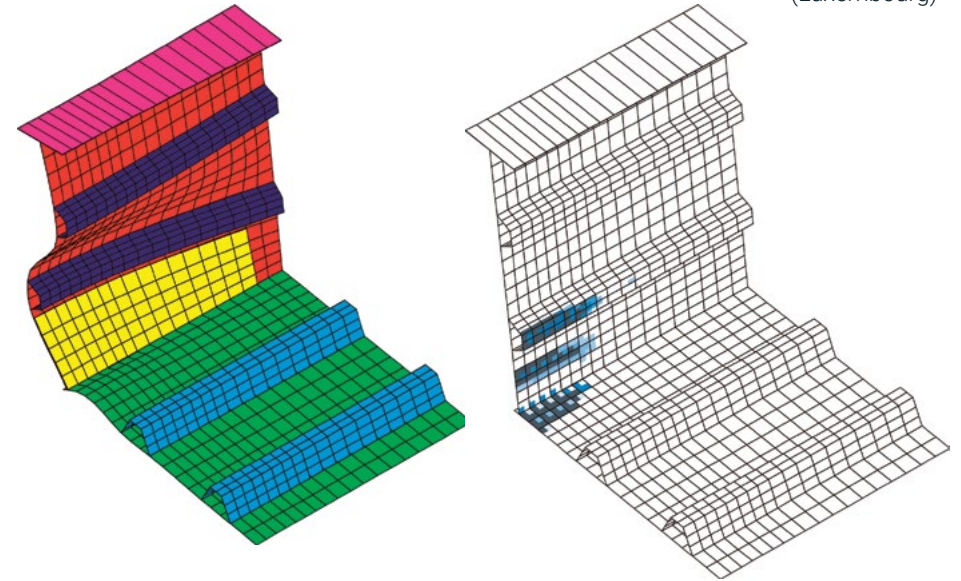


Vertical reactions versus web lateral displacement

Interaction criteria :
bending moment / vertical reaction



Schengen Viaduct
(Luxembourg)

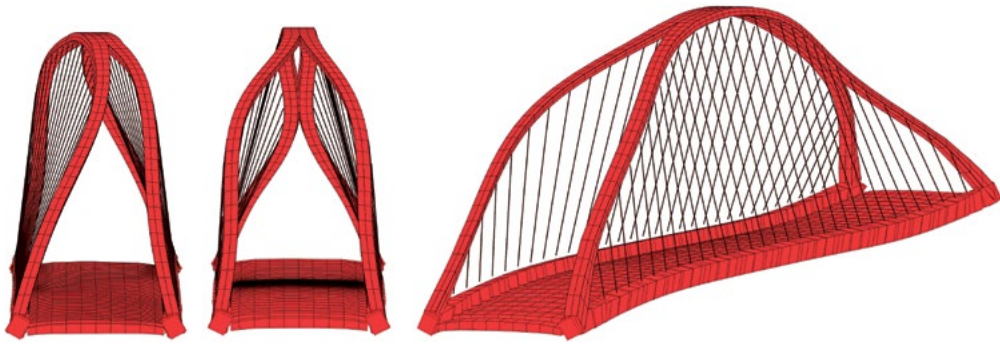


Patch Loading verification

Plastification pattern

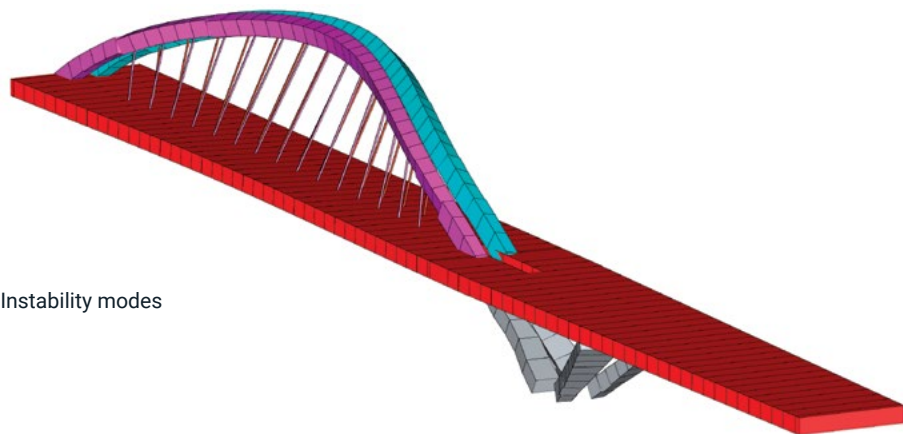


Canal Albert (Belgium)



Instability modes

Seibert (France)



Instability modes

Wind engineering - R&D

The analysis of the response under turbulent wind loading is fundamental to verify the stability and dynamic behaviour of large and slender structures, buildings, roofs, or bridges. For structures larger than 150m the Eurocodes suggest to consult an expert, to perform on-site measurements to define the wind profile, and to perform wind-tunnel tests. Based on the on-site measurements, numerical simulations of the dynamic behaviour of the structure can be performed, alongside with the test campaign. The goal of these computations is to verify, for example, the safety and comfort of car drivers on a bridge, or of the occupants of a building.

Often, wind tunnel engineers already have at their disposal some software to perform this kind of simulations. However, for a design office in charge of the design, the best solution is to develop its own computational tools, in order to remain autonomous, and to be able to analyse any desired configuration (e.g. the different stages of construction of a bridge). In this context, the presence of a R&D department, with close relationships with different universities, is one of Greisch major assets.



Riga station model in RWDI wind tunnel Lab

Wind engineering

TURBULENT WIND with FINELG (FEM software)

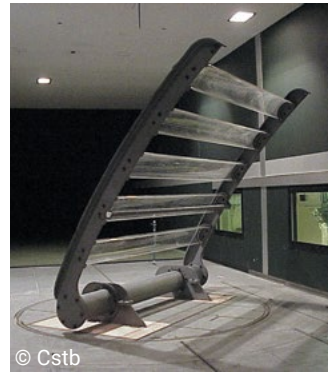
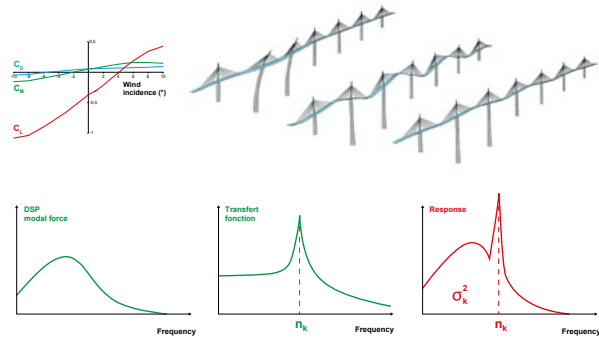
Structure behaviour under wind loading :

- + wind characteristics
(turbulence intensities, turbulence scales, coherence factors, ...)
- + aerodynamic coefficients
- + numerical simulations
- = wind responses
mean + background + resonant



Measurements on site

Millau Viaduct (France)



Wind shield



© Cstb



© Cstb

Aeroelastic model of a construction stage



© Cstb

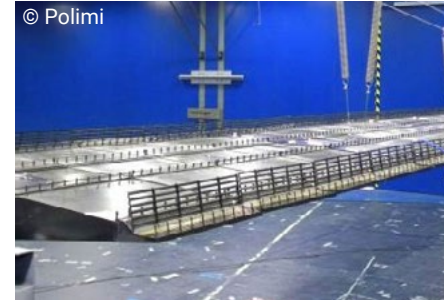
Temporary pier

Bosphorus Bridge (Turkey)

Wind tunnel tests



© Polimi



© Polimi

Wind shields



© ULiège

Deck lifting

Aeroelastic models



© Polimi

Pylon



© Polimi

Construction stage



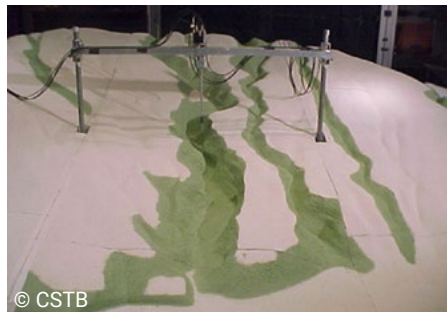
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Sectional models

Ravine-Fontaine bridge (Réunion Island - France)



© CSTB

Definition of wind profile

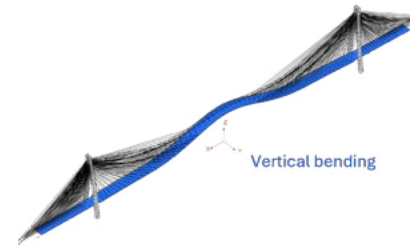
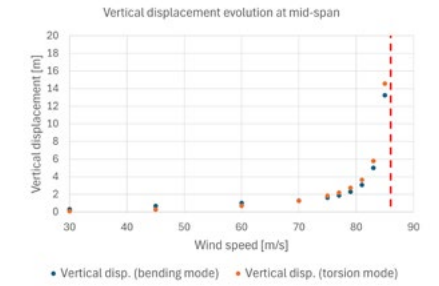


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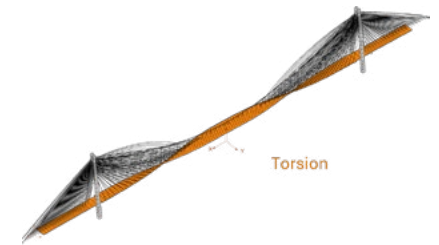
Sectional model



The instability limit is defined by the so-called wind mean 'limit velocity', at which the structural response grows unboundedly.

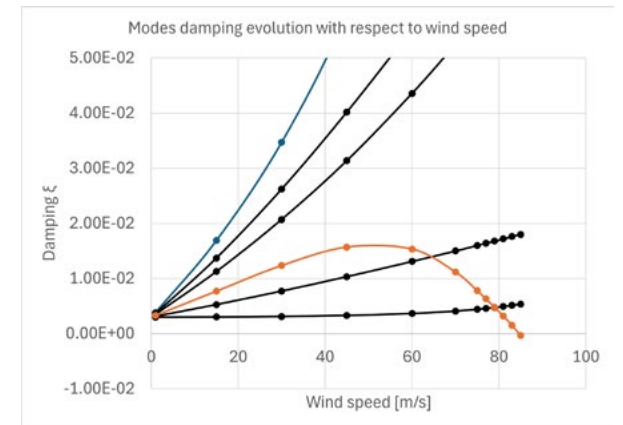


Vertical bending

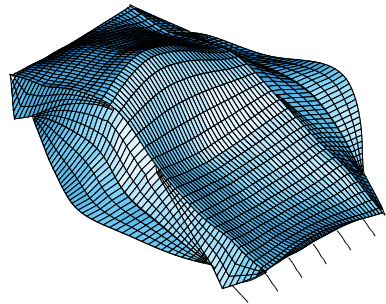
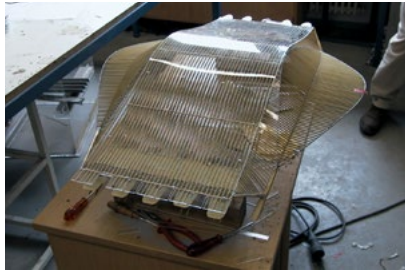


Torsion

Flutter is characterized by a coupling between bending and torsion vibration modes induced by wind forces. In this case, the instability speed coincides with the moment where the damping of the torsional mode goes to zero.



Guillemins Railway Station (Liège - Belgium) Vibrations modes



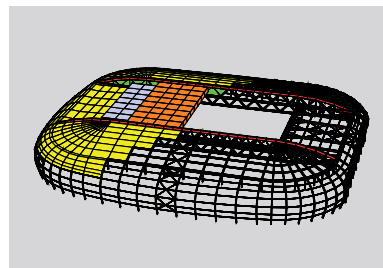
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Lille Arena (France)

Wind tunnel tests and numerical simulations



© CSTB

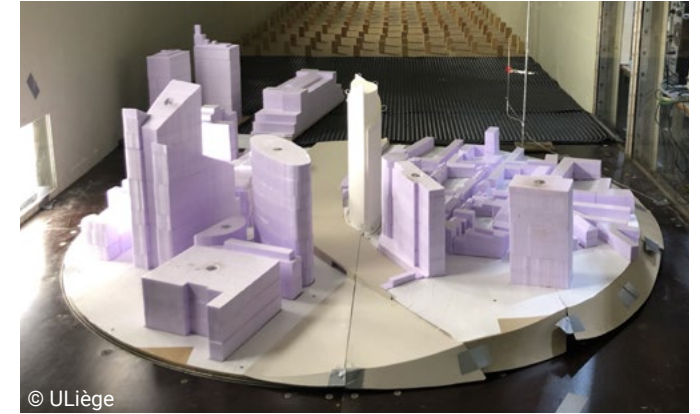


Model including the surrounding environment



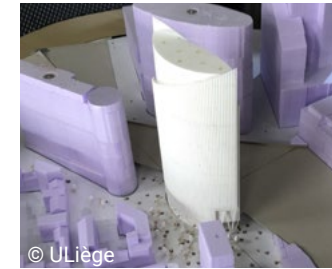
© ULiège

Rigid Model

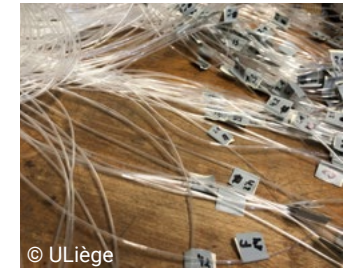


© ULiège

Model with its environment



© ULiège



© ULiège

Taps connectors

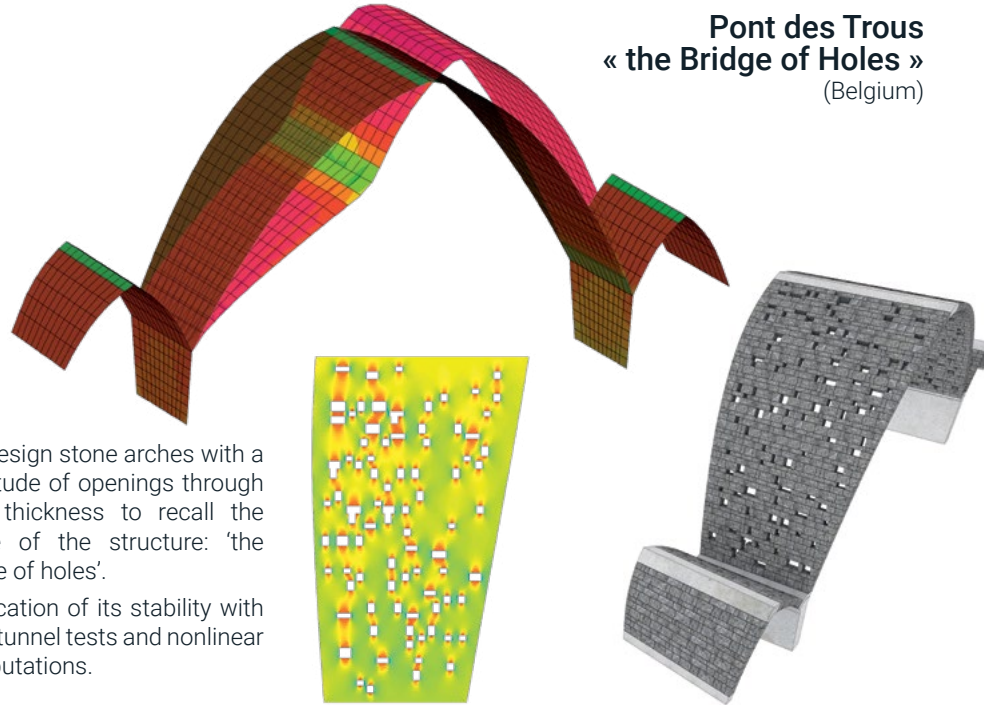
Greisch engineers in wind tunnel labs or on the work site





© O. Bastin

Pont des Trous « the Bridge of Holes » (Belgium)



Pre-design stone arches with a multitude of openings through their thickness to recall the name of the structure: 'the bridge of holes'.

Verification of its stability with wind tunnel tests and nonlinear computations.



© Uliege



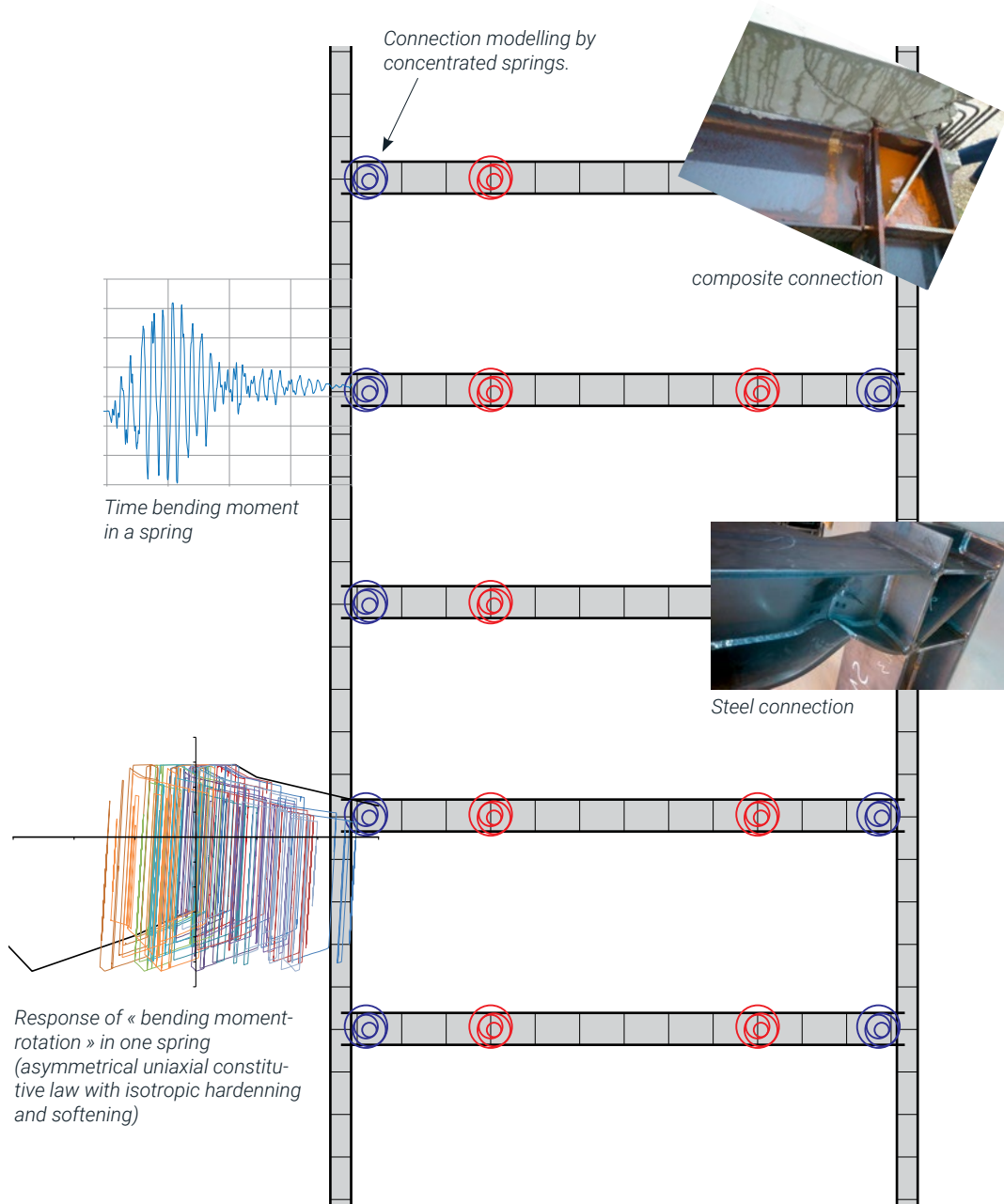
Greisch R&D team continuously strives to improve Finelg through cutting-edge theoretical developments and technological advances. Through time, this effort has been regularly supported by public funds, particularly from the European Commission and the Walloon Region.

In the case of European projects, Greisch usually takes part as a regular partner, while for projects at a regional scale Greisch is often the principal promoter.

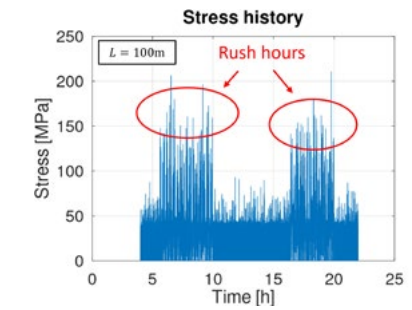
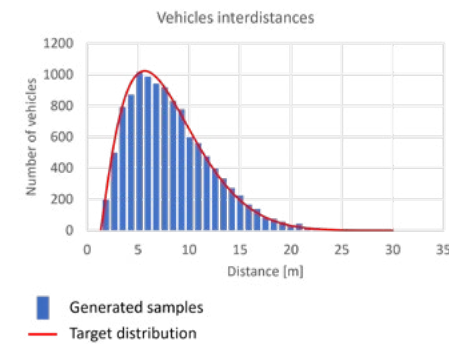
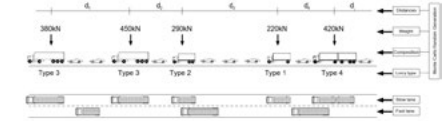
Historically, the majority of research activities has been conducted in partnership with the University of Liège. In recent years, also INSA Rennes (France) and UHasselt (Belgium) have joined different research projects, thanks to privileged relationships developed with some of the academic staff.

Research projects represent a unique opportunity for Greisch R&D team to perform long-term developments. Sometimes, the topics addressed within the research do not find immediate application to real-life projects Greisch is involved in. However, experience tells us that every development that has been performed has eventually found application. More than that, many of Greisch emblematic projects would not have been even possible without the advancements achieved during research projects.

Design of steel and composite structures with limited ductility requirements for optimized performances in moderate earthquake areas.

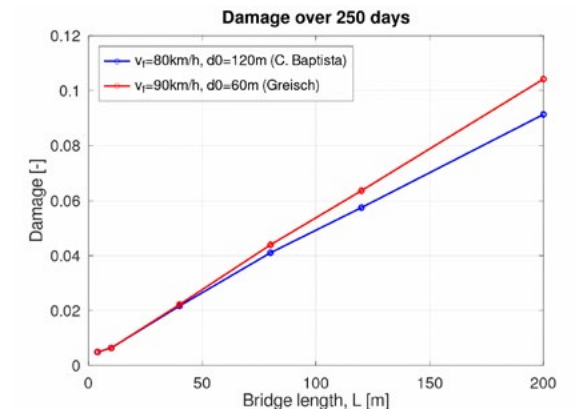


Computer-based synthetic traffic generation according to real-life probability distributions of vehicles inter-distances and weights



Evaluation of fatigue damage with respect to main span length, according to different traffic parameters:

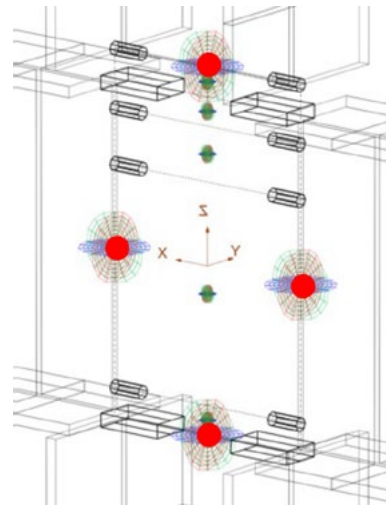
V_f : trucks mean speed
 d_0 : mean vehicles inter-distance



Semi-rigid joints have an important role in the overall behaviour of steel structures, particularly during seismic actions or exceptional events such as the loss of a column.

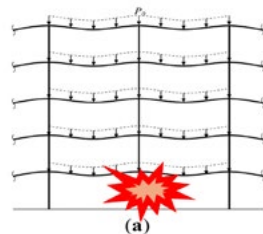
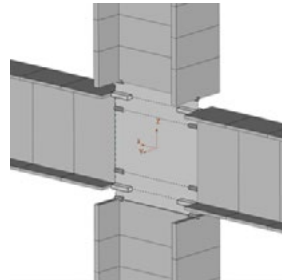
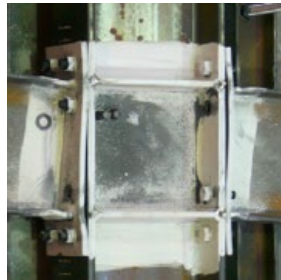
A super finite element integrates elementary components (plates, bolts, web panels, etc.), each of which is modelled as a non-linear spring calibrated according to the recommendations of Eurocode 3.

Group effects, interactions between components, and the variation in shear force along the height of the column web panel are captured.



Super FE nodes

Connected to columns/beams

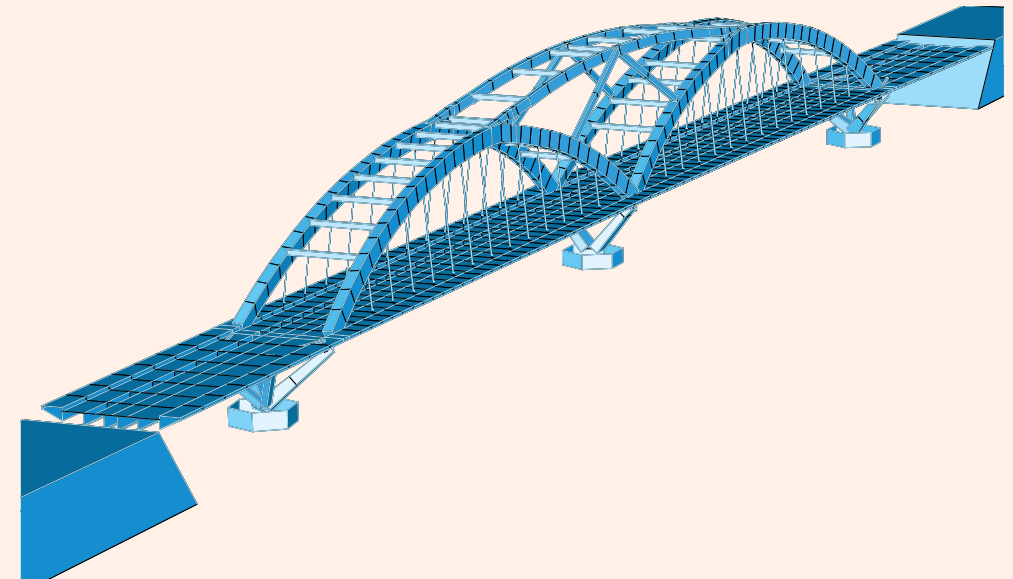


This framework allows the analysis of complex loading scenarios, including progressive failure or accidental situations such as loss of vertical support, facilitating advanced structural robustness assessments.

Today, structures exhibit more and more slender geometries and many of the loads applied on them are time dependent. For these reasons, the dynamic behaviour of the structure is of great importance. Typically, vibration phenomena can appear, and, for several reasons, it is often necessary to limit their effects.

Dynamic effects have to be accounted for in many situations:

- For HSR viaducts, in the case of crossing trains, for speeds ranging from 100 km/h to 350 km/h: for safety reasons, bridges accelerations and deformations have to be computed for different train speeds ;
- For any type of structure, its resistance to seismic events has to be verified ;
- For bridges, buildings, and stadium roofs: their dynamic response has to be examined to ensure the users comfort (bridges and buildings) on the one hand, and their resistance under the action of wind on the other hand. If necessary, tuned mass dampers (TMDs) have to be employed to limit accelerations, for comfort reasons. Every TMD is specifically designed for a given structure ;
- For footbridges: dynamic loads induced by pedestrians have to be accounted for and, also in this case, TMDs must be often employed to increase comfort.



Model of Donzere viaduct

Sado Viaduct

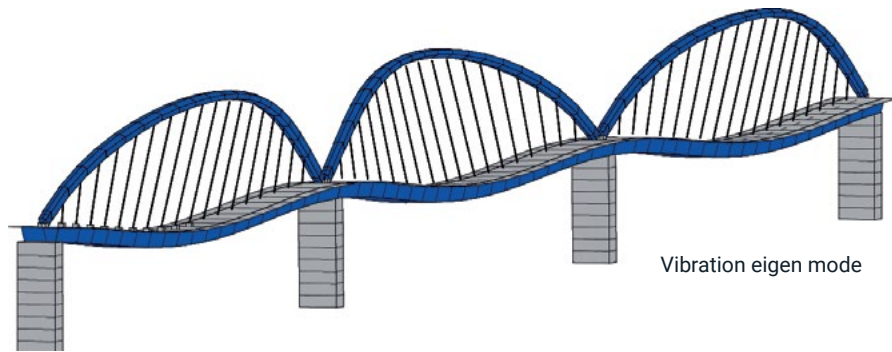
(Portugal)

Lots of high speed train viaducts are made of steel or composite (steel and concrete) structures. The high density of such railways in France gave us the opportunity to collaborate with several contractors in their construction.

In 1992, Greisch was in charge of the detailed design of the longest French H.S.R. viaduct (Saint-Omer - La Haute Colme). For this type of bridge, the understanding of technical railway bridges specifications, and the characterisation of their dynamic and fatigue specific behaviours are essential.

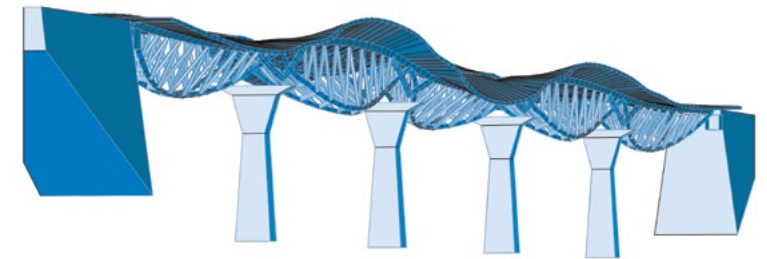
Later in the 90's, Greisch was called by SNCF, through the contractors, to perform the detailed design of the four most prestigious steel bridges along the new high-speed line between Lyon and Marseille : Arc, Donzère (Garde-Adhémar), Mornas and Mondragon.

The viaduct over the river Sado in Portugal has been realized in collaboration with the Portuguese engineering office GRID, from the global design of the multiple-arches bridge to the detailed design.

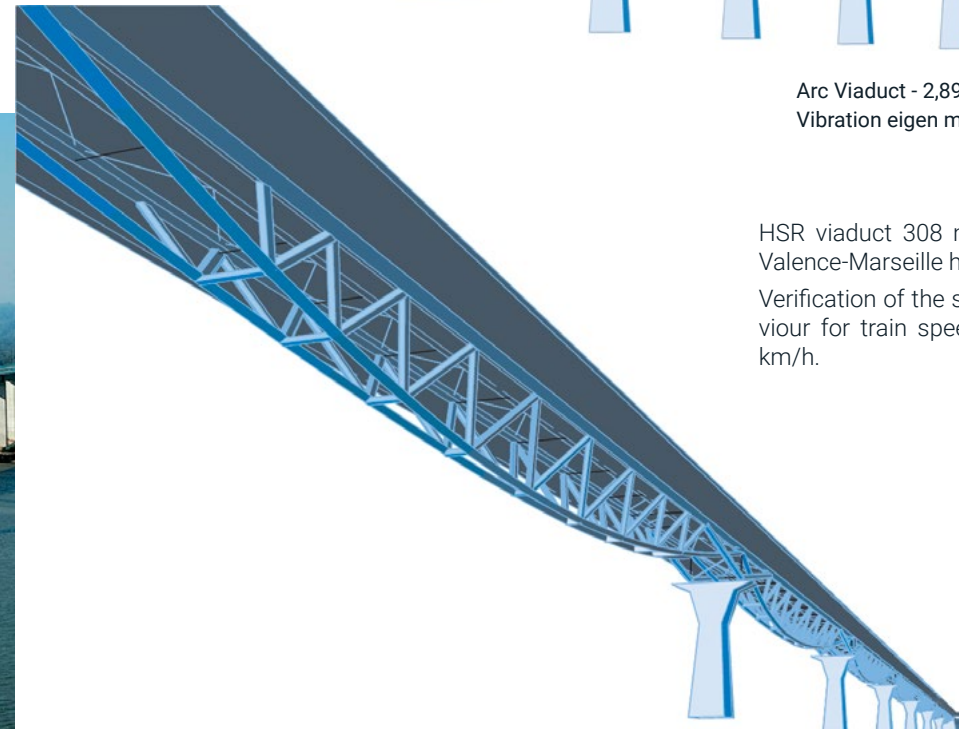


Arc Viaduct

(Aix en Provence - France)



Arc Viaduct - 2,89 Hz
Vibration eigen mode

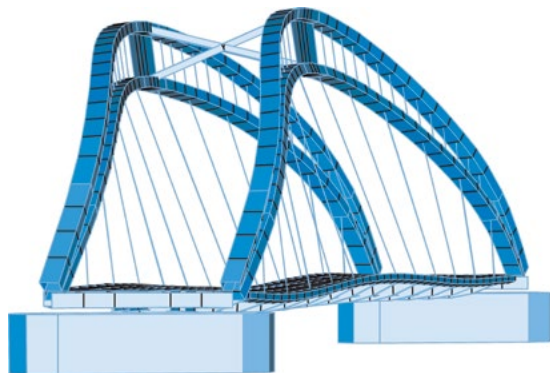


HSR viaduct 308 m long on the
Valence-Marseille high-speed line.
Verification of the structure behaviour
for train speeds up to 350
km/h.

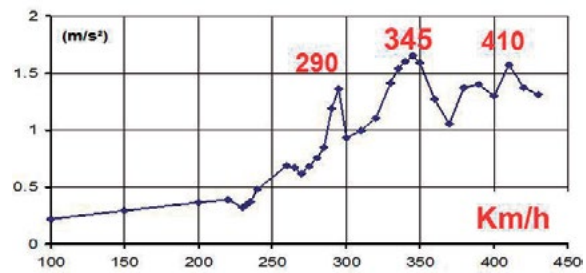
Mornas Viaduct (France)



HSR viaduct on the Valence-Marseille high-speed line.



FE model of Mornas Viaduct

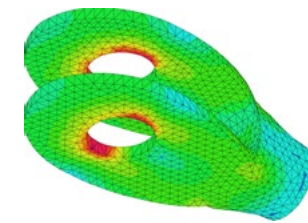


Acceleration versus train speed

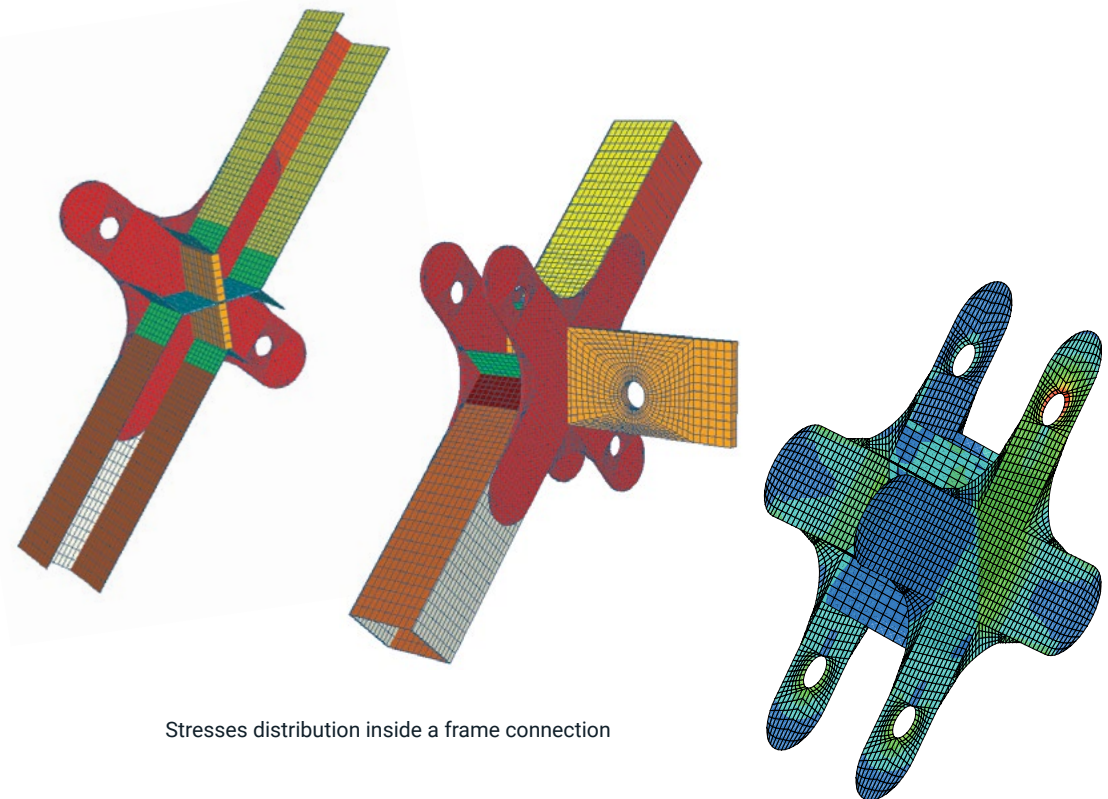


High speed line Savena – Sieve (Italy)

HSR-Savena (Sieve - Italy)

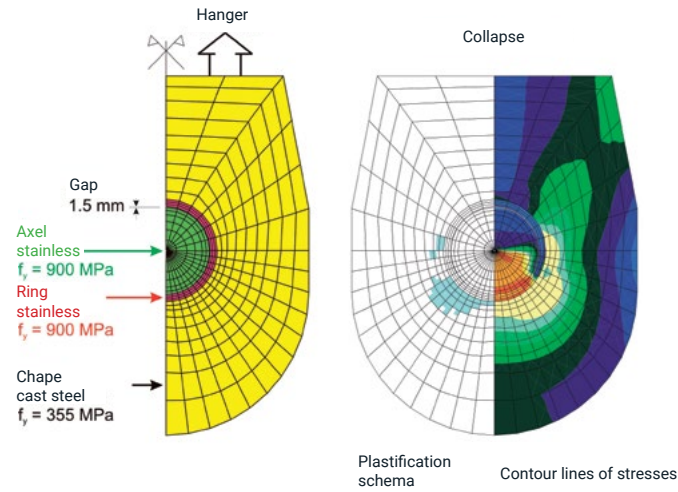


Test and models of hanger sockets

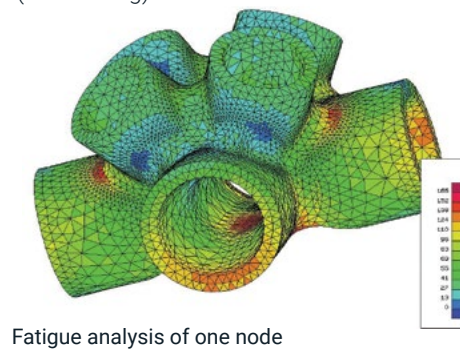


Stresses distribution inside a frame connection

Donzere Viaduct (France)

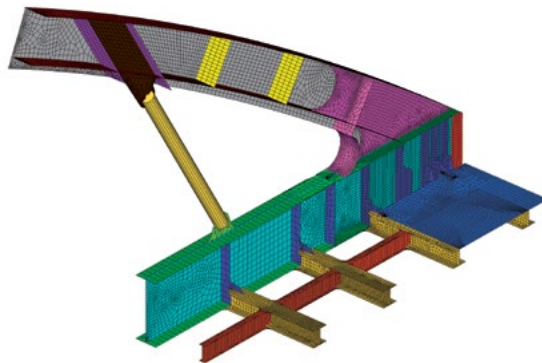


Pulvermühlen Viaduct (Luxemburg)



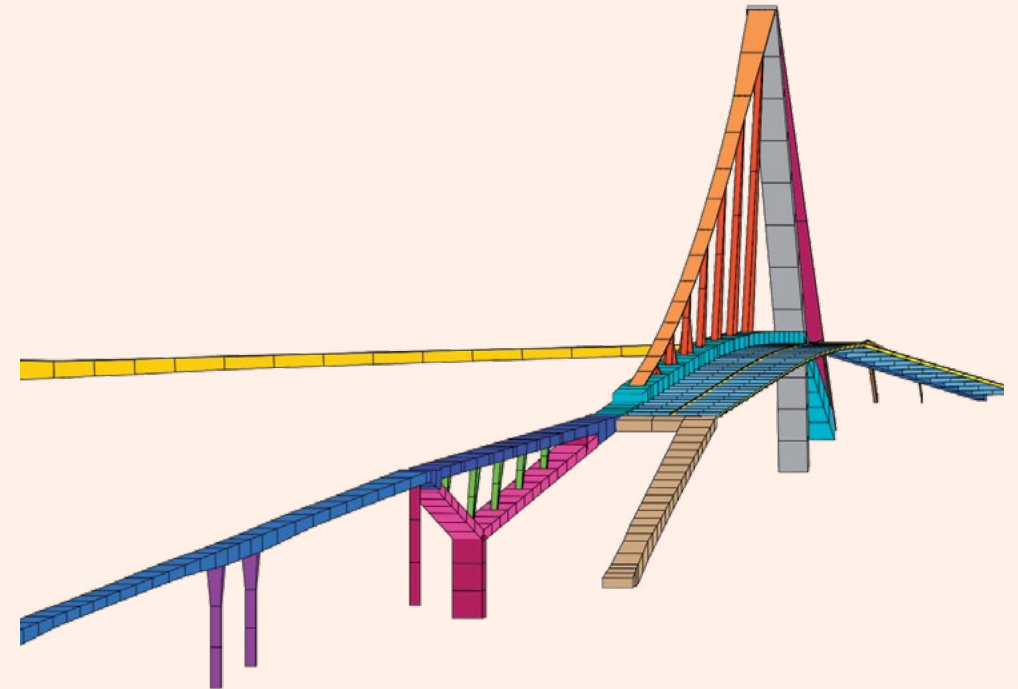
Bezon Viaduct (France)

Bowstring bridge for the RER E in Paris.



Nowadays, many footbridges are erected to allow pedestrians to cross a river or a valley. For architects and engineers, the main criteria that guide the design of a structure of this kind are:

- its location and its accessibility to pedestrians, joggers, cyclists, and people with reduced mobility;
- its comfort: accelerations induced by the movement of pedestrians have to be limited, possibly through the use of a tuned mass damper (TMD).



Model of « La belle Liégeoise » footbridge

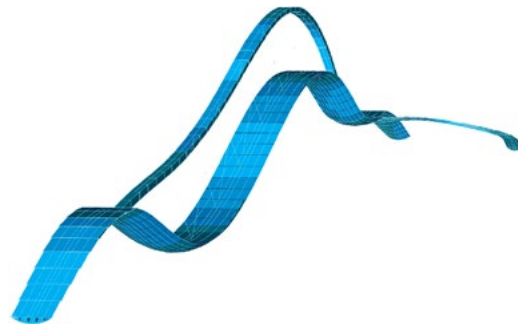
Hoge Brug
(Maastricht - Nederland)



261m-long arch Footbridge to link the new Ceramic district and the old city.



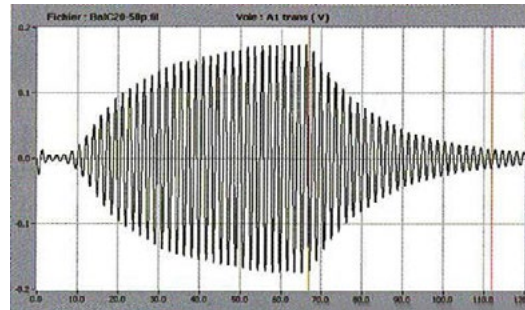
Dynamic tests



Vibration eigen mode

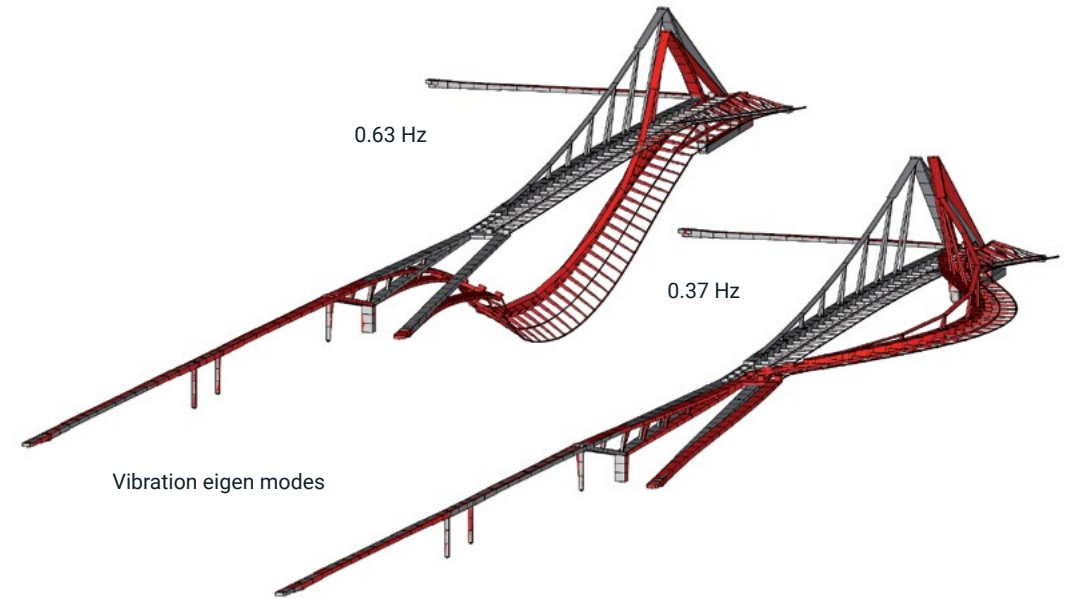


Tuned mass damper (TMD)



Bridge response with TMD

« La belle Liègeoise » footbridge
(Liège, Belgium)



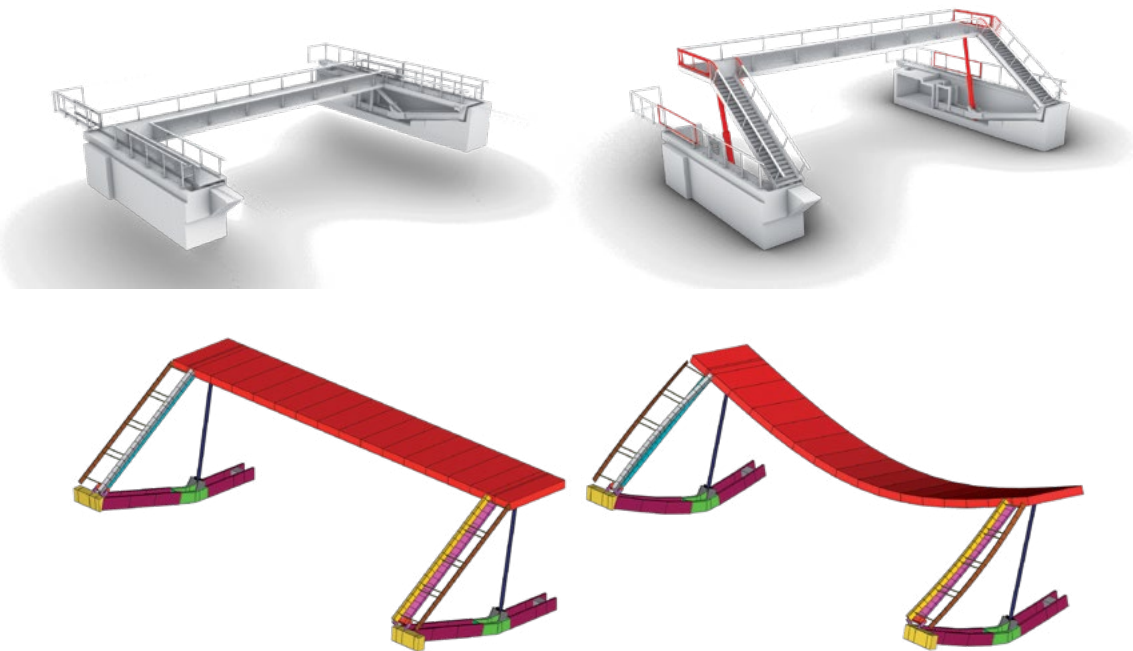
Crossing of the Meuse river in Liege with a width of 7 m and a total length of 294 m, the main span of 163 m is suspended.





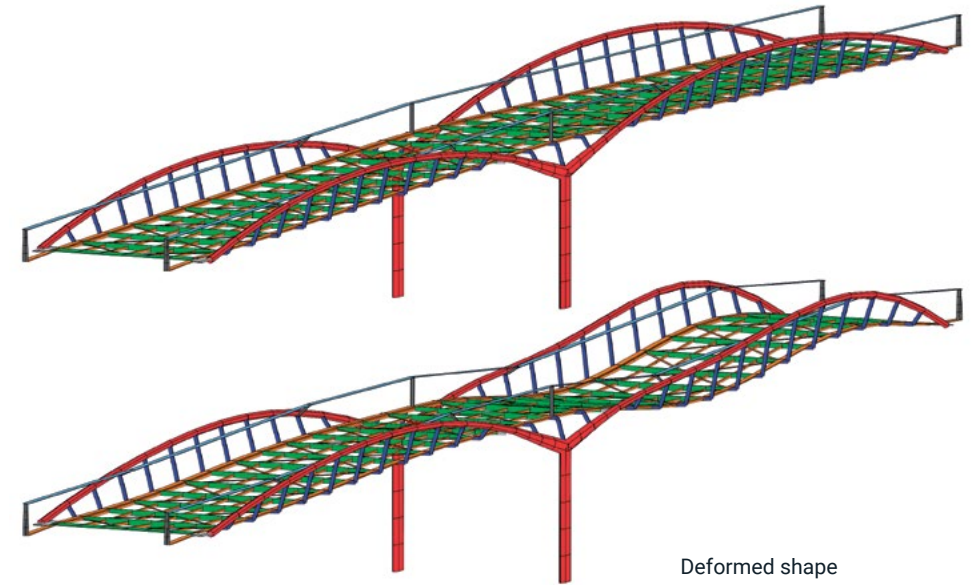
Molenbeek Footbridge
(Belgium)

The footbridge can be lifted when a boat arrives while pedestrians continue to cross it by using the mobile stairs.



Vibration eigen modes

Peterbos Footbridge
(Anderlecht – Belgium)

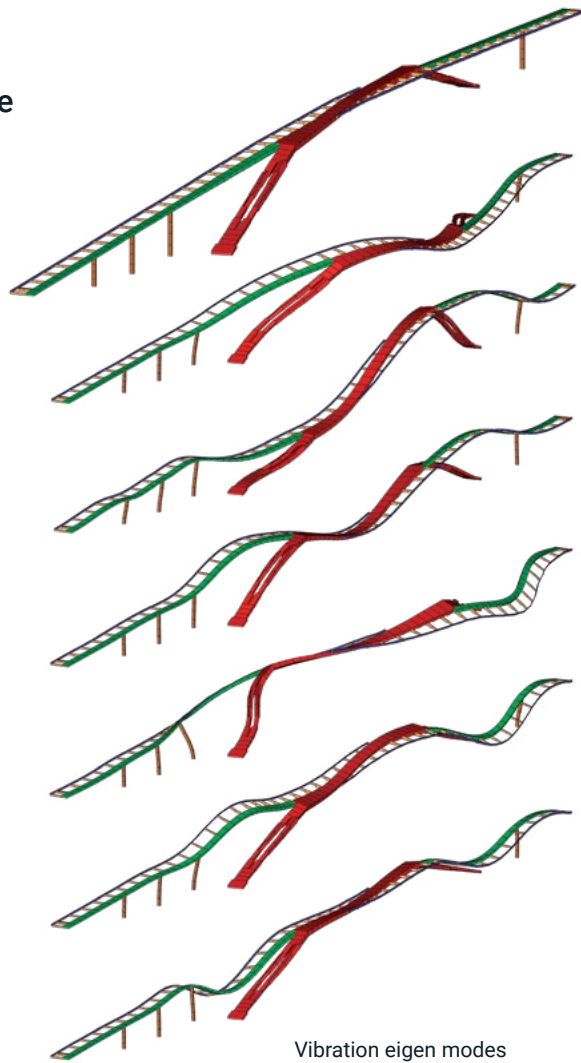


Deformed shape

58 m-long Footbridge.



«L'Enjambée» footbridge (Namur – Belgium)



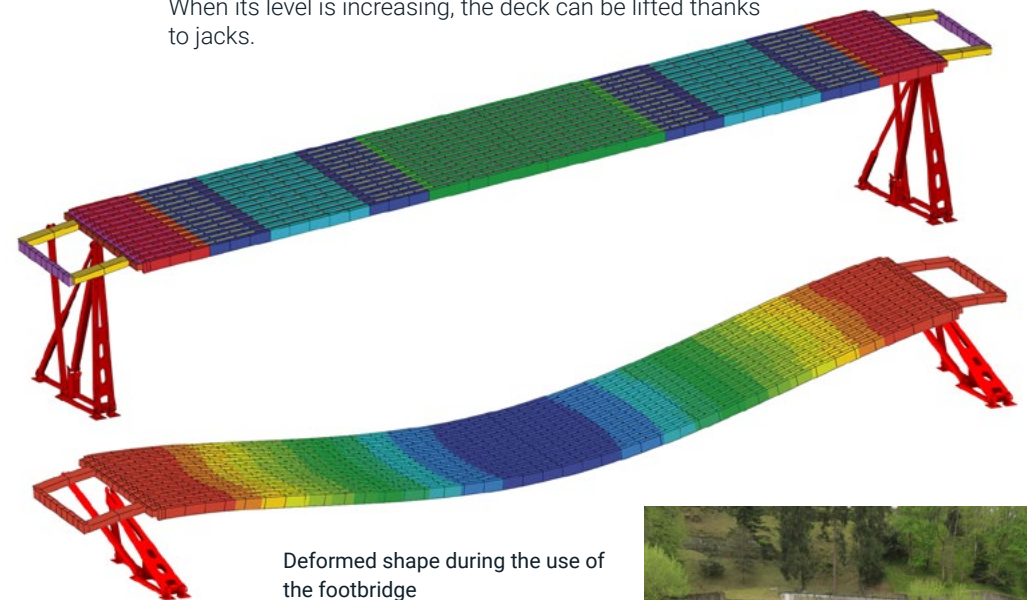
Vibration eigen modes

184 m-long steel arch
Footbridge to cross the
Meuse river.



Lourdes Footbridge (France)

The level of the Gave de Pau is very fluctuating.
When its level is increasing, the deck can be lifted thanks
to jacks.



Deformed shape during the use of
the footbridge



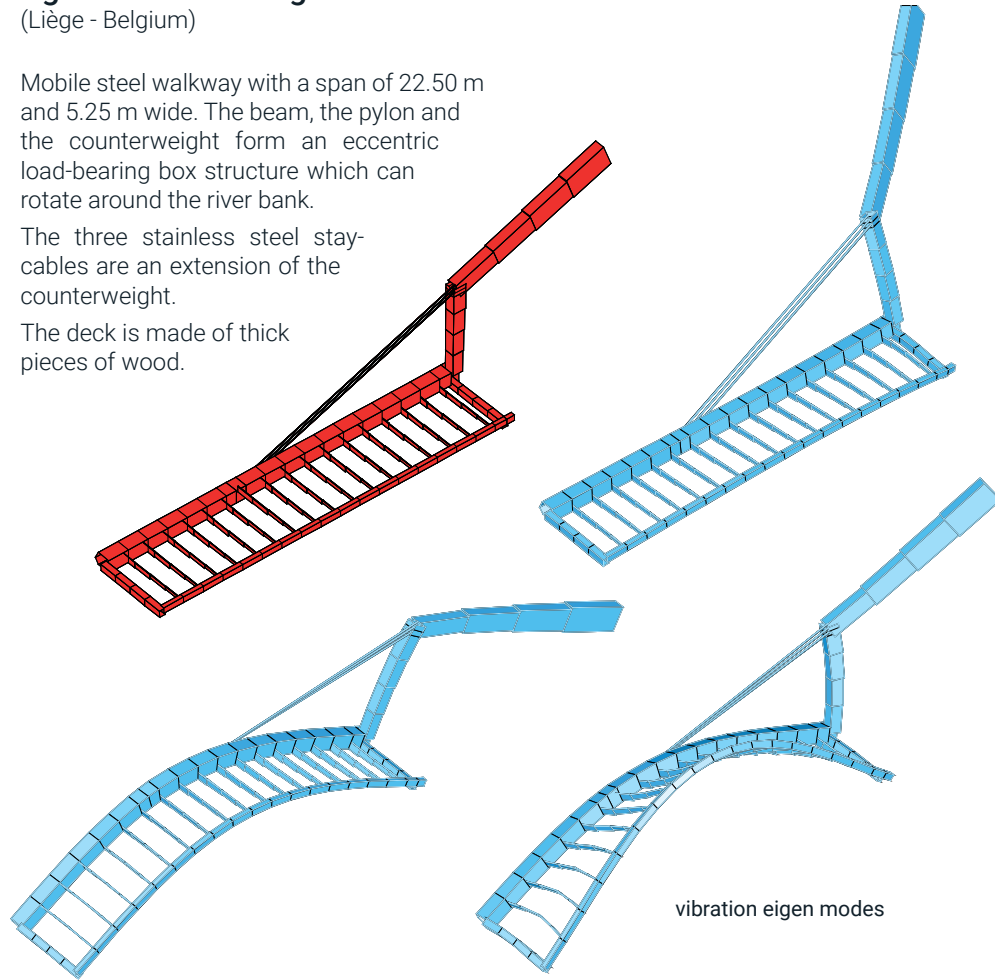
Aguesses Footbridge

(Liège - Belgium)

Mobile steel walkway with a span of 22.50 m and 5.25 m wide. The beam, the pylon and the counterweight form an eccentric load-bearing box structure which can rotate around the river bank.

The three stainless steel stay-cables are an extension of the counterweight.

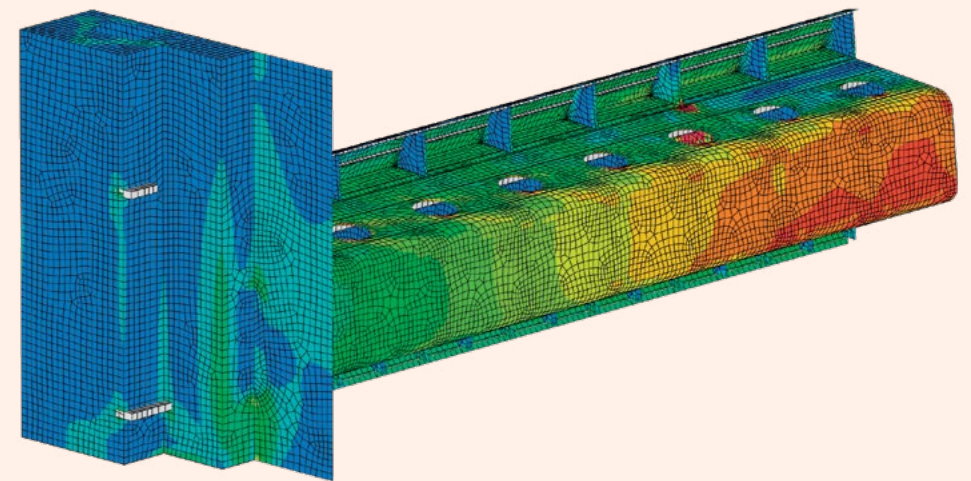
The deck is made of thick pieces of wood.



Fluvial and maritime structures

The peculiarity of fluvial or maritime structures are the solicitations acting on them. This means either hydrostatic or dynamic loads induced by waves, including both time-varying and impact effects.

The goal is to verify the structure resistance but also its behaviour against fatigue. Similarly to the definition of wind loading on bridges or large roofs, measurements in hydraulic labs are necessary to precisely define the loads acting on fluvial and maritime structures.



Stresses distribution in Monsin dam gate

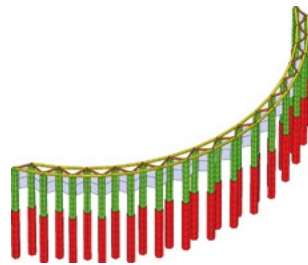
Blankenberge Pier (Belgium)

Blankenberge Pier, a unique example on the North Sea, has undergone major renovation/ refurbishment to provide new facilities.

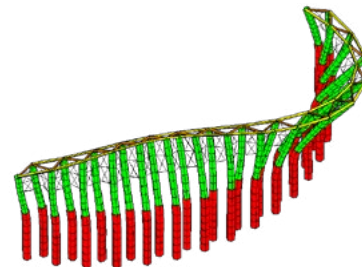
The extremely complex works, which included underpinning of part of the existing building and the creation of new spaces in the tidal zone, also had to deal with the problem of resisting to the effect of waves.



Test in a hydraulic lab



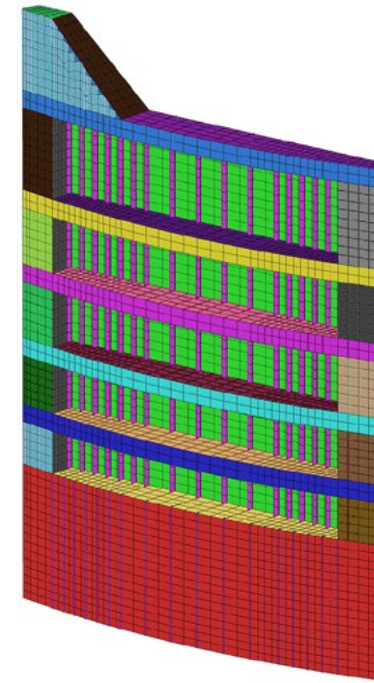
Piles wall model



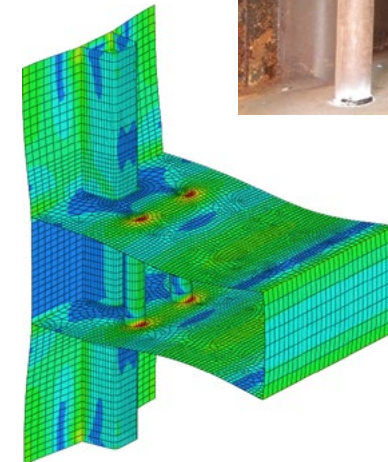
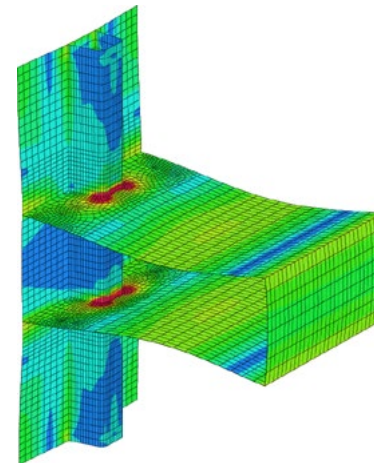
Deformed shape under the waves impact



Lanaye lock (Belgium)



Gate of the Lanaye lock

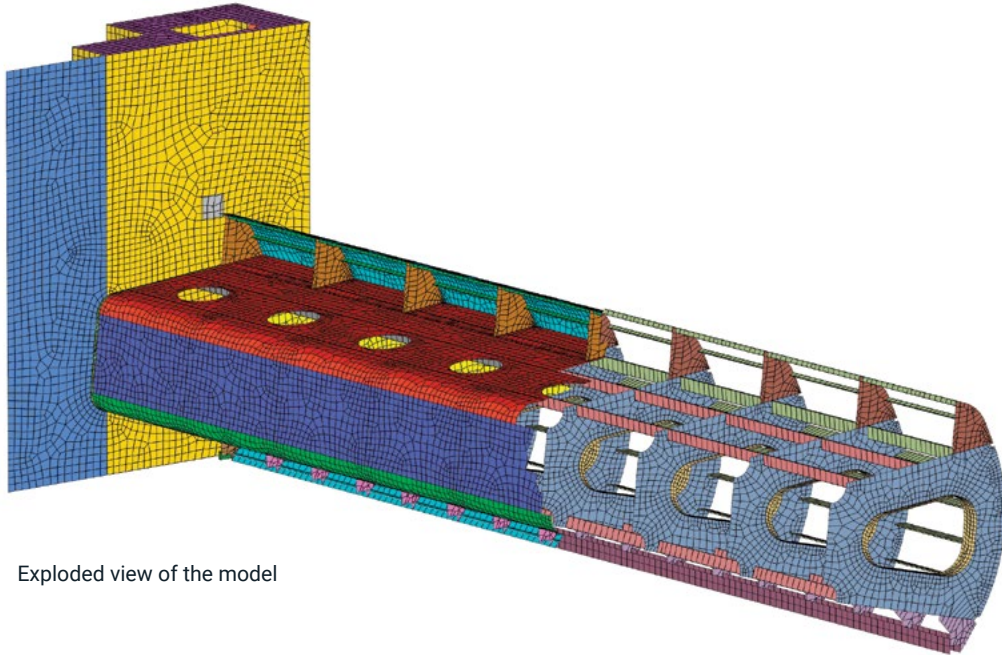


Stresses distribution in the transversal beams : without / with reinforcement



Monsin dam gate (Belgium)

New gates of the Monsin dam, consisting of 6 valves 27 m long and located on the Meuse in the downstream part of Liège.

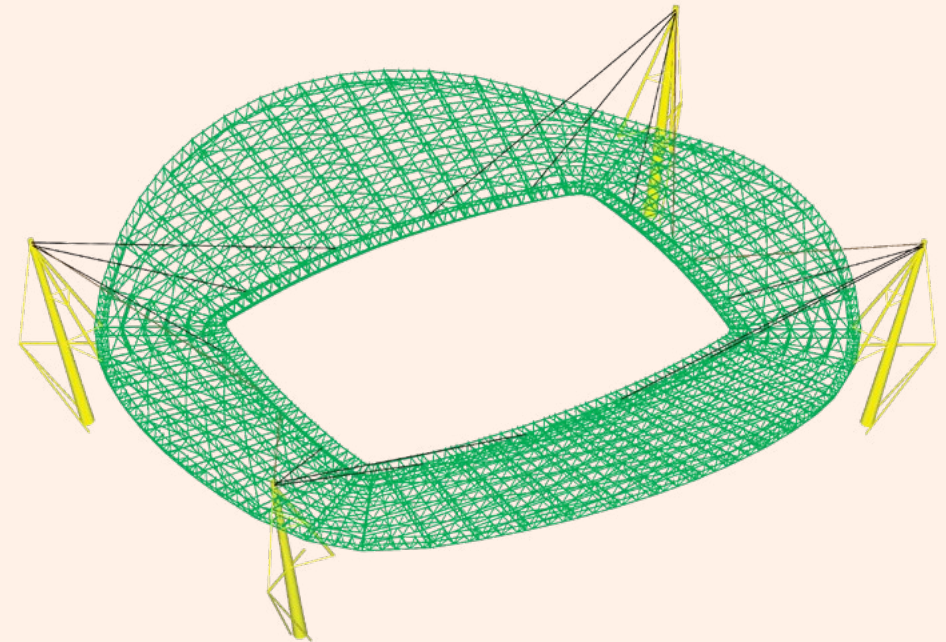


Exploded view of the model



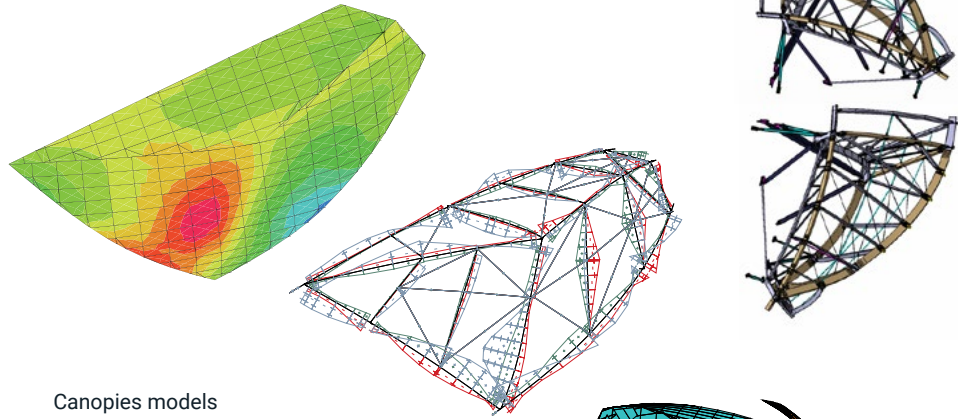
Large roofs are the result of discussion between architects and engineers. The architect draws the global shape of the structure and the engineer has to design it to ensure its stability.

The most important loadings are the dead load and the pressure induced by the wind. For the latter, the Eurocode only provides some generic guidelines. To get more accurate information, wind tunnel tests must be conducted.

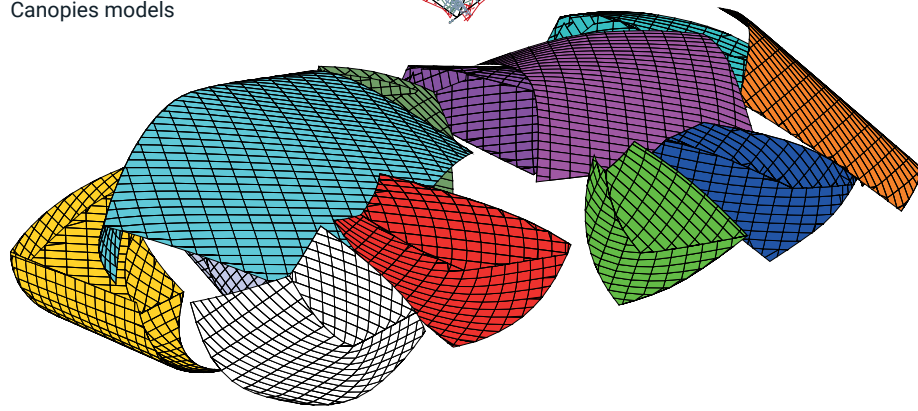


Lisbon Sporting Stadium

Louis Vuitton Foundation (Paris - France)



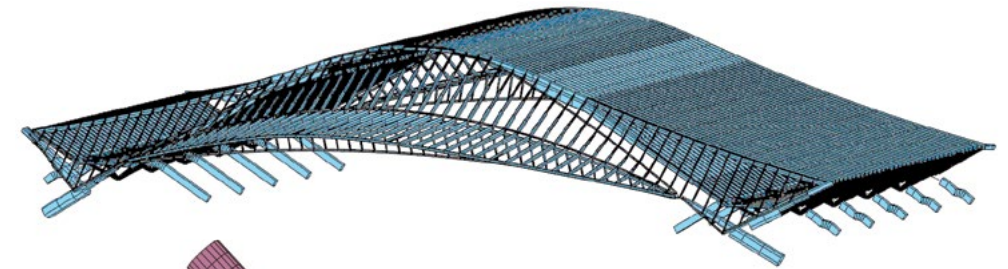
Canopies models



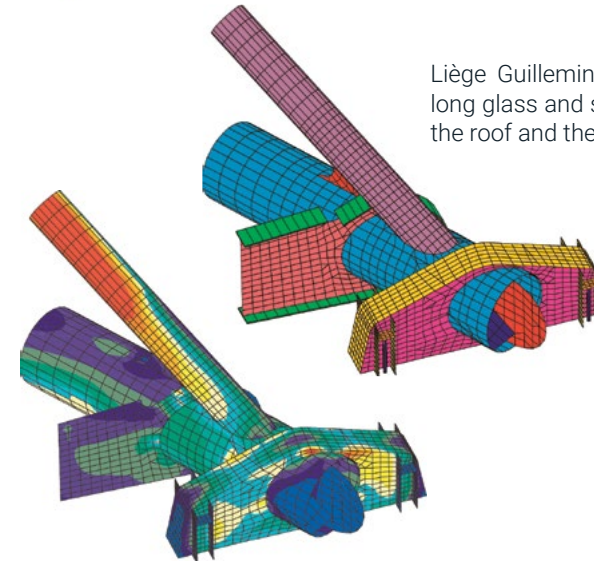
The modern art museum is covered by 12 canopies resembling glass sails with curved and variable geometries. The structural elements are a combination of steel and wood beams. The model takes into account essentially the dead and wind loads.



Guillemins Railway Station (Liège - Belgium)



Liège Guillemins train station is a monumental 200m-long glass and steel dome covering the tracks: design of the roof and the infra-structure.



Stresses distribution in the connection between the arch, the longitudinal hollow circular tube, the transversal beam and the support box (bridge giving access to the station).

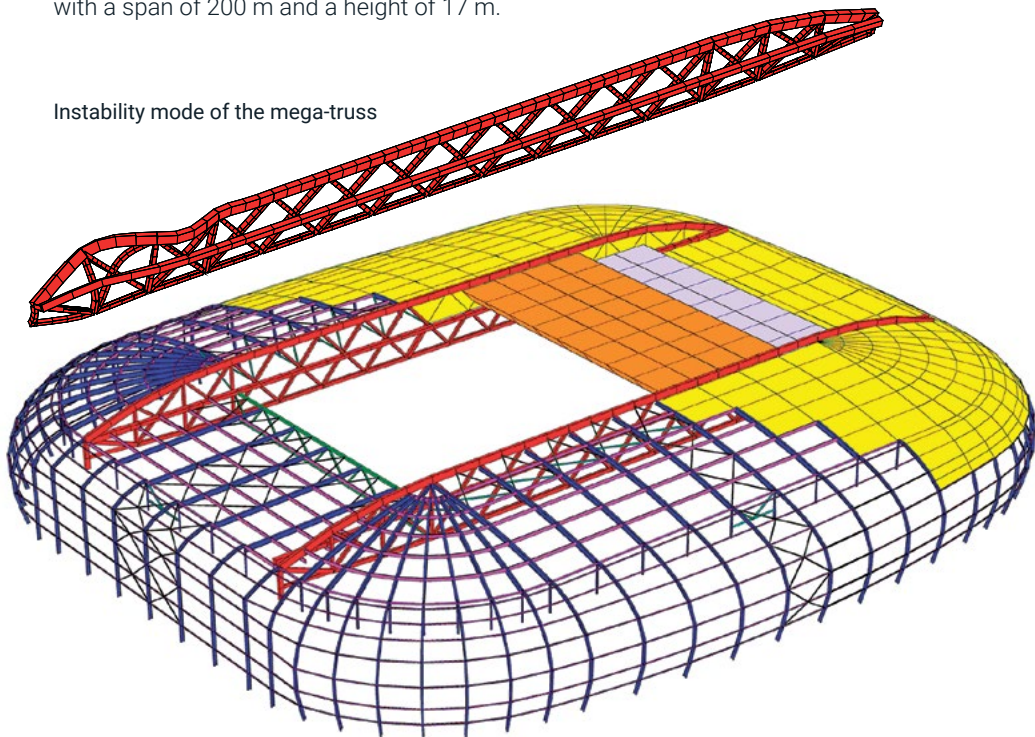




Lille Stadium
(France)

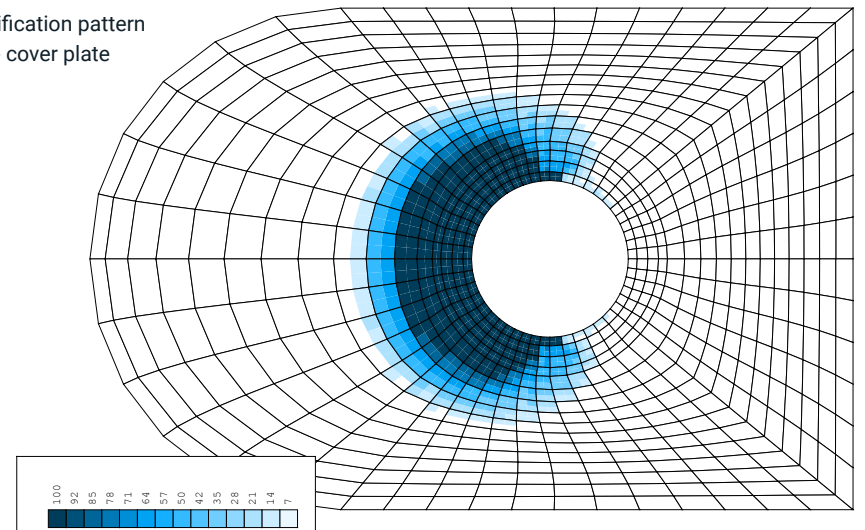
Design the roof supported by two mega truss beams with a span of 200 m and a height of 17 m.

Instability mode of the mega-truss

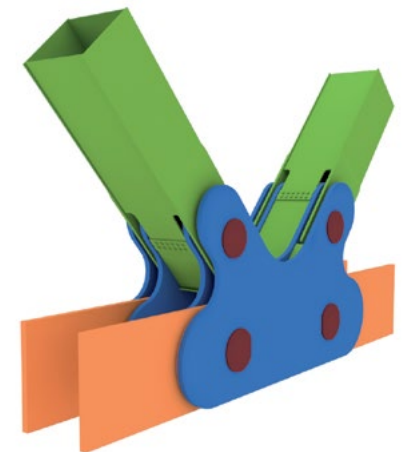


Buckling of one cover plate

Plastification pattern in the cover plate



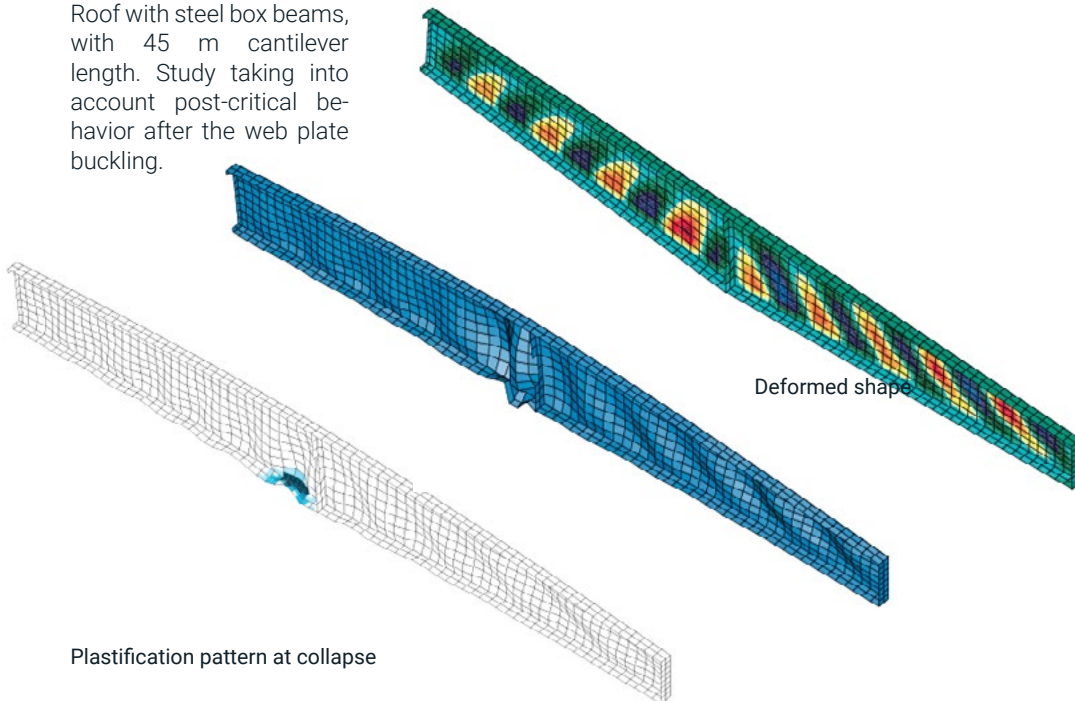
Member Connections with single axel





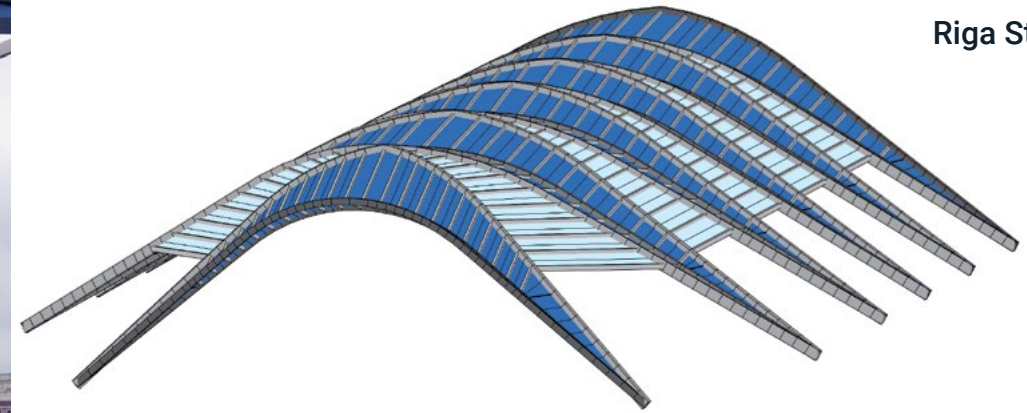
King Baudouin stadium (Bruxelles - Belgium)

Roof with steel box beams, with 45 m cantilever length. Study taking into account post-critical behavior after the web plate buckling.

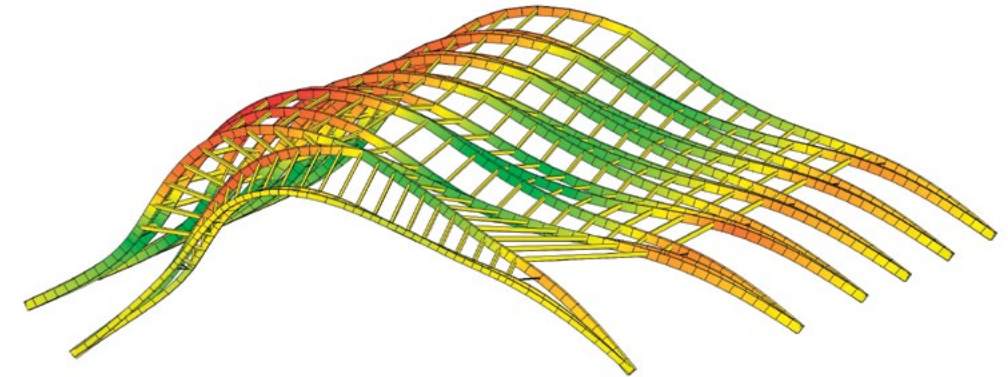


Deformed shape

Plastification pattern at collapse



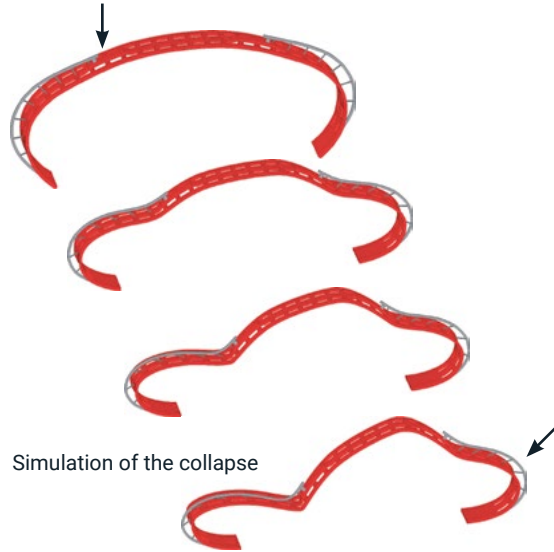
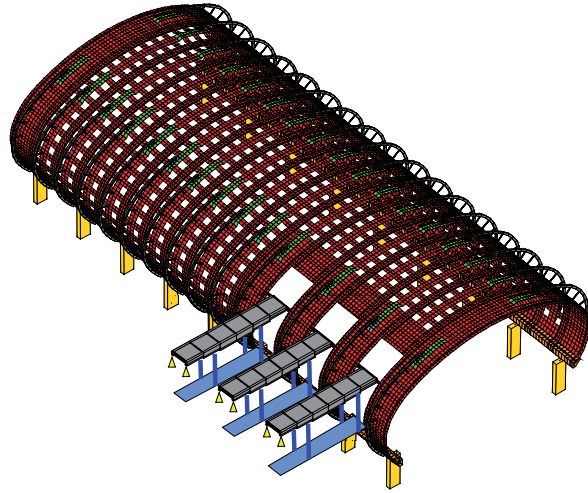
Design and verification of the arc-shaped steel structure



Contour lines of the vertical displacement under wind loads



Terminal 2E (Roissy - France)



Simulation of the collapse

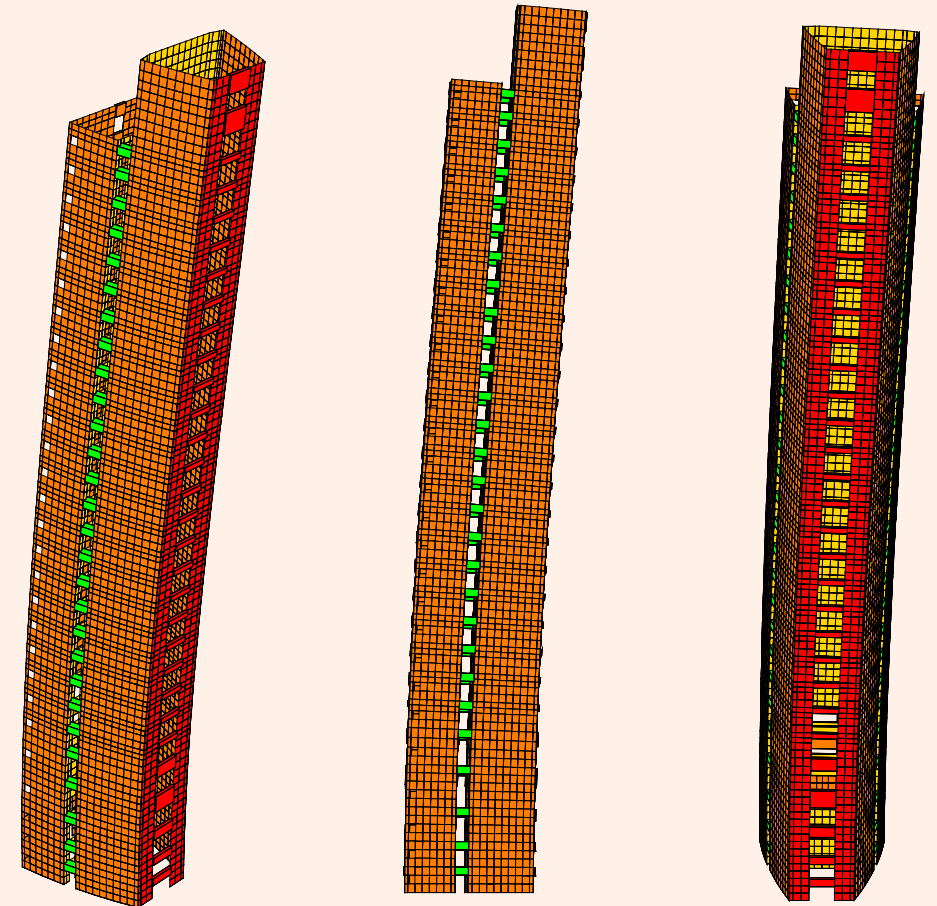
Expertise study concerning the collapse of the terminal 2E in the Orly airport



Tall and large buildings

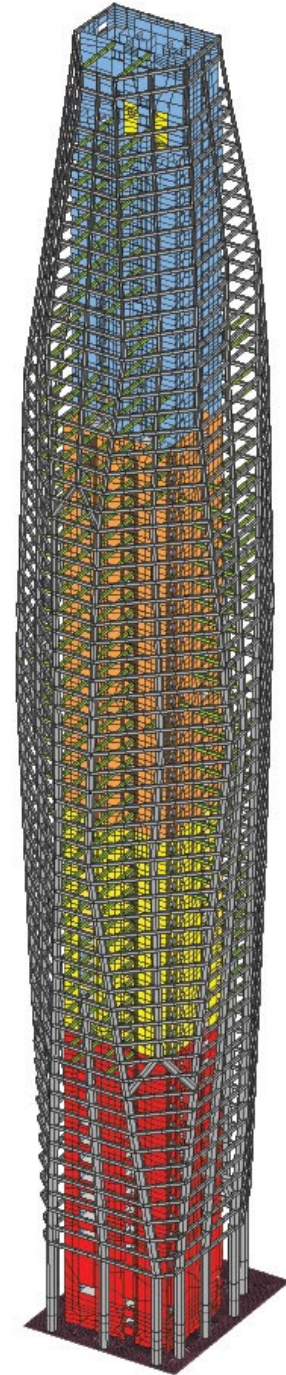
As for large roofs, for tall buildings, a finite element model is essential for the design engineers. If the main material is concrete, its time effects can be taken into account: shrinkage, creep, aging with building stages.

Concerning the wind loading, measurement of external pressures can be performed in wind tunnel labs and applied on the FE model to verify the stability of the building but also the comfort of the occupants. If the comfort criteria are not met, tuned mass dampers must be installed.



Abidjan Tower

(Ivory Coast)



The future tallest tower in Ivory Coast and Africa, with its asymmetrical geometry reminiscent of an African mask..

Tour des Finances

(Liège - Belgium)



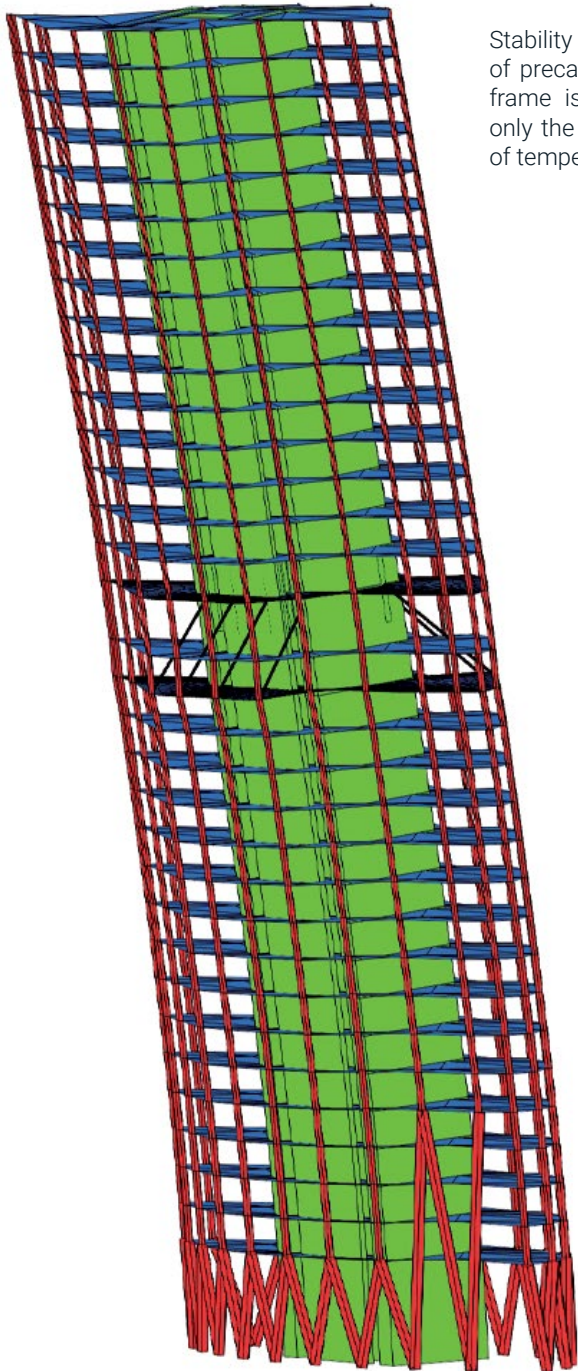
The structure of 120 m height consists essentially of reinforced concrete with a cast-in-place core that ensures the rigidity under wind loading, earthquakes, and forces generated by the inclined columns.



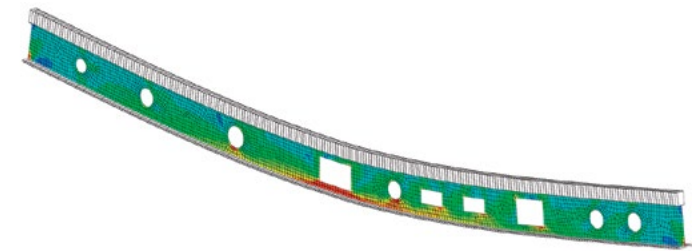
Silver Tower

(Bruxelles - Belgium)

Stability of a 137m-high tower with the use of precast concrete . At mid height, a steel frame is specifically designed to transmit only the dynamic forces but not the effects of temperature and creep.



Study of the steel frame and of the composite floors of two new towers with a height of 180 and 122 m.

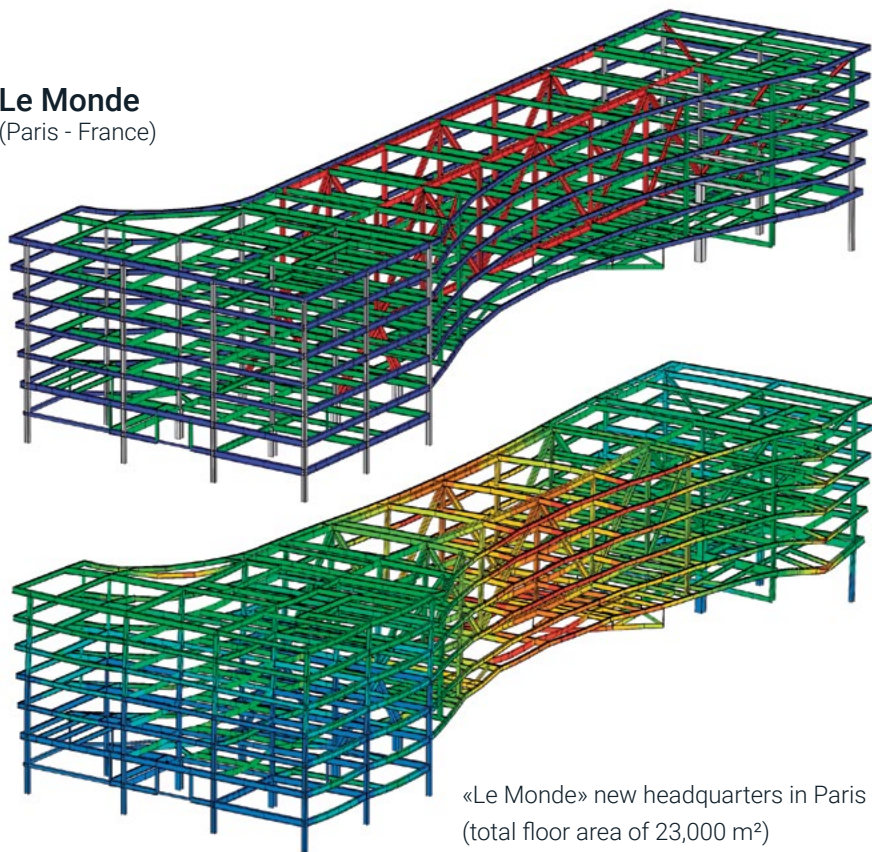


Tour Duo

(Paris - France)

Le Monde

(Paris - France)



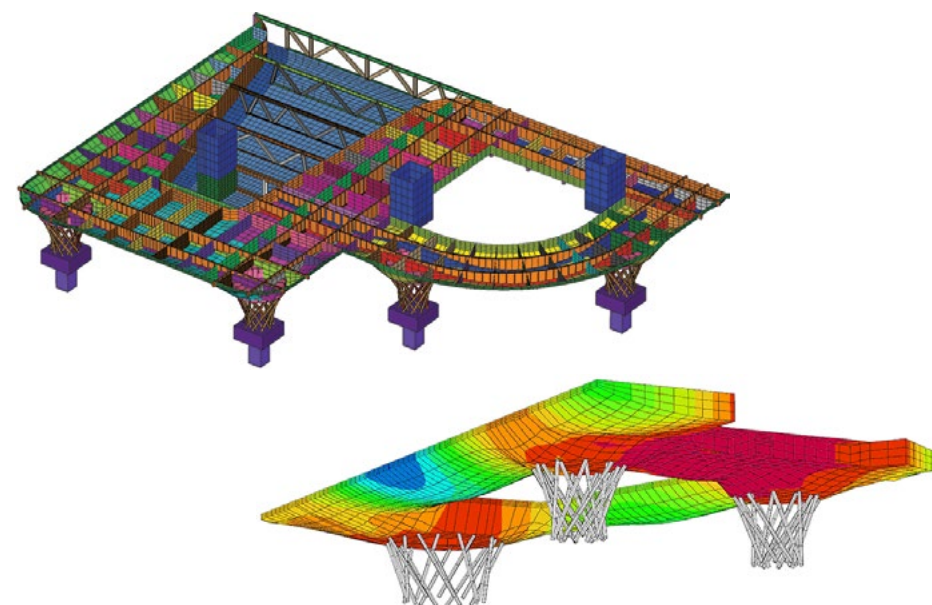
«Le Monde» new headquarters in Paris
(total floor area of 23,000 m²)



Knokke Hospital

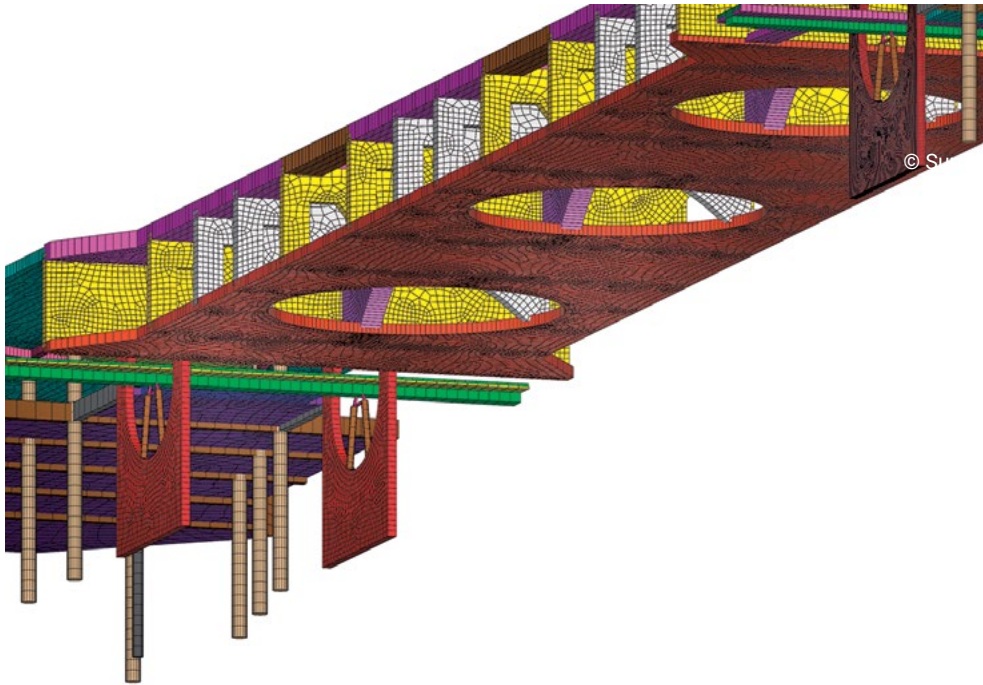
(Belgium)

Full 3D model of the first floor concrete slab that supports the entire three-story building supported at a few discrete points made of baskets of metal columns.



Toots Thielemans Subway Station (Bruxelles - Belgium)

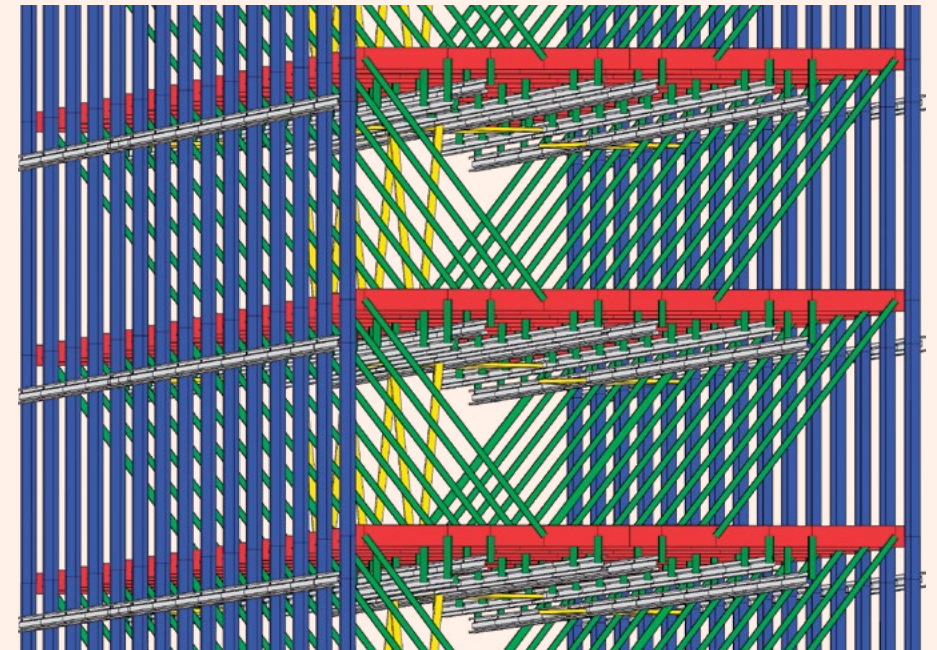
Study of the new metro station involving a global model of the entire building to consider the joint action of slabs and concrete walls.



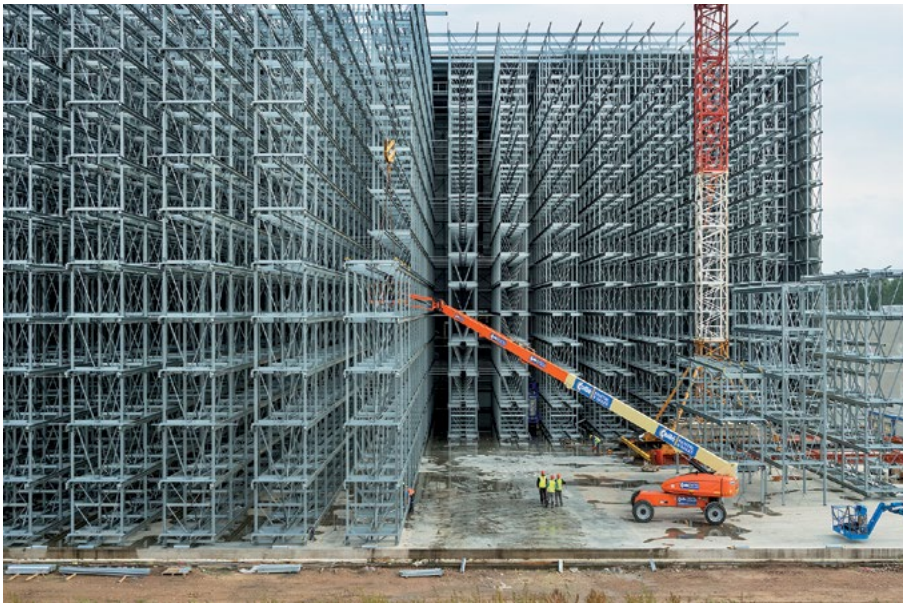
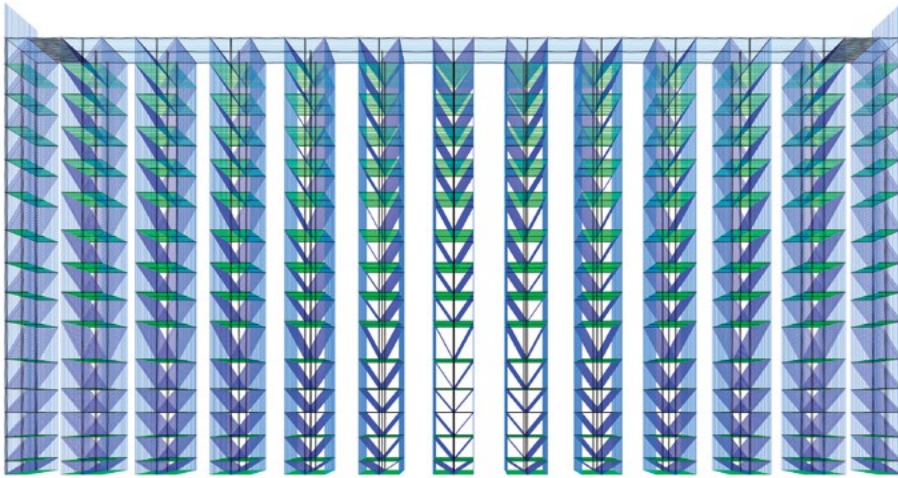
© Sum Project

Special structures

Special structures are characterized by the fact that they are not common in civil engineering. This generally results in unconventional complex calculations to justify their stability, which exploit **Finelg** most advanced features.



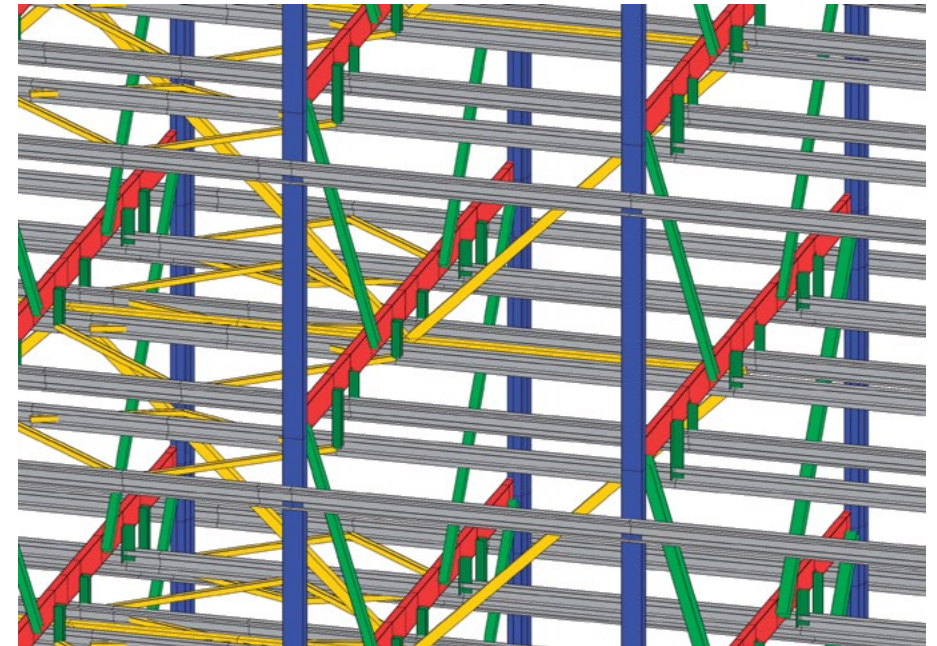
Storage racks of Geer (Belgium)

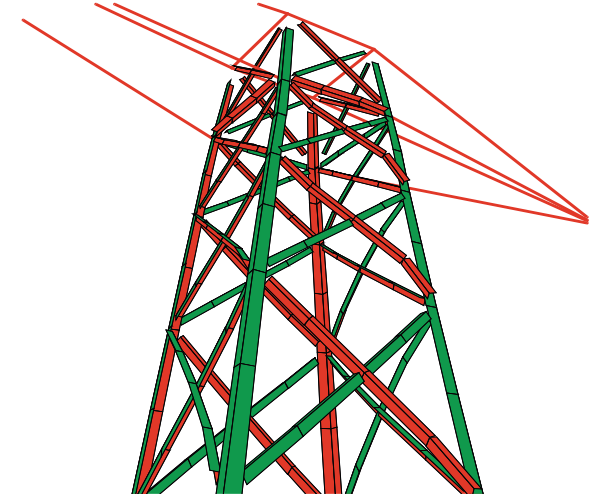
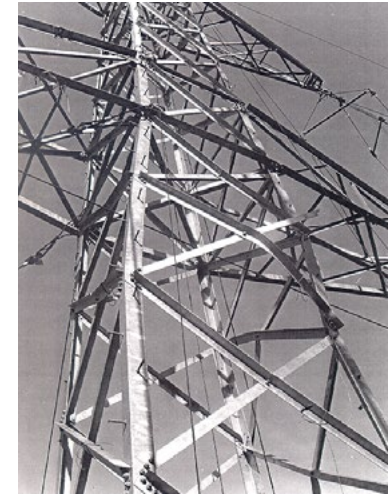


Design of storage racks under static and seismic loads. Optimization of the dimensioning of 3D self-supporting structures made of thin cold-formed profiles.

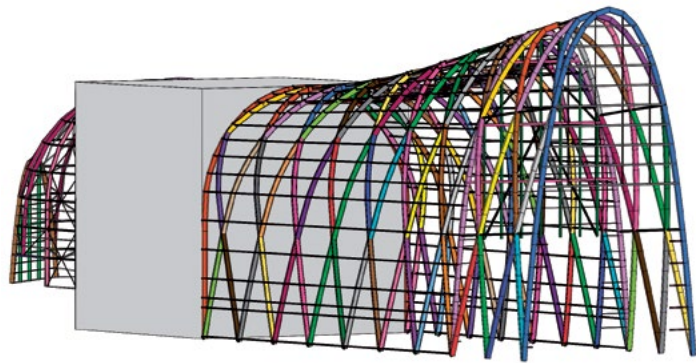
The multitude of columns and beams requires to optimize the cross sections shapes, the thickness of steel plates, and the bolts number of each assemblage.

Storage racks of Tongres (Belgium)

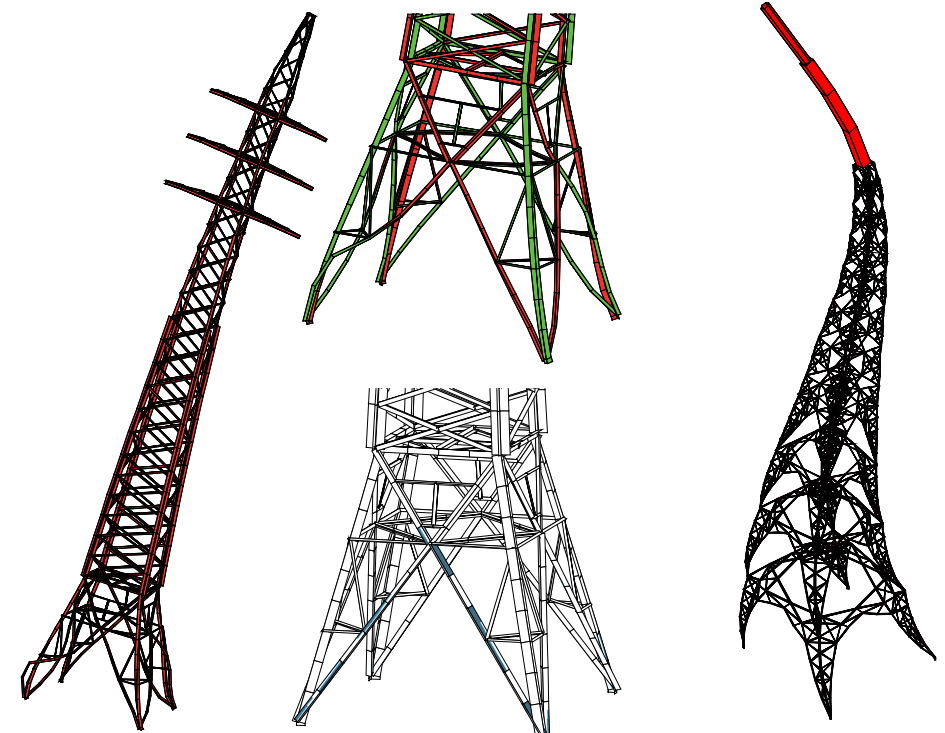




Simulation of transmission tower collapse



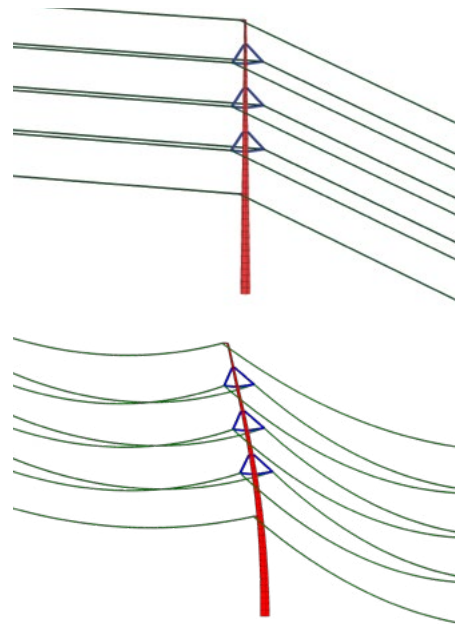
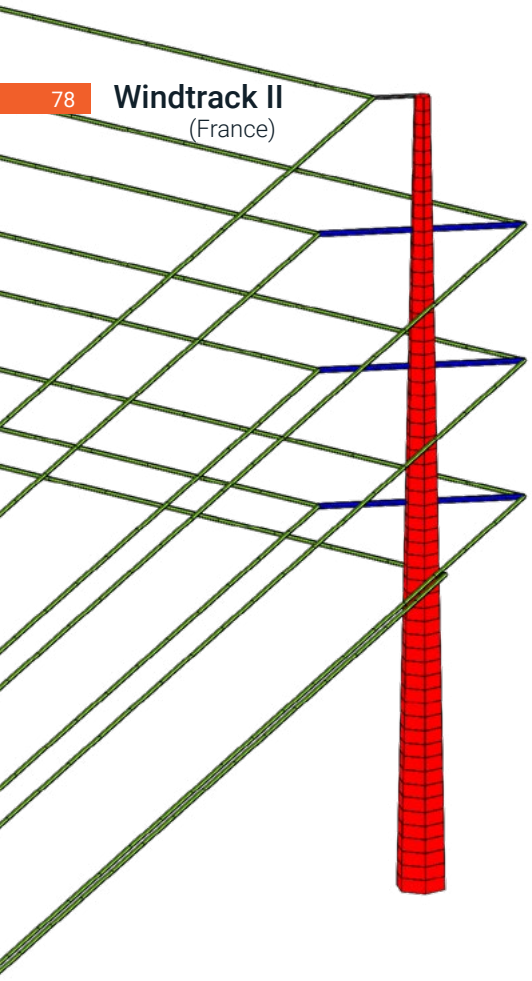
Semi-elliptical protective vault for a new waste incinerator in Antwerp.



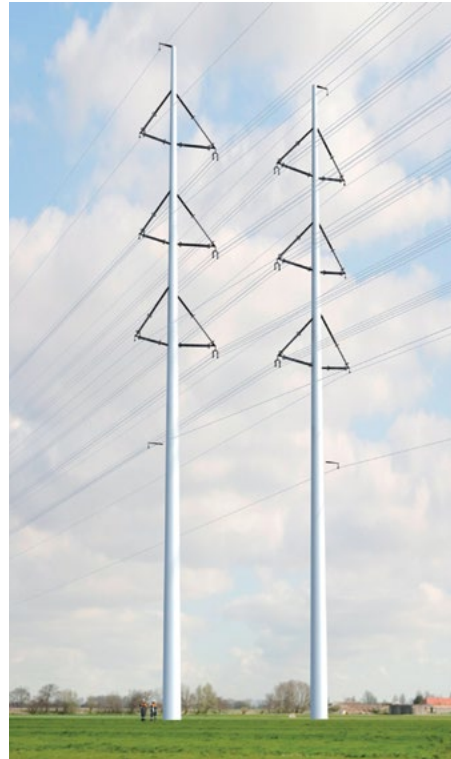
Transmission tower : instability mode and plastification pattern at collapse

Vibration mode of one telecommunication tower

Windtrack II (France)

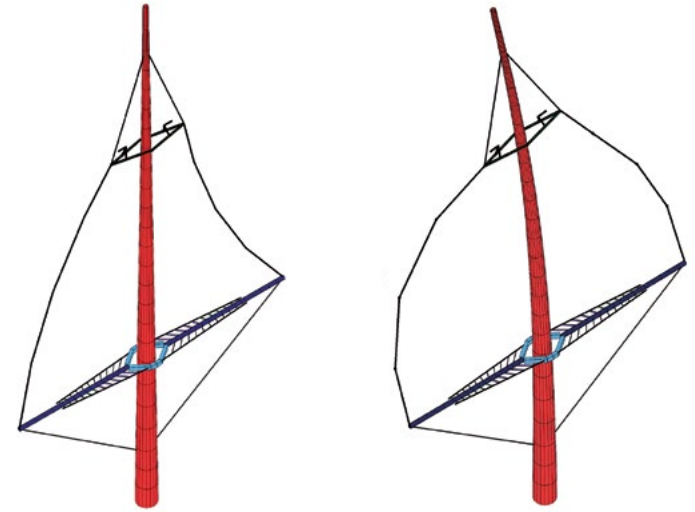


Vibration eigen mode



Vibrational interaction between cables and pylons of a high-voltage line

High-voltage line in northern France with an innovative shape for the pylons.



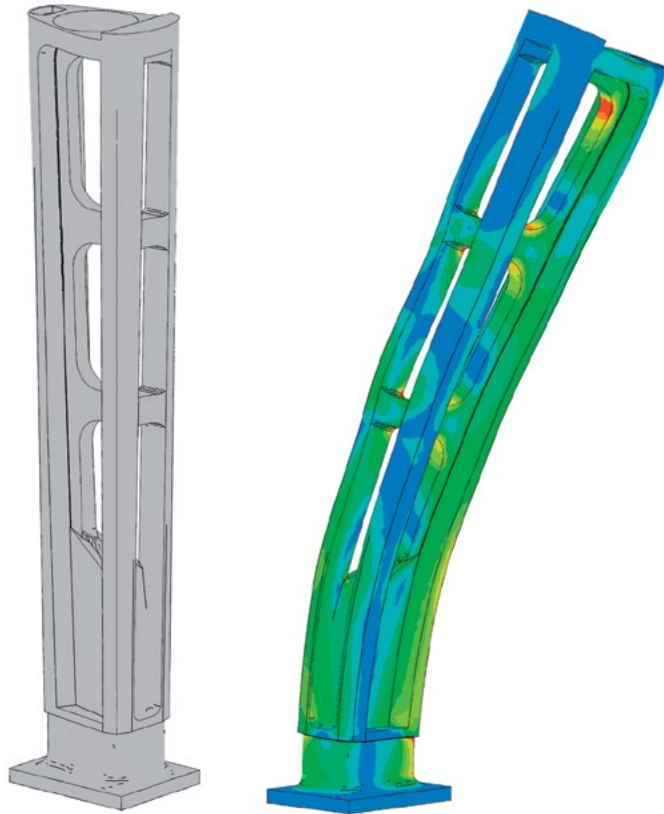
Deformed shape under self-weight

Vibration eigen mode



Pile Ligne 11 Paris (France)

3D finite element modelling of a cast steel pile of a railway bridge for fatigue and strength verifications.



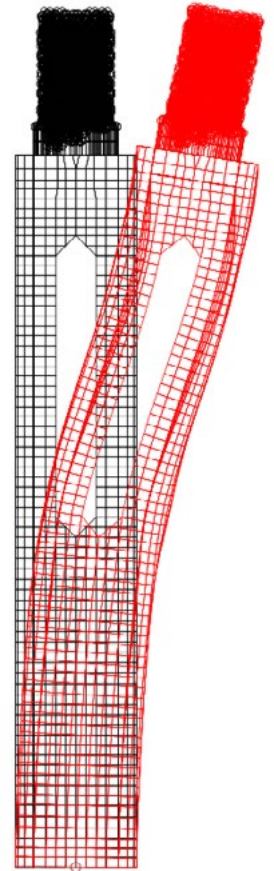
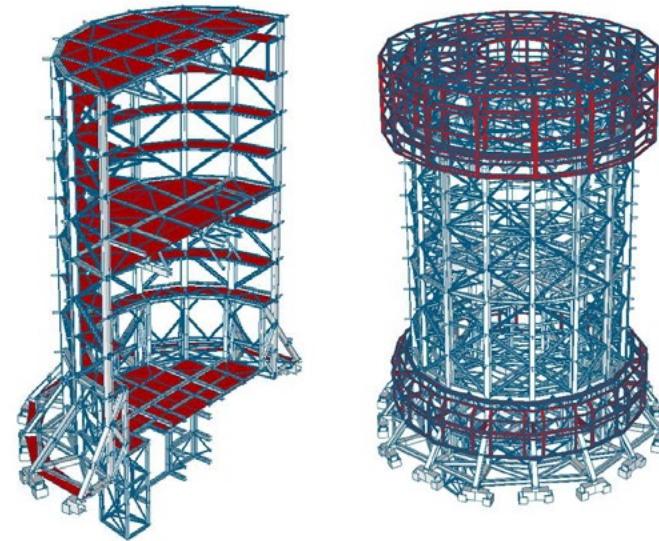
Contour lines of Von Mises Stresses



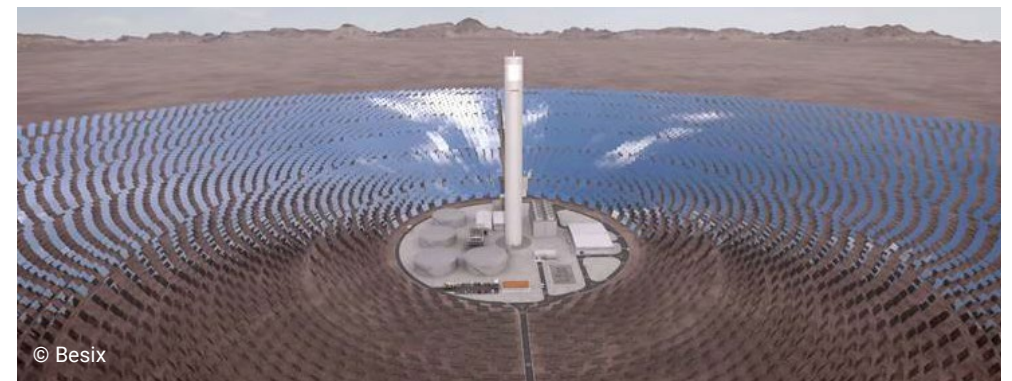
Solar power plant (Atacama - Chile)

Optimization of the steel structure of a solar receiver located at the top of a concrete tower submitted to strong earthquakes in Chile.

Steel receiver models



Concrete tower eigen mode

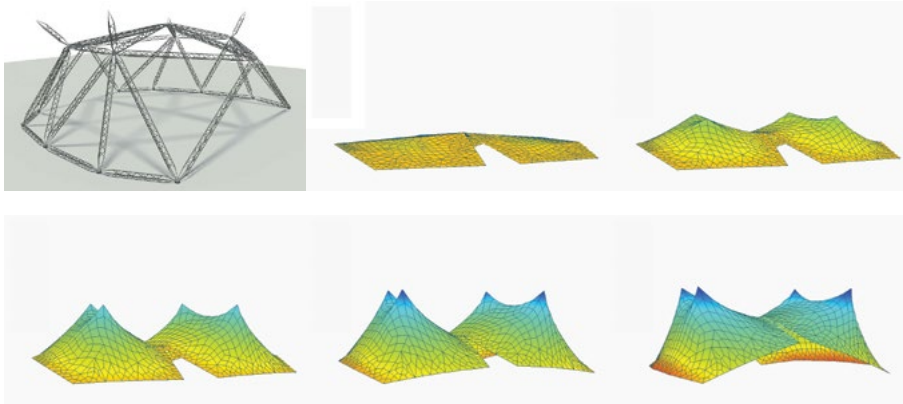


© Besix

Arsenic company

(Liège - Belgium)

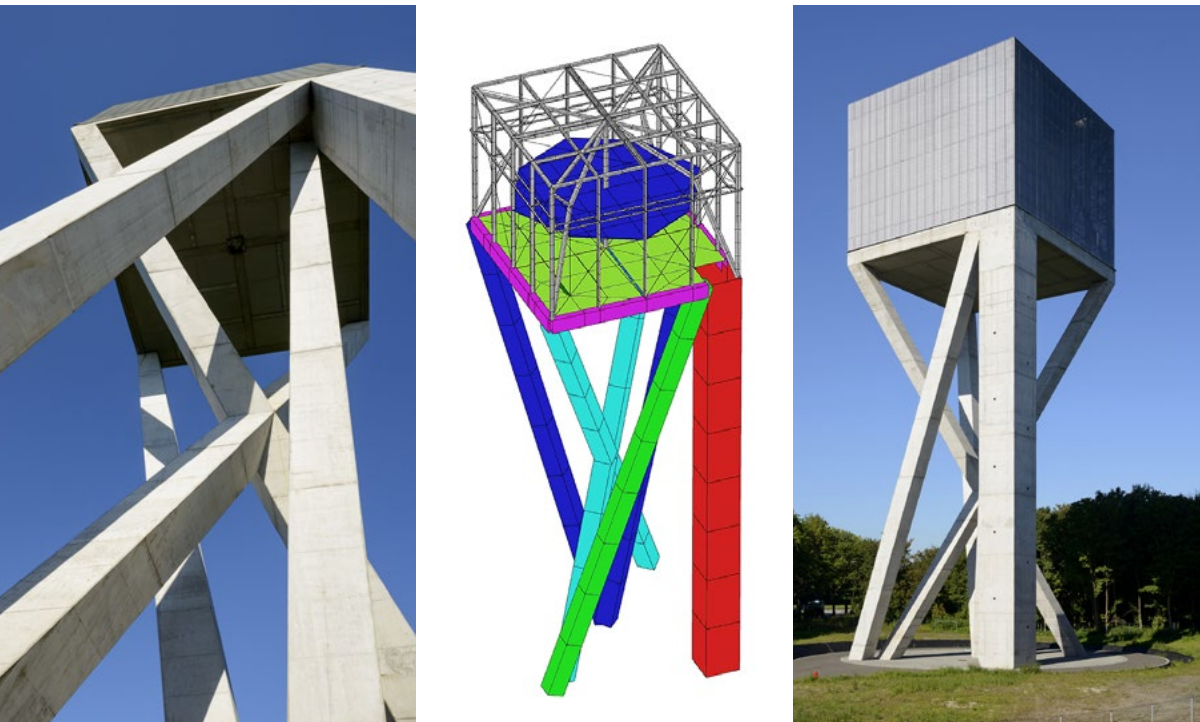
Modelling of the raising of a circus tent by lifting from the ground to its final configuration.



Water Tower

(Ghlin - Belgium)

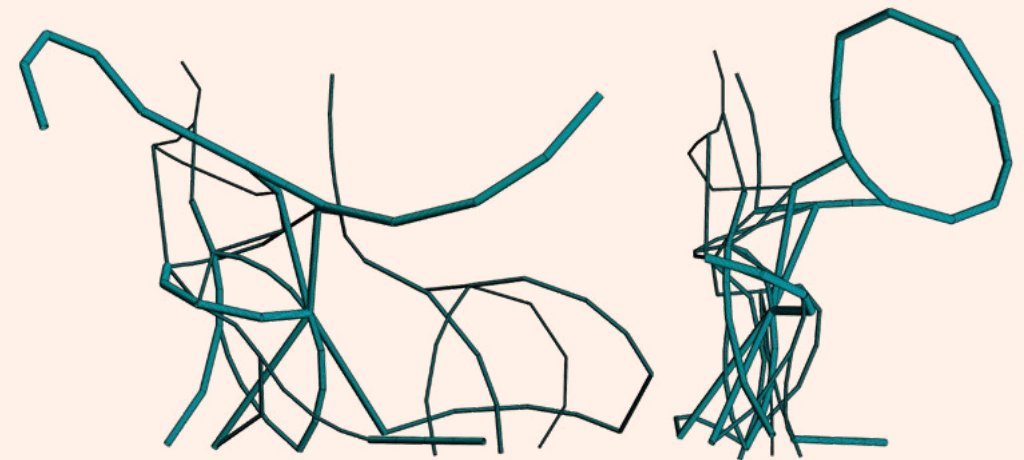
Modelling of the construction stages taking into account creep, shrinkage and structural response in case of earthquake.



Nowadays, artists are conceiving more and more imposing works.

In this context, the job of the engineer is to design an «invisible» structure that ensures the stability of the artist's work. Due their complexity, the optimisation and stability analysis of some of these structures demand the use of finite element modeling.

The goal of the engineer is to hide its intervention and let the artist take centre stage.



ATHELES ALLEY – BEJING 2008 – Olivier Strebelle

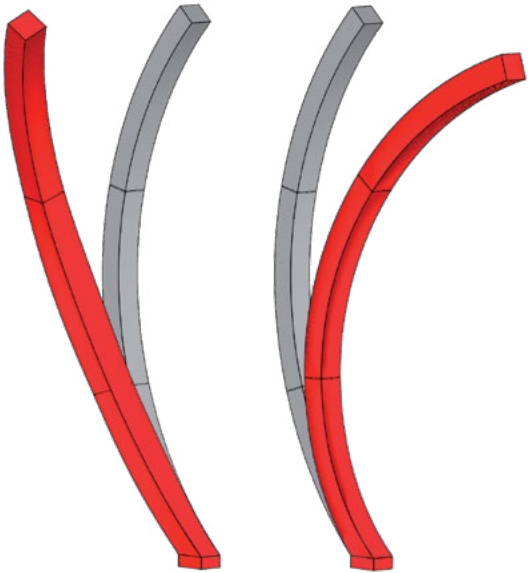


© B. Venet

Arc majeur

(Belgium)

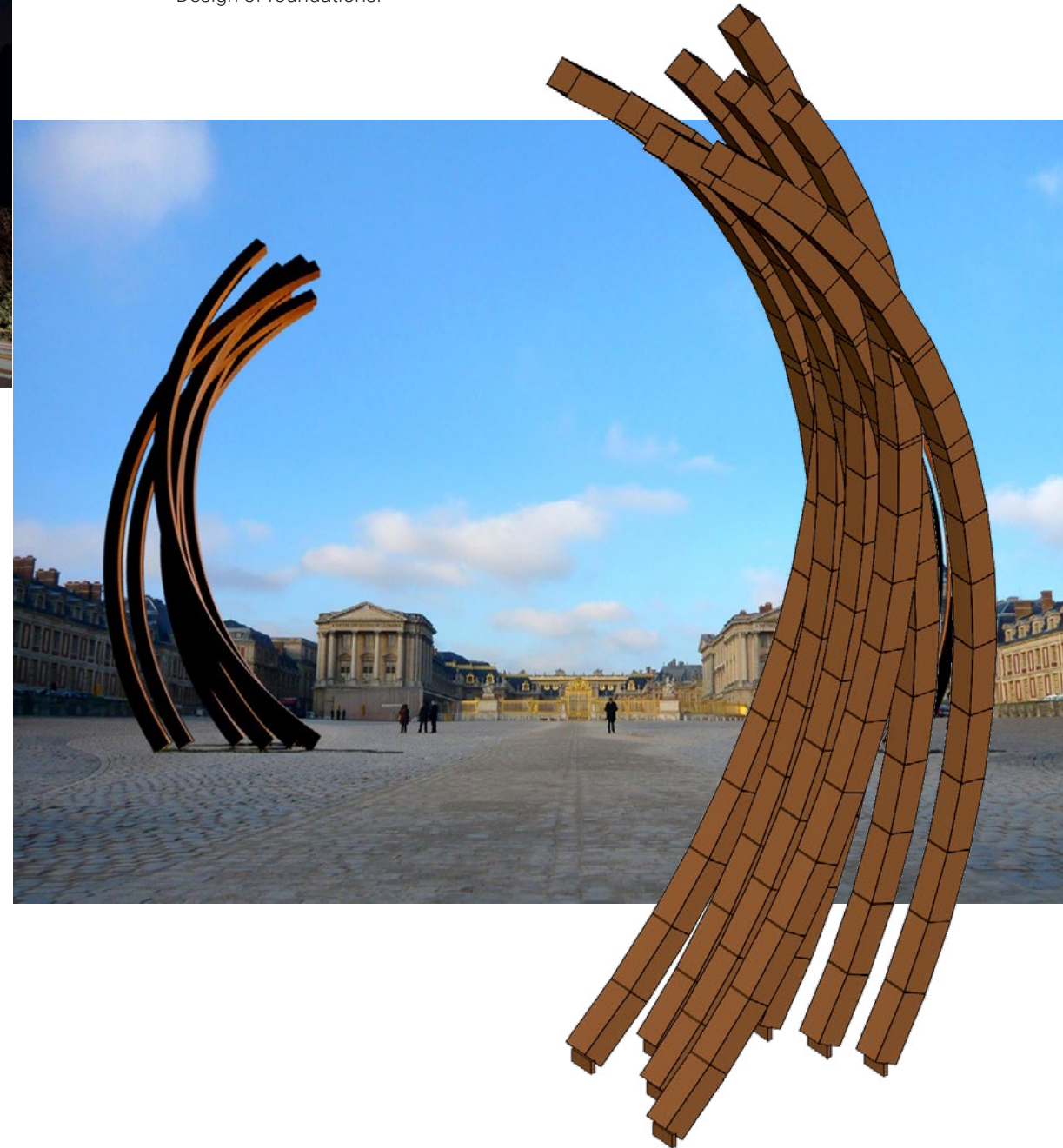
Named 'Major Arch' by Bernar Venet, this 60m-height arch is damped by a Tuned Mass Damper (TMD) at the top to mitigate Vortex Induced Vibrations (VIV) phenomena.



Arc Versailles

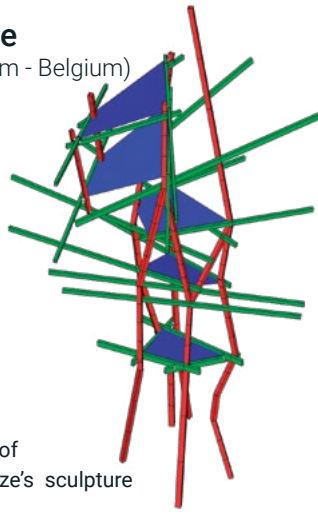
(France)

Bernar Venet in front of the *Château de Versailles* (Paris).
Design of foundations.

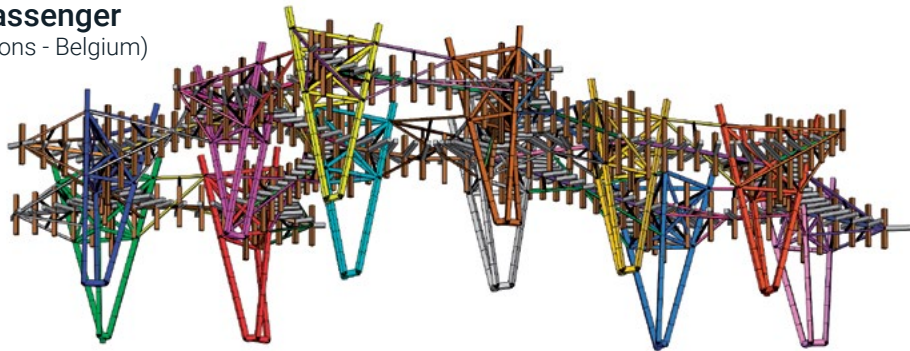


Deloitte

(Zaventem - Belgium)

Structure of
Arne Quinze's sculpture**Passenger**

(Mons - Belgium)

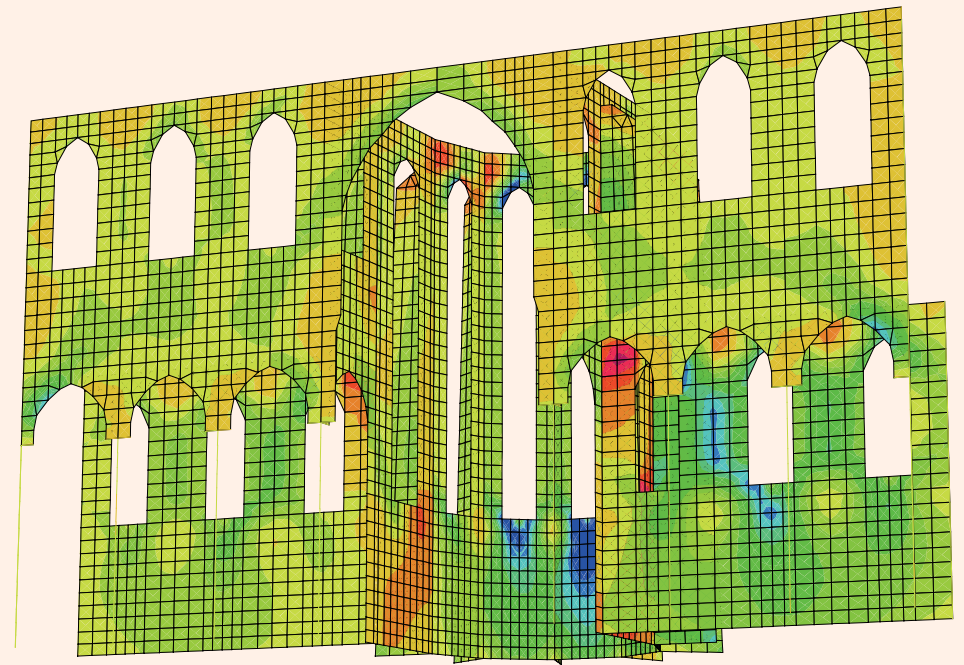


Design of the structural frame of Arne Quinze's Passenger



Old structures are among the most complicated structures to model due to their uncertain geometry and composition but also due to a structural scheme which results from the genius of our predecessors.

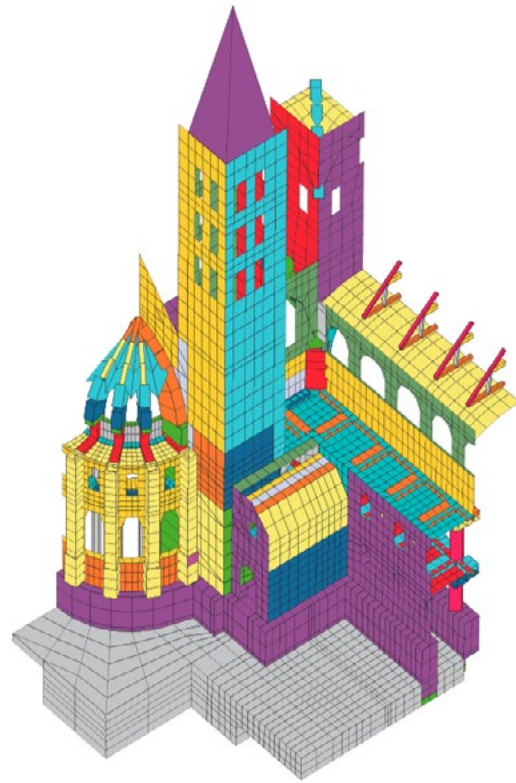
It is therefore often necessary to use relatively complex Finite Element modelling.



Stresses distribution in Aulne Abbey

Tournai Cathedral (Belgium)

Stabilisation of the Brunin Tower against settlements by designing the foundations reinforcement . Modelling of the tower and the surrounding soil to determine the distribution of the jet-grouting reinforcement.

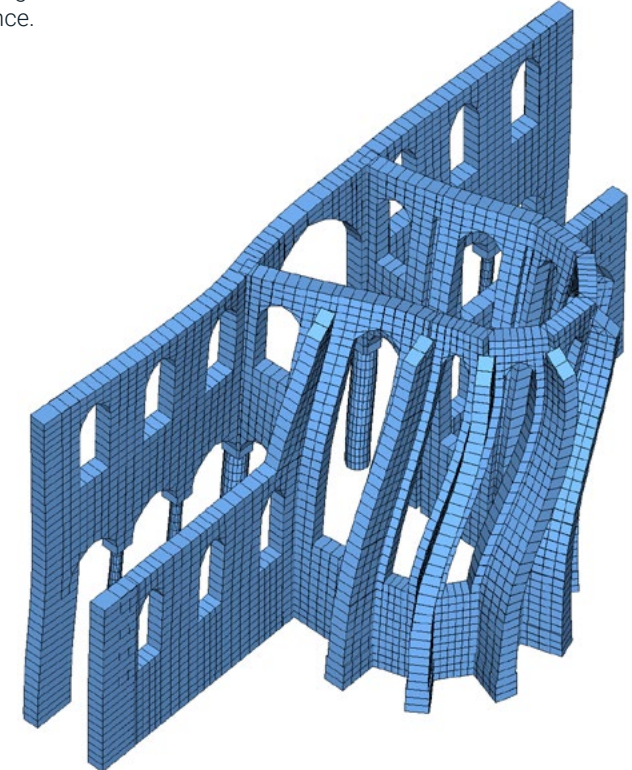


Model of the Brunin Tower including soil heterogeneity



Aulne Abbey (Belgium)

Stabilisation of the ruins according to the current norms for wind and earthquake resistance.



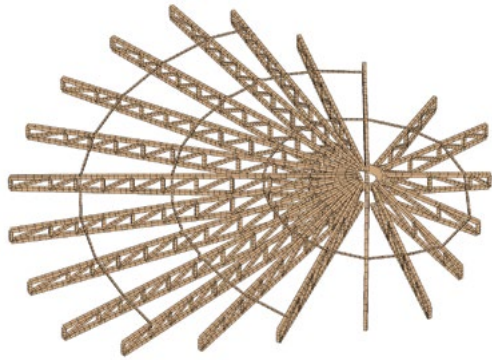
Deformed shape

Ceiling of the Hemicycle of the European Parliament (Belgium)

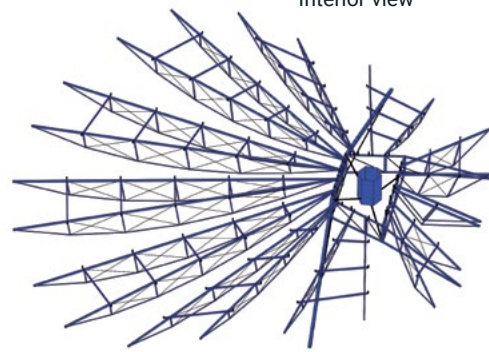
Reinforcement of the wood spatial frame by the addition of a steel frame.



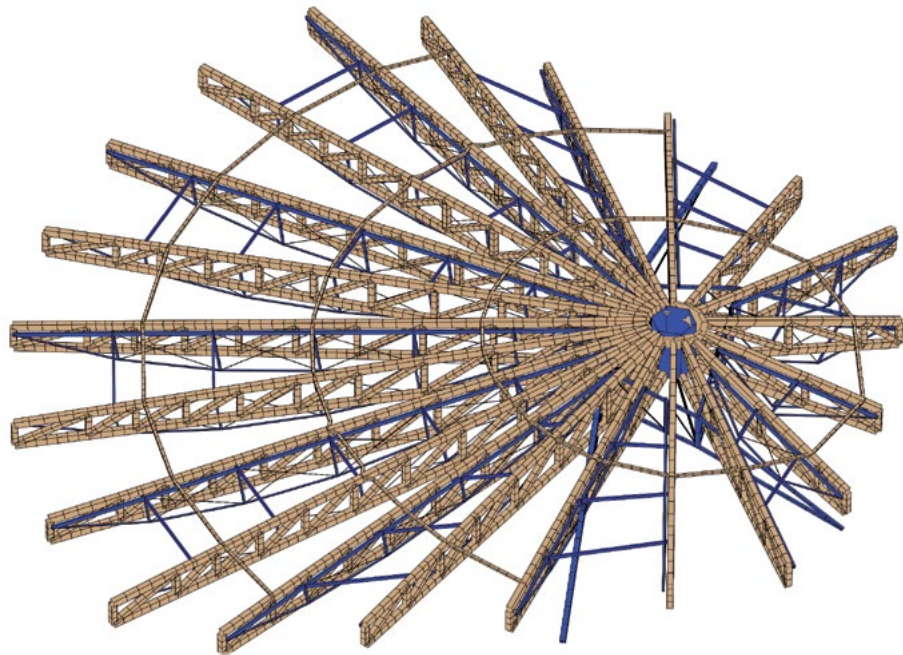
Interior view



Model of the existing framework composed of 21 wood truss beams



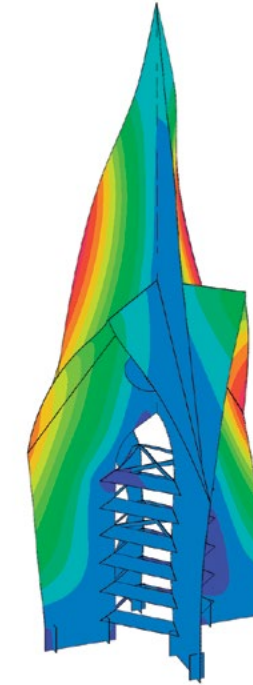
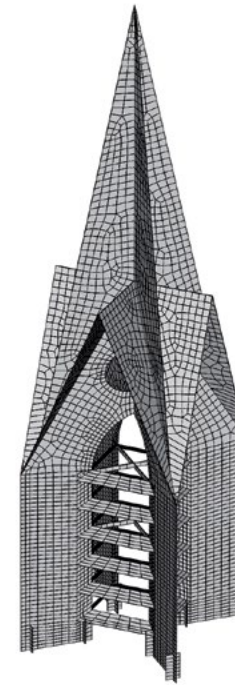
Creation of a quasi-isostatic reinforcement metal structure



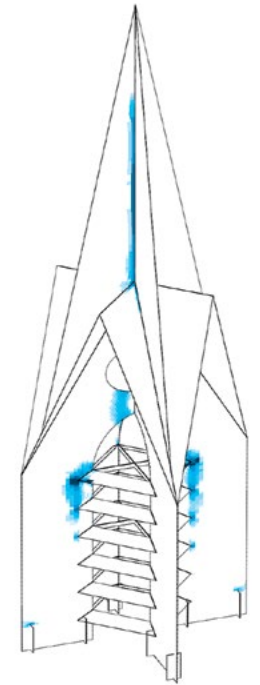
Model of the existing framework and reinforcement structure

Saint-Martin church in Ferrières (Belgium)

Replacement of the degraded masonry bell tower with a structure made of sandblasted stainless steel sheets, recalling the silhouette of the old bell tower.

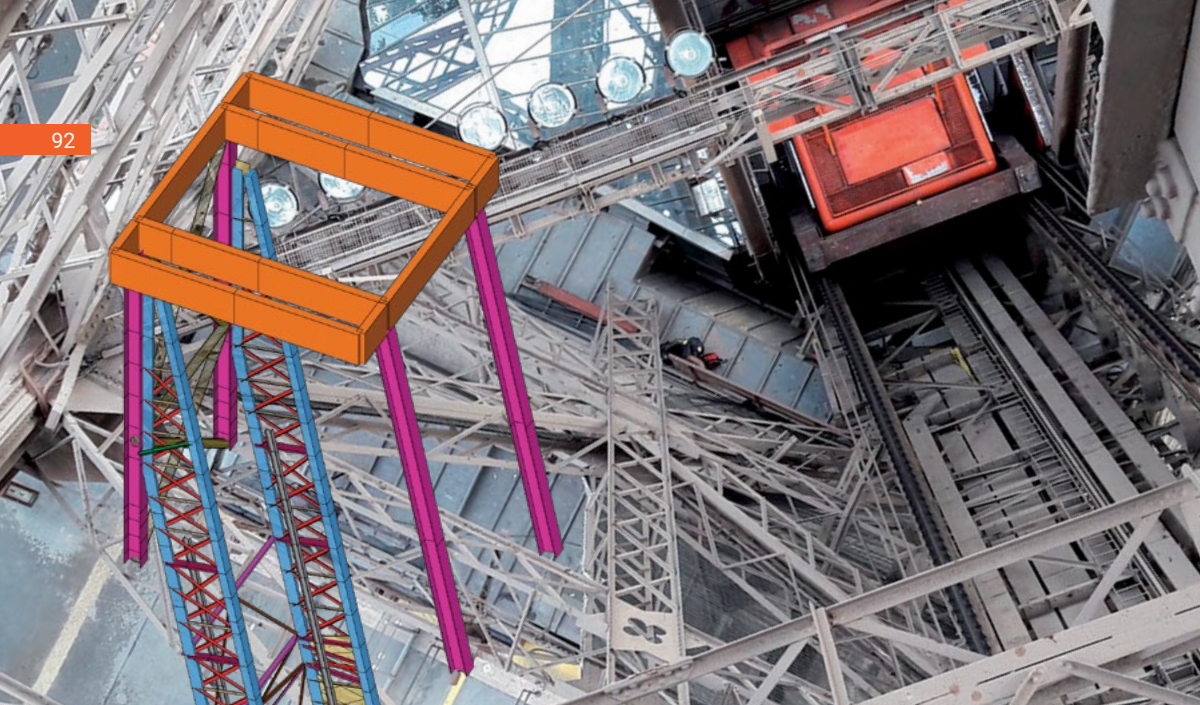


Stresses distribution



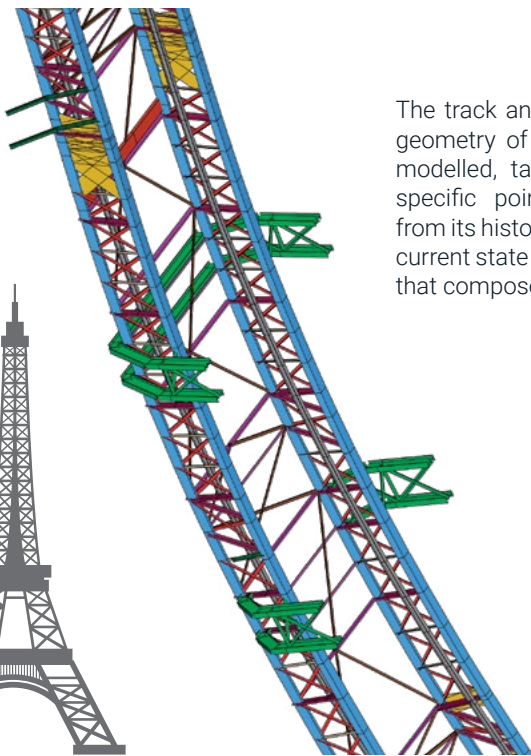
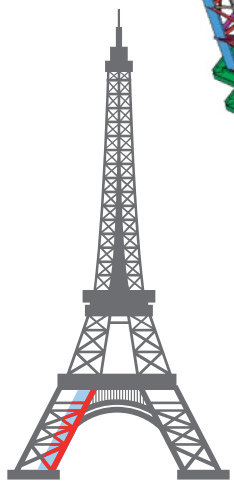
Plastification pattern





Eiffel Tower Renovation of the North elevator (Paris - France)

The track and the particularly complex geometry of the existing structure are modelled, taking into account all the specific points of attention deriving from its history, previous renovations, its current state of fatigue, and the material that composes it (wrought iron).



Model of the elevator track



Coordinated by Greisch R&D team for over 30 years, the development of FINELG FEM software has recently been the subject of a 4-year grant (2019-2023) issued by the Walloon Region (Belgium), in partnership with three universities: ULiège (Belgium), UHasselt (Belgium), and Insa-Rennes (France).

greisch.com



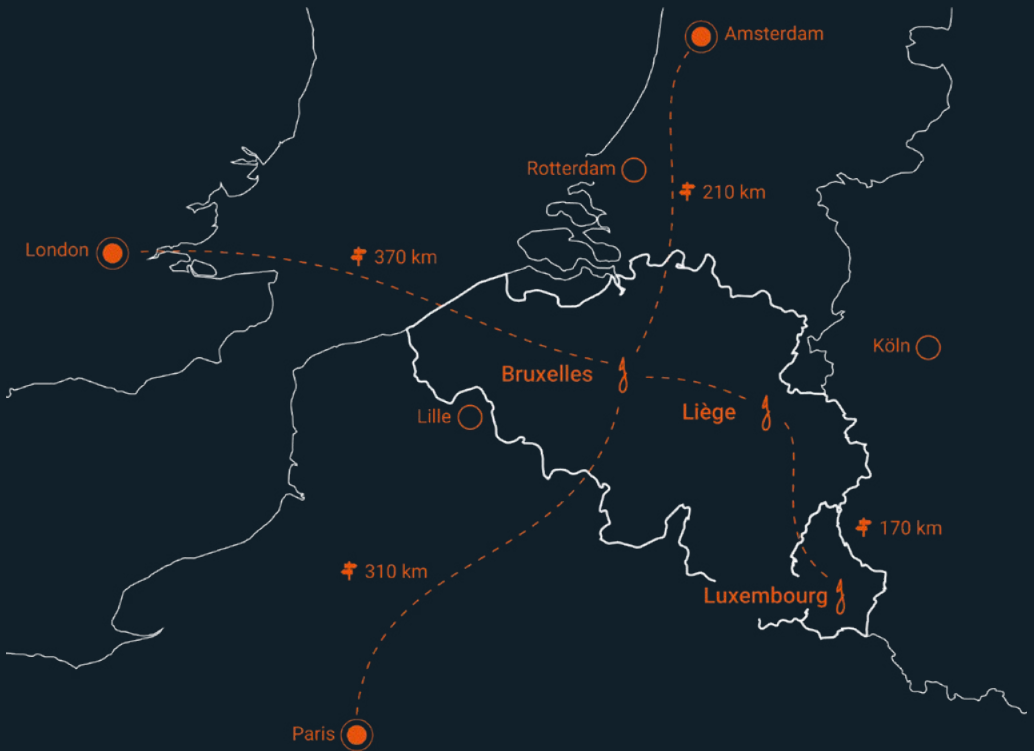
avec le soutien de



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