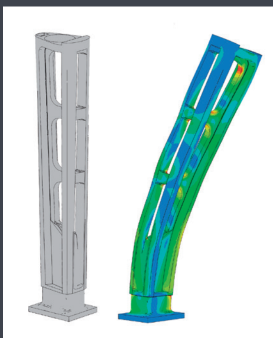
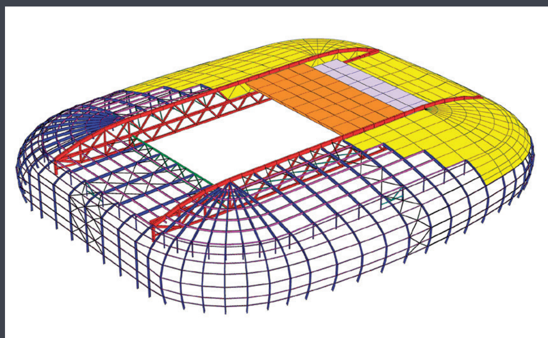
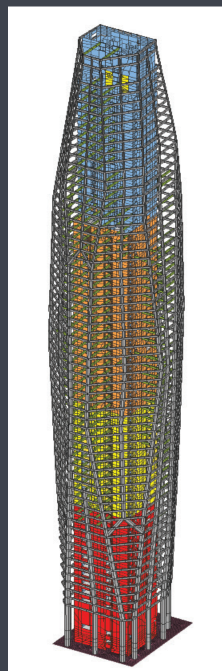
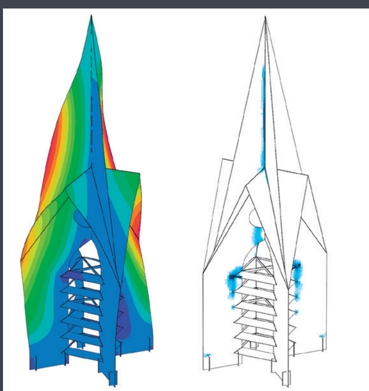
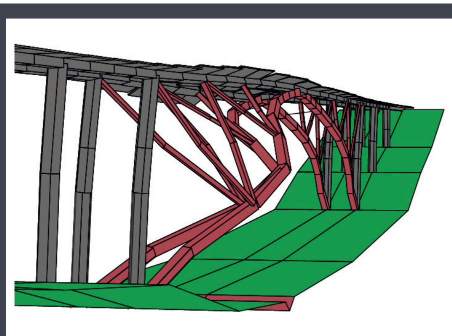
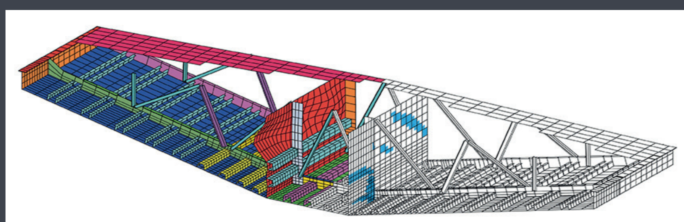












Greisch
Design with FINELG

MY FIN

greisch

Greisch R&D Department

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 (employees?) 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, for instance. 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.

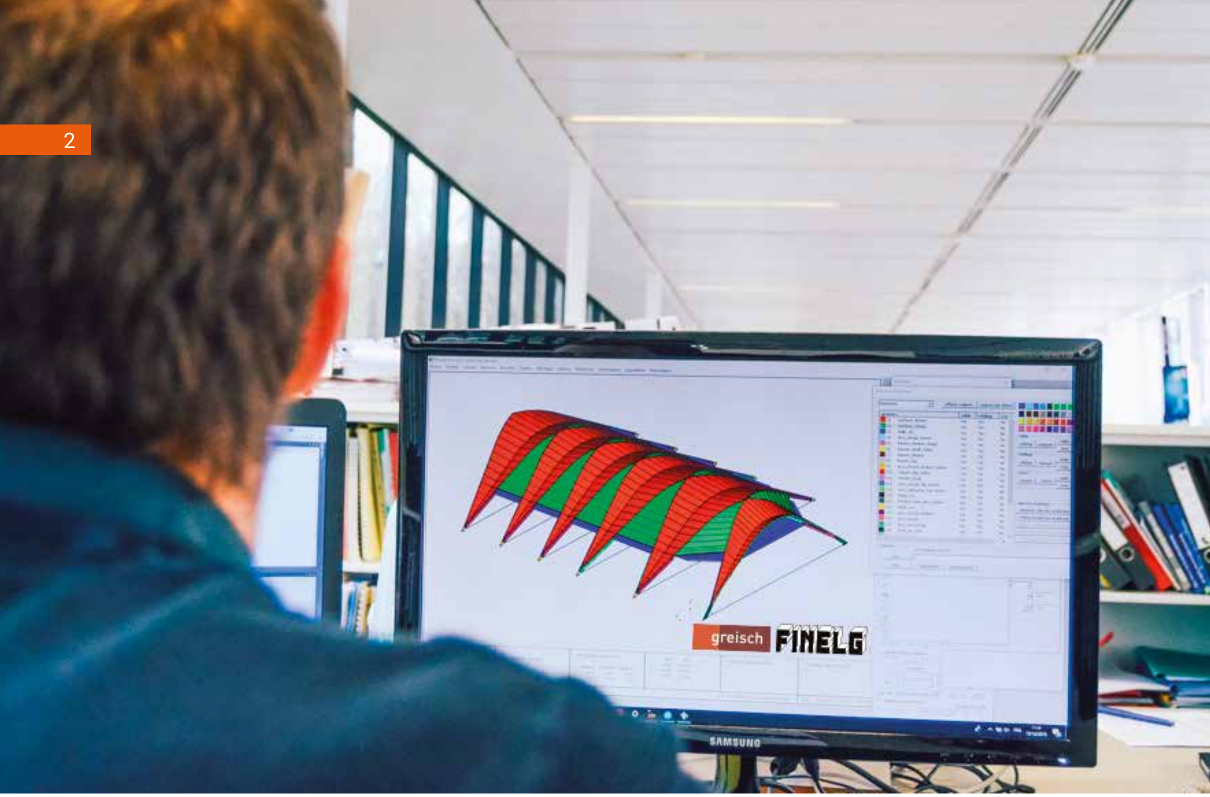
A profound knowledge of the construction companies we collaborate with, and of their potential in different fields, is another important asset. This enables us to work on challenging and highly innovative designs, by taking advantage of already available techniques but, at the same time, by constantly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

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

The discretion of our work, the absence of a ostentatious character, 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 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, and being careful not to show off all the amazing feats of which he or she is capable of.

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, by the 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 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 GiD 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. For instance, 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 cutting edge of technology and lie on solid theoretical bases.

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.

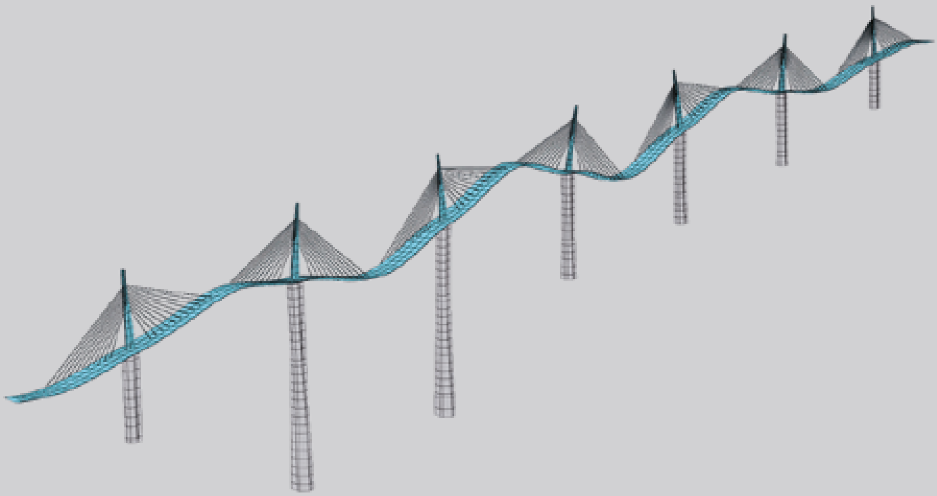
For such structures, although it is still possible to perform simple computations by hand to get a preliminary design, the use of some Finite Element software is unavoidable to achieve the final design, which demands extensive analyses and requires a deep understanding of the behaviour of the structure.

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

6 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.

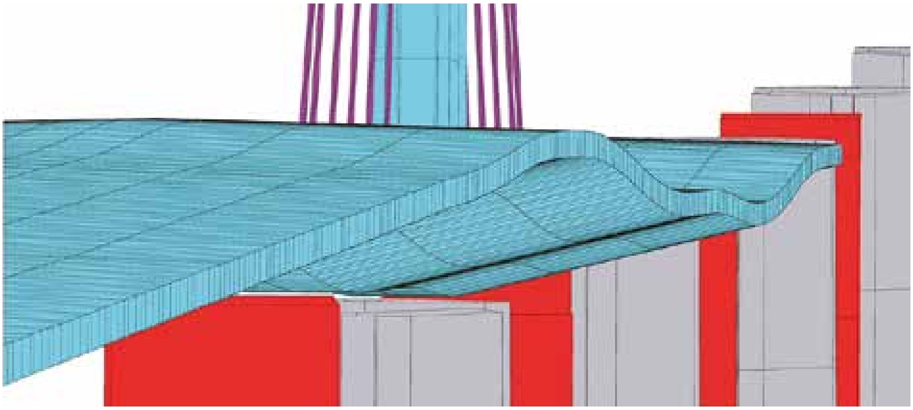
The superstructure is entirely made of steel – an orthotropic deck (28 m wide and 4.20 m high) and 7 pylons (90 m high). Total weight of steel: 50,000 tons.

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.

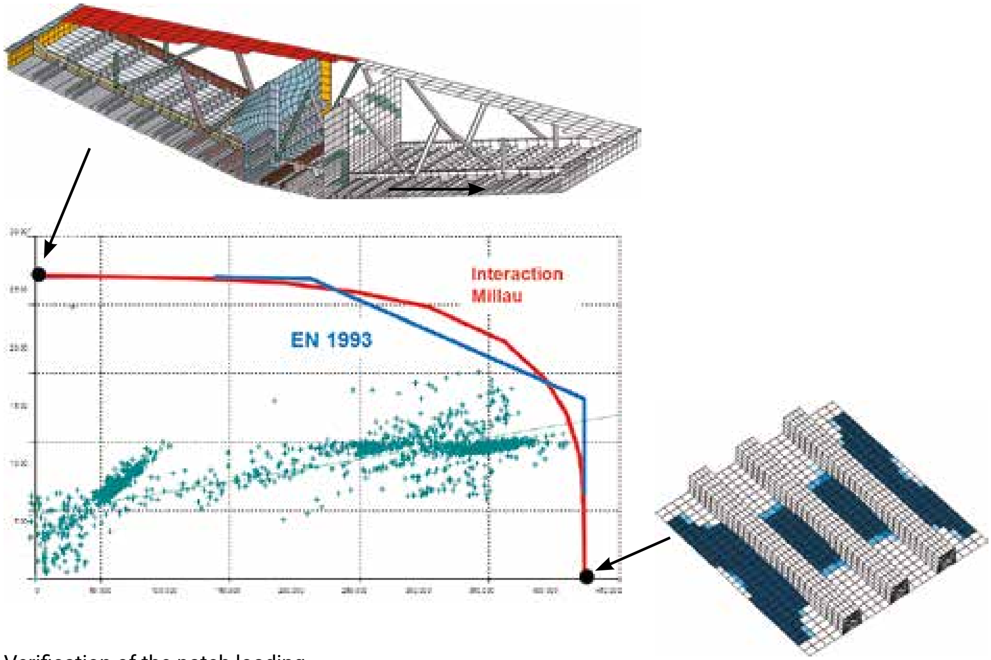
Greisch introduced a steel variant and carried out all the working calculations for the deck-pylon-cable structures for :

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

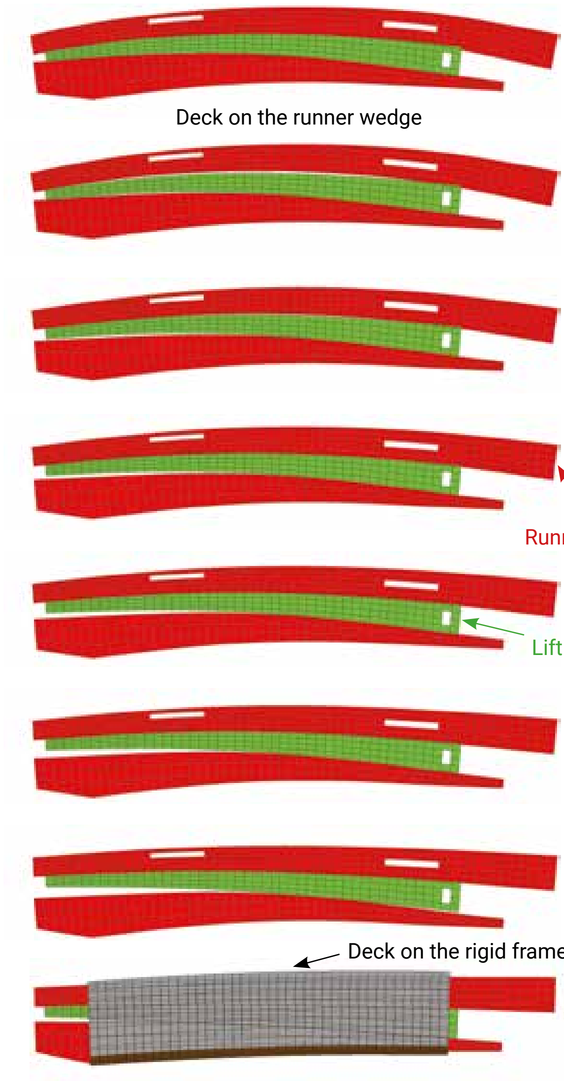
Deformed shape of deck during launching



Deformed shape simulation



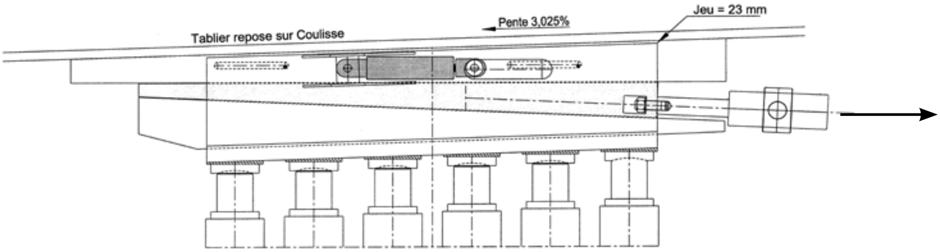
Verification of the patch loading



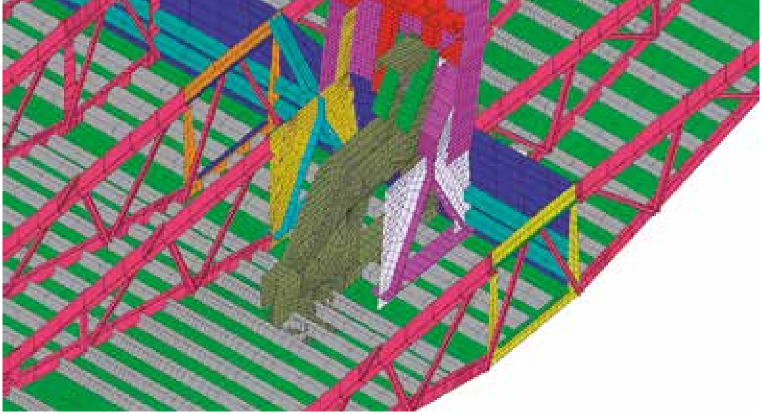
Simulation of the wedge deformations during a launching step

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

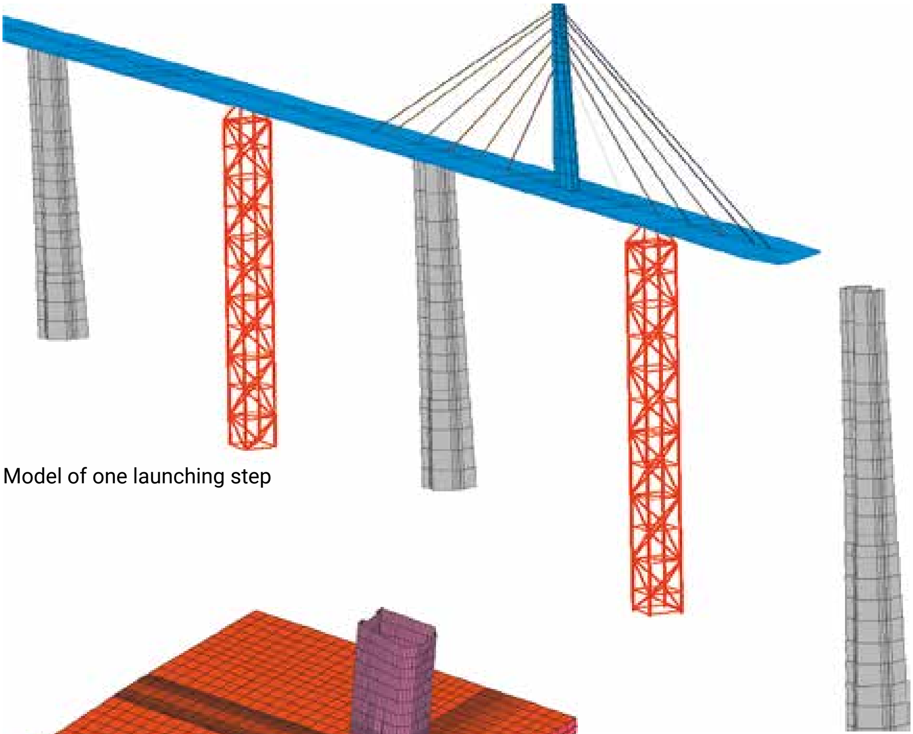
These tools were able to move the deck on a distance of 600 mm in about four minutes.



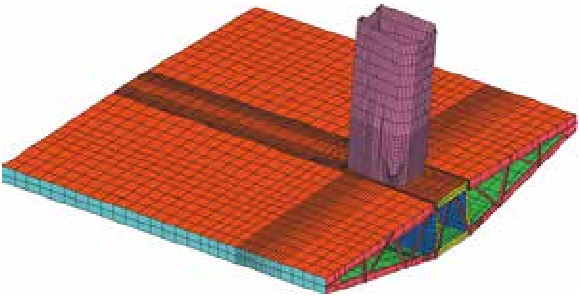
View of the translator



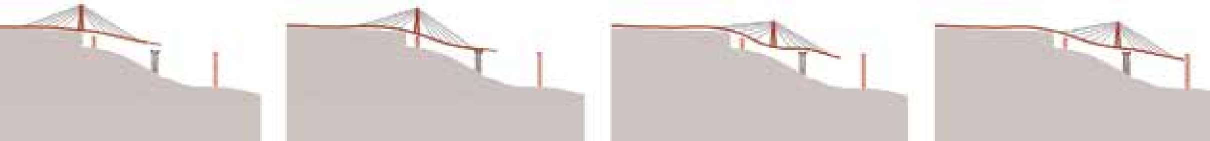
Study of the local stresses distribution in the node deck / pylon / pier.

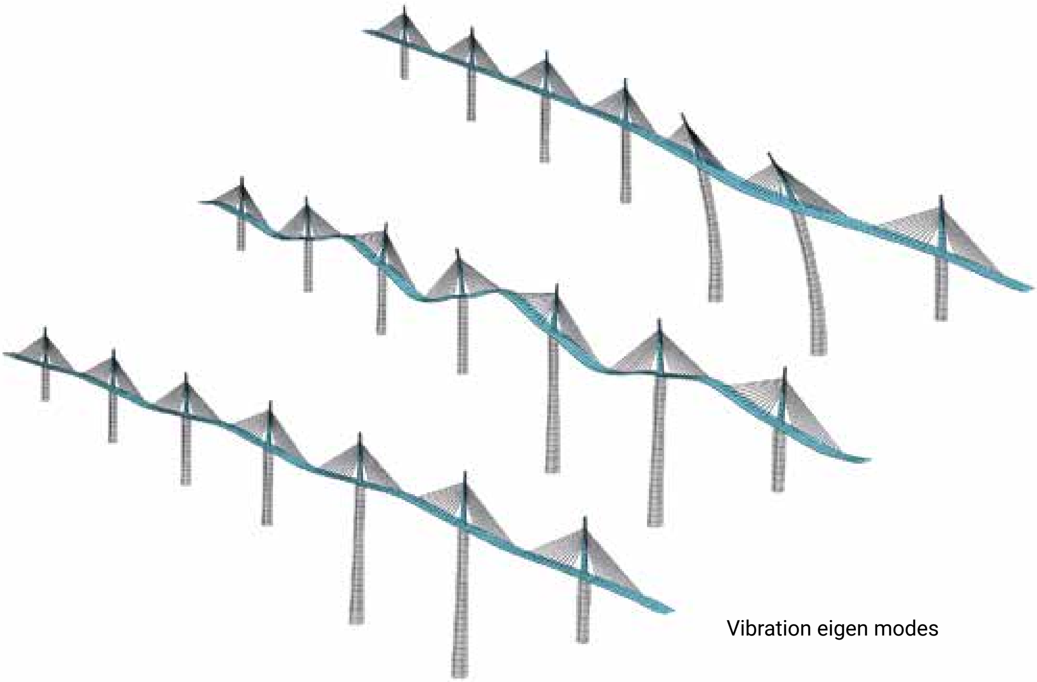


Model of one launching step



3D model of the connection deck / pylon / pier





Vibration eigen modes

Nonlinear simulations of the launching steps.

3^{rd} Bosphorus Bridge

(Turkey)

Suspension bridge with a 1408 m long main span and a total length of 2 408 m, located at the 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.

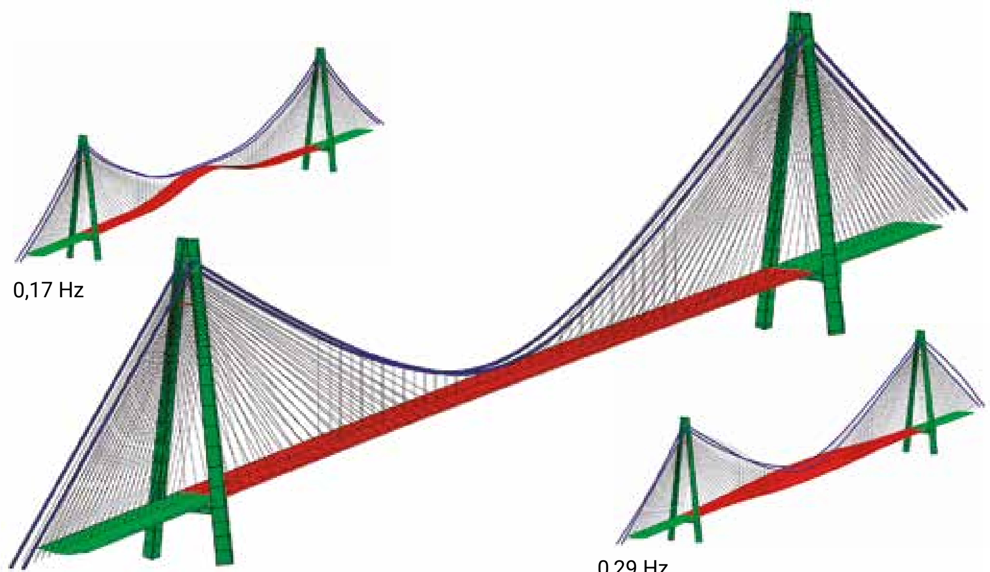
In the central span, the steel deck is made of an orthotropic plate (total steel weight : 45 000 tons). The side spans are made of post-tensionned concrete.

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

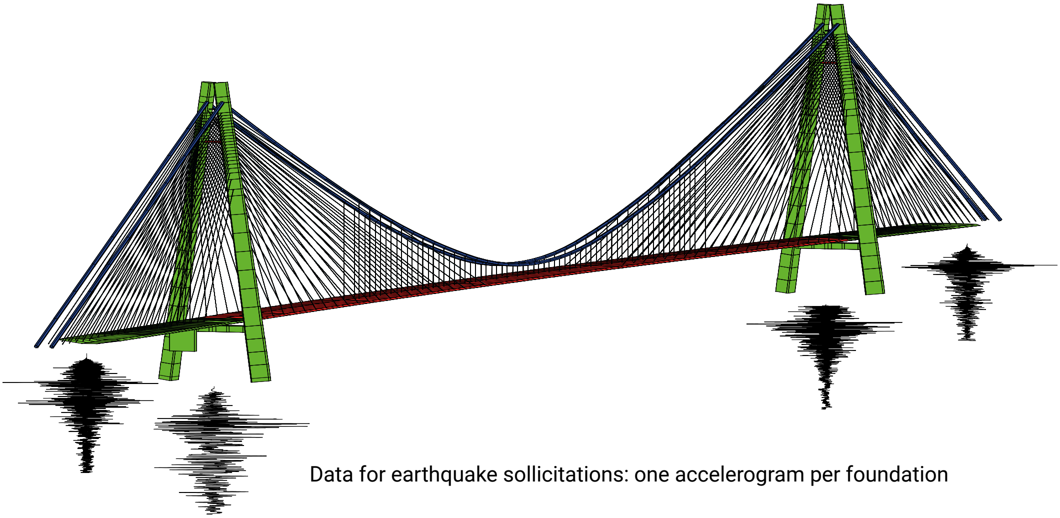
Wind tunnel tests

Greisch mission :

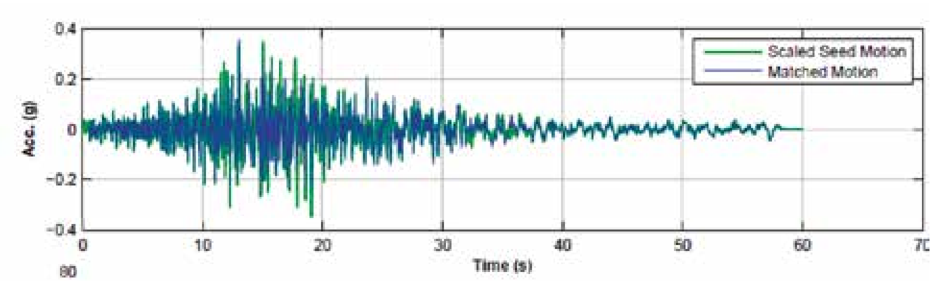
- calculations of the overall structure during its service life ;
- proposals for construction methods ;
- design of the steel deck in the main span ;
- dynamic studies necessary to verify the behaviour of the global structure :
- under the action of wind (during the service life and the construction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



Beam model and vibration eigen modes

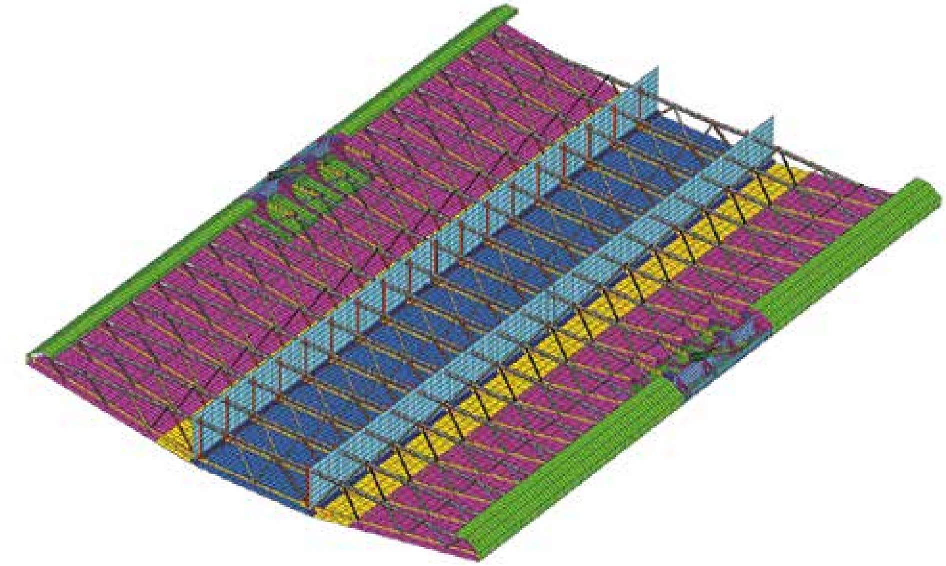


Data for earthquake sollicitations: one accelerogram per foundation

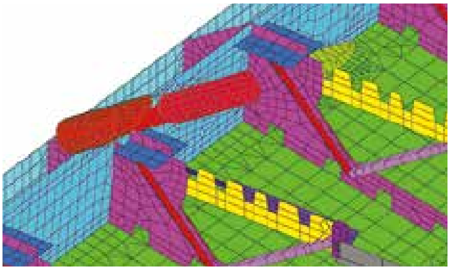


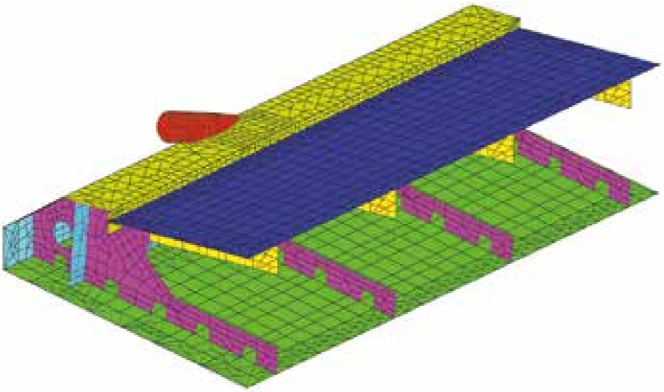
Accelerogram for seismic simulation

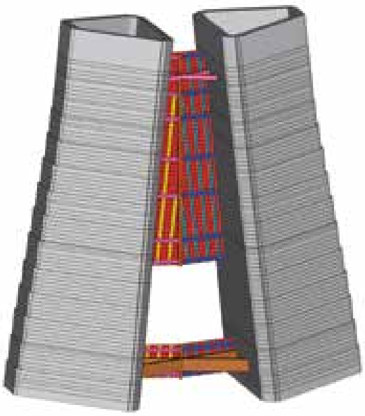
Deformed shapes during earthqake



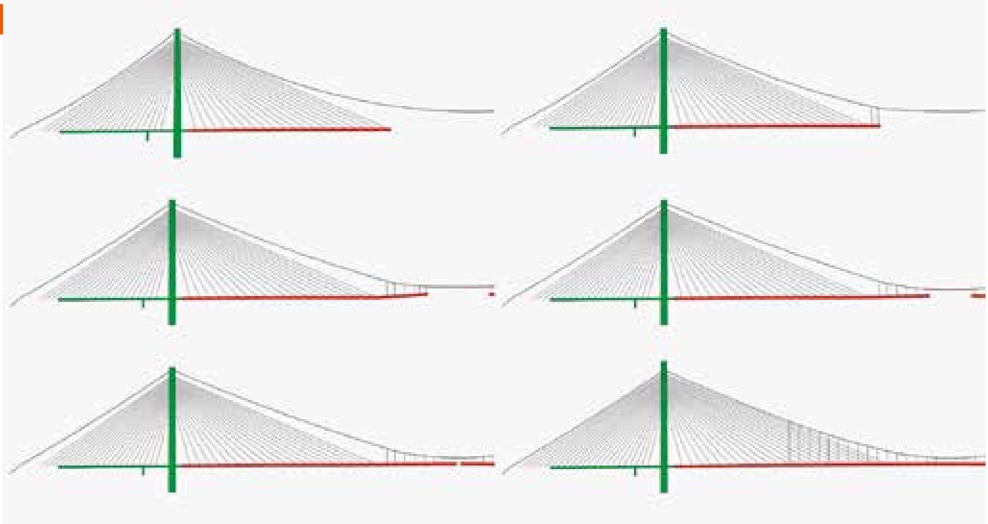
Model of the deck for the design of the stay cables anchorange







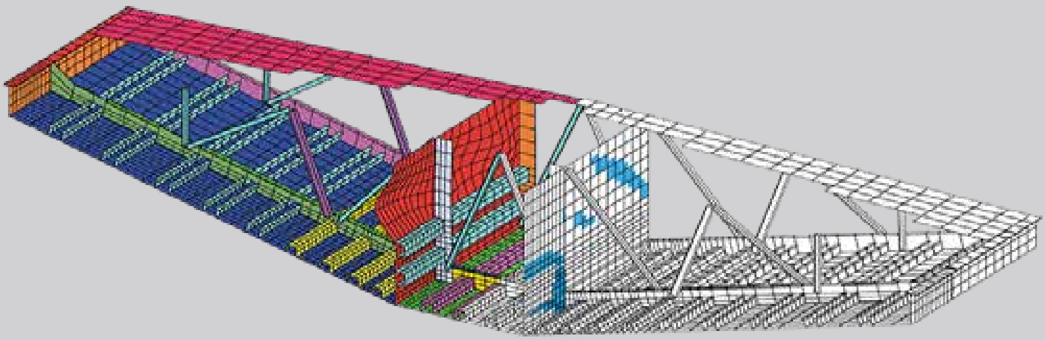
Model of the connection of the pylon legs at the top.



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 constructions 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.

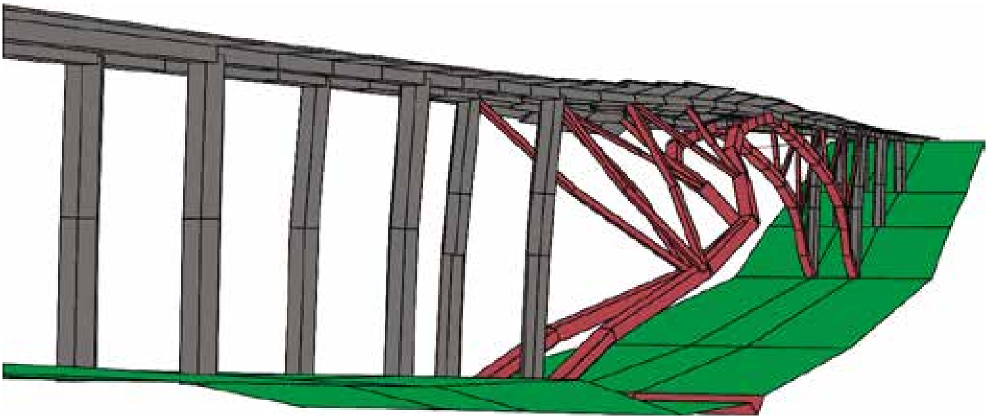
The final goal is to verify the safety of the design, for example, during the launching of one deck or after the suppression of stiffeners even if, in this case, it is necessary to increase the compression plates thickness. The suppression of external bracings will increase the slenderness of the structure, for example, for the bowstring bridges. Without bracings between arches, the construction will be easier.



Patch Laoding during the launching of the Millau Viaduct

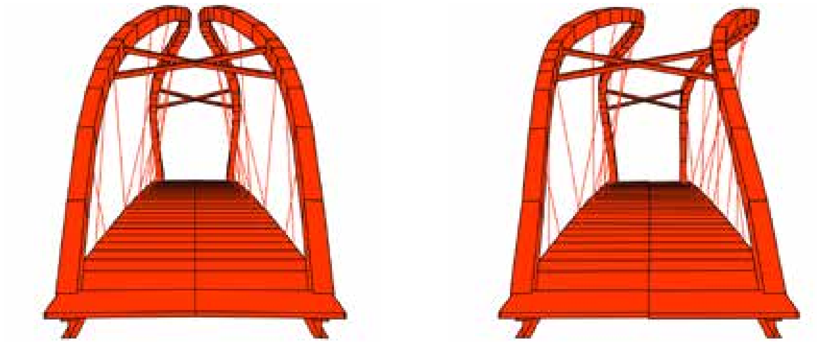
Eau-Rouge Viaduct

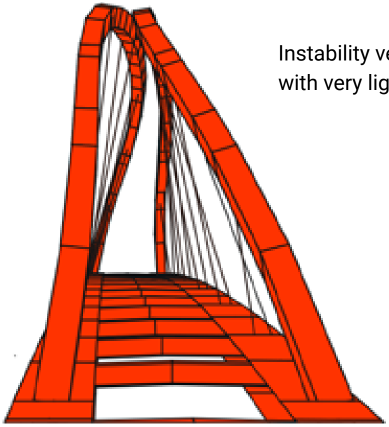
(Belgium)



Instability verification without bracing between both arches.

Milsaucy Bridge
(Belgium)

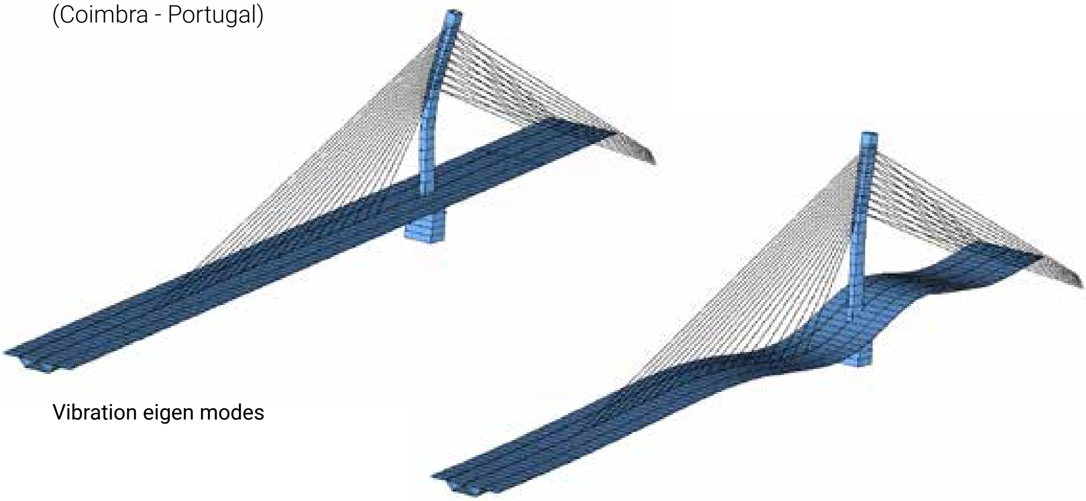




Instability verification without or with very light bracings.

Hermalle Bridge
(Belgium)

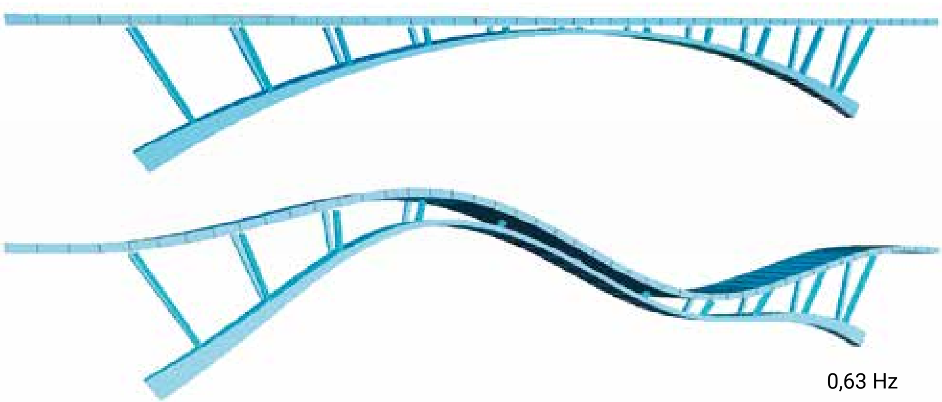
European bridge
(Coimbra - Portugal)



Vibration eigen modes

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

Ravine-Fontaine bridge
(Island Reunion - France)



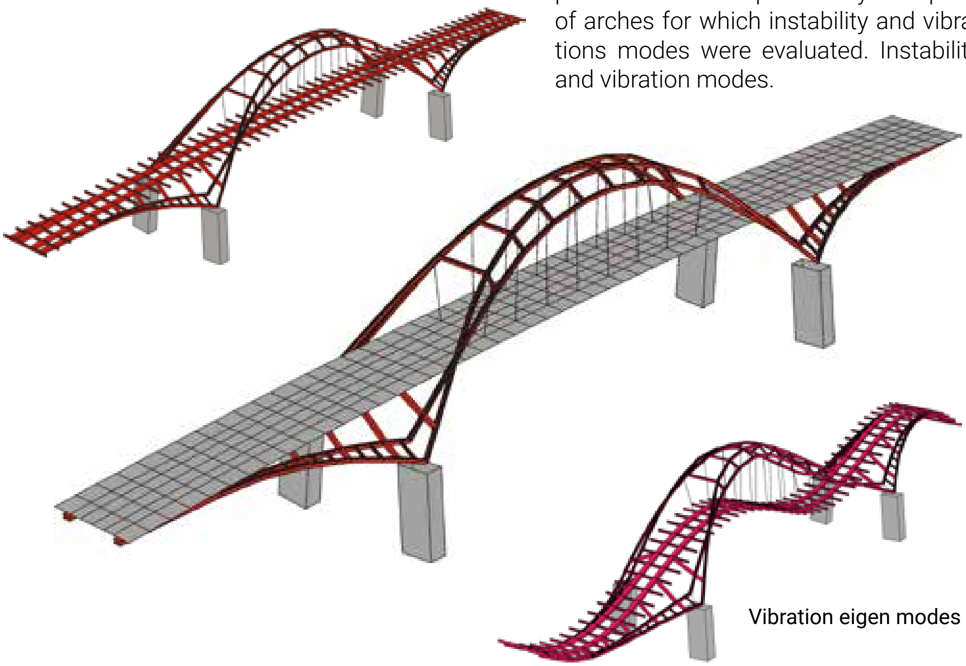
Vibration eigen modes

(with creep, shrinkage, cracking of concrete)

Arch Bridge

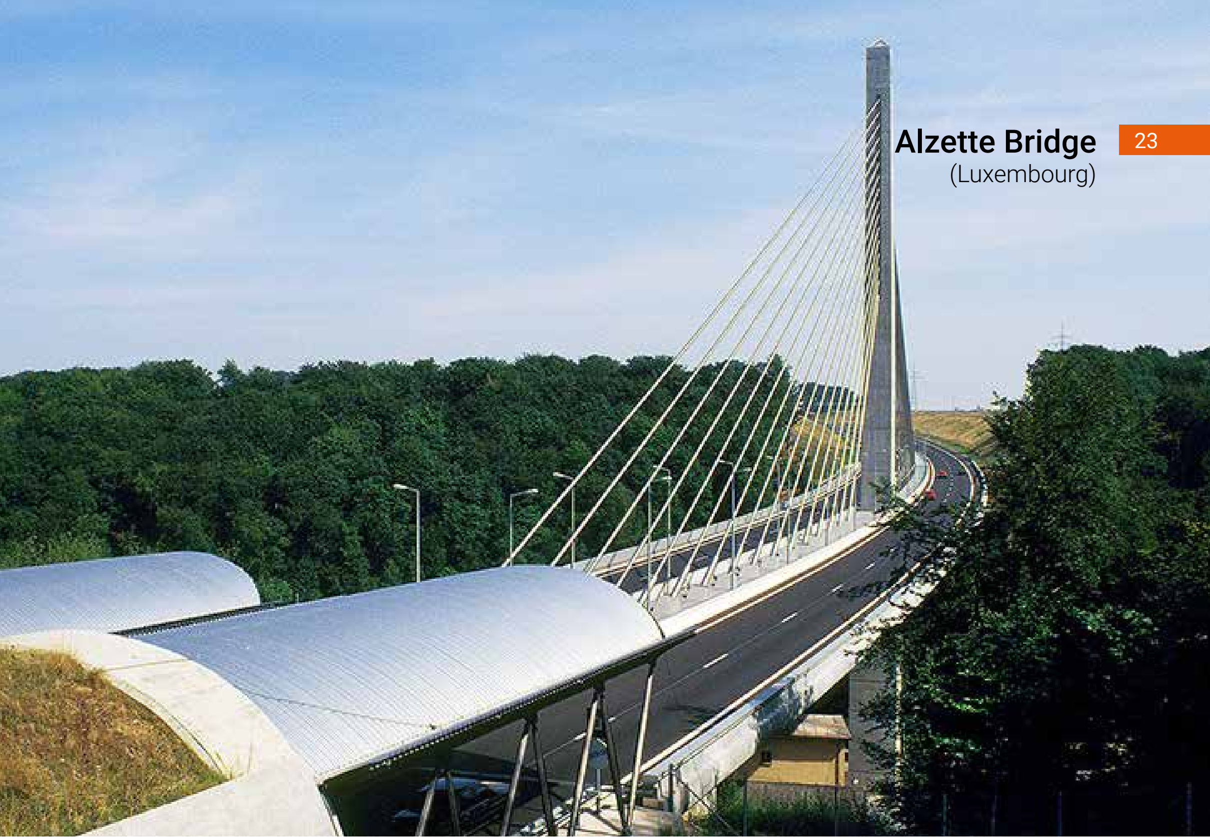
(Chooz - France)

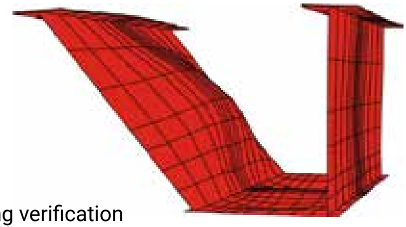
Bridge over the Meuse river. The composite deck is suspended by two pairs of arches for which instability and vibrations modes were evaluated. Instability and vibration modes.



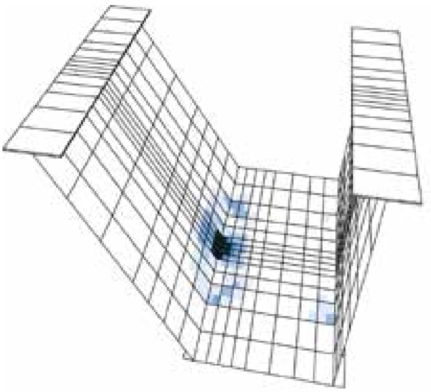
Vibration eigen modes

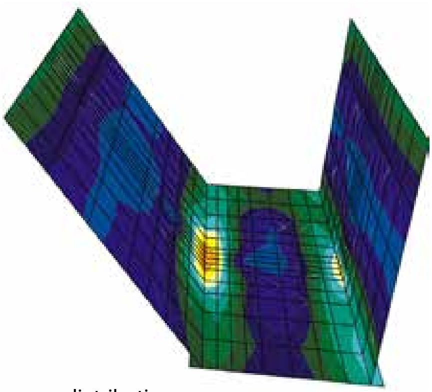
Alzette Bridge
(Luxembourg)




Patch Loading verification

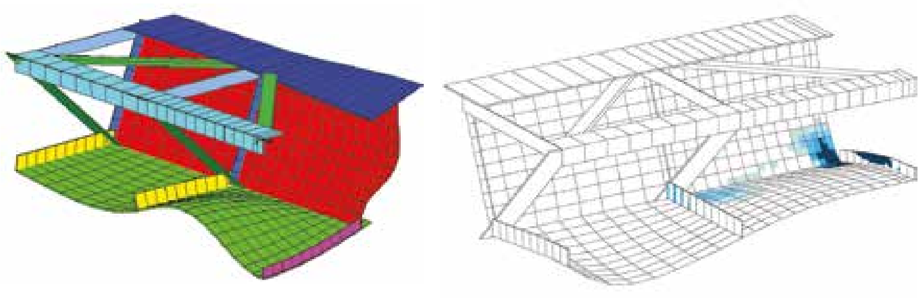

Measurements on work site


Plastification schema

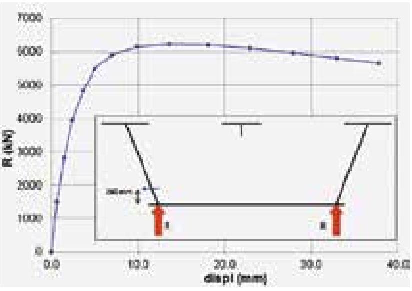

Stresses distribution

Sado Viaduct

(Portugal)

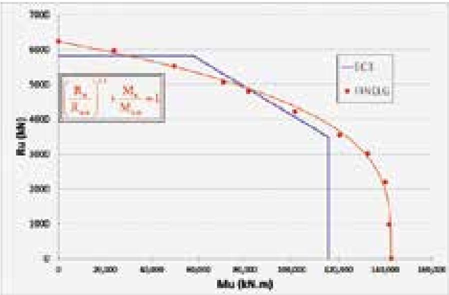


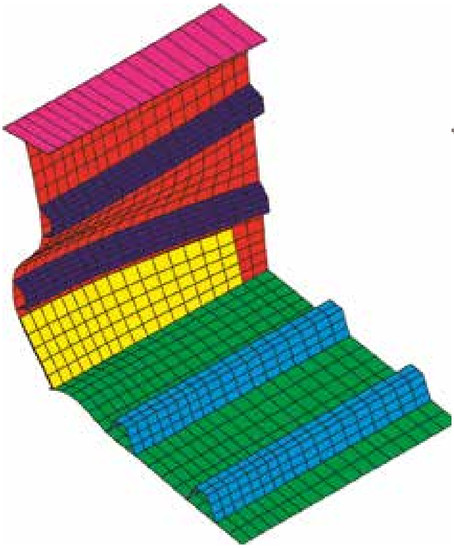
Patch Loading verification



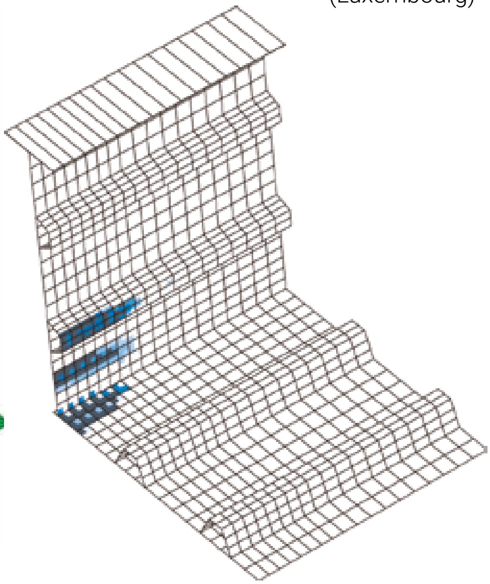
Vertical reactions versus web lateral displacement

Interaction criteria :
bending moment / vertical reaction





Patch Loading verification

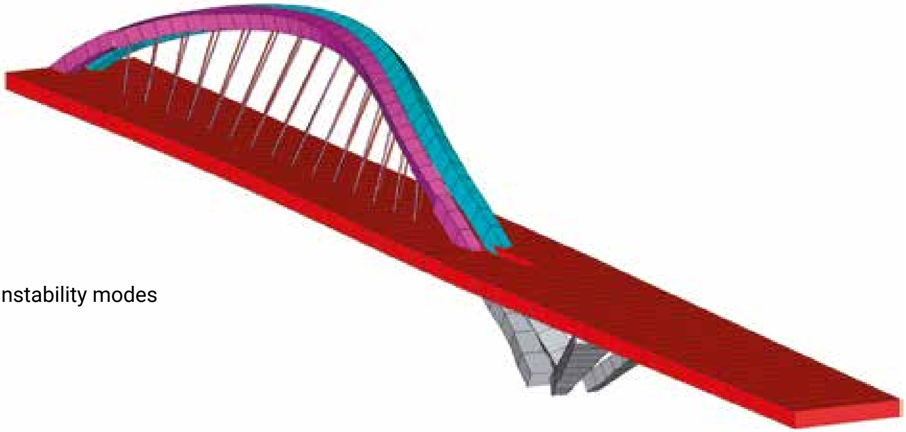


Plastification schema

Canal Albert
(Belgium)

Instability modes

Seibert
(France)



Instability modes

For large and slender structures, buildings, roofs, bridges, their behaviour under the turbulent wind loading is fundamental. Its stability and its dynamic behaviour have to be verified. For structures larger than 150 m, the Eurocodes suggest to consult experts, to perform measurements on site to define the wind profile and to do tests in a wind tunnel lab. With measurements made on the site and during the tests, simulation of the dynamic behaviour of the structure can be performed. The goal of these computations is to verify the safety and the comfort of the car drivers on a bridge or of the occupants of the building.

Often, the engineers of the wind tunnel lab have at their disposal the software's to do these numerical simulations. But the best solution for a design office in charge of the structure design is to develop their own software to be autonomous and to be able to analyze any desired configuration of the bridge during its construction, for example. In this conext, the R&D department with close relationships with different universities is one of Greisch major assets.

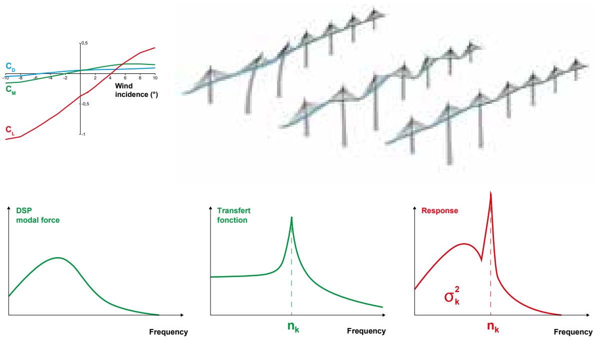
Riga station model in RWDI wind tunnel Lab

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


Measurments on site

Millau Viaduct (France)



Wind shield

Aeroelastic model of a construction stage

Temporary pier

Bosphorus Bridge (Turkey)
Wind tunnel tests

Wind shields

Deck lifting

Aeroelastic models

Pylon

Construction stage

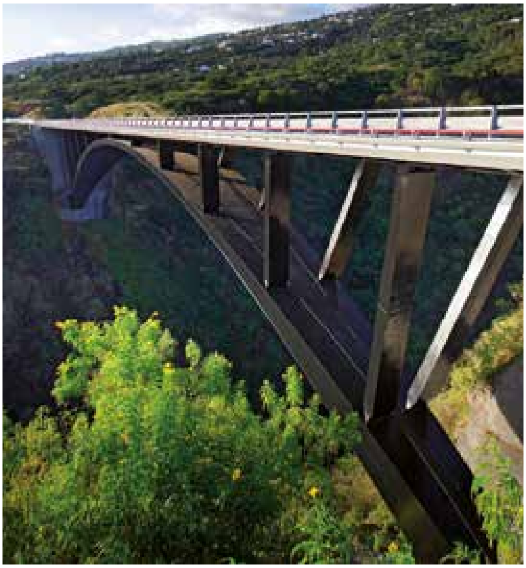
Motorway around Antwerp (Belgium)

Sectional models

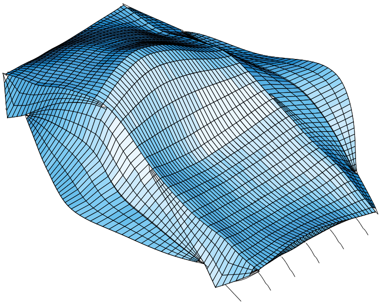
Ravine-Fontaine bridge (Island of Reunion - France)

Definition of wind profile

Sectional model



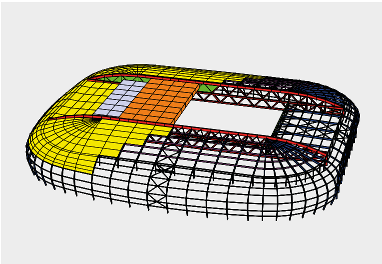
Guillemins Railway Station (Liège - Belgium)
Vibrations modes



© RWTH

Lille Arena (France)
Wind tunnel tests and numerical simulations

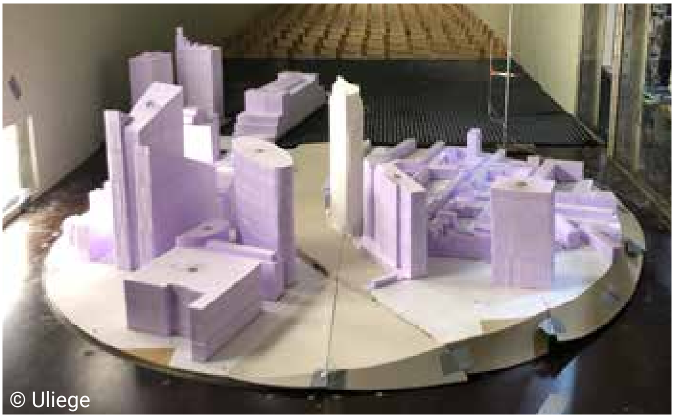
© CSTB



Model with its environment

Silver Tower (Belgium)

Rigid Model



Model with its environment

Taps connectors

Greisch engineers in wind tunnel labs or on the work site

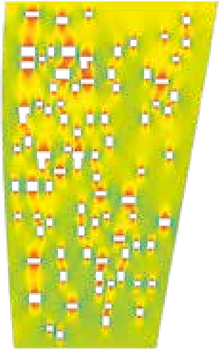

© O. Bastin

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.

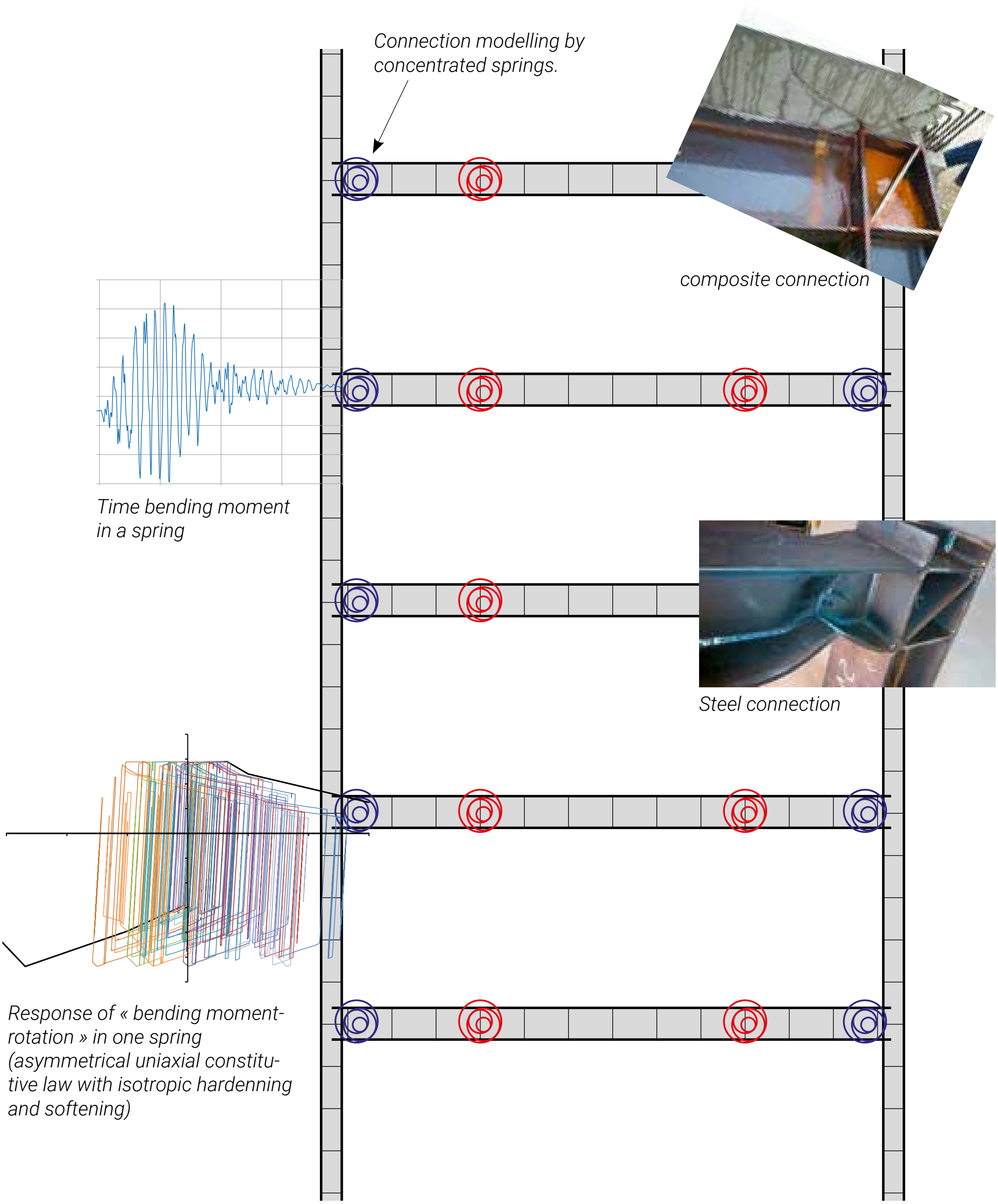



© Uliege

Meakado European research

(Belgium)

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

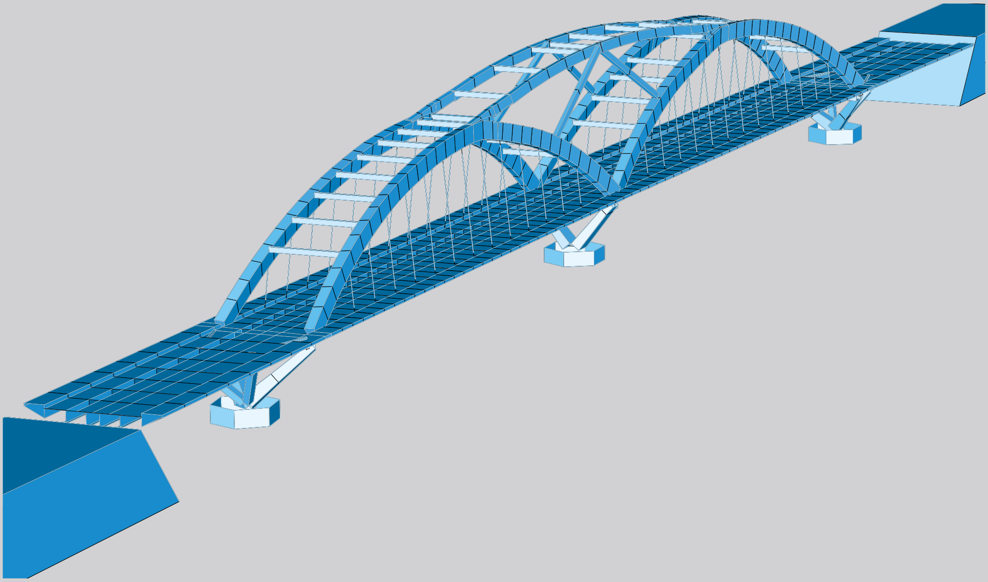


Dynamic behaviour - HSR

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

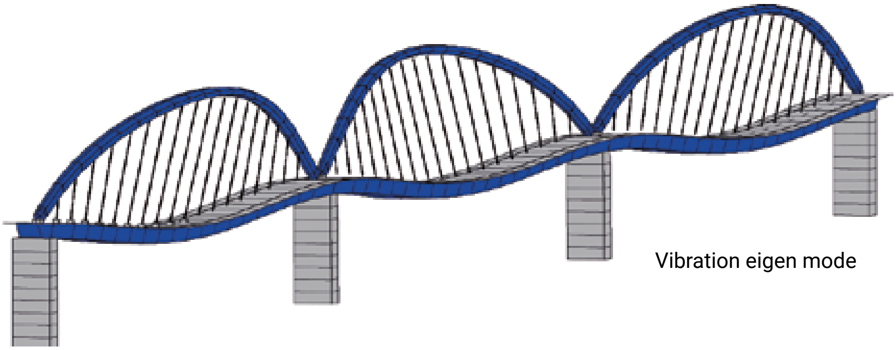
(Portugal)

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

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

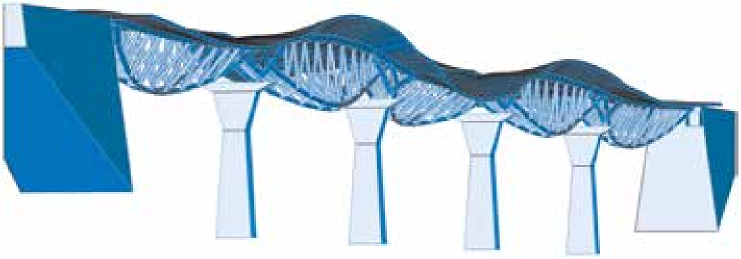
Later in the 90's, Gresich was called by the SNCF, through the contractors, to make the detailed design of the four most prestigious steel bridges along the new high speed line between Lyon and Marseille : Arc, Donzère (Garde-Adhémar), Mornas and Mondragon.

The viaduct over the river Sado in Portugal has been a collaboration with the Portuguese engineering office GRID for the full design of the multiple arch bridges, up to the detail design.

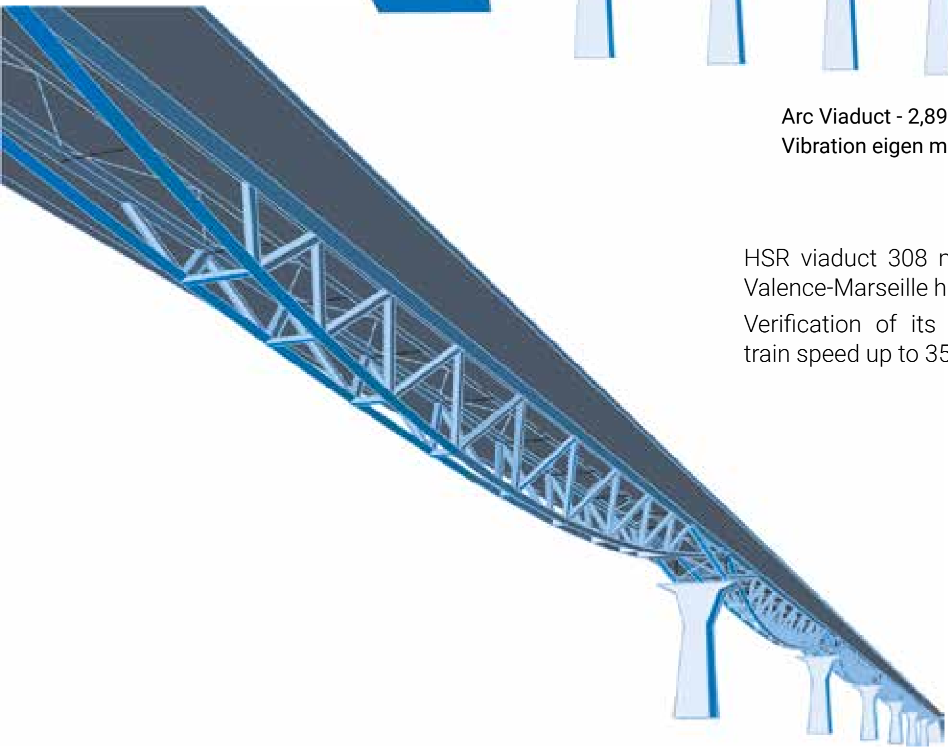


Vibration eigen mode

Arc Viaduct
(Aix en Provence - France)



Arc Viaduct - 2,89 Hz
Vibration eigen mode



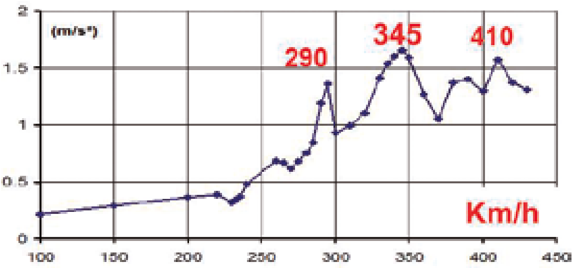
HSR viaduct 308 m long on the Valence-Marseille high-speed line.

Verification of its behaviour for train speed up to 350 km/h.

Mornas Viaduct
(France)

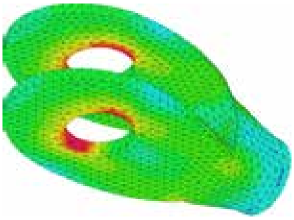
HSR viaduct on the Valence-Marseille high-speed line.

FE model of Mornas Viaduct

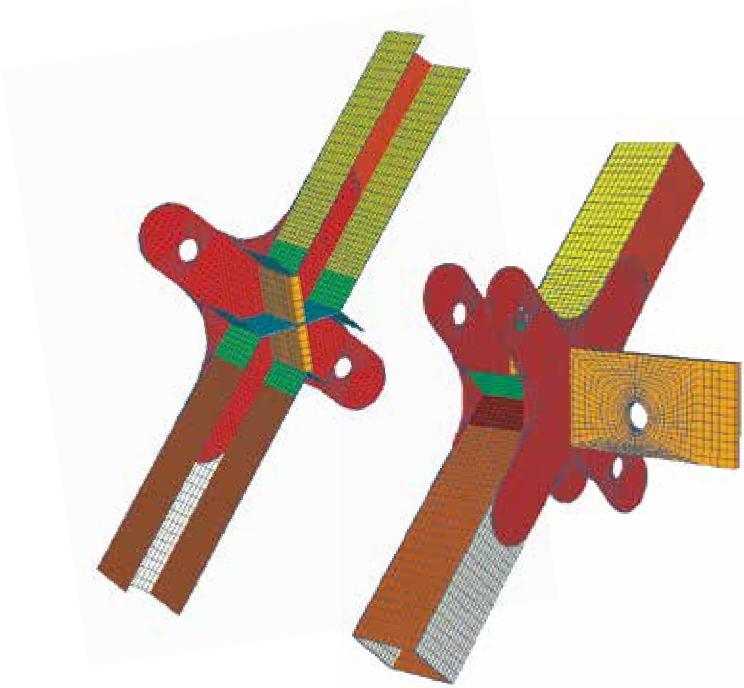


Accelaration versus train speed

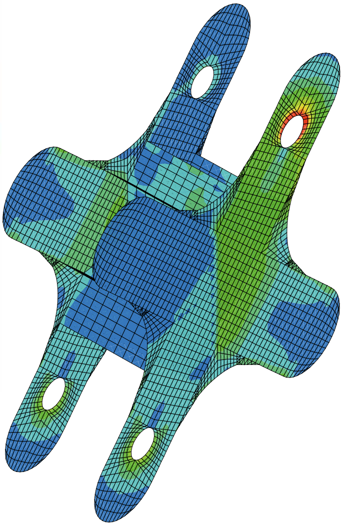
High speed line Savena – Sieve (Italy)



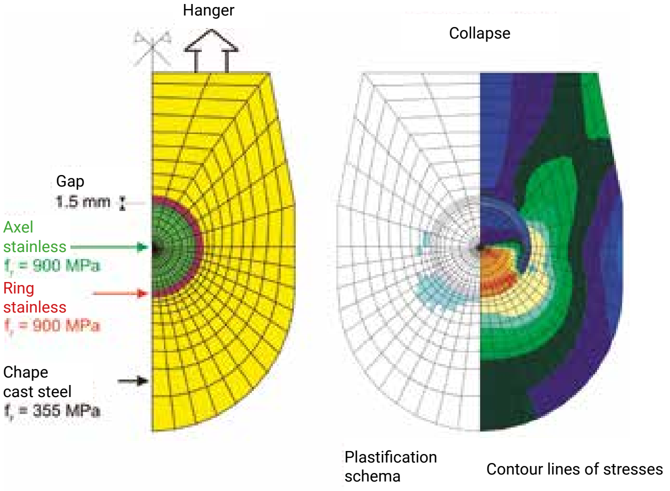
Test and models of hanger sockets



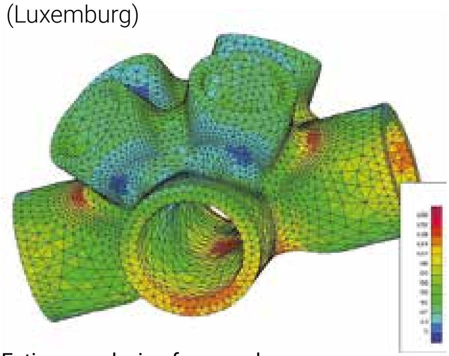
Stresses distribution inside a frame connection



Donzere Viaduct
(France)



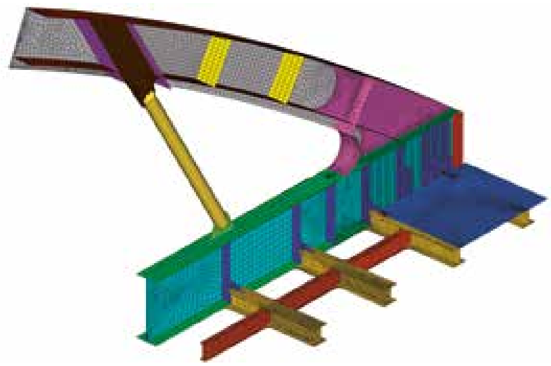
Pulvermühlen Viaduct
(Luxemburg)



Fatigue analysis of one node

Bezon Viaduct
(France)

Bowstring bridge for the RER E in Paris.



Nowadays, many footbridges are erected allow pedestrians to cross a river, a valley. For this type of structure, the criteria for the design of this type structure are, for the architects and the engineers:

- Its location and its accessibility to pedestrians, joggers, cyclists and people with reduced mobility ;
- Its comfort: under the movement of pedestrians the accelerations have to be controlled eventually throught tunned mass damper (TMD).

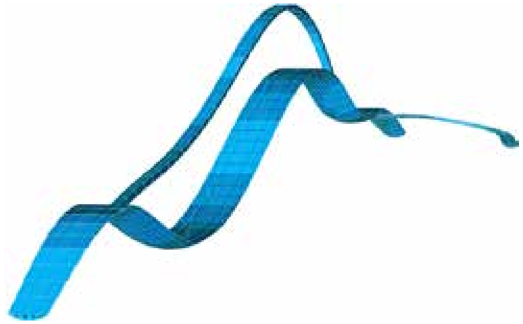
Model of « La belle Liègeoise » footbridge

Hoge Brug

(Maastricht - Nederland)

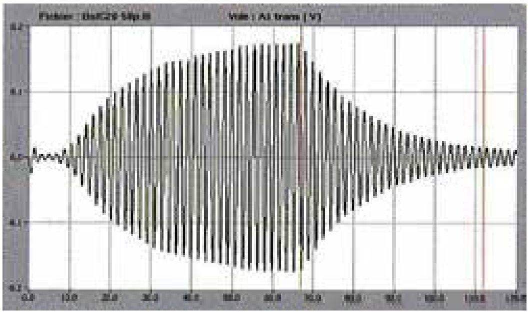
261 m long arch Footbridge to link the new Ceramic district and the old city.

Dynamic tests



Vibration eigen mode

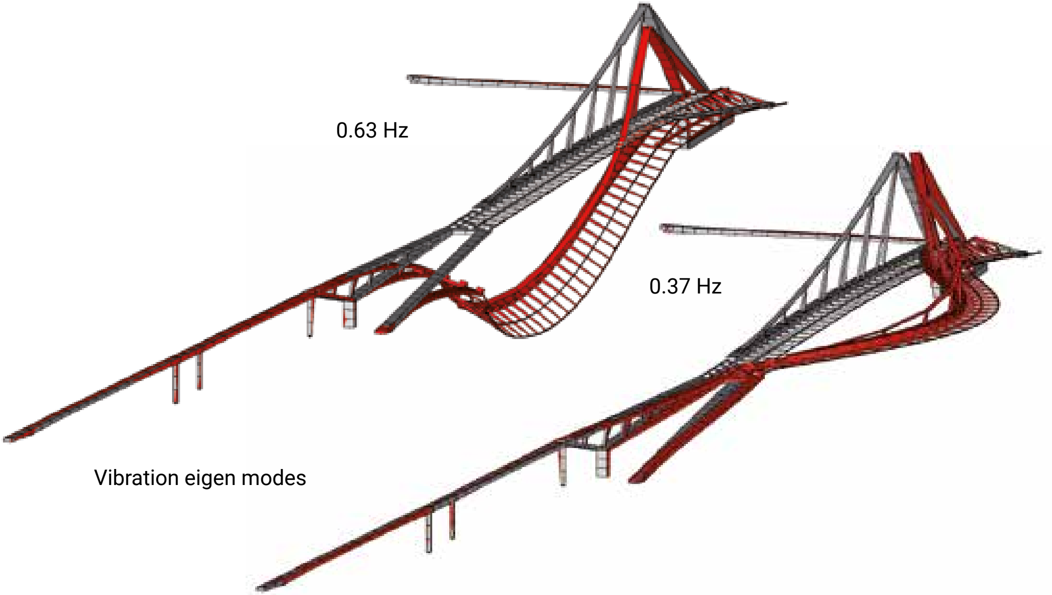
Tuned mass damper (TMD)



Bridge response with TMD

« La belle Liègeoise » footbridge

(Liège, Belgium)

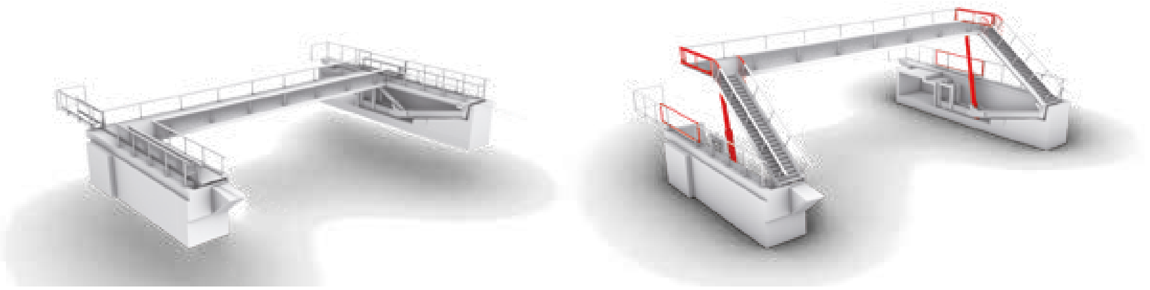


Vibration eigen modes

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.

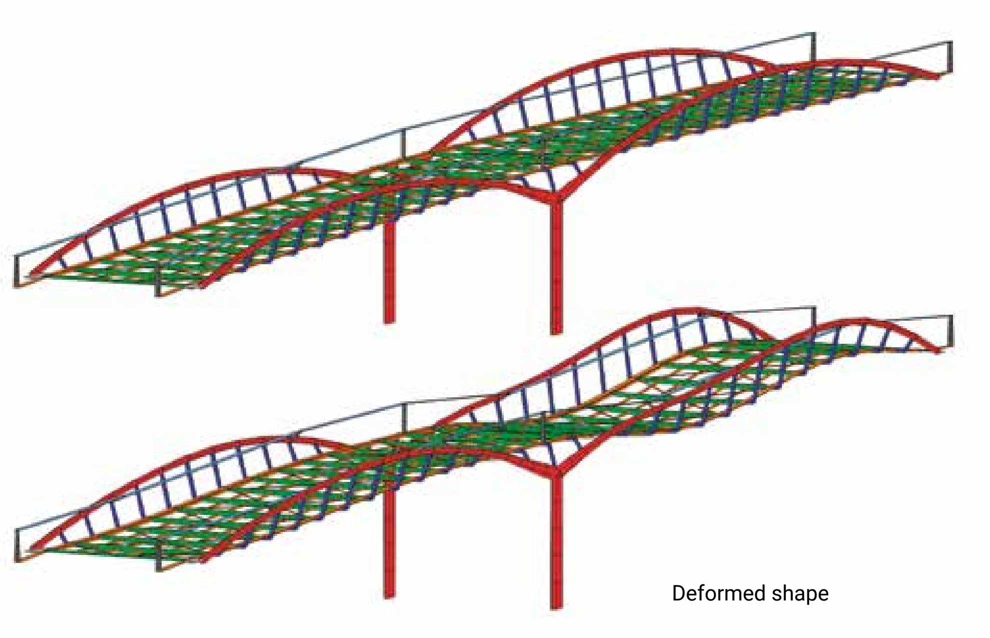
Molenbeek Footbridge
(Belgium)

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



Vibration eigen modes

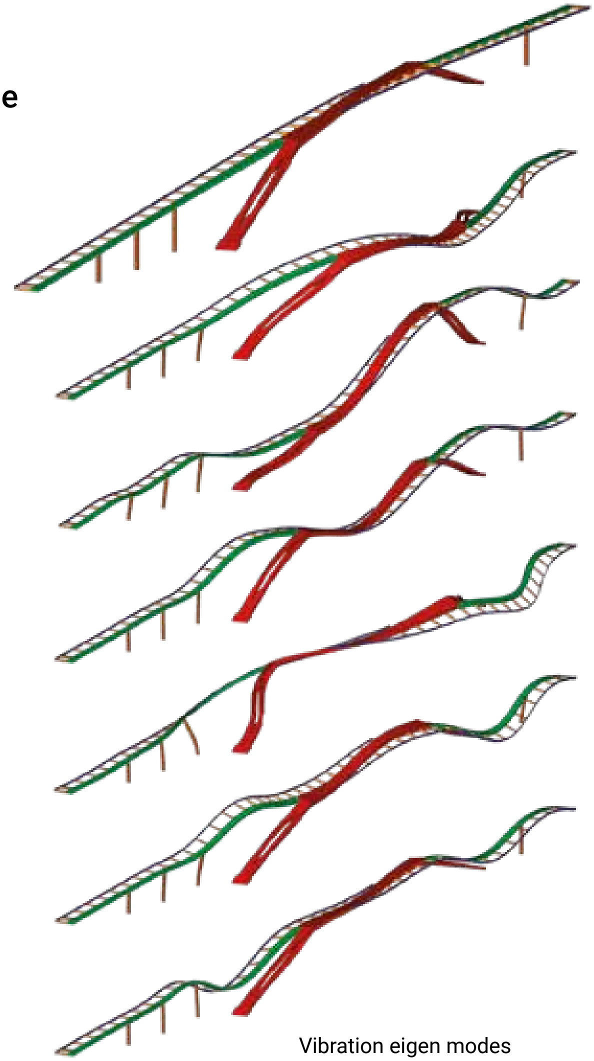
Peterbos Footbridge
(Anderlecht – Belgium)



58 m long Footbridge.

«L'Enjambée» footbridge

(Namur – Belgium)

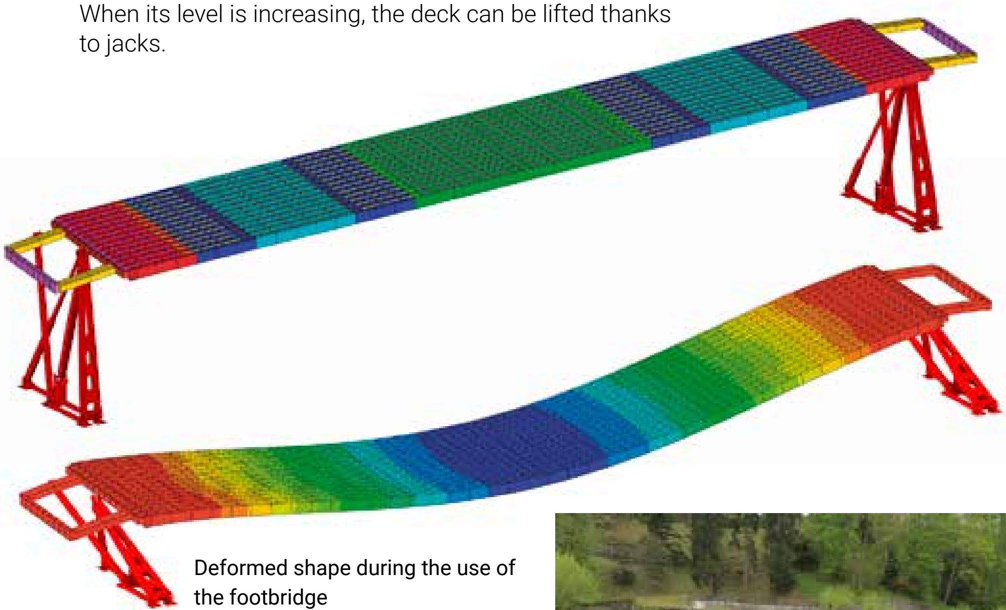


Vibration eigen modes

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

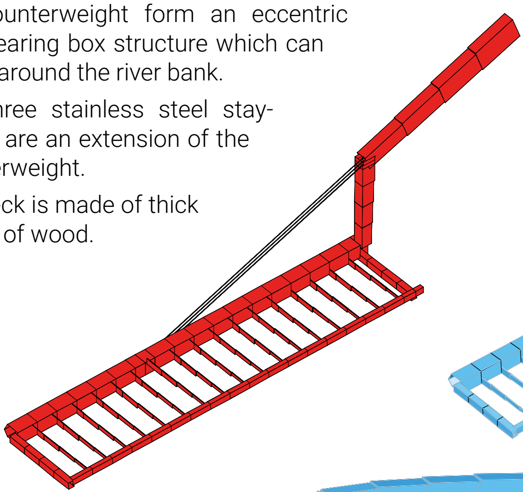
Aguesses Footbridge

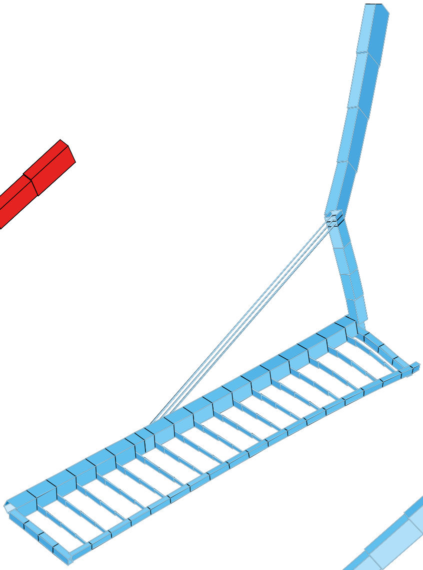
(Liège - Belgium)

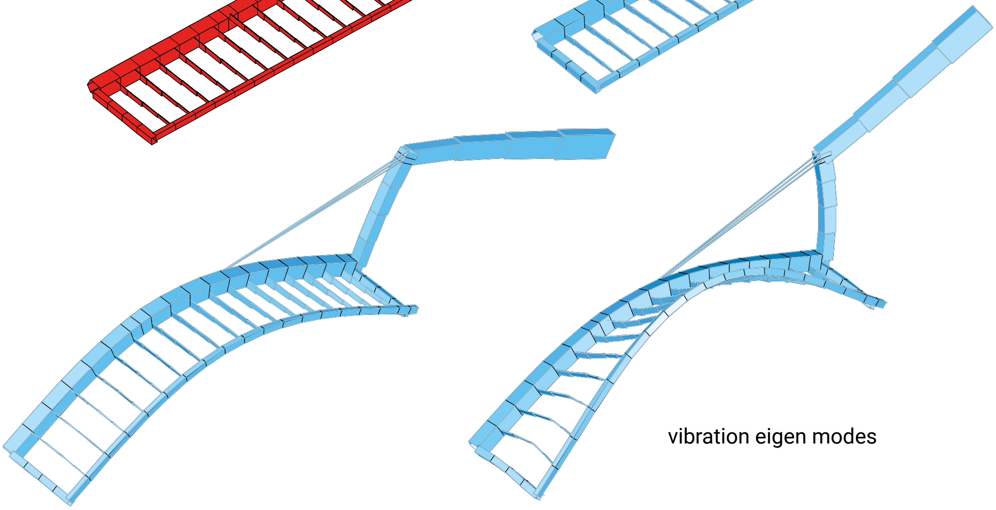
Mobile steel walkway with a span of 22.50 m and 5.25 m wide. The beam, the pylon and the counterweight form an eccentric load-bearing box structure which can rotate around the river bank.

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

The deck is made of thick pieces of wood.





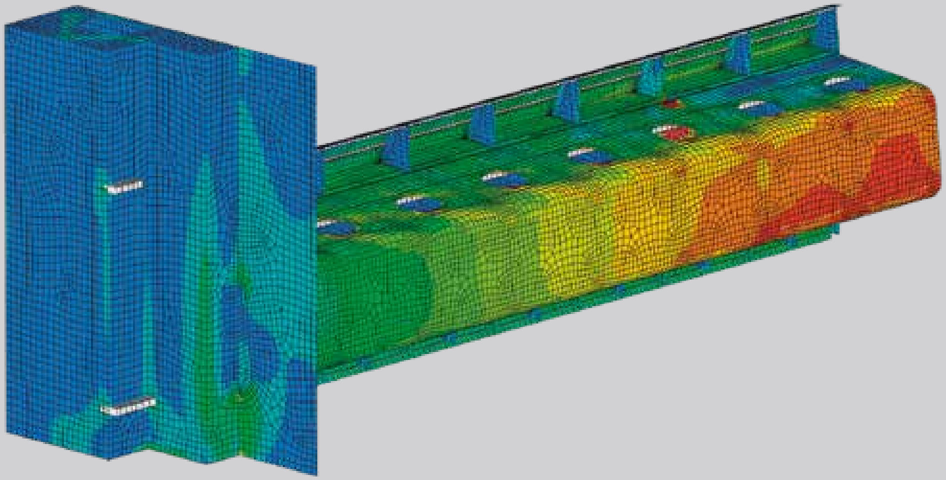


vibration eigen modes

Fluvial and maritime structures

The specificities of fluvial or maritime structures are the solicitations. It means either hydrostatic loads or dynamic loads induced by the waves depending of their variation versus of the time but also the impact effects.

The goal is to verify the structure resistance but also it's behavior versus the fatigue. As for the definition of the definition of wind loading bridges or large roofs, measurements in hydraulic labs are necessary to define this type of loads.



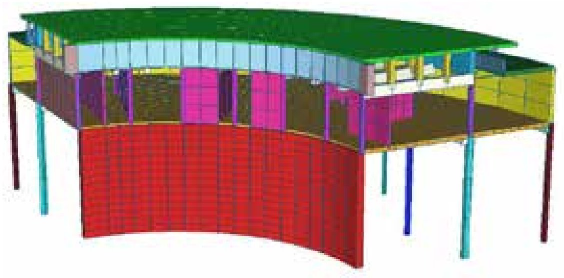
Stresses distribution in Monsin dam gate

Blankenberge Pier

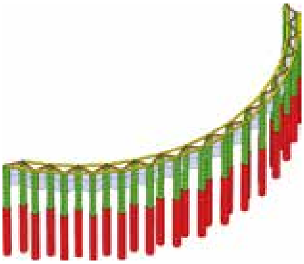
(Belgium)

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

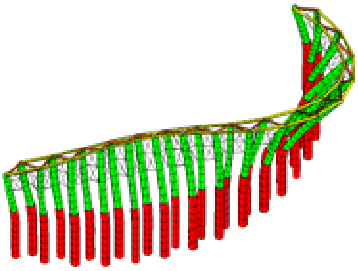
The extremely complex works, including underpinning of part of the existing building and the creation of new spaces in the tidal zone, also had to deal with the problem of resisting to the effect of waves.



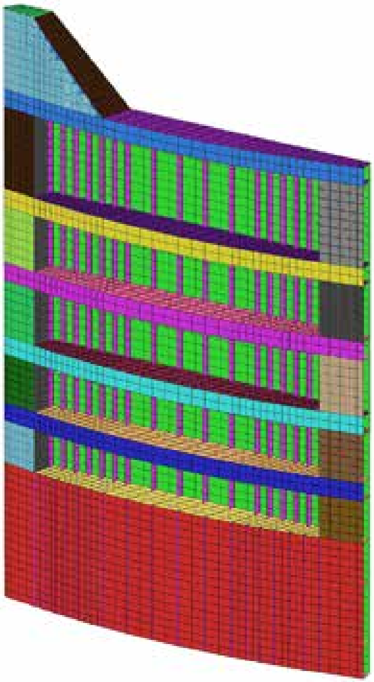
Test in a hydraulic lab



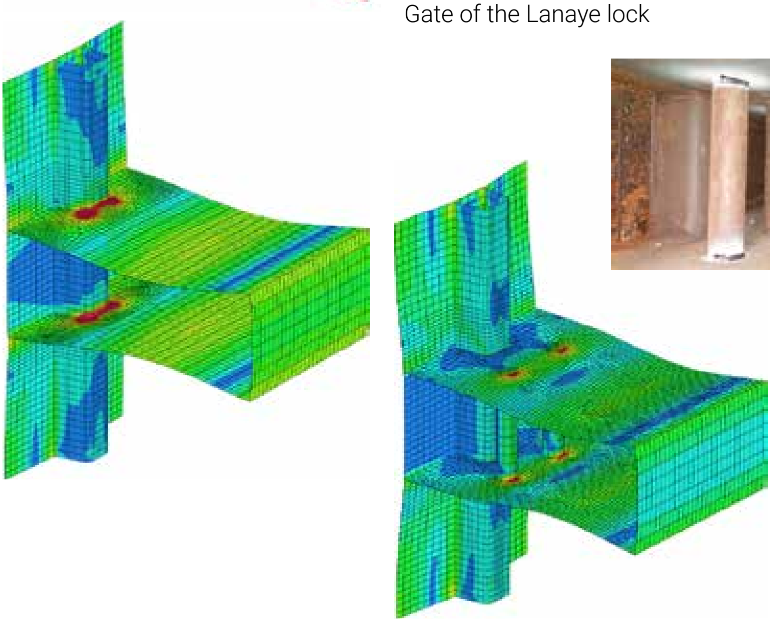
Piles wall model



Deformed shape under the waves impact



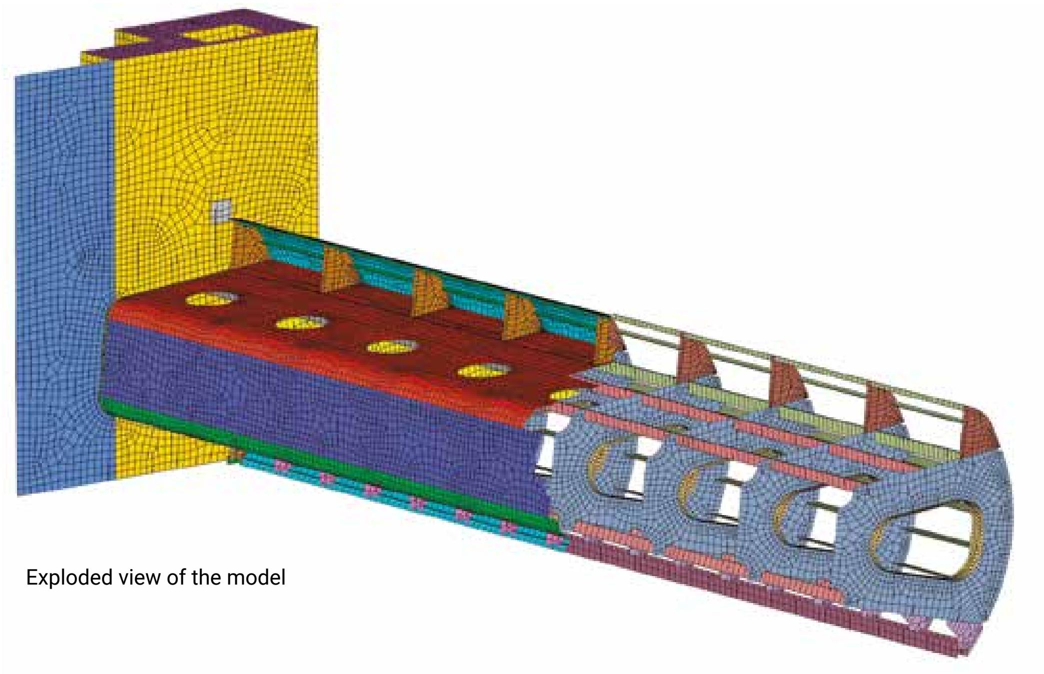
Gate of the Lanaye lock



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.

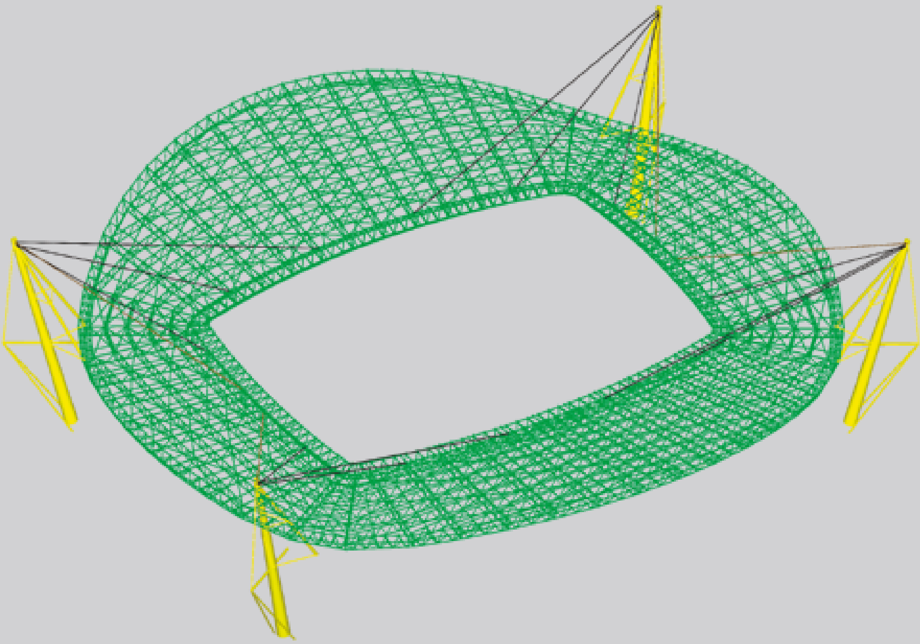


Exploded view of the model

Large roofs

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

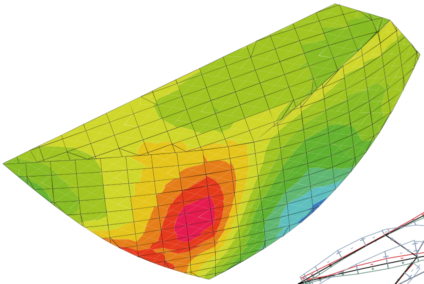
The most important loadings are the dead load and the pressure induced by the wind. For this last loading, the Eurocode give only some generic guidelines. For more precise information, tests have to be conducted in wind tunnel labs.

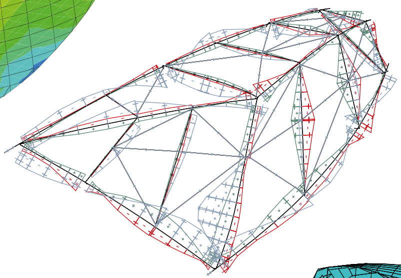


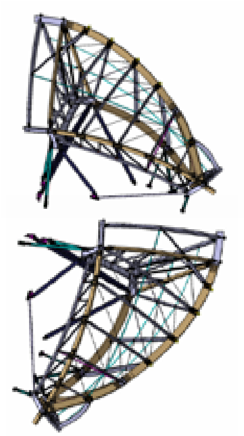
Lisbon Sporting Stadium

Louis Vuitton Foundation

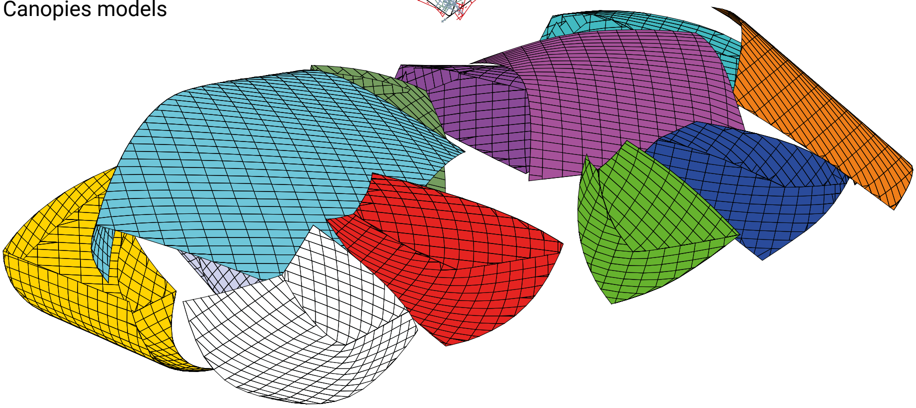
(Paris - France)



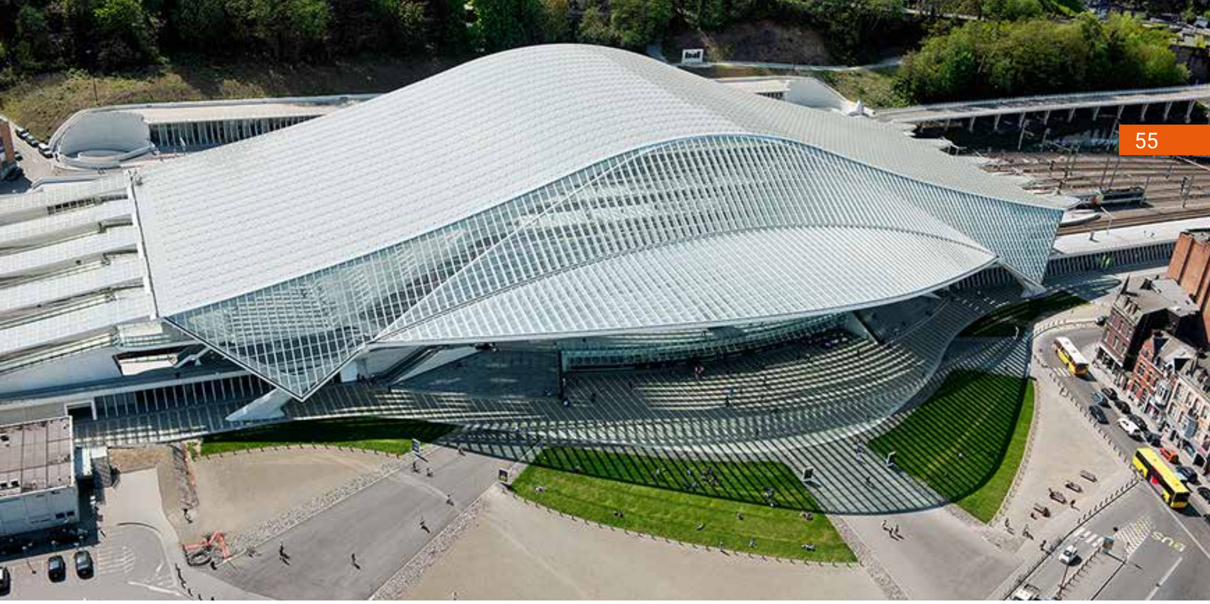




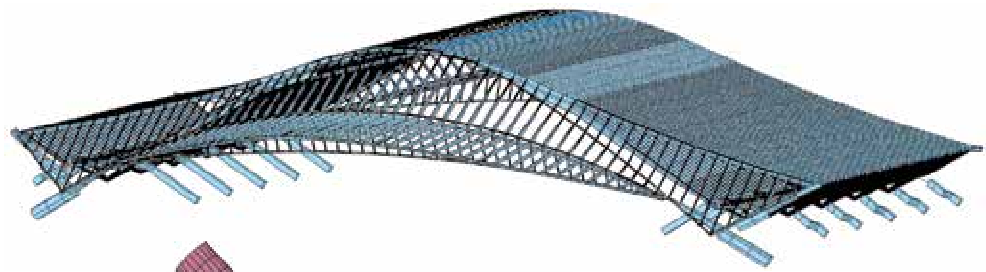
Canopies models



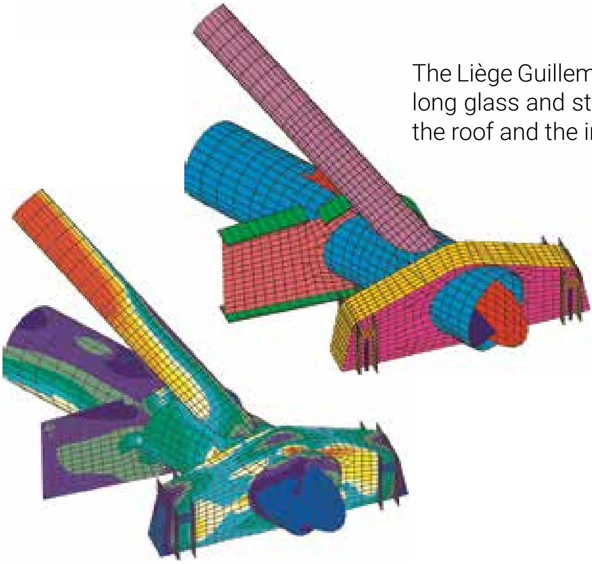
The modern art museum is covered by 12 canopies as glass sails with curved and variable geometrises. The structural elements are a combination of steel and wood beams. The model take into account essentially the dead and wind loads.



Guillemins Railway Station
(Liège - Belgium)



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

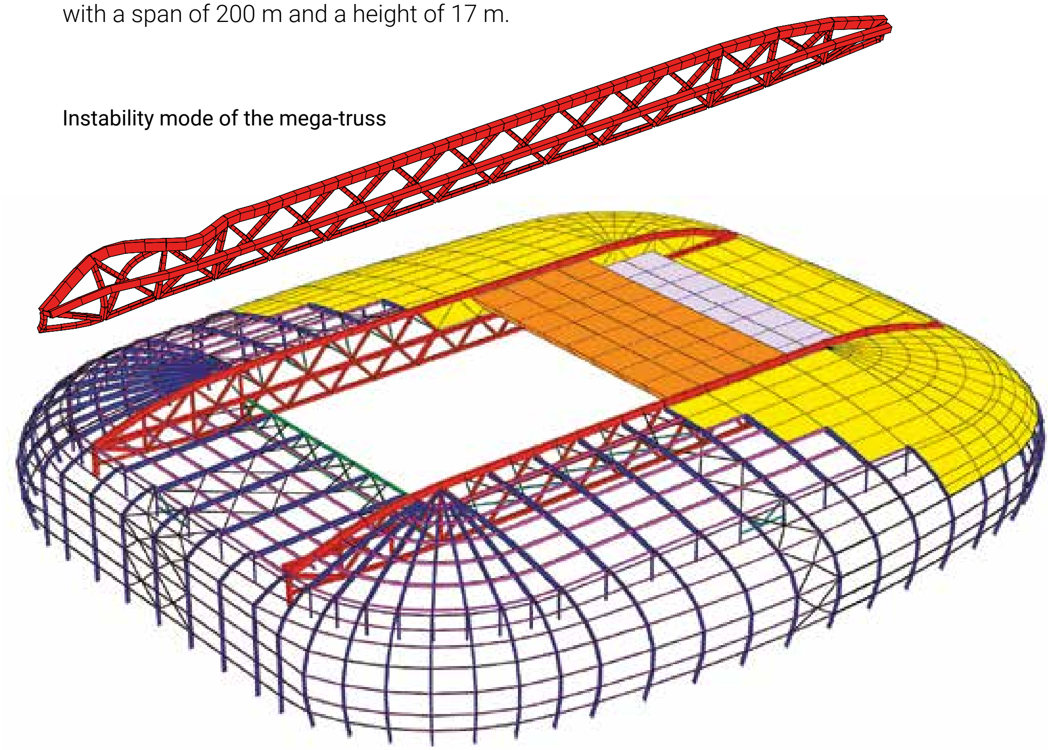


Stresses distribution in the connection between the arch, the longitudinal hollow circular tube, the transversal beam and the supprots box.

Lille Stadium
(France)

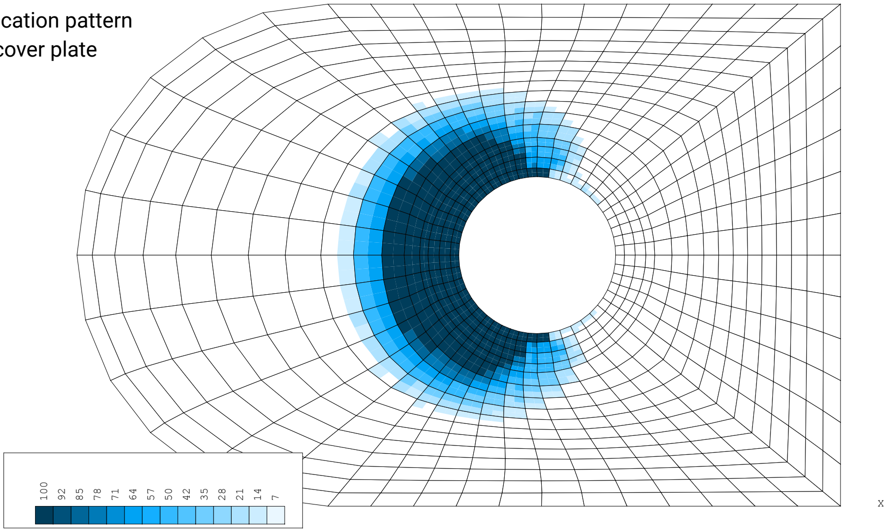
Design the roof supported by two mega truss beams with a span of 200 m and a height of 17 m.

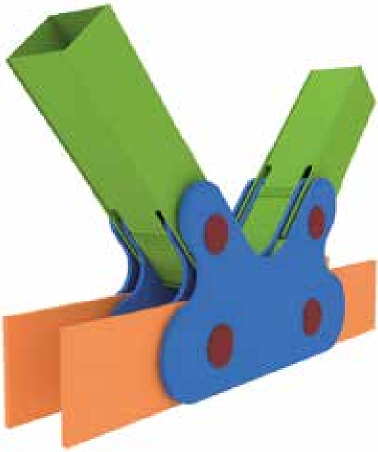
Instability mode of the mega-truss



Buckling of one cover plate

Plastification pattern
in the cover plate



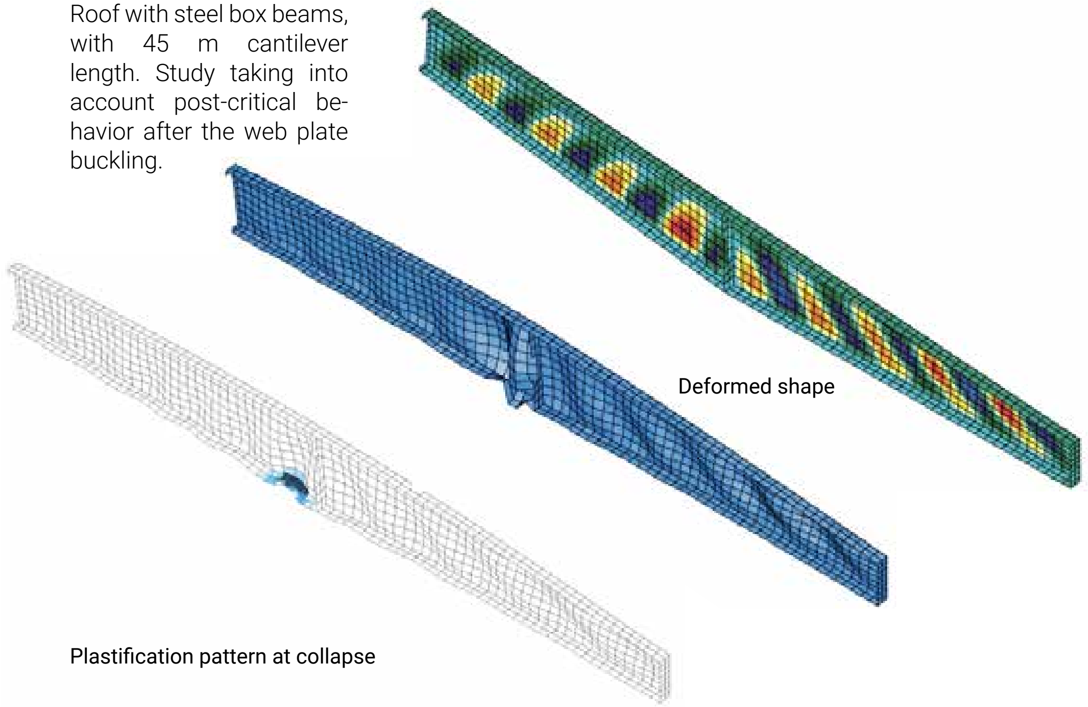


Member Connections with single axel

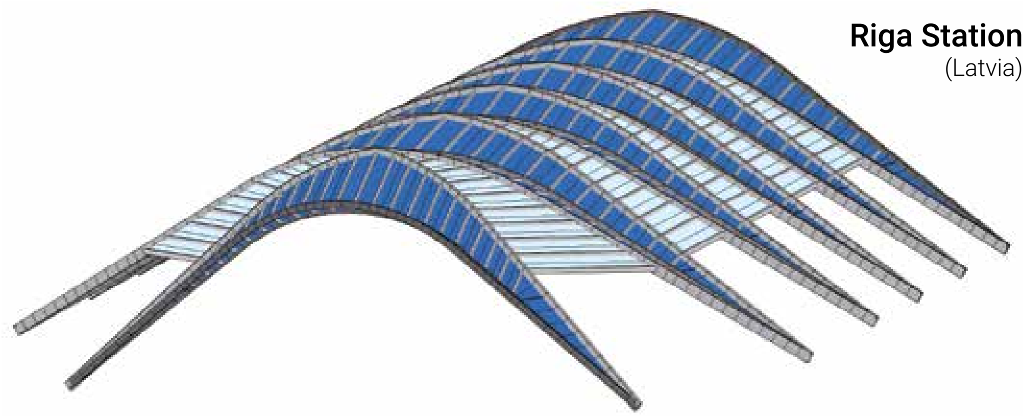
King Baudouin stadium

(Bruxelles - Belgium)

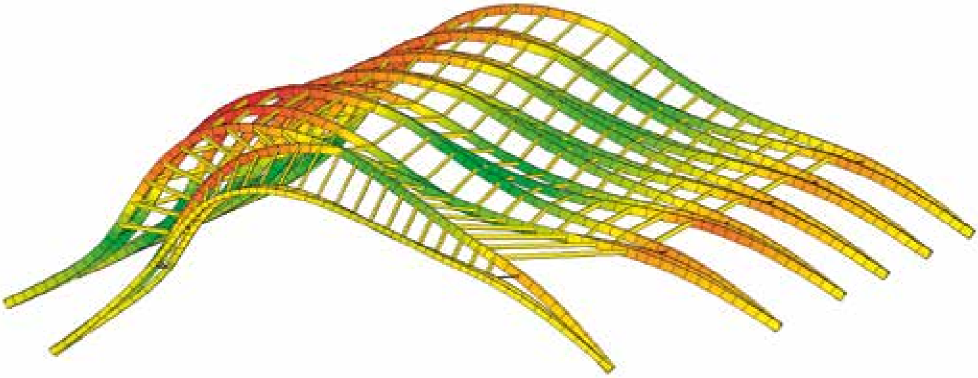
Roof with steel box beams, with 45 m cantilever length. Study taking into account post-critical behavior after the web plate buckling.



Riga Station
(Latvia)



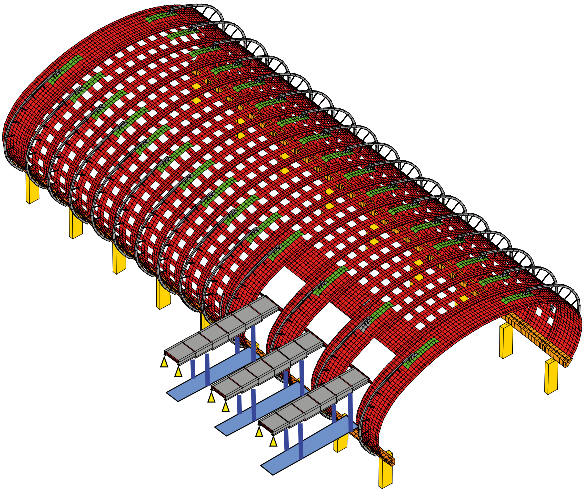
Design and verification of the arc-shaped steel structure

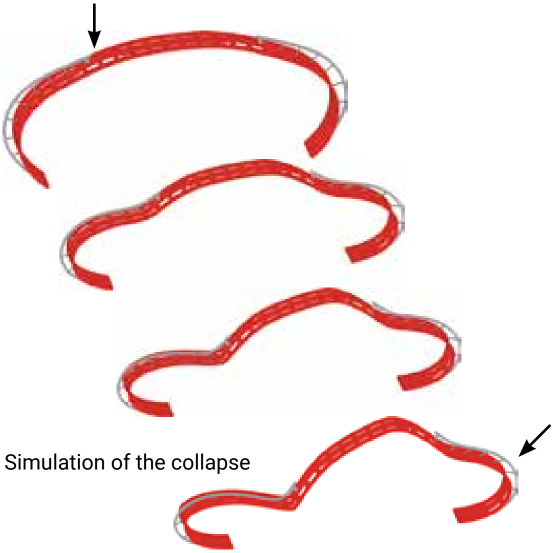


Contour lines of the vertical displacement under wind loads

© Mimram

Terminal 2E
(Roissy - France)



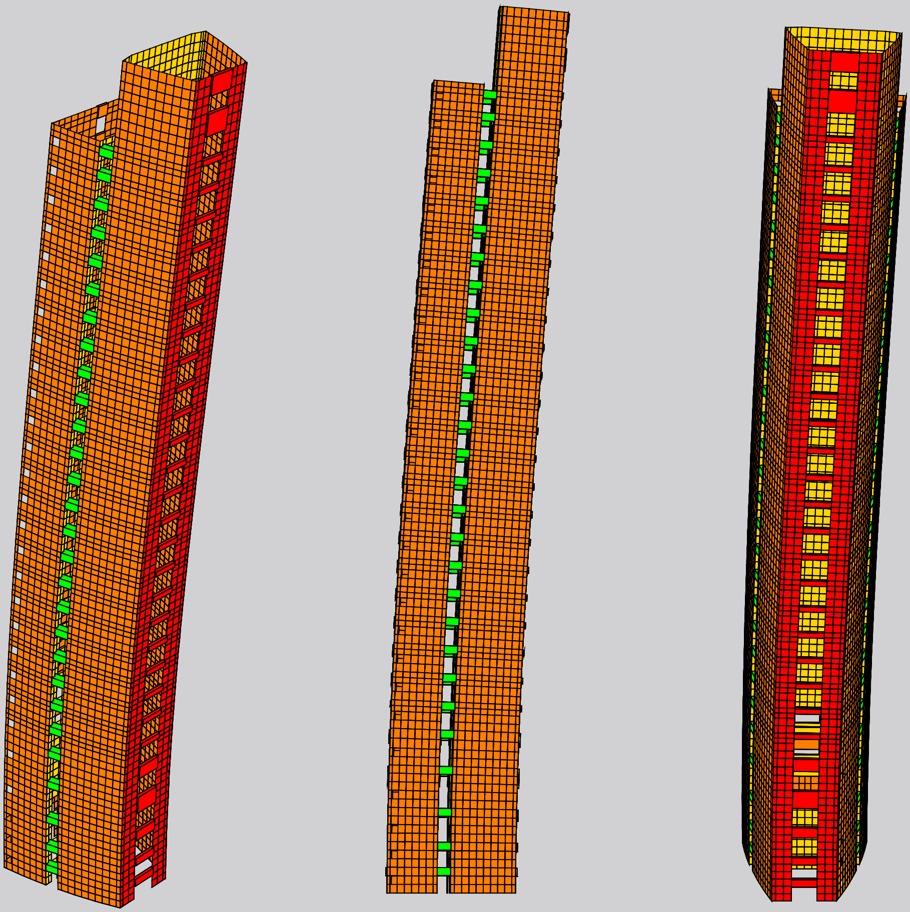


Simulation of the collapse

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

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 is not verified, tuned mass damper will be installed.



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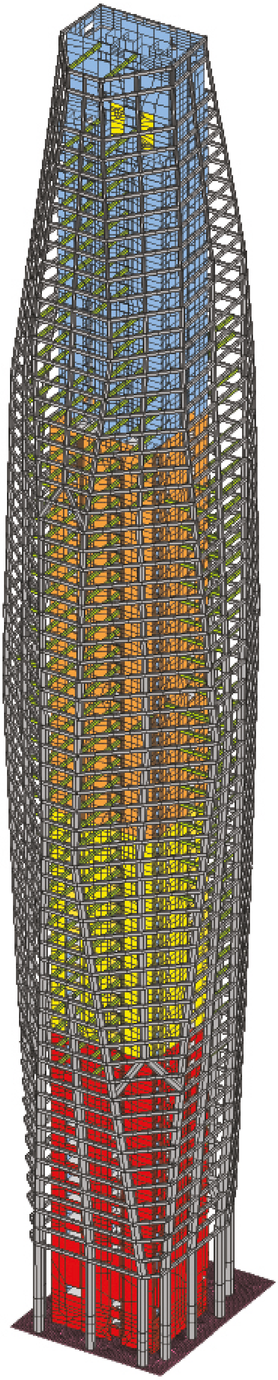
Abidjan Tower

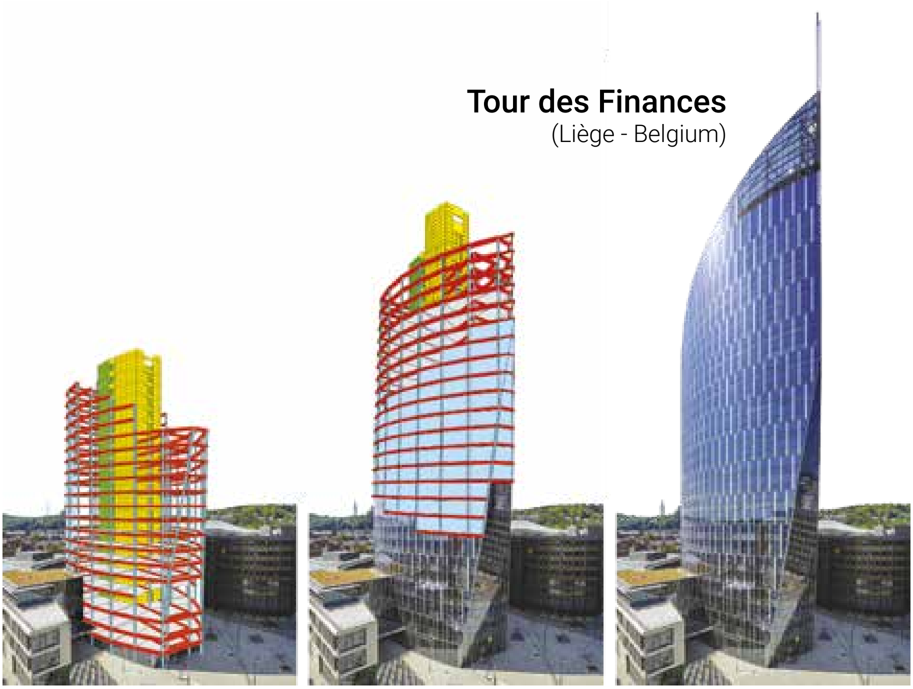
(Ivory Coast)

© P. Fakhouri



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

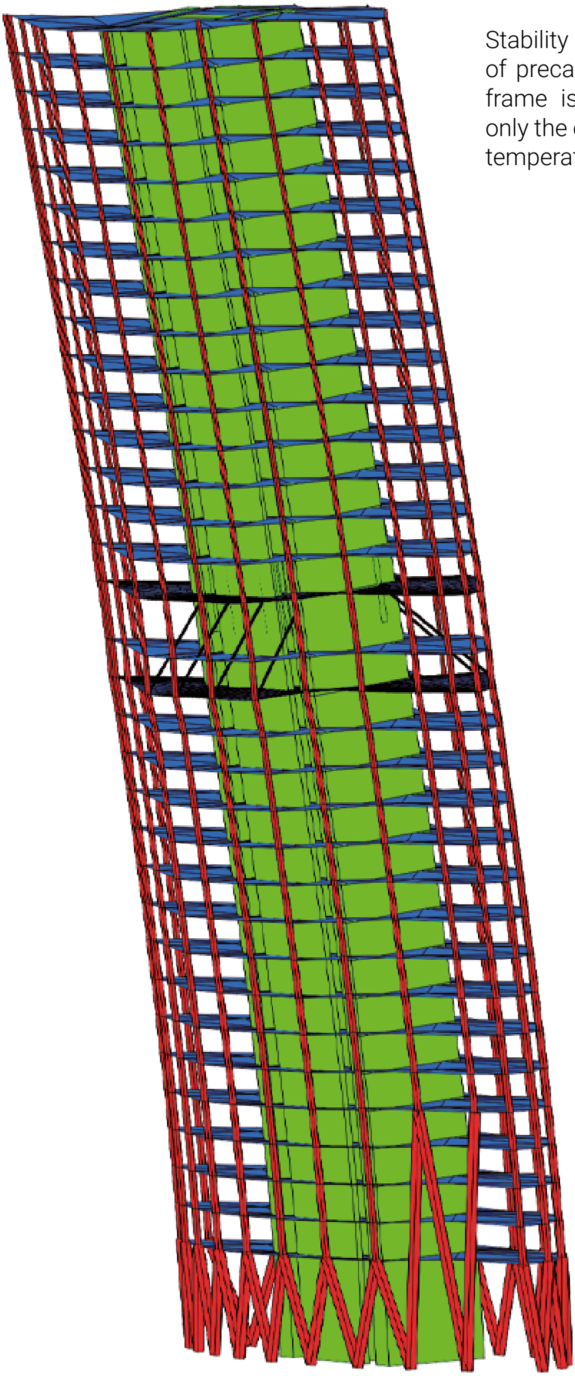
Tour des Finances
(Liège - Belgium)



The structure of the120 m high consists essentially of reinforced concrete with a cast in place core that ensures the rigidity under the wind loading, earthquakes and forces generated by the inclined columns.

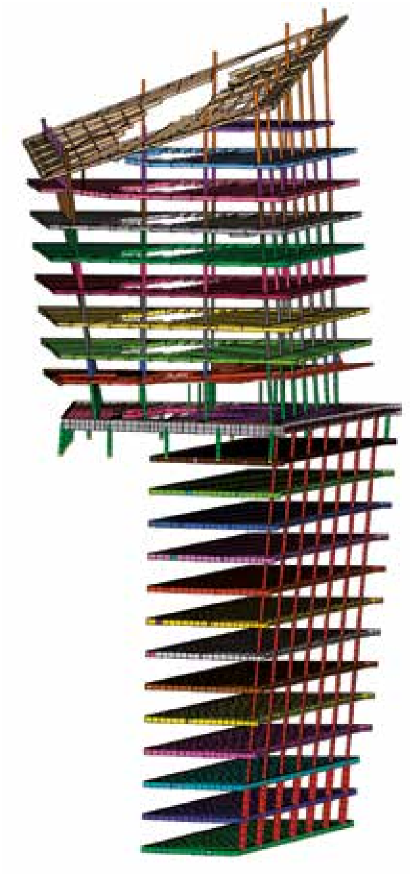
Silver Tower

(Bruxelles - Belgium)

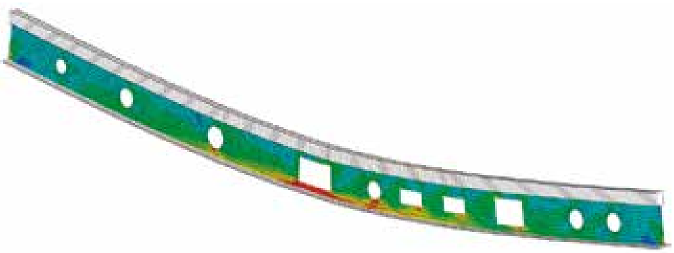


Stability of a 137m high tower with the use of precast concrete . At mid height, a steel frame is specifically designed to transmit only the dynamicforces but not the effects of temperature and of creep.

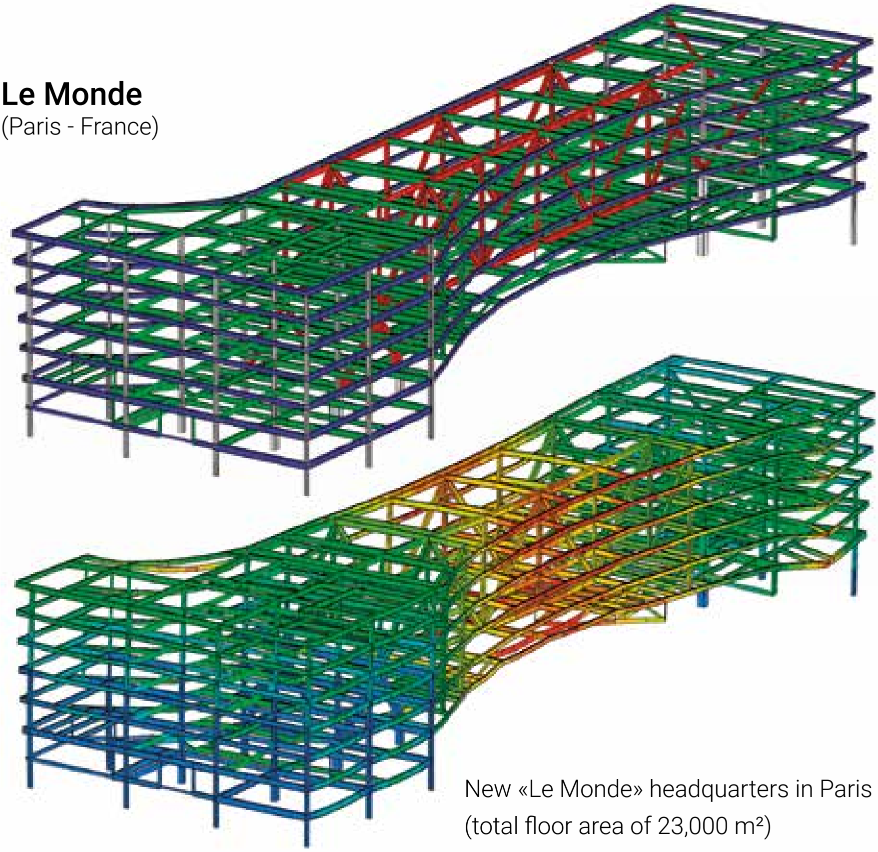
Tour Duo
(Paris - France)



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



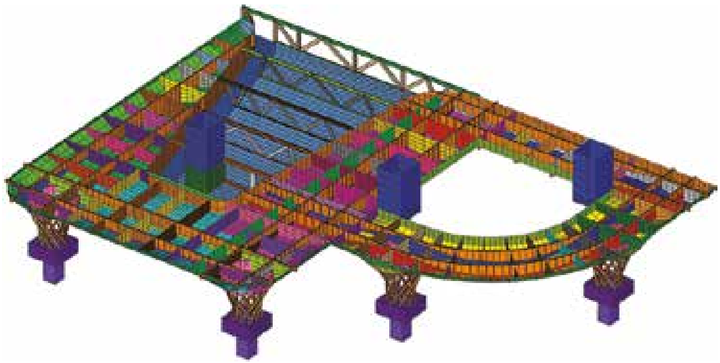
Le Monde
(Paris - France)

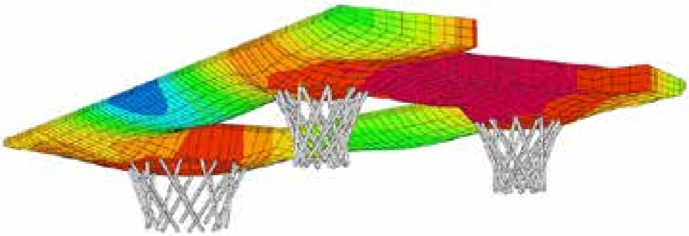


New «Le Monde» headquarters in Paris
(total floor area of 23,000 m²)

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.

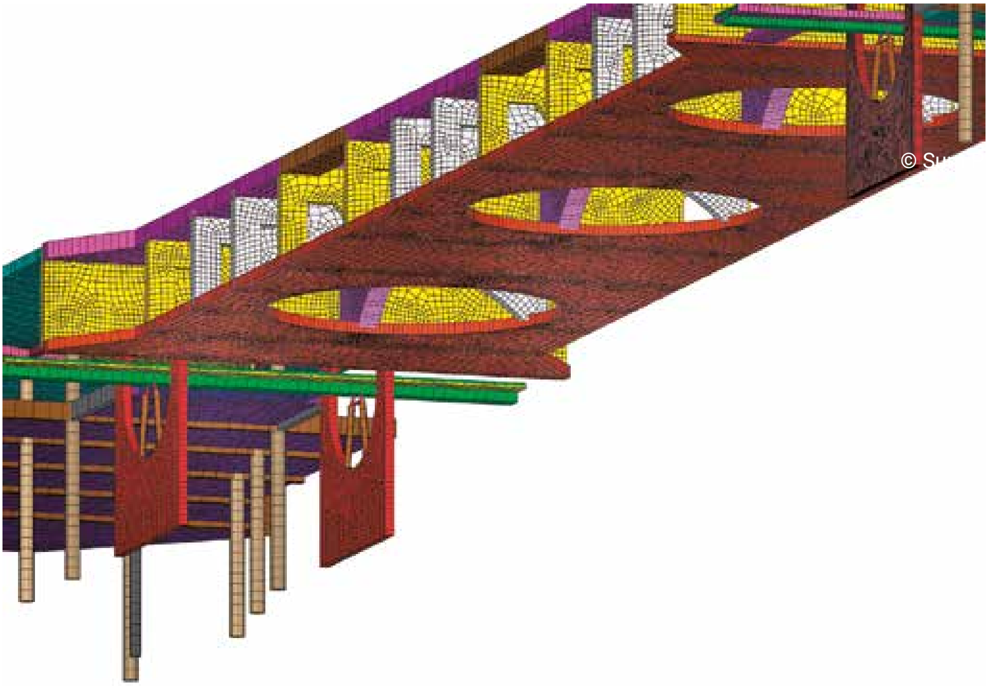




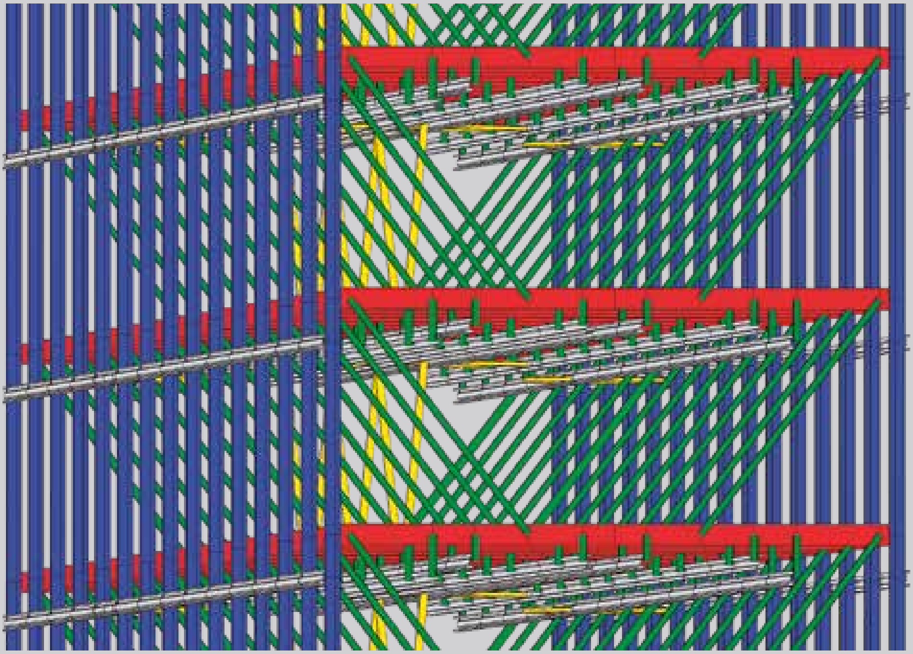
Toots Thielemans Subway Station

(Bruxelles - Belgium)

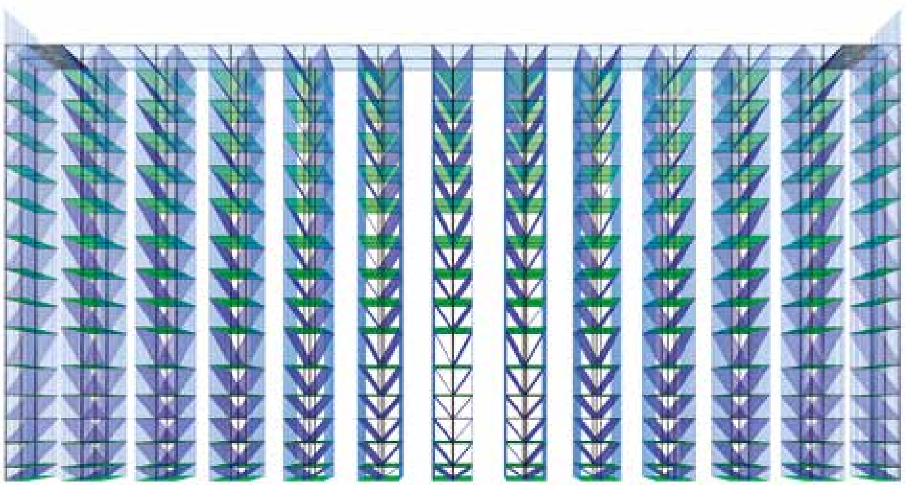
The new metro station with its a global model of the entire building to consider the joint action of slabs and concrete walls

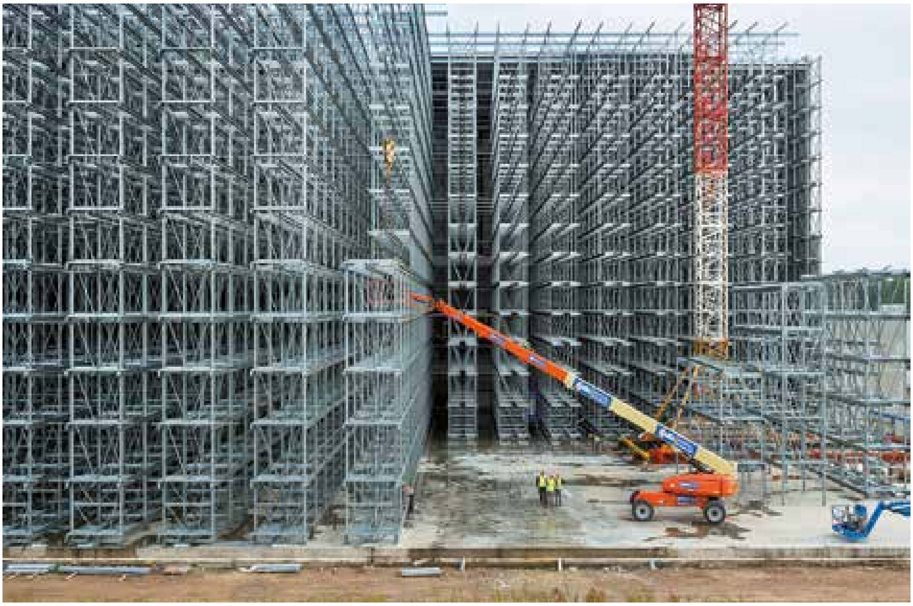


Special structures are characterized by the fact that they are not common in civil engineering. This generally results in unconventional complex calculations to justify their stability which exploite **Finelg** most advanced features.



Storage racks of Geer
(Belgium)

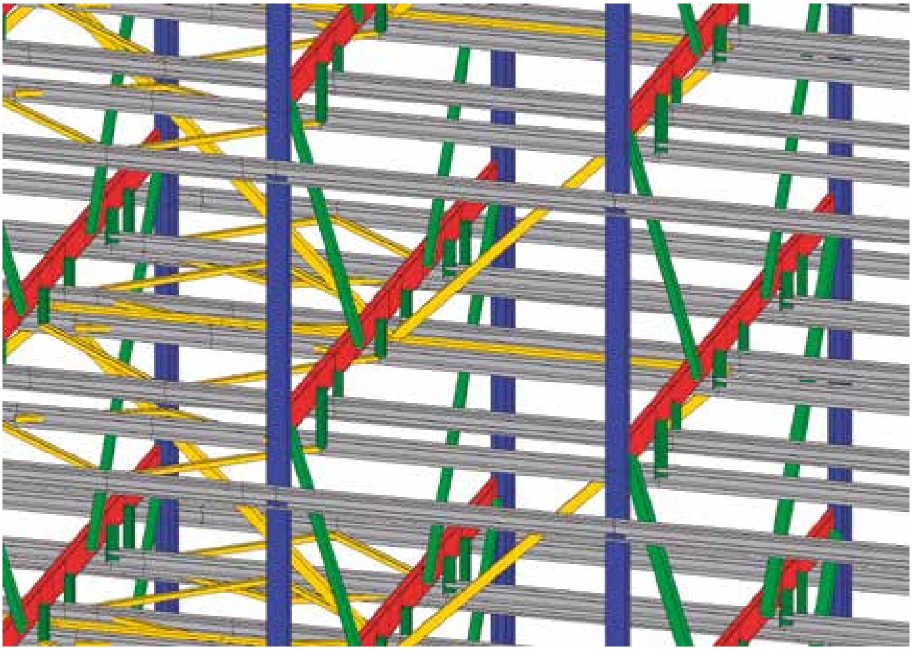




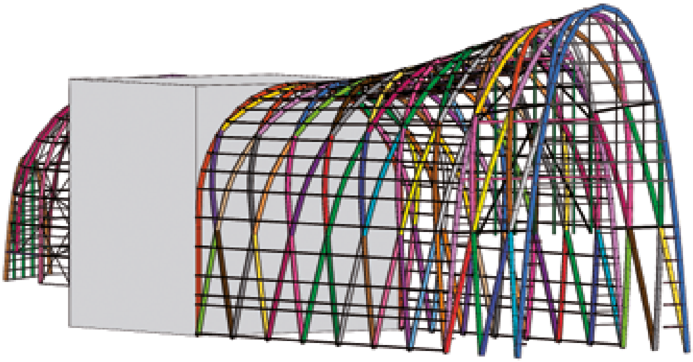
Design of storage racks under static and seismic loads. Optimization of the dimensioning of 3D self-supporting structures made of thin cold-formed profiles.

The multitude of columns, beam implies to optimize the cross sections shapes, the thickness of steel plates, the bolts number of each assemblage.

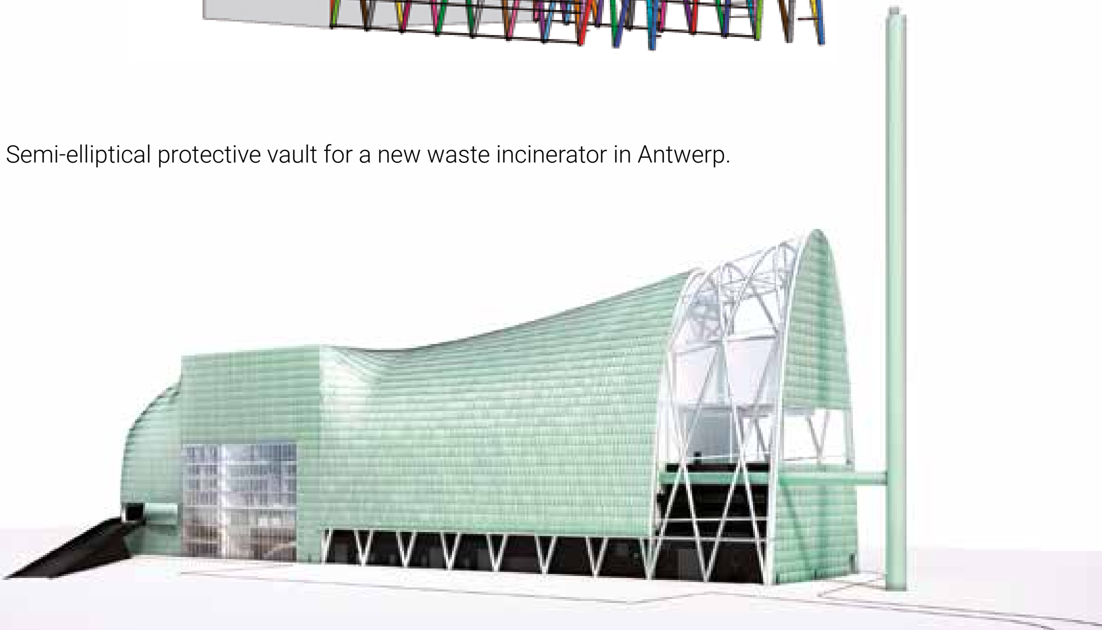
Storage racks of Tongres
(Belgium)

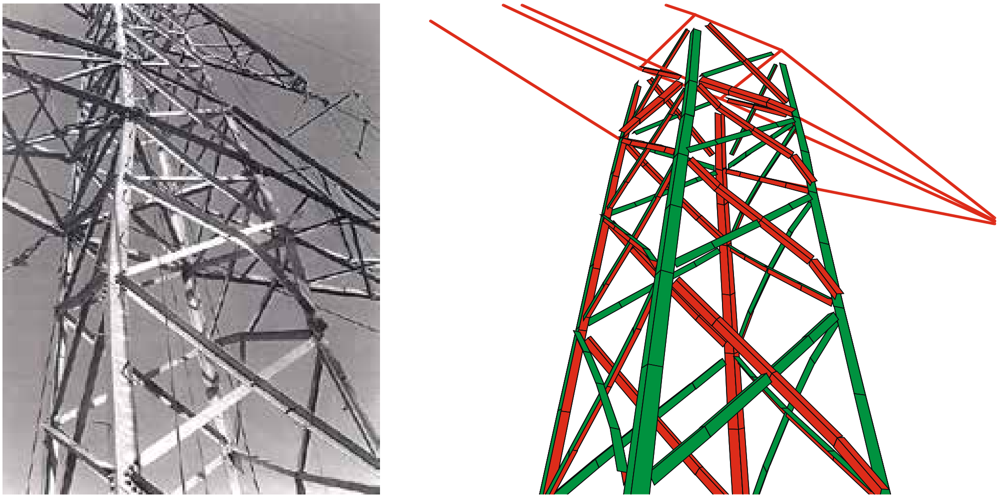


ISVAG
(Antwerp - Belgium)

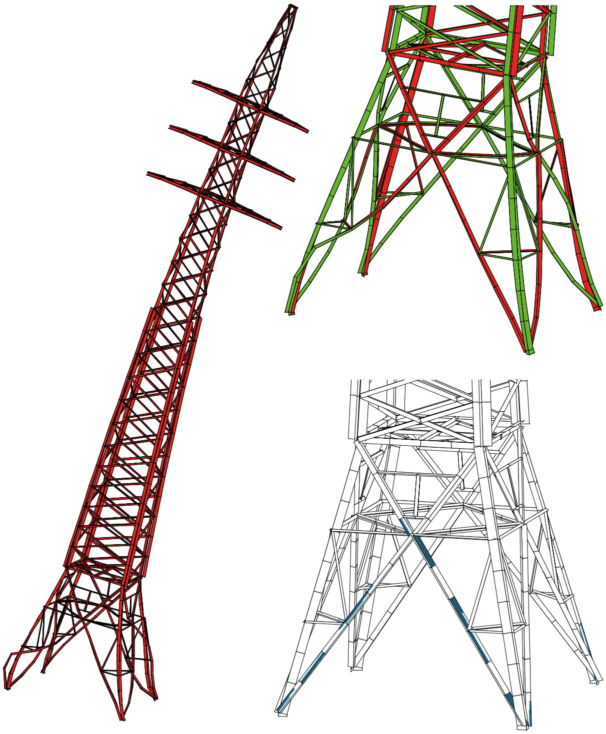


Semi-elliptical protective vault for a new waste incinerator in Antwerp.

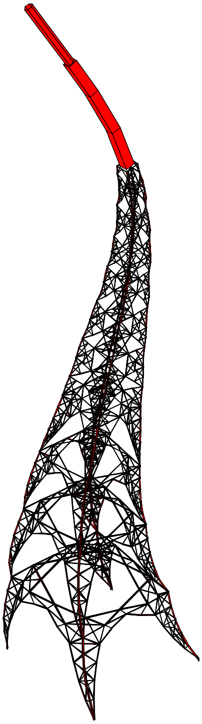




Simulation of transmission tower collapse

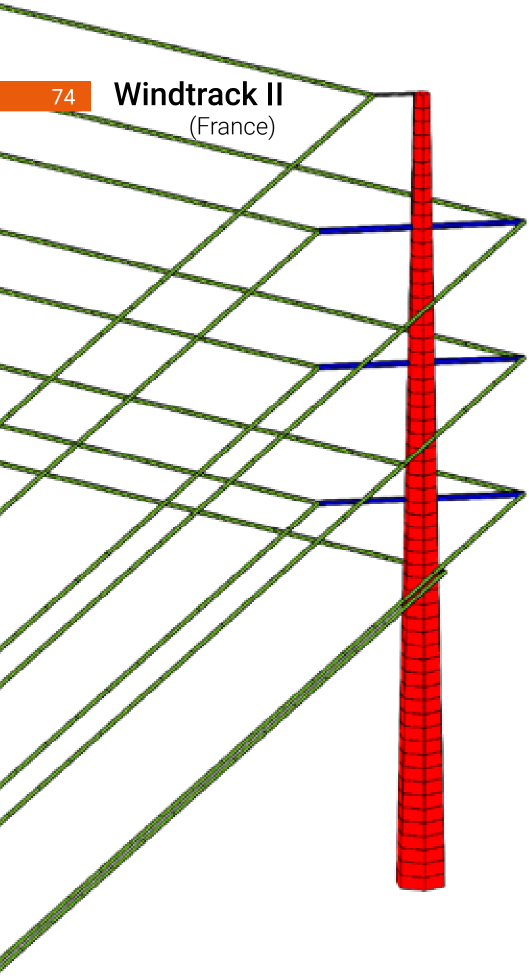


Transmission tower : instability mode and plastification schema at collapse

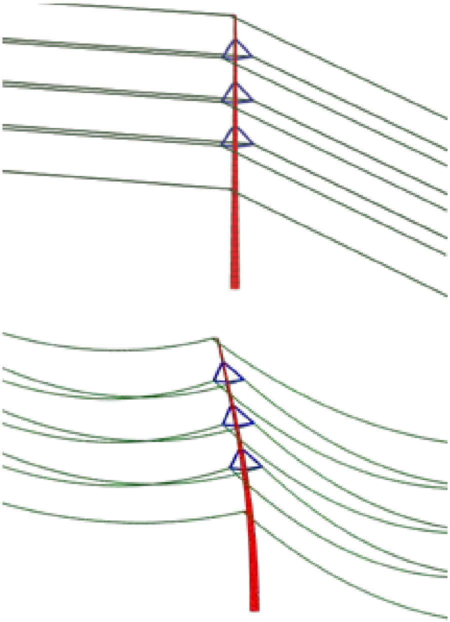


Vibration mode of one telecommunication tower

Windtrack II
(France)

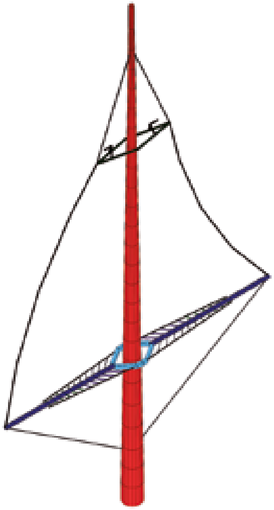


Vibrations interaction between cables and pylons of a high-voltage line

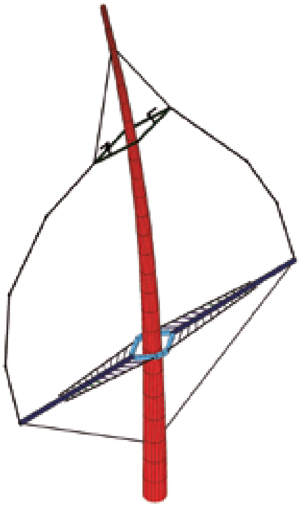


Vibration eigen mode

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



Deformed shape under self-weight



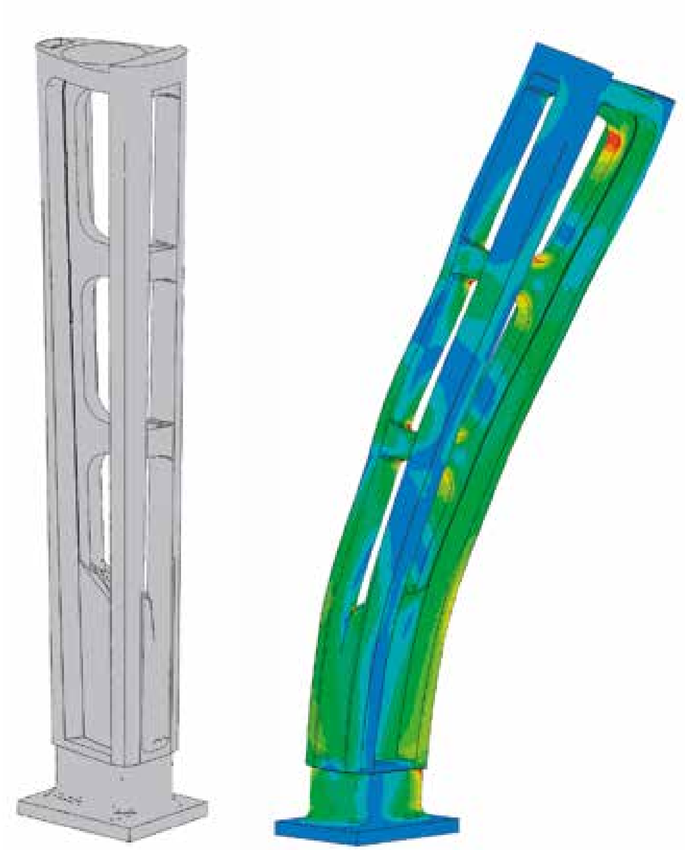
Vibration eigen mode

© HDA

Pile Ligne 11 Paris

(France)

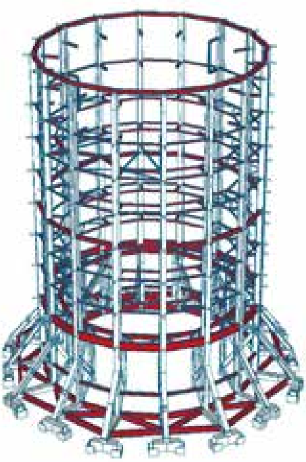
3D finite elements modeling of a cast steel pile of a railway bridge for thefatigue and strenght verifications.



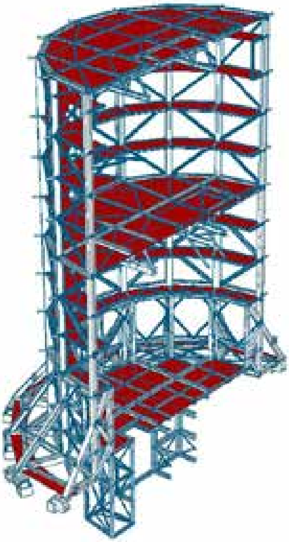
Contour lines of Von Mises Stresses

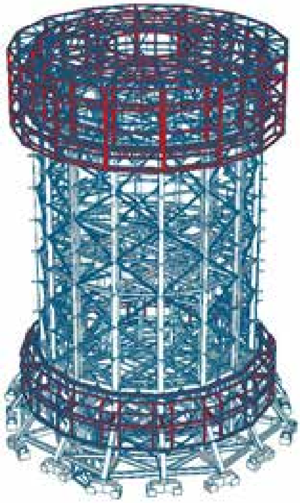
Solar power plant
(Atacama - Chile)

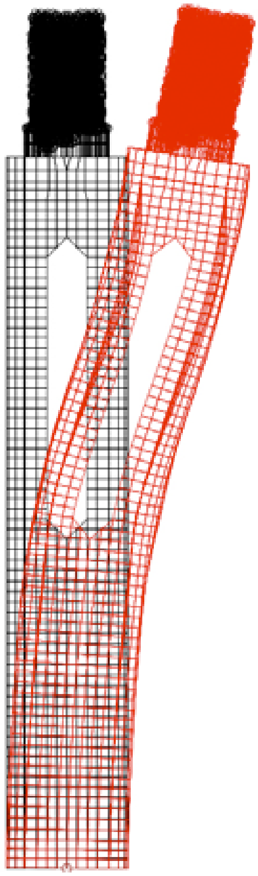
Optimization of the steel structure of a solar receiver located at the top of a concrete tower submitted to very important earthquakes in Chile.



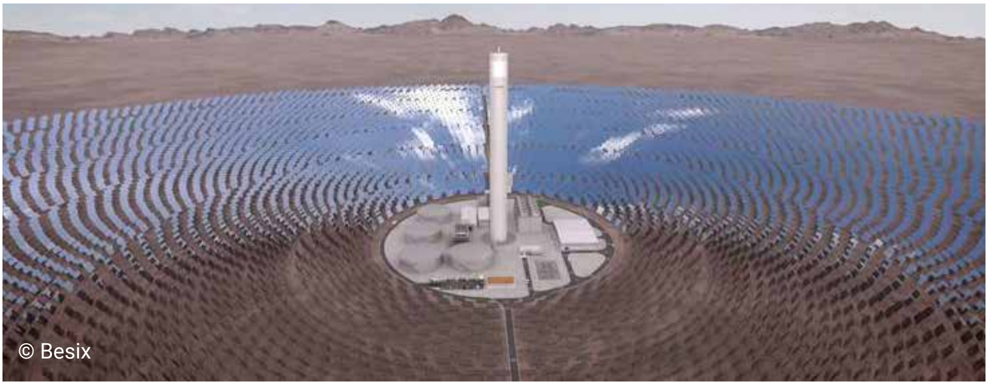
Steel receiver models







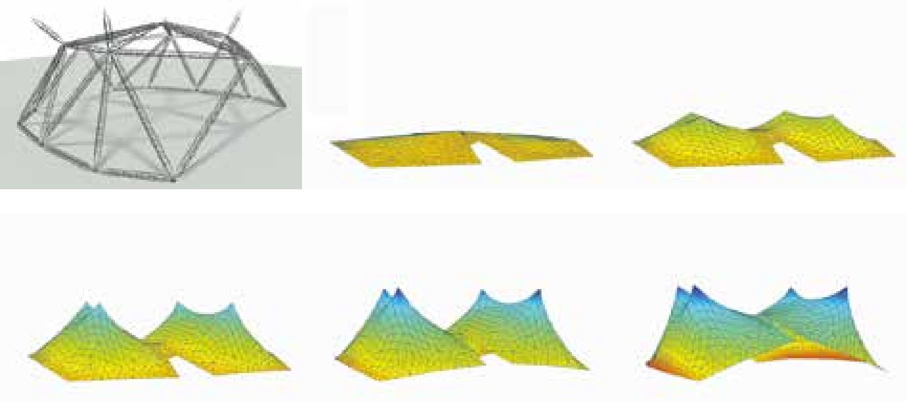
Concrete tower eigen mode



© Besix

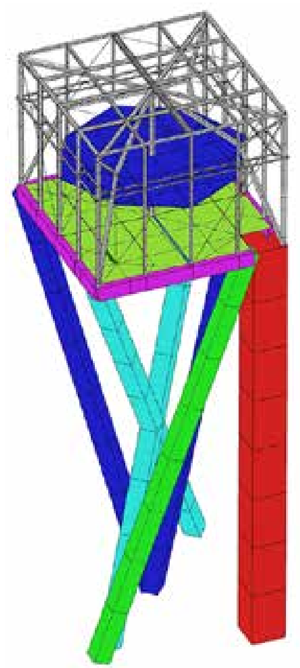
Arsenic company
(Liège - Belgium)

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



Water Tower
(Ghlin - Belgium)

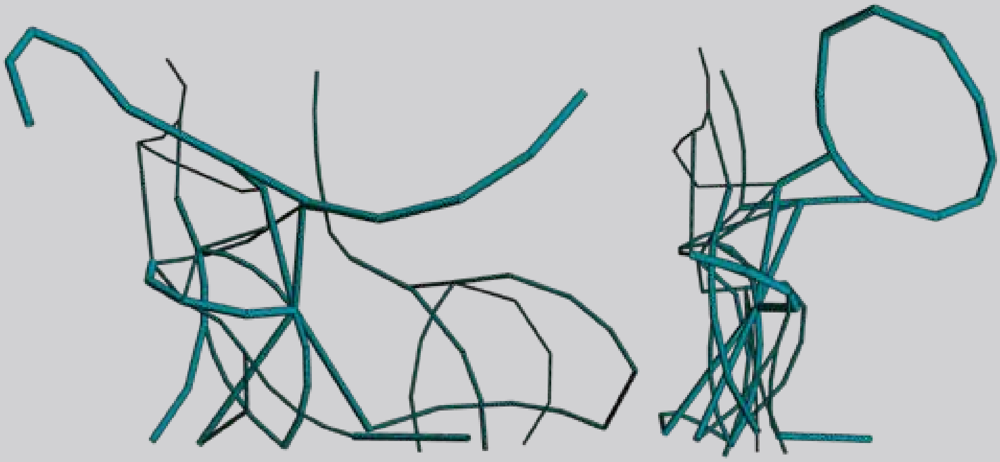
Modelizaation of the construction stages taking into account creep, shrinkage and of its behaviour in case of earthquake.


Nowadays, artists are conceiving more and more imposing works.

In this context, the job of the engineers is to design a invisible structure to stabilize the artist's work. Due their complexity finite element modeling is necessary to guarantee their stability.

The goal of the engineer is to hide its intervention and to leave the first role of the artist.



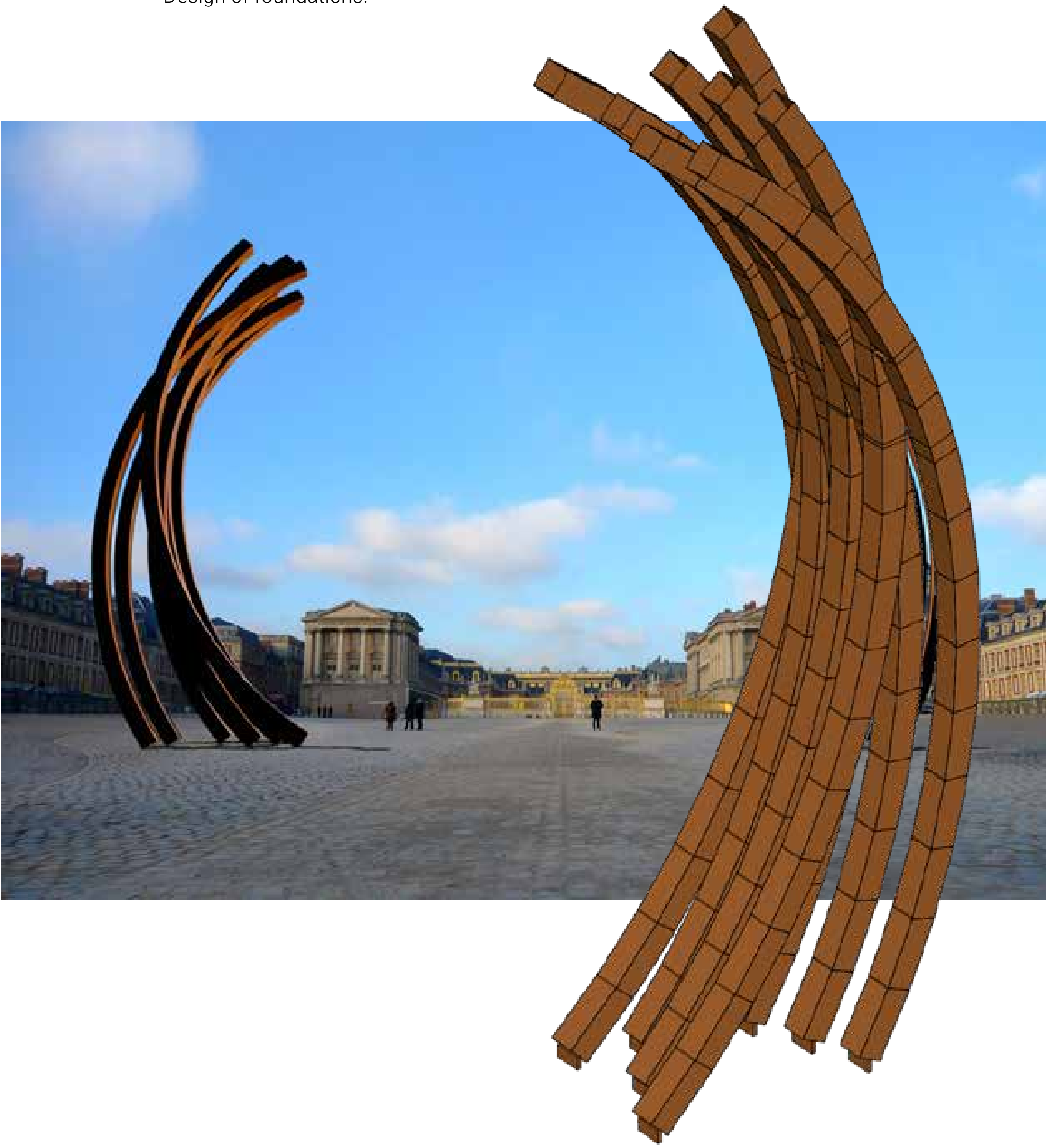
ATHELES ALLEY – BEJING 2008 – Oliver Strebelle

Arc majeur

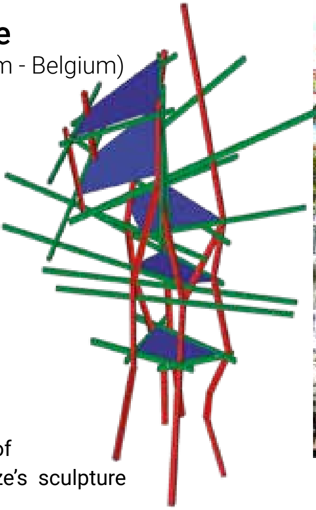
(Belgium)

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

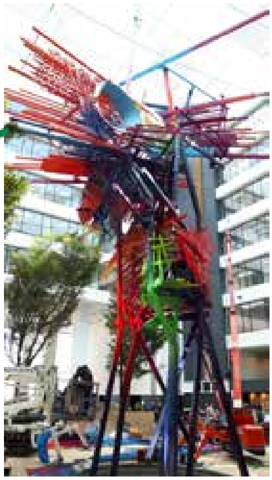
Bernar Venet in front of the *Château de Versailles* (Paris).
Design of foundations.

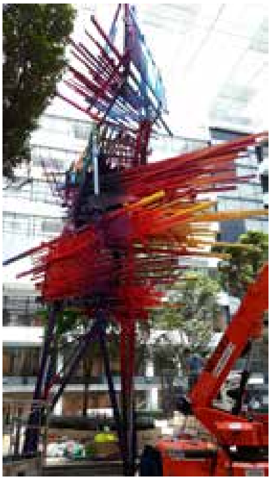


Deloitte
(Zaventem - Belgium)

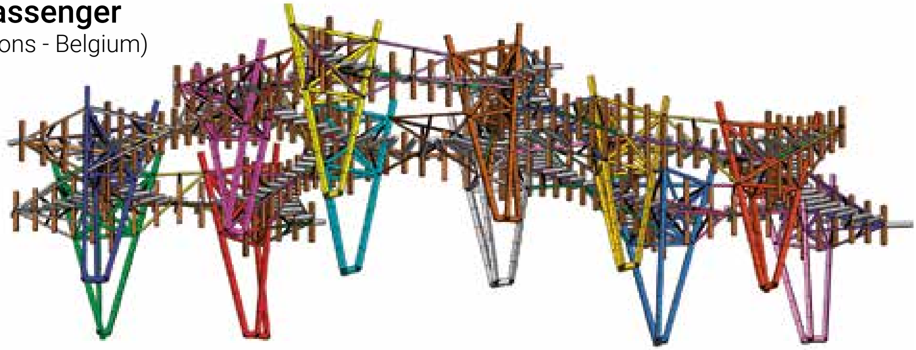


Structure of
Arne Quinze's sculpture





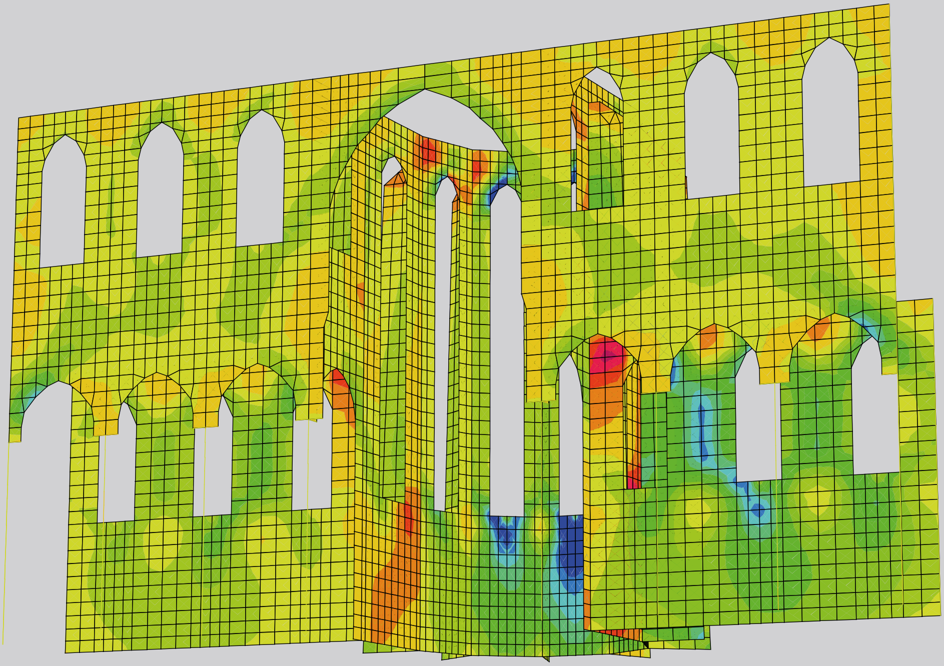
Passenger
(Mons - Belgium)



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

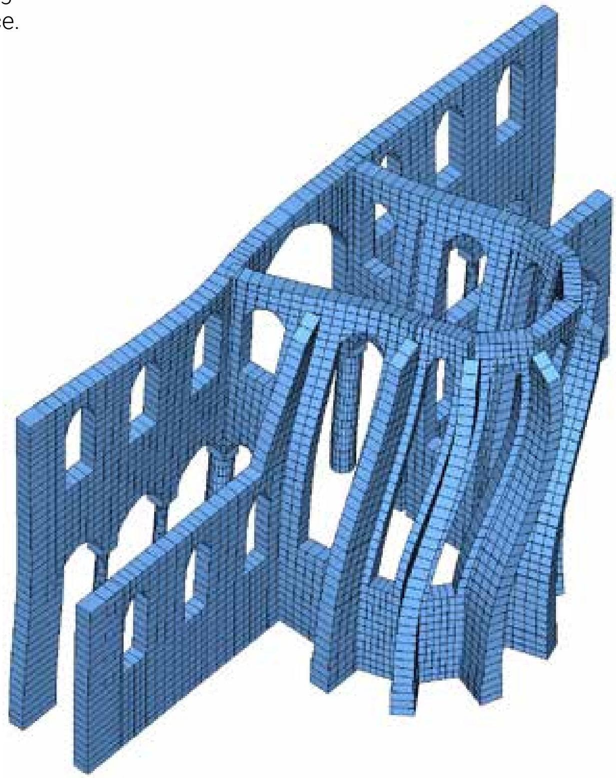
(Belgium)

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 the soil hetegenerosity

Aulne Abbey
(Belgium)

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

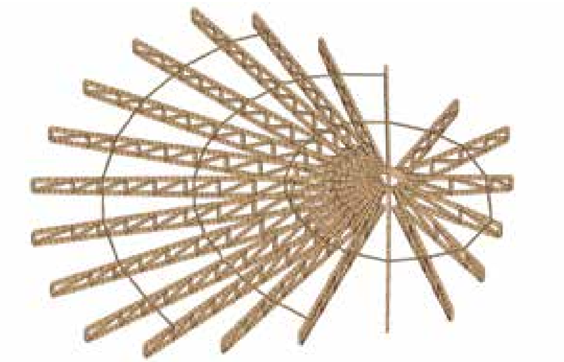


Deformed shape

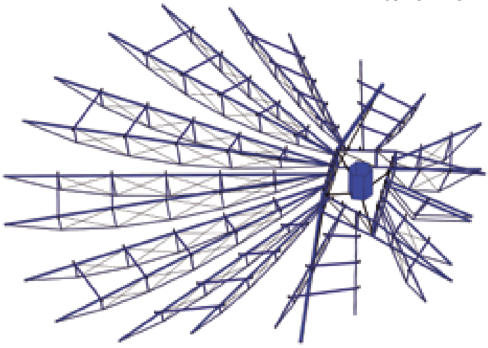
Ceiling of the Hemicycle of the European Parliament
(Belgium)

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

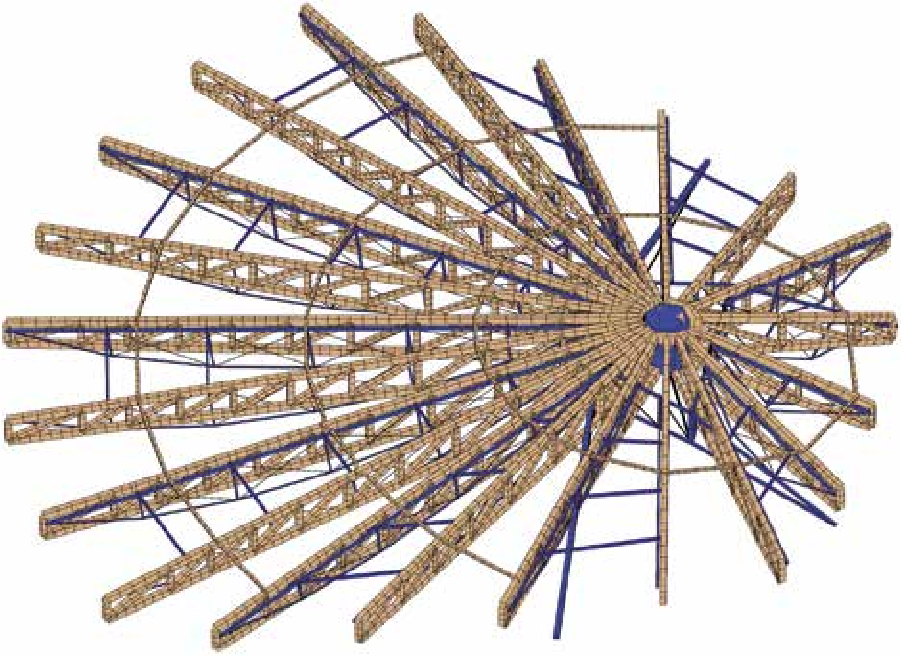
Interior view



Model of the existing framework composed of 21 wood truss beams



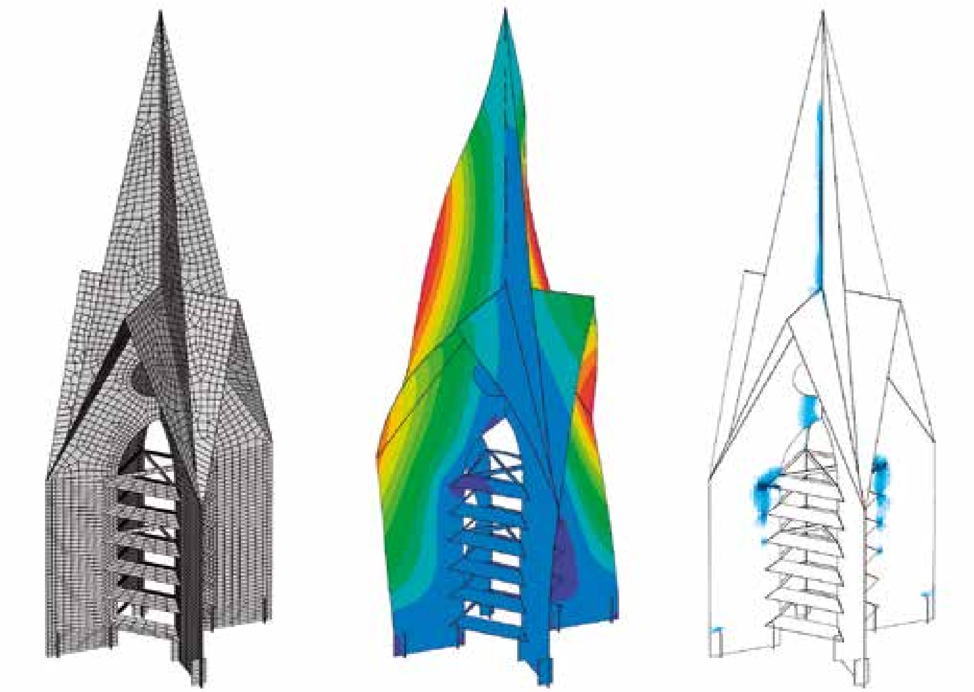
Creation of a quasi-isostatic reinforcement metal structure



Model of the existing framework and the reinforcement structure

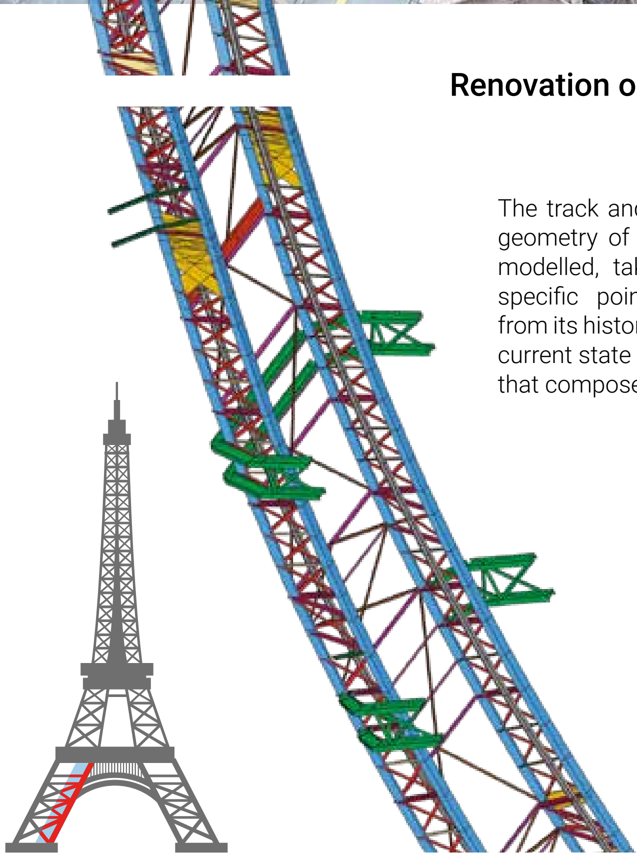
Saint-Martin church in Ferrières
(Belgium)

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

↑↓ Exterior view and interior ambiances of the Greisch office

Coordinated by the Greisch R&D team for 30 years, the development of the FINELG FEM software is the subject of a new grant issued by the Walloon Region (Belgium) in partnership with the universities of ULiege (Belgium), UHasselt (Belgium) and Insa-Rennes (France), for a period of 4 years (2019-2023) .

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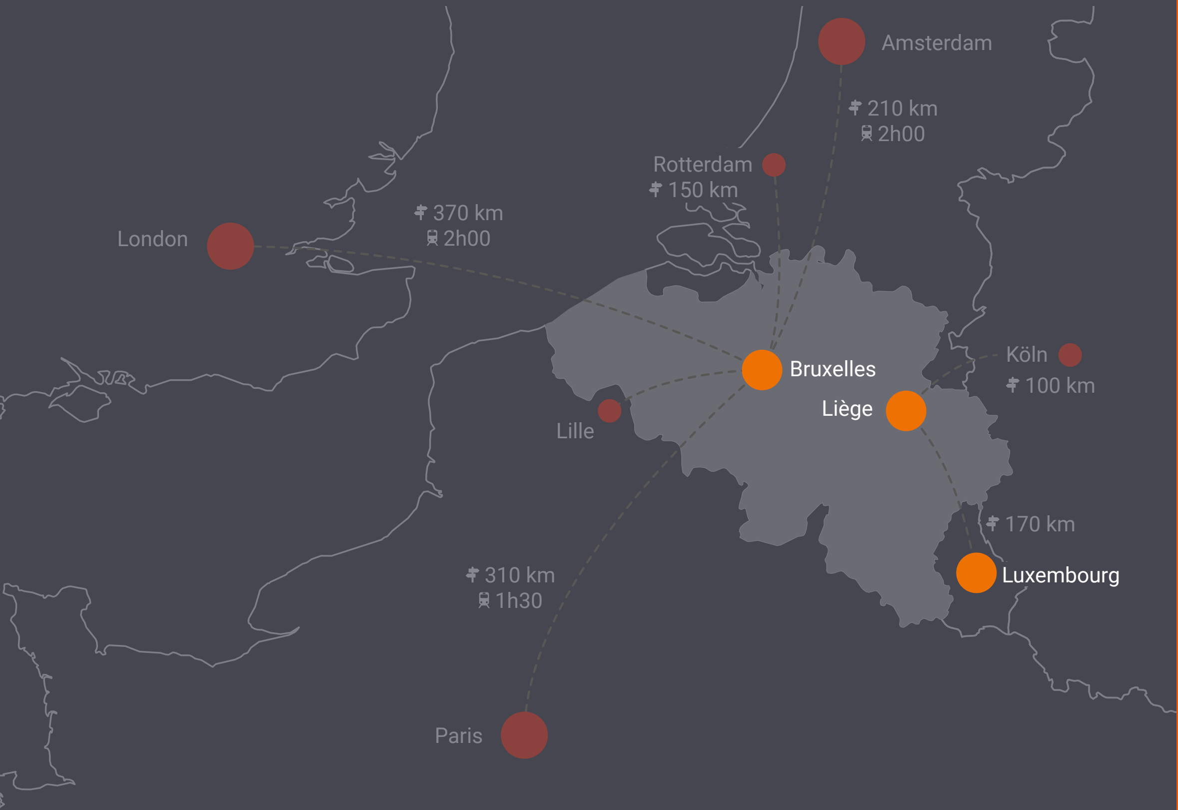

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