Footbridge Chur 2025

3rd — 5th september

in situ

Footbridge Chur 2025

Introduction

«In situ» means an interest in a particular place, in a specific local material, in an almost forgotten handicraft – the antithesis to an «international style» applicable almost everywhere. Basically, it is a romantic attitude. The spontaneity of an independent subject, the longing for a difference from the ubiquitous mainstream, can be a starting point for creating an «in situ» design. It seems consistent that this can be primarily an affair of small countries, regions or small groups of people, with emphasis on the culture of minorities.

Therefore, Chur, as the capital of the canton of Graubünden in Switzerland, can be regarded as an ideal location for the research of in situ-phenomena. The diversity of this alpine country is reflected in nature such as topography, climate, geology as well as in cultural history. Seven languages are spoken there, and international relations, which developed through the intense traffic over the alpine passes, go hand in hand with almost medieval agricultural traditions. When Badrutt's hotel in St. Moritz was by far the first institution to generate and use electricity in the 19. century, the remote village of Furna in Prättigau, with its 200 inhabitants, did not receive its first electric light until 1968.

Today we refer to an important part of architecture and art production between 1900 and the First World War as «National Romanticism». In this sense, Switzerland was not the only prolific country. During these years, there were strong relations, e.g. with Finland or Slovenia.

In civil engineering, the Rhaetian Railway became famous for its viaducts, which were built from local natural stone. The traditional of using natural stones in engineering still lives on – parallel with a lively development of reinforced and posttensioned concrete (visible in works of Robert Maillart, Walter Versell, Emil Schubiger and Christian Menn).

With this in mind, we invite you to spend some days discussing together peculiar projects and structural ideas for footbridges, small and large, from unspectacularly sophisticated to the most extravagant solutions – as long as they have something to do with a specific place.

Jürg Conzett / Gianfranco Bronzini
September 2025

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Paris, France

Theory of structure and public space

1 Create a link, create a place

Beyond the functional link they represent, footbridges belong to the public space they shape. We have worked on numerous footbridge projects, highlighting the public space character in a generous, deliberately oversized, or symbolic manner. This paper will focus on the approach we developed in Saint-Denis, involving a bridge spanning over 48 railway tracks between the two railway stations, extending over a length of more than 300 meters. To limit the height for trains passing by, the structure extends as a superstructure above the deck, creating a suspended square in the center of the structure that opens up to the railway river and the Paris skyline.

Keywords: multiple arches, vierendeel beam, public space

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The Pleyel Bridge: a structure that meets urban requirements and the multiplicity of uses

We proposed a structure composed of multiple arches that shape two large naves, each 120 meters long and 11 meters high, which simultaneously accommodate outdoor public activities and a station connected to the lower-level railway tracks. We decided to develop a structure that constitutes a true, usable space: a way to inhabit the structure. These naves, by creating a virtual, usable volume, offer a true public space while freeing up a volume for appropriation.

We organized a longitudinal system of multiple arches and a transverse system of parallel arches, forming a Vierendeel grid (with no diagonal stabilizing elements or shear force transfer), and the whole behaves as a very large three-dimensional Vierendeel beam within which space is offered for public activities. For reasons related to accessibility for people with reduced mobility, the longitudinal system is supplemented by a Y-shaped section supported by a continuous steel surface, three-dimensionally modeled. This type of very slender three-dimensional structure, composed of multiple arches, is made possible only through sophisticated calculations of a network of beams developed in space. The stability of the entire structure is ensured by nodes made from thick plates or unit blocks. The whole is stabilized by welded assemblies.Thus, we see how the theory of structures allows the creation of new, free, but reasoned forms that serve the appropriable space of the footbridge. The connection is made here between the theory of structures and the development of a unique form designed to serve a generous urban intent centered around the quality of public space. This trilogy – structure theory, manufacturing methods, and public space – finds its full expression in this large-scale footbridge project.

The public space of the Pleyel Bridge

Sully-sur-Loire, France

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A subtle crossing to the castle

2 The Chateau de Sully-sur-Loire, a unique heritage site

The construction of the Château de Sully-sur-Loire dates back to 12th century. Initially built as a medieval fortress surrounded by protective moats, the castle is part of a larger ensemble of castles known as “les Châteaux de la Loire”, which were built along the Loire River and transformed into aristocratic residences during the Renaissance. The Castle and its park, listed as historic monuments in 1944, form a unique heritage site.

Keywords: design & build; genius loci; heritage; historical monument; minimalism; constructive details; thin plate; steel box girder; accessibility

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Genius loci

In 2022, a design & build competition was launched to reimagine the 48-meter link between the castle and the nearby town center. The existing timber footbridge, which was at risk of collapse, had to be replaced. The competition brief called for a contemporary design, made from durable materials, that would be carefully integrated into the site and its historical context.

The design and of the construction of the footbridge embody the concept of genius loci. The design choices indeed focused on ensuring that this contemporary object would belong within the historic setting. Every detail contributes to this goal, from the architectural concept, inspired by river Loire flat-bottomed barges, to the structural design with a 6 cm thick river pier to minimize the impact of the bridge in the moat, and the carefully crafted parapet details.

The stability of the thin pier as well as the dynamic behaviour of the footbridge were the main challenges that arose from these choices. Besides, building a footbridge over moats and within a listed castle park also required specific methodology.

The continuous dialogue between contractors and designers enables the project to evolve and to keep its structural delicacy. The footbridge stands as a masterful example of how sensitive contemporary design can reinforce the identity of historic sites, ensuring their accessibility and relevance for future generations while embracing architectural excellence.

Positioning of the central pier

Bilbao, Spain

Moveable sails For Bilbao

3 Set sails For spectacle

During movement, moveable bridges perform a spectacle: they are more alive than most bridges we design, which is also their peculiar challenge. This paper focuses on the conceptual design of one such bridge currently under construction, between Erandio and Barakaldo, in Bilbao, two communities physically close, but historically divided by the estuary. Two steel sails form the characteristic feature of the slender, elegant bridge, with the mechanisms for the structure's opening integrated in the piers. The sails pick up on the industrial and maritime character of the surroundins, creating a new visual landmark.

Keywords: moveable; double-swing bridge; mixed foot and bike bridge; sail bridge.

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A city's character forged in iron

Estuary ports are a recurring feature of European coastlines. Where adventurous explorers set sail towards shores unknown (to them) hundreds of years ago, industrial port structures of unseen size were built during the 20th century. Now, nature and people are reclaiming their parts in these areas. We, as bridge designers, are increasingly asked to develop foot and bike links between suburbs, somewhat lost between ports and city center.

The conceptual design of the new bike and footbridge in Bilbao Bizkaia, halfway between the city and the port, takes special consideration of the historical background and the close relationship between the city, the sea and iron and steel industries. Bilbao, which bases its economy on services, and has been praised as an example of urban regeneration, was a major industrial center not so long ago.

Bikers and pedestrians can traverse the river estuary, divided by vertical steel sails (as main load bearing elements) and benches along its length. The two sail-supported segments allow the passage of larger ships and sailboats by elegantly rotating horizontally on slewing bearings concealed in the main piers. In the open configuration, they flank the entrance to the city by water, a subtle reminder of the historical background. The back-spans of the sails are locked to the fixed approach spans at their ends to create a continuous girder in when closed.


Deck view at night


Open bridge seen from Barakaldo

Geneva, Switzerland

Footbridge over the Foron river rendering (Archigraphie, Philippe Cointault)

Integral Footbridge over the Foron river

4 A solution in weathering steel to minimize maintenance in a natural environment

This paper describes the conceptual design process by a team of architects and engineers that led to the design of the footbridge over the Foron river at the Swiss-French border. This project is part of a renaturation plan developed by the Office Cantonal de l'Eau (République et canton de Genève) and the Syndicat Mixte d'Aménagement de l'Arve et de ses Affluents. This case study is presented as an example of integration of the reflections on the site-specific conditions in the conceptual design of a footbridge.

Keywords: footbridge, integral structure, box girder, integration, natural landscape, weathering steel

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Footbridge concept

In the last years, the increase in intensity of the floods of the Foron and Arve rivers raised the concern about protection of the surrounding businesses and users of the park. This led to the enlargement of the river bed and the elevation of the pathways on both banks, that laid at a distance of 46 m. Considering these parameters, the variant analysis finally converged towards an integral continuous beam with two spans of 23 m. This solution allowed to minimize the depth of the deck and profited from the easy access to the river bank on the Swiss side to build the intermediate pier. The deck is a box girder in weathering steel with variable width and height, ranging from 2.90 to 3.35 m and 0.35 to 0.55 m respectively. This results in a depth to span ratio of around 1/40. The natural protective layer provided by the oxidation of weathering steel avoids the need for protective paint, that needs to be replaced periodically. The integral solution resting on flexible abutments allows to accommodate the bridge displacements and avoids the need for support replacement. The integration of the reflections on the surrounding landscape, the critical site conditions and the structural performance resulted in a footbridge that is well integrated and responds efficiently to the need for a pedestrian connection between the two banks of the new natural environment.

Brussels, Belgium

Tondo Footbridge

5 Introduction

The Tondo pedestrian bridge is a collaboration between Office kgdvs architects and Bollinger+Grohmann engineers. The footbridge located in Brussels, connects the Chamber of representatives, a building from the 19th century and the Forum building, a modern building from the 21st century.

The height difference between the two buildings is 84 cm. With a span of 15 m, a straight bridge would be too steep for people with reduced mobility. The architects used a simple classic geometry to solve this issue: the path is a perfect circle to reduce the slope.

Keywords: classic geometry; context; steel-concrete; force flow; parametric design; mirror; autonomous object; Tondo.

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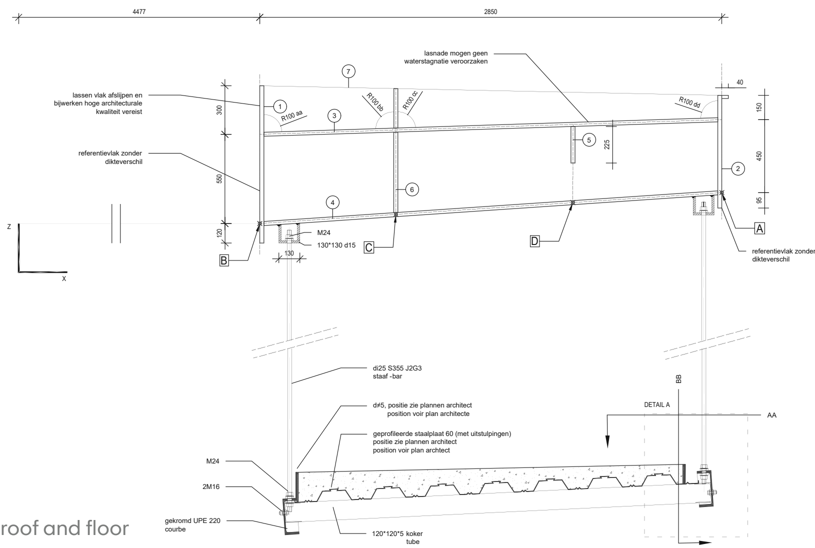
Structural concept

The main structure of the footbridge is the roof (fig. 1). The roof is a closed steel box girder. Every stiffening plate is carefully positioned according to the force flow and has been optimized in thickness and height. The steel-concrete composite floor (fig. 2) is suspended from the roof using circular tensile rods. This allowed for a minimal deck thickness, thus maximizing the public space underneath the bridge.The outer circle is cladded with mirrored panels, reflecting the complex 19th and 21st century built context while being an autonomous object, absorbed by its surroundings. For the inner circle curved glazing is applied. This allowed the user to keep a connection with the vivid city life, but in a much more intimate way. The name Tondo refers to the circular work of art made in the renaissance that defines the compositions within its appearance.

Steel roof structure



Section through the roof and floor

Les Cèdres Footbridge

6 The Footbridge and its surroundings

The pedestrian and bicycle footbridge of Les Cèdres, at Chavannes-près-Renens (Switzerland), crosses over the A1 motorway running along the northern shore of the Geneva Lake and connects two highly developing districts located in the west part of Lausanne. The footbridge is in addition conceived to improve the urban landscape and to represent a new landmark. At its western side, the footbridge develops at approximately 4.5 m above the road level, requiring the creation of an artificial hill with a mild slope, accessed by a concrete staircase and a ramp.

Keywords: footbridge, integral bridge, composite structure, prestressing, dynamics, aesthetics

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Structural concept

The structural concept of the footbridge is aimed at allowing for a fast construction sequence, with the lowest possible interference to the motorway traffic, and minimising its visual impact. To achieve such goals, a slender arched-shaped frame is designed, with a rise-to-span ratio equal to 1:16. The structure presents a main span and two lateral spans. It is an integral footbridge whose total length is equal to 62 m and with a clear span between pier bases equal to 56.50 m. The structure is constituted by composite piers and deck and presents some peculiarities due to the unfavourable soil conditions, the significant width of the deck, the demanding vibration requirements and the search for a slender structure. The composite deck presents a structural height of 1.13 m and 1.66 m at mid-span and over the inclined piers respectively, resulting in slenderness values of L/50 and L/34.

Paper content

This paper aims at describing some relevant features of the structure and its construction, and a synthesis of the secondary elements which have required a thorough analysis during the design and construction phases. It explains also its evolution from the original design of the competition (based on a stress-ribbon) to the actually built structure. Some considerations on the dynamic response of the structure are finally presented.

Main span lifting and installation

General view of the footbridge from below

Footbridge with 25.5 m span

Generic Footbridges in Eupen (BE)

7 Summary

The terrible floods during July 2021 in the Vesdre basin in Belgium damaged many infrastructures. In Eupen, 7 bridges were heavily damaged or totally destroyed. Of these 7 structures, 4 footbridges must be rebuilt with similar interest for a functional and aesthetic point of view. The new static behaviour is defined as two arches supporting a deck. The site topography and the different spans (17.5 m, 21.5 m and 25.5 m [2×]) have defined the arch geometry. The constant 4 m variation guided the approach towards a structural design allowing to “cut” the ends of the largest structures to obtain the smallest ones, without any geometric modification.

Keywords: aesthetics; structural concepts; generic design; precast concrete; stainless steel reinforcement; minimal design; durability; footbridge

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Moreover, the identical arches on each bridge led to a single design approach: the use of a unique formwork for the construction of these 8 precast concrete arches is the essence of this project. A steel formwork with non-developable warped surfaces and a common reinforcement principle were planned and implemented.

Alongside the structural considerations, short construction time and high durability led to propose a design that met the customer's expectations and the site's specific characteristics. This minimalistic approach reduces the use of materials to the strict minimum.

Steel formwork

Concrete is the unique material. No additional waterproofing or pavement is applied on the upside, which led to use stainless steel reinforcement for two reasons:

- to eliminate the risk of concrete bursting due to corrosion
- to limit the thickness of concrete cover, thereby reducing the dead-weight and obtaining a slender structure.

Finally, the footbridges beams are integral structures. They are continuous with their foundations, which eliminates the need for any bearing or expansion joint which is equipment that requires maintenance.

This geometry also increases the hydraulic gauge of the rivers crossed by eliminating the central piles of the old footbridges. This reduces the risk of damages in a future event of flooding.

4 precast concrete arches in the factor

Vigo, Spain

Halo circular footbridge and elevators, aerial view

Halo, a new circular Footbridge and elevator connection

8 Design concept

The paper presents the design and construction of the Halo. The main elements of the Halo structure are an urban elevator shaft tower and a footbridge but – instead of featuring a straight footbridge – two diverging paths are presented within a circular ring that serves several purposes. The design creates a combined promenade and sightseeing platform with views over the Atlantic while also providing two separate curving footbridges, one sheltered from the rain and the other open to the landscape.

Keywords: Urban elevator, circular footbridge, glazed façade, steel truss, structural glass, solid surface, architectural lighting, sustainable mobility, sculptural design, reshaping the future

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Project details

This new mobility solution opened in February 2024 includes a two-elevator tower to cover the 40 m height difference, and a circular footbridge with 84 m diameter over the highway with 6 lanes below, with two curved spans of 80 m. The elevator tower is equipped with two cabins, each capable of accommodating 17 passengers, facilitating vertical mobility across the city's varied topography. The structure relies on just three points of support, one of which is the elevator tower. And it has no connection to the train station building that connects, just an expansion joint device between them.

From a structural perspective, the footbridge employs a spatial truss design. The covered section of the footbridge is an asymmetrical cross section in which the users pass through with open views to the inside, taking advantage of the coupled performance of torsion and longitudinal bending. Conversely, the open footbridge section utilizes a symmetrical truss girder, positioning pedestrians atop the structural element. The steel structure includes 800 tons of S355 grade steel. The project required a complex construction process to allow its erection with a large crane over the busy highway and roads below. But the result with glass facades and solid surface Krion paraments, turns this functional element of sustainable mobility into a sculptural volume that reshapes the changing sky line of the city in Vigo. Architectural lighting is an important part of the project, as the light filters through the glass facades and the sculptural volume of the structure, and it becomes a lighthouse over the city, allowing also for dynamic lighting effects and soft color changes.

Footbridge in the beautiful area of Hvidkilde

Curved Footbridge in Hvidkilde Lake Denmark

9 Curved Footbridge

The article details the development and construction of a curved pedestrian bridge at Hvidkilde Lake, Denmark. Initiated to improve conditions for cyclists and pedestrians, the bridge blends naturally into the landscape, following the road's curved form. Constructed of steel with an Azobé wood deck, it features a railing matching historical safety railing. Special care was taken to protect local wildlife. The bridge has gained popularity and recognition for its harmonious design.

Keywords: functionality; aesthetics; steel; structural concept; wood; lake; sustainability; curved bridge; protected area; planning.

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Introduction

The area around Hvidkilde Manor is one of Denmark's most beautiful and idyllic regions. However, traffic conditions have long challenged vulnerable road users. Cyclists navigating narrow lanes, sharp turns, and large trucks have faced unsafe conditions, making the installation of a new footbridge essential.

Project Development

The project faced several challenges, including opposition from cultural heritage organizations and the need to protect local wildlife. Initial attempts to establish a cycle path between Svendborg and Ollerup were unsuccessful due to concerns about the cultural environment. In 2021, a breakthrough was achieved through collaboration with Hvidkilde Manor, relevant authorities, and local stakeholders. The bridge was designed to blend into the surroundings and enhance biodiversity by reusing felled trees.

Erection of the bridge elements

Bridge Design and Construction

The bridge is constructed of steel with an Azobé wood deck and a railing that matches the historical safety railings at the nearby mill embankment. The design ensures minimal impact on the environment, with special attention given to protecting bats and eagles etc. The 165 m bridge spans 17 sections, each varying in length and curvature, and is supported by reinforced concrete piles. The project also includes a 2.5 km cycle path, with 750 meters of single-direction and 1,650 meters of double-direction paths.

Eichstätt, Germany

New Herzogsteg Foot-bridge over the Altmühl

10 Artificial stone crossing

The new Herzogsteg bridge, which connects the old and new towns over the Altmühl in Eichstätt, Germany, is an impressive, slender, integral reinforced concrete structure that blends perfectly into the cityscape. Key design parameters were flood protection and accessibility requirements, leading to a stream-lined cross-section of structural concrete that does not require further sealing or covering. The structure's durability is ensured by a suitable concrete composition, stainless steel reinforcement ('Top 12', material no. 1.4003) and deep hydrophobization. Due to the 'cast stone' it is expected to require minimal maintenance or repair, resulting in low life cycle costs.

Keywords: Herzogsteg, pedestrian and cycle bridge; aesthetics; water law procedure; flood protection; accessibility; integral structural concept; cast stone; top 12 – stainless reinforcement; durability assessment; deep hydrophobization

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Urban connection

The Herzogsteg Bridge is located at a key urban site in Eichstätt, linking the old town with the hospital town and the public transport hub at the railway station. Following the closure of the previous bridge in 2016 due to severe deformations, the city council decided in 2017 to demolish it and build a new, barrier-free bridge. A design competition was launched to reflect the city's high design standards. The brief included connecting the two districts, integrating the bridge into the existing path network, and meeting requirements for flood drainage, river hydraulics, and subsoil. Traffic and open space planning for the adjacent areas was also part of the task. The winning design by Bergmeister + J2M Architects features an asymmetrically tapered shape that reflects the character of both riverbanks. From Herzoggasse in the old town, the bridge widens towards the open banks of the Altmühl and Franz-Xaver-Platz in the new town. Pedestrians from the station or hospital district are welcomed by the opening railings into the narrow streets of the historic center. Bridge design links baroque forms with modern architecture. The result is a slender, jointless, and bearingless integral reinforced concrete structure, an integral monolith with high design quality without additional waterproofing or surfacing, good grip for traffic safety, and a streamlined form suitable for flood run-off.

View from the west, towards the old town

View from the water

Shanchuan Glass Suspension Bridge

Taiwan Shanchuan Bridge: Paiwan Indigenous Art

11 The Bridge and the Glass Beads

The Shanchuan Glass Suspension Bridge, a culturally themed pedestrian bridge decorated with glass beads inspired by Paiwan Indigenous culture. Despite its name "Glass", it refers to the use of colorful glass beads, not a bridge made of glass. These glass beads, known in Paiwan language as "qata", meaning "to protect", and are regarded as sacred objects, believed to embody spirits that safeguard the natural environment and ecosystems. Incorporating local culture into transportation infrastructure design has become a key consideration in engineering projects within remote mountainous regions. By embedding artistic elements into the bridge's design, the project achieves a harmonious integration of cultural heritage, structural form, and the surrounding landscape.

Keywords: suspension bridge, Indigenous culture, aesthetic design, public art, glass bead, planning, structural engineering, construction methods, rebar hoisting, catwalk access

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Shanchuan Bridge

The Shanchuan Glass Suspension Bridge, located in Pingtung County, Taiwan, is a striking pedestrian suspension bridge measuring 262 meters in length and rising approximately 45 meters above the riverbed, connecting Sandimen Township and Majia Township. It was constructed with the goal of revitalizing tourism in Indigenous communities of Pingtung, particularly in the aftermath of typhoon, which severely impacted the community's infrastructure. In addition to providing a vital transportation link and attracting visitors, the bridge also stands as a symbol of cultural resilience, blending modern engineering.

The bridge exemplifies a cultural engineering project that integrates the artistic traditions of Taiwan's Indigenous peoples with modern construction. Glass bead installations at the entrance, along railings inspired by the Hundred Pacer snake, and on inner story panels that also serve as safety barriers. Mosaic artwork on each anchorage block is created by local students, and stone sculptures resembling taro and sweet potato to symbolize cultural integration. The bridge itself stands as a cultural landmark that merges structural engineering with artistic expression.

This paper examines the distinctive construction methods applied during the building of the bridge, including slope stabilization, hoisting of preassembled rebar, and the installation of a catwalk. In addition, it discusses how the engineering team established safe access routes across steep terrain, enabling efficient movement of personnel, equipment, and materials. The project successfully integrates natural topography with Indigenous cultural aspects, shaping a unique skyline that now defines the identity of Paiwan community.

Northbrook, Illinois, USA

Modern Footbridges – An Owner's Dream or an Engineer's Nightmare

12 Summary

Unlike modern signature highway bridge designs, which strive (sometimes unintentionally) to set firsts in length, scale, and cost, but are heavily constrained by current bridge design codes and the conservatism associated with building a publicly funded structure, today's footbridge designs are often unfettered from these restrictions permitting engineers to create unimaginable structures at the behest of owners (private or public).

Keywords: Constructability, Creep, Fabrication, Erection, Materials, Structural Behavior, Fatigue, and Vibrations

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For owners, these eccentric designs call attention to the beauty of certain forms or the creativity in elegantly meeting a defined function; however, for engineers, these designs often push the limits of structural analysis, behavior of materials, and constructability. As a result, when executed well, they highlight engineering innovation and progress; however, when they fail to perform as intended, they can create a nightmare of claims for the engineers and the contractors that build them.

This paper examines various footbridges that, at the time, pushed the limits of performance or their designer's knowledge into structural behavior. The London Millennium Footbridge, opened in June 2000 and subsequently closed two days later before reopening again in February 2002 after the installation of dampers, is a much publicized example of a footbridge design failing to meet expectations. This and other lesser known footbridge performance problem examples highlight that what might have worked at a larger scale for a highway bridge, may not work when scaled for a lighter footbridge design. Moreover, complex geometries often generated from the creative shapes submitted through design competitions, produce construction tolerances much more stringent than contractors are used to or even can fabricate or erect. Even more problematic is the entry into signature footbridge projects of designers and contractors unfamiliar with the basics of bridge engineering and construction who create otherwise avoidable conditions that affect the long-term serviceability of the bridge.

Through the discussion of these engineering nightmares, this paper attempts to identify their causes and presents possible recommendations for avoiding such issues in future footbridge projects.

Perth, Australia

Boorloo Bridge

13 **Showcasing Whadjuk Noongar culture to the world**

Boorloo Bridge comprises two curved cable-stayed bridges and a 1.1 km long, 6 m wide segregated path alignment for pedestrians and cyclists crossing the Derbarl Yerrigan (Swan River) between Victoria Park and Perth (Boorloo) via Matagarup (Heirisson Island) in Western Australia.

The bridges' innovative design responds to the area's unique cultural and historical significance, acknowledging the Swan River's spiritual and cultural importance to Whadjuk Noongar traditional custodians. It integrates with existing landscape and urban design, providing an attractive link for the local community and a new landmark destination.

Keywords: cultural recognition, connection to country, cable stayed bridges, wind and pedestrian induced dynamics, weathering steel, cable force finding

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Two cable stayed bridges

The alignment's S-shaped curves represent the sinuous movement of the Wagyl (Rainbow Serpent), a key figure in Noongar mythology, which also minimises the impact on existing trees and adds stability to the bridges. The commitment to minimizing environmental impact ensured the preservation of local flora and fauna.

The lightweight high strength weathering steel bridge decks and pylons reflect Western Australia's iron ore rich heritage and reduce maintenance. The shape and form of the pylons, symbolising Noongar tools, were heavily influenced by the Matagarup Elders Group, 18 Noongar Elders who participated in the project.

The bridge at McCallum Park comprises two 46 m high pylons symbolising digging sticks, a central span of 155 m length and side spans of 60 m length. The bridge at Point Fraser comprises a single 52 m high boomerang shaped pylon, a main span length of 100 m and a total length of 236 m. Both bridges are designed to accommodate marathon events, while maintaining a high level of comfort for spectators, and a bespoke developed integrated LED stay-cable lighting system capable of displaying moving images and text. Since it's opening, Boorloo Bridge has become a popular destination, attracting over 80,000 users in its first week.

Boorloo Bridge displaying the Whadjuk Noongar leader Yagan on its digital canvas

Shin-Sapporo, Japan

An inclusive design approach for a bridge

14 The Bridge as shared public space

The Active Link is an elevated passageway that spans seven sites: four hospitals, a high-rise condominium, a commercial facility, a hotel, and a road area. The bridge connects these buildings in an elliptical shape, providing protection for pedestrians during winter. The perimeter opening is supported by a Vierendeel structure, with the roof and floor cantilevered over the main structure. The inner perimeter is made entirely of glass. The bridge spans all sites as a single, indivisible structure without expansion joints, creating an opportunity for each landowner to contribute land and collectively establish a shared public space.

Keywords: inclusive design; Vierendeel structure; maintenance considerations; environmental control; shared public space; geometric rule by computational algorithms

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Maintenance, slope for the hospital patients

The structure has no finishes or coverings, eliminating the risk of secondary components falling onto the road. This design also allows for easy inspection and maintenance from the outside, and it can be easily repainted. Each hospital was designed with different floor heights to accommodate various specialties. The circular form was considered ideal for facilitating the movement of inpatients during their rehabilitation. The floor level of the Active Link is set at a gentle slope of approximately 1.5 %, ensuring that it does not interfere with barrier-free access to each facility and providing a manageable level of effort for patients during ascent and descent. To realize this complex form, the mathematical rules of the geometry were first determined and coded, and then the geometry was defined by computational algorithms.

A collaborative process with different people

Given the differing purposes of the hospital, commercial facility, condominium, and hotel, the planning and design process involved meetings with all parties to ensure that the details of the plan were shared and agreed upon. This collaborative process also fostered connections between businesses that typically would not interact with each other, such as hospitals and commercial facilities.

Rehabilitation walking for the patients

Bird's eye view

Madrid, Spain

Special pedestrian areas in road bridges

15 Integrating Pedestrian Areas in Road Bridges: Urban and Structural Design Perspectives

Urban bridges are vital mobility infrastructure and extensions of public space. As cities evolve, integrating pedestrian areas into road bridges is increasingly relevant – functionally and to enhance urban continuity. While full separation via independent bridges is often pursued, a single, well-designed structure can achieve comparable results. Thoughtfully addressing pedestrian needs in a shared system supports comfort and safety without a separate footbridge. Through selected projects by the CFC design firm, this study examines structural and spatial approaches that balance technical efficiency, pedestrian experience, and urban integration.

Keywords: pedestrian sidewalk, road and pedestrian bridge, arch bridge, cable-stayed bridge, truss bridge, urban integration

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Separation and Integration: Design Solutions in Practice

Several designs focus on physically separating pedestrian zones from road traffic, thereby enhancing safety, comfort, and spatial quality. Architectural finishes such as landscaped elements, protective canopies, lighting, and street furniture contribute to this experience and help bridge the transition between infrastructure and the urban environment.

However, full separation is not always the optimal solution. In certain contexts, integrating pedestrian pathways within the same structural system as vehicular or light rail traffic can be more appropriate – whether to preserve continuity in pedestrian routes, reduce visual fragmentation, or optimize construction efficiency. In many cases, building a single structure that accommodates both uses proves more economical and contextually responsive than developing two independent crossings. The design challenge, then, lies in ensuring that shared-use configurations still offer pedestrians a safe, comfortable, and engaging environment.

The article presents a selection of completed projects and recent proposals developed at CFC, examining a range of structural and spatial strategies for incorporating pedestrian areas into road bridges. Examples include cantilevered walkways supported by transverse ribs, spatially integrated decks suspended from primary arches, and pedestrian paths combined with vehicular lanes under shared structural systems. Case studies such as the Euskalduna Bridge (Bilbao, Spain), Zizur Bridge (Navarre, Spain), Congost Bridge (Barcelona, Spain), Fourth Bridge over the Ebro River (Logroño, Spain), Bridge over the Galindo River (Vizcaya, Spain) and East Bridge (Chengdu, China), along with international proposals like the Obhur Creek Bridge (Jeddah, KSA) and Bahe River Bridge (Xi’an, China), illustrate the diversity of approaches adopted to suit varying urban, structural, and economic conditions.

Opening ceremony for Oyo River Bridge in 2012

Trail Bridges on the Nias-Islands, Indonesia

16 The Tsunami of 2004

On December 26, 2004, a massive earthquake off Aceh, Sumatra, triggered a tsunami claiming 250,000 lives across 14 countries. On March 28, 2005, a second 8.7-magnitude earthquake struck the Nias-Islands, killing over 1,000 people and destroying infrastructure, including foot suspension bridges. In response to the disasters, the Government of Indonesia enlisted the ILO to assess accessibility infrastructure needs, aiming to restore connectivity, improve construction standards, create jobs, and enhance livelihoods. The Nias-Islands are a remote archipelago, located on a major tectonic rift. 900,000 people live on the islands.

Keywords: Project selection, structure types, design standards, community participation, capacity building, local material use, foundations and anchors, motorbike traffic, cooperation potential, bridge design opportunities, remote areas.

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Challenges and Solutions

The weak insitu soils in conjunction with an extremely wet climate posed the most serious challenges on the technical side. Low capacities of the local construction industry, poor shipping services and destroyed or unreliable road networks were further difficulties to overcome in the reconstruction efforts.

Subsequently, the Nias-Islands Rural Access and Capacity Building Project (Nias-Islands RACBP) identified, designed, and constructed approximately 72 foot and motorbike river crossings, with a total combined span of 2,169 meters. The average construction cost was $ 980 per meter of crossing. The project was successfully completed in mid-2013.

The applied design solutions included i) culverts, ii) boardwalks, iii) drifts, iv) palm log bridges, v) I-beam composite bridges, vi) steel truss bridges, vii) suspended bridges, and viii) suspension bridges. For structure types (i) to (v) the project developed its own designs while for the larger bridge categories of (vi) to (viii) Nepal Trail Bridge Design Standards were applied.

Present Status

In June 2025 a team assessed present bridge conditions and traffic volumes. 93 % of the structures are in or good or fair condition, 4 structures had been replaced by road bridges and 1 bridge had collapsed due to missing drainage in approaches.

In 2019, the Indonesian Government sought technical assistance from Helvetas to scale-up trail bridge construction. However, the process was interrupted by the COVID-19 pandemic.

Motorbike traffic on Oyo River Bridge in June 2025

Galway, Ireland

Aerial view of Droichead an Dóchais (c) Photo: Anthony Shaughnessy, Superfly Ireland / Xposure

Salmon Weir Pedestrian and Cycle Bridge.

17 Droichead on Dóchais, Bridge of Hope.

Droichead an Dóchais is a new pedestrian and cycle bridge crossing the River Corrib in Galway City, translating as Bridge of Hope. The bridge is located 24 m from the existing listed masonry arch Salmon Weir bridge dating from 1815. The new crossing provides a separate, safe, active travel connection for over 10,000 pedestrians and cyclists daily, removing conflicts between them and vehicles and helping to reduce dependency on private vehicles in line with national transport and planning policies. Droichead an Dóchais stands as a beacon of modern engineering and well-integrated sustainable urban design and has become a landmark in Galway City.

Keywords: Pedestrian and Cycle Bridge; Arup; Sean Harrington Architects; Active travel; Place making; Urban; City; Galway; Ireland; River Corrib; Salmon Weir; Arch; Steel; Public Realm; Protected, Integral, Droichead an Dóchais.

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Bridge Design Approach

This design of the bridge is particular to place, culture and time. Uniquely, the bridge crosses three rivers; Persse's Distillery River, the River Corrib and Friar's River, creating three distinct character areas whilst maintaining a coherent overall composition. Approach bridges, across the 2 minor watercourses, are flared to reflect desire lines to ease urban connectivity. Each features an oculus to view the water below and as a reference to Irish holy wells.

The structural system of the main span is a fully integral, single span with a variable depth central steel box girder and variable width cantilevered walkways. Spanning 55 meters over the watercourse, the bridge's semi-elliptical arch, steel central spine beam and transparent handrails create an illusion of the structure hovering over the river, an elegant, light touch in the historic context. Post-tensioned connections are provided to the foundation at both sides of the main span, minimising hogging at midspan, structural deflections and vibrations under live load.

The design positions the bridge as more than a piece of transport infrastructure; it is an architectural and urban amenity, a landmark development and a focal point in Galway City which enhances the quality of life for residents and visitors alike.

As lead designers in collaboration with Seán Harrington Architects, Arup provided structural bridge design, planning, environmental, geotechnical, lighting, H&S and landscape architecture services.

Looking west over the canal, river and mill race. (c) Photo: Anthony Shaughnessy, Superfly Ireland / Xposure

Addis Ababa, Ethiopia

Suspension footbridge over Akaki river, Oromia Ethiopia

Localizing trail bridges: Enhancing rural connectivity in Ethiopia

18 Localizing Trail Bridges Construction

Trail bridges provide cost-effective, reliable year-round river crossings for pedestrians and motorbikes, offering a crucial advantage in connecting remote rural areas. Ethiopia has adopted a trail bridge construction practice based on the Nepali model. The paper examines the Ethiopian trail bridge construction materials, methodology and overall design practices, evaluating their adequacy and adaptability to the local context. The study identifies areas for improvement and offers insights for localization and enhancement to scale trail bridge construction and improve rural connectivity in Ethiopia.

Keywords: Adaptation; Construction Materials; Localization; Sustainability; Trail bridge; User-friendly

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Design & Construction Features

Design load is a critical aspect of trail bridge planning, influencing mainly cable sizing and steel deck. The Ethiopian manual prescribes a distributed design load of 4 KN/m^2, with slight variations for spans exceeding 50 m. Point load assumptions include two porters, each carrying 150 kg, spaced laterally and longitudinally along the walkway, but these specifications fail to reflect some real-world conditions. For instance, motorbike traffic has increased, and livestock, exceeding 800 kg, frequently use the bridges. This loading conditions limits the bridge's scalability in Ethiopia's lowland areas. Additionally, walkway width is a crucial factor affecting usability. Ethiopia's standard width of 1.06 m, while consistent across built structures, does not accommodate pedestrians carrying horizontal loads or allow bikers to pass simultaneously.

Nepal has adopted construction methodologies tailored to its mountainous topography, with materials primarily transported by porters. For Ethiopia, achieving efficiency and sustainability requires approaches that are adapted to its unique terrain and logistical realities. Therefore, trail bridge construction practices in Ethiopia must be context-sensitive – incorporating designs that reflect actual loading conditions, prioritize usability and practicality, and promote consistency. Such alignment is essential to enhance accessibility and ensure long-term sustainability.

Bikeramp Spoor Noord, Ney & Partners © Gilles Alonso

Fossvogur multipurpose bridge

19 New link between Reykjavik and Kopavogur

A 5 span 270 m long steel bridge was the winner of a 2021 design competition for a new connection across the Fossvogur inlet in Reykjavik, Iceland. The structure serves as a multipurpose bridge with a modern aim of cohabitating different users with special focus on creating attractive spaces for pedestrians and other non-vehicular commuters. The bridge deck is divided into three main spaces. A shared use path for pedestrians and slower non-motorised traffic on the east side, a separate lane for commuter cyclists on the west side and bus lanes in the centre of the deck. The bus route is an important link in the first phase of a new electric Bus Rapid Transit (BRT) system for the Reykjavik capital area.

Keywords: steel bridge design; structural design; steel fabrication; aesthetics; transport; structural concepts; planning; multipurpose.

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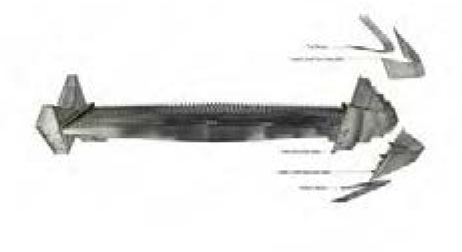
Variable shape

The bridge design is generally defined by a low horizontal form developed in respect of height restrictions imposed by the adjacent Reykjavík airport and is architecturally distinguished by the variable depth fabricated longitudinal girders on each edge. The edge girders carry steel transverse girders in between them which again carry a concrete deck plate in composite action through shear studs welded onto the top flanges.

The width between railings at edge girders varies over the length of the bridge; from 14,8 m in the end-spans and over intermediate supports, to 17,3 m in the middle of the three 60 m long centre spans. This variance is caused by the serpentine line of the deck edge on the east side. As the deck swells out at the mid-spans the shared use path (SUP) pulls away from the bus lanes to leave long voids in the deck that are covered by sculptural furniture assemblies with integral benches. These assemblies reference 'elf-stones', a folklore tradition of large rocks said to be the home of 'hidden folk' (or elves), of which there are many examples local to the bridge.

The structural detail design has emphasized the optimization of the different structural components to minimize material usage, and detailed modelling and analysis towards securing the constructability of the variable shape steel girders.



Structural steelwork, exploded model view

Sea rendering, bridge underside

Lyon, France

Bois Canal Footbridge, a monolithic UHPFRC structure for an "ordinary" crossing

20 An Ultra-High Performance Fiber Reinforced Concrete Footbridge

The past two decades have witnessed the emergence of numerous Ultra-High Performance Fiber Reinforced Concrete footbridges, a material mainly used for its plastic properties. These projects often involve costly and complex techniques, such as custom metal formworks or external post-stressing, to create ambitious, non-standard and often random shapes, questioning the relevance of the means employed. The Bois Canal footbridge project on opposite tries to get the most out of the technical properties of the UHPFRC, that's to say its long-lasting durability, high compressive strength, relative lightness and environmental performance.

Keywords: Footbridge, UHPFRC, new materials, stonework, aesthetics, monolithic, Art Deco, France, Saone river

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Bois Canal footbridge, an "ordinary crossing" near Lyon, France

In France, many common pedestrian bridges are owned by small municipalities with limited financial means. As a result, these short span structures often end up deteriorated: rotten wooden decks, rusty metal beams, etc. The Bois Canal footbridge is typical of such situations. The project is located on an oxbow of the Saone River, near the town of Pont-de-Veyle. An old footbridge dating from the early 20th century has been dismantled, leaving only disjointed masonry supports and an 11 meters long gap. The proposal for new footbridge draws on the current know-how in the Saone Valley, especially the presence of numerous fine sand quarries and prefabrication factories. It takes shape as a monolithic lateral-beam bridge made of UHPFRC. The footbridge is fully built in the prefabrication factory, then delivered and craned into place. It can be realised using only a formwork table for precast panels and punch dies made of wooden planks, leading to a low-cost structure adapted to this "ordinary" crossing.

Architectural and technical design process

The beams shape is the result of both an architectural and a technical design. The variation of thickness optimizes the structure's efficiency by creating a Vierendeel beam. The form of the punch dies echoes the Art Deco architecture of the early 20th century, which earned Pont-de-Veyle its reputation through the creation of numerous metal footbridges in the town's castle park. The approach developed in this project aims at finding the right form adapted to its situation by drastically limiting the technical means involved and the resources. The comparative life cycle assessment of the footbridge shows a reduction by 80 % of CO_2eq between an UHPRFC structure and an allow structure.


Digital rendering, Bois Canal footbridge

Lookout Königsstuhl, Rügen (© T. Allrich, NPZ)

Two loop bridges in the Baltic Sea

21 Summary

While many say that bridges are no destination, for the two bridges described here destination is the only 'raison d'être'. The lookout above the heritage chalk cliff called "Königsstuhl" on the island of Rügen and the "Pier Maritim" at Timmendorfer Strand are footbridges which rather than connecting points A and B bring you back to A. Loops of curved steel boxes supported only by a single cable plane on Rügen or individual single piles in Timmendorfer Strand, serve their purpose by providing visitors with new perspectives and allowing them to intimately experience the remote and delicate surroundings into which they are embedded.

Keywords: ring girder bridge, cable loop bridge, viewing platform, Seebrücke, Königsstuhl, Baltic Sea.

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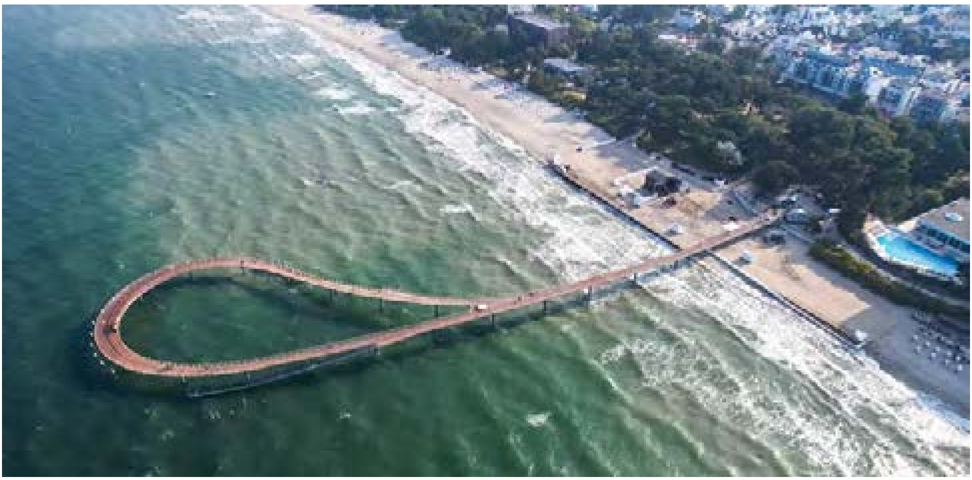
Introduction

This paper introduces the reader to the Conceptual and Structural Design of both bridges and the pertinent construction procedures, in the first case cantilevering out high above the sea and in the second case piloting right in the waters of the Baltic Sea.

The first modern curved girder bridge, the Kelheim footbridge across the Rhine-Main-Danube Canale by Jörg Schlaich, was completed in 1987 and during the 38 years since then, 15 bridges of this type by schlaich bergermann partner were built. The two recent examples presented here not only show the large structural and formal variety of such lightweight bridges, but also that they can nicely be integrated into remote and delicate surroundings. Even though both loop bridges must withstand the extreme weather conditions of the Baltic Sea, their situations could not be more different.



Pier Maritim, Timmendorfer Strand (© S. Stoll, L+W)

Kangaroo point bridge

22 A Bridge for Brisbane's Future

The Kangaroo Point Bridge is a transformative addition to Brisbane's urban landscape, redefining the way people move between the city centre and eastern suburbs. Focused on the future of transportation, it is part of a Brisbane City Council program to promote pedestrian, cycle, and e-mobility transport across the city, opened in December 2024. Crossing the Brisbane River, the 460 m-long bridge provides a striking, elegant form, connecting two active areas of the city: the densely residential suburb of Kangaroo Point and the centre of the Central Business District (CBD) via the Botanic Gardens.

Keywords: sustainable construction; iconic bridge; pedestrian dynamics; active transport; international collaboration; bridge architecture; digital engineering; parametric design; long span.

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New City Fabric

While options to connect Kangaroo Point and the Brisbane CBD have been studied since 1860, the final product focuses on accessibility and reducing congestion on other bridges, while activating key areas along and adjacent the bridge alignment.

Crossing one of the widest parts of the river, the Kangaroo Point Bridge successfully integrates a long-span bridge into the existing fabric of the city, with a respectful skyline, integrated landings, ample room for multi-modal transport, an above deck restaurant and bar, a riverside café and landscape interventions.

Originally forecast to accommodate 6,000 trips per day, the bridge is experiencing up to 10,000 and will reduce car crossings by up to 84,000 each year – lowering carbon emissions, pollution and congestion in the city.

Structurally Effective

With a composite steel box superstructure and 95-metre-tall steel box tower, it is Brisbane's tallest bridge. The 182.7-metre asymmetric main span, paired with the narrow width required for a pedestrian and cycle bridge, is one of the longest of its kind internationally. To enhance the structural performance and constructability of the four individual mast legs, an innovative mid-height cruciform cross-bracing member was introduced. The cruciform improved performance of mast legs under axial load, leading to reduced structural dimensions, a net savings in steelwork and a dramatic feature for pedestrians as they pass through the mast.

The bridge provides shaded open spaces on the bridge or users to enjoy the river and views of the city

Landing on the lush South Bank of the Brisbane River, the architecture blends with the semi tropical environment

Green Ribbon Footbridge at the Train Station in Renens

23 The Missing Link

The Green Ribbon footbridge is part of a vast urban project to redevelop the train station and the surrounding public spaces in Renens, situated in the greater Lausanne area in Switzerland. It is the result of a design competition won in 2007 by the "Rayon vert" (Green Ribbon) consortium, a close collaboration between architects and engineers. The proposal created one unique and continuous urban space by extending a ribbon-like footbridge over 11 railway tracks. After a long design phase, the construction finally began in 2017 with the general refurbishment of the train station and reached its climax in the end of 2019 with the installation of the four prefabricated footbridge segments. The footbridge opened to public in 2021. Its total length is 130 meters.

Keywords: steel bridge, structural concept, arbiform, site constraints, lifting, train station, railway tracks, complex building site

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Project Genesis

Throughout the project, the engineers were given significant creative freedom, which pushed the structural concept to the limit. This in turn strengthened the architectural concept, and the resulting design is both coherent and poetic.

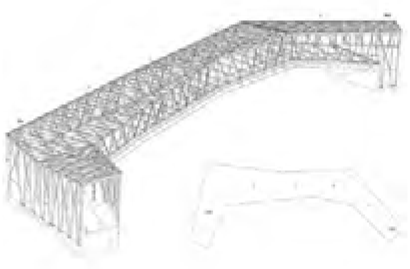
The architectural concept was driven by both the desire to connect two disparate parts of the city and to incorporate a natural vegetation. Structure had to fit within this approach. From the onset, the team tried not to pursue an ordinary solution with a basic truss girder with vegetation covering it. Thus, starting from a classic lattice geometry, we developed a system with very thin Y-shaped strut elements to take the compression force. This tree-like approach makes these elements more rigid against buckling in the plane of the lattice. They can therefore be expressed in filigree form, with high slenderness despite their considerable height.

Construction

Building in the heart of a busy railway station requires a major coordination effort between those involved directly in the construction project and the actors working for the development of the entire sector.

For the lift-in process, the footbridge was subdivided in four segments, entirely prefabricated offsite. Since casting the concrete slabs could have disturbed the railway traffic, the slabs were poured on site prior to placing the prefabricated segments.

The construction required a 94-meter-high caterpillar crane, the biggest available in Switzerland. In total, four bridge segments were lifted in, with a maximum weight of 190 tons and at distances up to 62 m. Since the railway traffic could not be disturbed, lift in took place during three consecutive nights.



Axonometry and schematic ground plan of the footbridge

Posing of the third bridge segment; 160 tons at 62 meters

Dugny – Le Bourget (93), France


Aerial view of the whole project

Timber crossing for Paris 2024 Olympic Games

24 **Minimum carbon footprint was a key decision**

As part of the Paris 2024 Olympic Games, the development of a new neighbourhood (the Cluster des Médias) required the construction of a footbridge over the A1 motorway between the towns of Le Bourget and Dugny. The project was intended to leave a legacy for this northern Parisian area and was awarded through a design-and-build contract with the stipulation that the project should have a minimal carbon footprint (2,087 TCO_2eq). Our project included a 100-metre-long glued laminated timber deck made from locally sourced materials, reinforced earth embankments and low-carbon concrete foundations. These achieved 1,166 TCO_2eq, so 1,000 TCO_2eq lower than the required target.

Keywords: Low Carbon Footprint, Timber deck, Earth structures, Paris 2024 Olympic Games

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Design of the project

Although the carbon footprint was an important factor, our main goal was to create a generous 415-metre long landscaped walkway comprising a series of contrasting sections, each of which is linked to the specific features of its immediate surroundings. Designed for pedestrians and other non-motorised users, the promenade aims to create diverse environments of significant ecological value, supporting a variety of flora and fauna, helping to rebuild the green network and gradually introduce the 'park city' concept of the 'Media Cluster'.

The footbridge

The sequence spanning the motorway was designed to be a minimalist sculptural object whose form and material can be grasped instantly. Its structure consists of superimposed glued laminated timber slats. These slats create a kind of 'reversed topography' that illustrates the flow of forces when interacting with daylight. They give the footbridge a unique identity, somewhere between children's building blocks and minimalist sculptures. The structure consists in a frame bridge with inclined low carbon concrete piers and a continuous of two GL24h Douglas fir laminated timber 'bloc sections' beams sourced from the French Morvan forests. The central span is 49.7 metre long and two side spans measuring 28.6 and 21.7 metres, respectively. Given the heavy goods vehicle and TMD traffic on the A1 motorway, the structure had to be certified for two hours of fire resistance under the ISO834 standard curve, in accordance with CEREMA recommendations.

Timber deck and its inclined pier.

Ghent, Belgium

The Annie Vande Wiele bridge

25 A site specific hybrid structure

The cycling- and footbridge over the Watersportbaan is part of the F400, the cycling highway around Ghent, and the Wester-Ringspoor cycling route. This bridge addresses a critical "missing link," not only within the larger F400 network but also within the local connectivity. The Watersportbaan, a prominent feature in Ghent's urban landscape, required a bridge that blends into its surroundings rather than dominating the views. The design prioritizes minimal visual disruption and seamless integration with the vistas.

Keywords: site specific, structural efficiency, hybrid structure, transparent structure, landscape

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Between beam and arch

The main span of the bridge is 78 m – too much for a simple beam bridge yet too small for a traditional arch bridge. Additionally, the structural height under the bridge deck needed to remain as low as possible to ensure cyclist comfort. Sufficient space under the bridge is required to accommodate the Watersportbaan's clearance and the running track encircling the Watersportbaan. This posed the challenge of creating a structure that is both efficient and cohesive. The new bridge achieves this through a hybrid structure that can be interpreted as both a beam and an arch.

A spatially coherent and innovative geometry

The geometry of the bridge is based on a straightforward yet innovative strategy. The cross-section consists of three ruled surfaces: a horizontal plane forming the bridge deck, side plates inclined at 45° on either side, and top flanges at 90° to the side plates. These ruled surfaces vary in width along the bridge's trajectory, collectively forming the load-bearing structure of the bridge. This approach results in a design that is spatially coherent, structurally efficient, and respectful of the iconic landscape.

Night-view of the flowing movement of the load-bearing structure – copyright Geert Buelens

London, United Kingdom

The A379 Southwest pedestrian and cycle bridge required precise modelling and detailed drawings for accurate onsite construction.

Enhancing Footbridge design with a novel Level of Information Need (LoIN) Framework

26 Summary

The future of footbridge design will be revolutionised by sustainability, innovative materials, and advanced digital tools. Materials like ultra high performance concrete (UHPC), high grade steel, and fibre reinforced polymers (FRP) will boost durability and sustainability. Meanwhile, smart technologies such as sensors and structural health monitoring systems will enhance maintenance and safety.

Keywords: BIM, LoIN, sustainability, innovation, digital tools.

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Central to this transformation are Building Information Modelling (BIM) and the Level of Information Need (LoIN) framework, which will improve collaboration, data accuracy, and ensure stakeholders receive the right information at each project stage.

Approach

This paper highlights the importance of a tailored LoIN matrix for bridge projects. This matrix includes both graphical and non graphical data, along with sustainability information, to enhance project deliverables. This approach not only improves the quality of project data but also facilitates the application of digital strategies to footbridge projects, which remain challenging compared to other sectors.

Incorporating sustainability data such as material passports and Environmental Product Declarations (EPDs) into BIM models supports several United Nations Sustainable Development Goals (UNSDGs). This method not only enhances the environmental performance of footbridges but also fosters innovation and collaboration among stakeholders.

Aerial view of the bridge

Lochnagar pedestrian and cycle bridge in London

27 A crossing and public space rooted in history

The River Lea, one of the main tributaries of the Thames, has historically played a significant role in driving industry in west London, providing a vital trade infrastructure. Nowadays, it fosters development value in one of the largest urban regeneration sites in inner London, where emerging developments will deliver thousands of new homes, businesses, community assets, and green spaces.

However, the river presents an east-west barrier for existing communities and new residents, with no river crossings within a 2 km stretch. The Lochnagar Bridge will provide a vital link in the area, encouraging active mobility and delivering significant social and economic benefits to the local community and the broader city.

Keywords: context; constraints; reference to site history; holistic design; traffic cohabitation; aesthetics; user experience; movable footbridge; complex steelwork

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The 63 m-span bridge is a steel bowstring arch with a permanent 33 m-wide and 3 m-high navigable channel for smaller boats to pass underneath. The deck features a bench that is part of the bridge structure, making the bridge a place to stay and enjoy the Cody Wilds (one of the most remarkable natural areas in that part of the city) and the meandering course of the river, not just a crossing point. One of the bridge's ends can be raised using hydraulic jacks to allow larger vessels to pass. This makes it possible to keep the crossing lower than with a fixed bridge, making it more accessible for everyone and providing a higher quality public space out of the bridge.

The design, which strikes a balance between simplicity and cleanliness from a distance, and expressiveness and attention to detail upon closer inspection, emerges from the constraints and the character of the surroundings, paying tribute to the area's industrial past. The bridge form is generated by gentle longitudinal curves springing from a limited number of points and transverse elements in between them, as in a ship hull, referencing the ship-building industry that was once key in the area. As a homage to the rich history of calico printworks on the site, a distinctive orange hue has been chosen for the steelwork, details, and finishes, referencing the madder dye used in the printing process. A collaboration with a renowned artist, whose patterned artwork is applied to the inner steel surfacing, further references the heritage of the Lower Lea and its textile industry.

Image of the bridge in closed and open positions

San Diego, California, USA

Idaho Avenue Pedestrian Bridge

Pedestrian Bridge Selection Client Guide

28 Summary

Clients have visions for their bridges that many times exceed the limits of their resources. Bridges can be iconic or utilitarian and the associated cost range is often greater than owners realize. This is especially true with pedestrian bridges where the form and finish require a higher level of scrutiny than vehicular bridges.

Keywords: Aesthetics; planning; footbridge; context sensitive design; vibration analysis; estimating

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As architects and engineers, our duty to owners is to guide them through the process of type selection. Clearly communicating factors that increase cost facilitates proper bridge type selection. This paper reviews the factors that influence the total price tag of a pedestrian bridge. Beginning in design, the depth of analysis and technical studies required increases as a structure envisioned by the architect becomes more complex. Maintenance costs increase for the owner when a bridge developed is of the boutique variety. Providing the range of time and cost allows a design team to agree on the appropriate scope, schedule, and budget required for successful project delivery. This paper presents historical ranges of cost for key factors during each of the phase of project delivery. These findings are a useful and objective tool to guide the expectations of those we work and facilitate successful project delivery.

Trubschachen, Switzerland

Rope mesh for lightweight footbridge structures

29 Rope mesh as structural substitute – Learnings from case studies

Rope meshes, composed of individual wire ropes, woven together or interconnected by sleeves, are characterised by their mesh diamond geometry, rope diameter, knot type and steel grade and are mainly made of stainless steel, less frequently of galvanised steel or fibre ropes. Due to their favourable mechanical properties of high strength and flexibility, rope meshes are typically used in applications for fall protection, spatial lightweight structures as well as bridge constructions.

Keywords: lightweight structure; new structural component; rope mesh; cable; suspension bridge; design method

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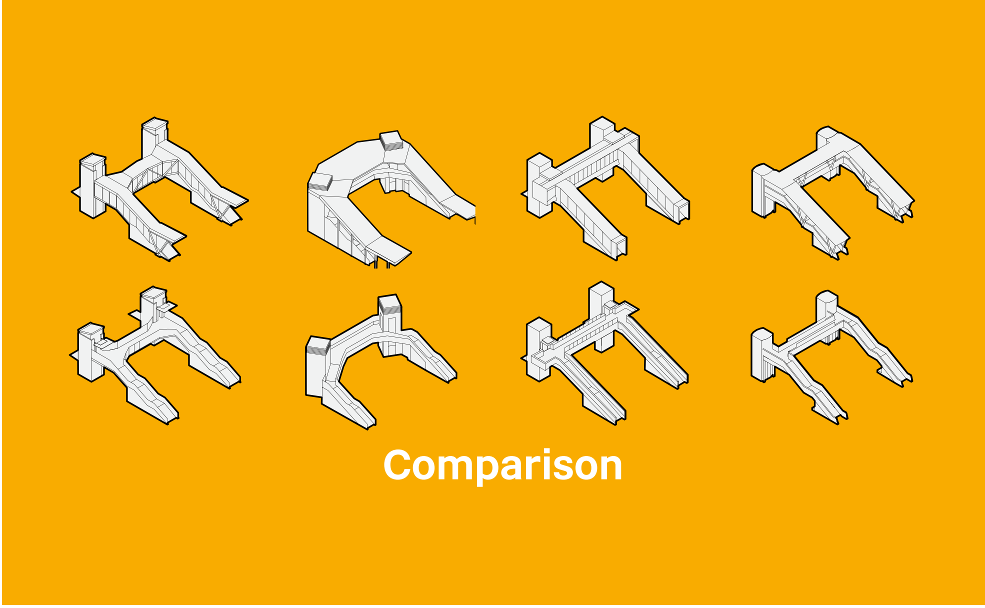
In bridge construction, rope meshes classically act as infill elements for vertical and horizontal fall protection. The case studies Pedestrian bridge – Himmelhausmattesteg (span 26 m) and Suspension bridge – LaPendenta (span 270 m) illustrate how mesh can be integrated into the primary structural system, serving as a combined substitute for classic hanger cables and fall protections. The design of the mesh with its resistance and stiffness is determined by empirical methods to calibrate the FEM analysis. The meshes are tested as a system in uniaxial and biaxial tests to determine their stiffness, but also as individual nodes to evaluate their resistance from the resulting loss factors of the ropes.

These case studies provide valuable insight into the design process including structural calculations, design details, method statements and basic behaviour.

Suspension bridge "Himmelhausmattesteg", Trubschachen – Switzerland, span 26 m

Suspension bridge "LaPendenta", Disentis – Switzerland, span 270 m



Extract from the Guidance

Footbridge desgin guidance for the railway

30 Summary

Following a 5-year period of developing 5 new footbridge designs, Network Rail is proud to present its new guidance that explains the outcome of this programme. This guidance update was compiled by the Danish firm Gottlieb Paludan Architects. In addition to providing a varied range of footbridge designs that allow more choice for specific locations, the guidance also provides advice on the design of bespoke railway footbridges in locations where the use or adoption of the generic designs is preferable.

Keywords: Railway, Footbridge, Architecture, Generic, Bespoke, Guidance.

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Unique features

For the first time this guide provides full capital cost and whole life carbon calculations which form part of the comparative assessments of the standard footbridges. The comparison of the footbridge types distinguishes between station and non-station environments for which Network Rail developed different generic designs. The guidance also includes a section on subways that helps to identify situations where the preferred solution to crossing the tracks from a customer and visual point of view is not always a footbridge.

A user-friendly 'Helping guide' feature aids the reader by asking relevant questions and bringing attention to aspects that should be given special consideration when deciding on the best bridge or subway solution. By directing attention to the critical factors, the guide ensures that all relevant elements are thoroughly examined before a decision is made. Generally, the guidance offers a simple and communicative introduction of the relevant topics to consider when deciding how to integrate a new connection across a railway line.

The guidance was a winner of the 2024 New Civil Engineer (NCE) Bridges Conference under the category of Best new bridge concept design. This is the link to the guidance – https://www.networkrail.co.uk/wp-content/uploads/2024/05/NR-GN-CIV-200-07-Footbridges-Subways.pdf

Madrid, Spain

View of the Santullano Bridge with nighttime lighting.

Spatial Cable-Stayed Footbridges: Design Practices

31 Cable-Stayed Footbridges designed at Carlos Fernández Casado design Firm

A series of curved spatial cable-stayed footbridges designed by the Carlos Fernández Casado (CFC) firm are studied to describe how pylon positioning, deck curvature, and cable layout influence structural behaviour and spatial articulation. Notably, the Santullano Footbridge adopts a refined solution by eliminating anchoring cables through optimized pylon placement. Parametric analysis enables structural balance despite geometric asymmetry. The study suggests that thoughtful structural efficiency can enhance visual expression, performance, and long-term durability in footbridge design.

Keywords: Spatial structural configuration. Footbridges. Aesthetics. Cable stayed footbridges. Steel Bridge

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Santullano Footbridge

Located in northern Spain, in the city of Oviedo, the Santullano Footbridge is the most recent design among the cases reviewed in this study. This semi-circular, cable-stayed, steel structure spans 63.2 m with an 84.50 m curved deck and is supported by a single pylon with a slightly fusiform shape. The hanger system adopts a fan-like configuration that generates a warped surface reminiscent of a hyperbolic paraboloid, contributing to both spatial complexity and visual refinement. With a clear daytime profile and illuminated nighttime presence, the bridge strengthens pedestrian and cyclist connectivity between neighbourhoods separated by the highway and serves as a symbolic urban marker.

The bridge distinguishes itself from earlier designs by eliminating the need for conventional anchoring cables to stabilize the pylon. While back stay cables are commonly used in this type of arrangement, this design achieves equilibrium without them. Instead, stability is ensured through the geometric configuration and refined pylon placement, identified via iterative parametric analysis. Additionally, the deck is embedded into the abutments, which obviates the need for expansion joints and bearings, significantly reducing maintenance requirements and enhancing long-term durability.

Expo 2008 Footbridge

Cheorwon, South Korea

Hyperboloid Cable-Net Suspension Footbridge

32 Innovative New Footbridge

This paper presents the design and construction case of a 201 m long, non-towered, hyperboloid cable-net suspension footbridge built in the Hantan River Gorge, a UNESCO Global Geopark. In an environment where wind cable installation was challenging due to the continuous exfoliation of the columnar joint layers, lateral stability and wind resistance performance were secured by utilizing a double helical cable net structure. The effectiveness was demonstrated through structural analysis and wind tunnel tests, and construction efficiency was improved by presenting an innovative sequential construction method using a ring beam placement device.

Keywords: Cable-Net Suspension Footbridge, Hyperboloid Design, Wind Stability, Structural Analysis, Wind Tunnel Testing, Construction Methodology, Ring Beam

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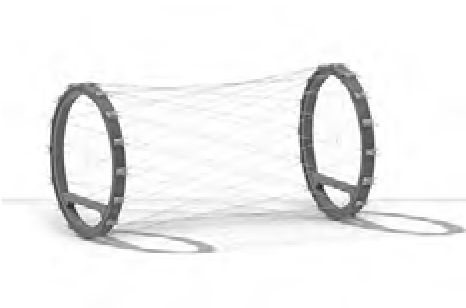
Hyperboloid Cable-Net Structure

In this project, a unique hyperboloid unit module was created by cross-arranging 16 cables each in clockwise and counterclockwise directions between 9 m long circular ring structures. By continuously connecting these hyperboloid modules to form the entire bridge, the inherent characteristics of the cable net structure were maximized, effectively improving resistance to lateral deformation and torsion.

In particular, the hyperboloid structure enabled the securing of sufficient wind resistance stability without separate wind cables and allowed for an aesthetically pleasing design that harmonizes with the surrounding natural scenery. Structural analysis and wind tunnel tests scientifically demonstrated the actual effectiveness of this hyperboloid cable net structure in securing lateral stiffness and enhancing wind resistance stability.

Additionally, this project utilized a ring beam placement device to sequentially install closed ring beams, ensuring that the main cables maintained stable step-by-step tension and sag. This method significantly improved construction efficiency and contributed to the successful construction of the footbridge.



Hyperboloid unit module

Top view

UHPFRC segmental Footbridge velodrom in Brno

33 Versatile and sustainable design

The new crossing of 7 road lines is designed as a single-span parapet beam with overhanged parts. The superstructure is composed of 7 UHPFRC segments that are prestressed by unbonded strands. This approach was adopted because of the temporary life in this place. After finalizing of city road ring, the layout of proposing junction will not be compatible with the position of the footbridge. Thus UHPFRC segmental footbridge was selected because it allows a dismantling of the footbridge and its reassemble in different segmental layouts elsewhere.

Keywords: UHPFRC; segmental bridge; prestressing; aesthetics; sustainable.

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Combination of U and L segments

The main span is 53.8 m with an overhang is 2.5 m at each side. The cross section in the main span is 'U shape' with a recessed wall, the total height is 1.4m. Overhang parts are "L shape" segments and they are connected to U shape by a combination of prestressing bars and tendons.

With regard to the versatility of use and long-term durability, a material solution made of UHPFRC was chosen. The main benefit is the high level of material savings, which is reflected in the weight of the individual segments (maximum 28 tonnes).

Abutments

The parapet beam is supported by two similar abutments that are composed of a central bearing wall and cantilevered ramps along the wall. The total length of the abutment is 37.4 m and the wall is 0.75 m thick. The wall has an asymmetrical cantilever layout of 17.6 m on the stair side and 11.8 m on the superstructure side. The asymmetry is deliberately chosen to balance the mass of the structure. The entire abutment structure is prestressed with a system of 5 traced tendons per abutment. The tendon routes correspond to the stresses on the structure and the construction phase, which was carried out in four stages.

Overall view

Aerial view of the footbridge

A620 Foot and Cycle bridge

34 Active travel takes off in Toulouse

This footbridge and its access ramps solve a major challenge for the Toulouse metropolitan area: to create an urban link for pedestrians and cyclists between the new district of Montaudran to the north, and the sports and aeronautical university colleges to the south. To create an inclusive, comfortable, and safe user experience, the crossing uses a subtle curved language for both the alignment and the steelwork geometry.

Keywords: structural morphology; curved alignment; dynamics; weathering steel; damping.

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When aeronautical profiles inspire girder's geometry

Combined with the continuity of materials and railings, the route is legible from A to B, allowing users to easily understand where the crossing starts and ends. Inspired by the aeronautical profiles and strong history of the Toulouse Montaudran Aerospace site, the asymmetrical design of the main span frames users' views. The height of the beam varies along the length of the crossing, making it possible to open up or close off views, while at the same time ensuring that the bending and torsion moments generated by the span and the positioning of the supports on either side of the motorway are taken into account: a way of responding to the urban challenges of the site with a structural form that is just right, while at the same time optimising the tonnage of steel.

The paper describes in detail the architectural approach to the alignment and form, and the analysis model developed to assess the distribution of forces between the three different box girders which, together, give the overall shape of the steel girder. The dynamic analysis will be detailed, and the need of dampers will be explained.

Seattle, USA

Crab Creek Footbridge

Three Weathering Steel Footbridges

35 Summary

This paper discusses the design considerations and aesthetics of utilizing weathering steel in three bridges. The warm color of the patina is shown to blend into the forested landscape of western Washington and the high desert landscape of central Washington.

Keywords: weathering steel; girder; trestle; network arch; aesthetics; water crossing; trail bridge; environmentally sensitive; user experience

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Weathering steel can be fabricated in a similar way as mild steel, but does not require painting. The use of weathering steel in these three bridges proved to be a great choice for their settings – the public has embraced their aesthetic quality. By pairing the weathering steel with concrete decks, a nice level of contrast is achieved.

Steel is a versatile material to use in design, providing engineers with the ability to create lightweight structures, utilize standard sections or weld deep plate girders with custom variable sections. Weathering steel was key to ensuring the structures showcased here could be constructed within the environmentally sensitive areas using practical means and methods.

The end result is a portfolio of bridges that stand in harmony with their settings.

Foothills Trail White River Footbridge

Artist impression of the Zwolle train station footbridge, south staircase grandstand

Sustainable wooden bridge designed as elevated inner city park Zwolle, the Netherlands

36 Zwolle train station Footbridge

It's bold, large and impressive and sets the tone for future city development in the Netherlands and elsewhere: the Zwolle train station footbridge. It has been designed as an inner city park, measuring 130 by 10 meters, elevated above the railway tracks. Sustainability was key in the entire design process and resulted in a loadbearing wooden bridge deck and ground breaking wooden elevator shafts.

Keywords: sustainability, timber structure, innovation, spatial integration, aesthetics, multifunctional design, green public space, climate adaptive.

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Sustainable wooden bridge designed as elevated inner city park

Our paper will describe how the design of this bridge came about and what its main features are. It will also focus on the key role that this bridge has in connecting the towns city center with new developments on the southside of the railway tracks. Furthermore, we will get into its multipurpose nature, acting both as a recreational area, a place to wander or meet, an outdoor waiting area for the bus and train station and an explosion of nature in the midst of a busy transport hub.

Finally, our paper will also talk of the design process itself, in which several parties were actively involved and working closely together.

Artist impression of the Zwolle train station footbridge, public space on the bridge deck

Artist impression of the Zwolle train station footbridge, view from the bus platform

Lapleau, France

Restoration of the Rochers noirs viaduct

37 The pre-existing conditions of the Viaduct

Completed in 1913, the Viaduct of the Rochers Noirs has a main span of 140 m, at 92 m above the Luzege river. It was originally constructed for the Transcorrézien railway line, thanks to an innovative triangulated cable arrangement designed to support the train loads while limiting the deflection of the deck. Like many old suspension bridges, the suspension cables suffered from severe corrosion and brittle tie bars at the connections between the cables. For these safety reasons, the bridge was closed to the public in 2006. Besides, the paint was flaking and no longer protecting the steel works. The masonries of the piles were in a reasonably good state but required renovation works on the facings. The decking was locally torn and perforated, deformed, and unable to resist future loads.

Keywords: historical monuments, heritage buildings, restoration, Gisclard bridge, hybrid suspension cables, suspension bridge, footbridge

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Listed as a Heritage Building in 2000 and located within a territory designated as a UNESCO World Biosphere Reserve, the Viaduct deserved full restoration to preserve its exceptional heritage value. The restoration involved converting it into a footbridge as part of a broader tourism initiative aimed at highlighting the region's history and surrounding natural environment. This particular type of viaduct, featuring the rare triangulated suspension system, was designed by the engineer Albert Gisclard, and only five such bridges remain worldwide.

The restoration work began with the replacement of the cables for safety reasons, requiring careful planning and structural modelling. Temporary suspension cables were installed to relieve the load from existing cables and allow the suspension replacement. A steel frame supporting these temporary cables was erected using a helicopter, due to the site's difficult access. During the load transfer process, a hundred hydraulic jacks were used simultaneously.

The masonry was carefully restored and cleaned by skilled craftsmen certified to work on historic monuments. The steelwork was entirely repainted using suspended scaffolding and an encapsulating membrane to prevent the release of toxic waste during the removal of old paint. The new steel decking consists of transversely stiffened steel plates, connected to the original girders using round head bolts that reuse the original rivet holes. Finally, the handrail was raised and upgraded to meet current safety standards.

Reopened in September 2024, this project exemplifies the delicate balance between heritage conservation and modern engineering, ensuring the bridge's legacy for future generations.

Completed steel decking with sandblasted resin coating and round head bolts

Retrofit of pedestrian suspension bridges

38 Bridges that connect communities

The northern region of Pakistan is renowned for the natural beauty of its many mountain ranges and torrential rivers. This terrain can result in isolated communities, especially during the monsoon season when river flow volume increases dramatically due to snowmelt and heavy rainfall. Footbridges over these rivers are crucial, providing essential access to healthcare, education, agriculture and trade, thereby reducing rural poverty. Preventative and reactive maintenance of these bridges is crucial to help ensure their safety and to mitigate against the risk of bridge failure and associated social and economic impacts.

Keywords: suspension bridges, remote construction, climate change, social value, geohazards, resilience

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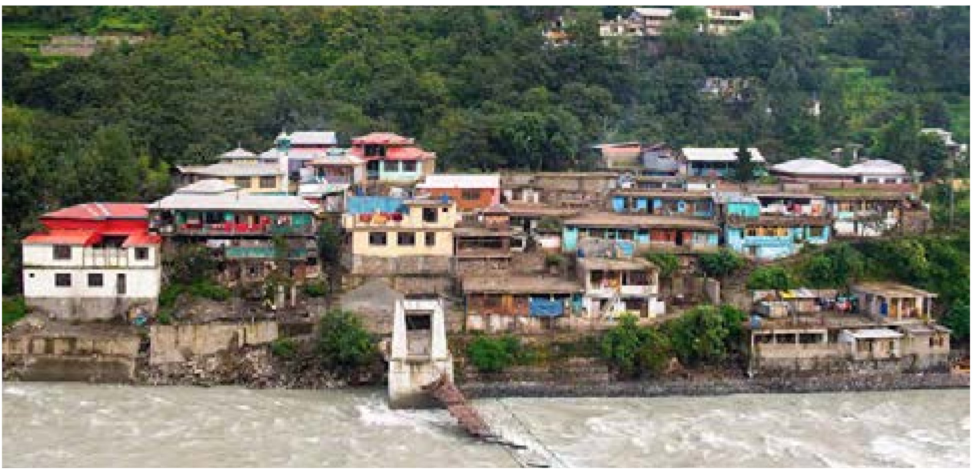
Maintenance, retrofit and replacement

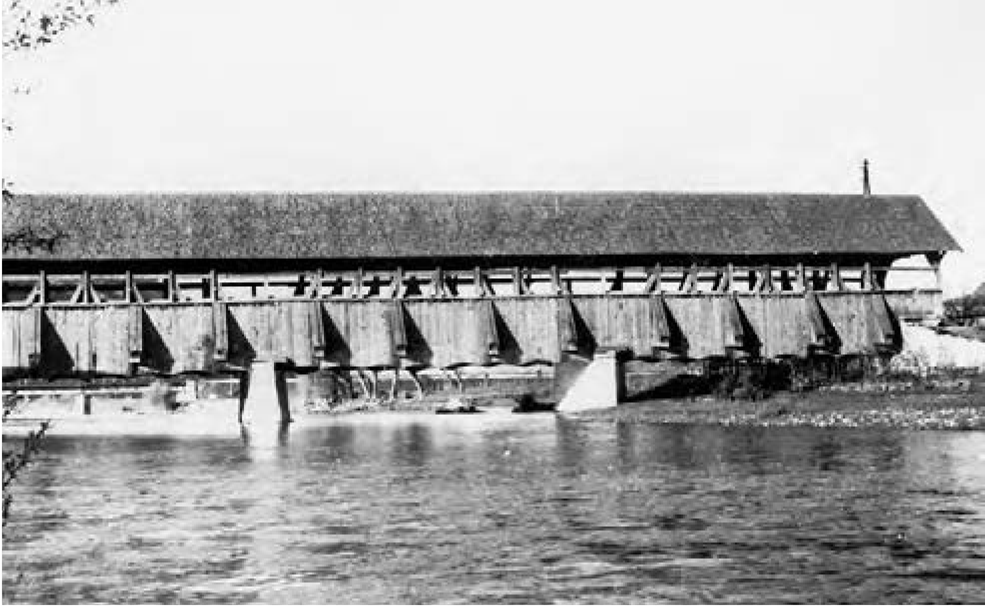
The maintenance, retrofit and replacement of pedestrian footbridges in geohazard-prone areas presents significant engineering challenges. These challenges include natural hazards, ground conditions, working with existing structures on which limited data is available, and site constraints during construction. Although approaches to manage these challenges and reduce risk are possible, it can be excessively costly and unfeasible to fully design and construct for all natural hazards at the locations where bridges can best serve local communities, and a risk of repair and / or replacement may need to be accepted. Approaches to manage these unique challenges and risks in Pakistan are presented in this paper.

Resilience

A catastrophic flood event during the retrofit of existing bridges has led the authors to question the approach to both the retrofit and design of new footbridges in remote mountainous regions of northern Pakistan. The challenge is striking a balance between lower-cost retrofit, capitalising on existing structures (e.g. towers, foundations and anchors) and accepting the risk of damage or failure due to inherent natural hazards, and the significantly higher cost of re-siting the bridge to reduce this risk and build anew.



Isolated village after 2022 floods, Kalam, Pakistan.



Bridge in Salva, author unknown, image from the archive of Muzeul Graniceresc Nasaudean

Historical timber bridges in Transylvania

39 In the Transylvanian old border region or the Năsăud Land existed numerous covered timber bridges, built during the operation of the Second Wallachian Border Infantry Regiment. Of these, only three remain in operation today. In this article, we propose to use the story of the origin of these structures located in the middle of Transylvania as a base for the discussion of the importance of the local integration of bridges and the mechanisms of their adoption by the local community. We will highlight connections between structures build in places as distant as Ancient China and their relation with timber bridges of the Renaissance period.

Keywords: timber bridges, covered bridges, local, historical, import of technology, adoption of technology, social impact of infrastructure, Transylvania, heritage

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A study of local integration of infrastructure

Few studies investigate the appearance of bridges in Transylvania at the end of the 18th century and although similar structures are found in other areas of current day Romania, their concentration in a restricted area and short time frame, as well as their remarkable technical quality stand out. Most focus on the connection between these bridges with the border regiment under the command of Baron of Enzenberg. Born in Tyrol and educated in Switzerland, he had knowledge of the construction methods of timber bridges, having seen examples of such structures in the Austrian and Swiss Alps.

In Transylvania, bridges were erected by all the members of the community. Their importance from a military, socio-economic and cultural point of view is certain and although their model was brought from another part of Europe, they were built by local craftsmen, maintained by the community, a source of pride for their descendants, as well as effigies of these places for more than two centuries.

The structural solution has stood the test of time, being kept through different repairs and complete rebuilds. These crossings became so intricate to the local communities, that after almost two centuries and a complete destruction in the war, they were still being rebuilt in the same way.

This is an important characteristic of a bridge that designers should always remember: it anchors in the place by creating a new connection and by doing so it becomes inseparable from the life of the community.

Bridge in Lesu, author unknown, image from the archive of Muzeul Granicerесc Nasaudean

Bridge in Zagra, author unknown, image from the archive of Muzeul Granicerесc Nasaudean

Renovated footbridge over Ripoll River in Sabadell, Spain

Renovating two Foot-bridges over Ripoll River

40 These two footbridges are twins and were part of the Ripoll River channeling works in Sabadell (Spain), carried out as a response to the historic rapid floods of 1962. At that time, they represented an innovative structural solution in Spain: cantilever cable-stayed structures composed of three isostatic spans. In fact, the tensile elements had to be imported with a special permit.

Keywords: Rehabilitating; Cable-stayed; FLC; Cultural Heritage; Steel structure

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After several inspections and technical reports, the complete restoration of the footbridges was deemed necessary. However, since the structures are listed by the City Council, their restoration required maintaining their typology, volumetry, and materials while ensuring compliance with current standards and regulations.

Both footbridges have a single span slightly exceeding 50 meters in length and are 2 m wide. The deck is supported by four pairs of stay-cables that pass through two pylons placed at the abutments and are anchored to the ground.

The rehabilitation work involved replacing the cables and the deck, restoring the pylons and abutments, and demolishing and reconstructing the anchorage blocks.

Renovated footbridge over Ripoll River in Sabadell, Spain

Budapest, Hungary

Upcycling an obsolete railway bridge structure

41 A sustainable approach

The reconstruction of the Southern Railway Danube bridge in Budapest was carried out between 2019 and 2022. Due to the increased railway traffic, the deck elements of the superstructures suffered serious fatigue damages in the past decades and therefore had to be completely replaced with new superstructures, leaving two, nearly 400 m long truss steel structures to decay. However, the dismantled 98-meter span truss bridge elements, with significant residual load-bearing capacity, were still suitable for reuse as footbridges.

Keywords: upcycling, sustainability, reuse, urban context, accessibility

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The Óbuda Danube Bridge

Budapest's pedestrian and bicycle network has numerous connectivity deficiencies in need of addressing, that has been recognized for decades. Parallel with the demolition works of the old bridge structures, our multidisciplinary design team designated a 74.5-meter section for reuse, and selected a suitable location within the city with a high demand for connectivity.

A new direct pedestrian connection over the Óbuda Danube branch would greatly improve the viability of residential areas on the Buda side, enable access to the Danube over the H5 suburban railway and therefore provide opportunities for broader recreational use of the parks and natural woodlands of the Óbudai-Island, which currently has only one direct entrance open to the public.

The demolition plans and technology were successfully modified in collaboration with the Contractor to ensure that the selected bridge element remains most suitable for its site-specific reuse. The design of the 111 m long structure, combined with a lightweight two-story steel deck serves as a contemporary, forward-looking example of the reuse of aging structures while also providing solutions to a pressing issue from an urban perspective.

The upcycled bridge element makes three formerly segregated public spaces accessible on foot

Kendal, UK

Elevation view of footbridge

Low Sizergh Suspension Bridge

42 Flood loading on heritage footbridges

The climate emergency is bringing challenges to all structures through changes in environmental conditions. Given repeated and increasing flood levels, what action should be taken to protect a 150-year-old footbridge? Given the footbridge does not comply with modern design standards, at what point does a repair to an existing structure need to bring the capacity up to current standards?

Keywords: rehabilitation; repair; construction; existing structures; climate change; conservation

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Low Sizergh Suspension Bridge crosses the River Kent near the village of Sedgwick in the Lake District, UK. Built to provide a route for workers from the village to access a gunpowder factory, the bridge is owned and maintained by the National Trust.

The bridge spans 35 m across the river. The main span is supported on a reused suspension chain (sag of approximately 2.7 m) with masonry piers and short approach spans to the west. The deck structure is timber, and deck stiffening consists of crossed timber braces within the parapet.

The footbridge has suffered repeated cycles of damage and repair over the last few years due to what was formerly considered "extreme" flooding. This paper asks what the appropriate response is to climate dependent increased loading for heritage protected structures.

The relevant design decisions are explored for Low Sizergh Suspension Bridge, referring to the tension between principles of conservation and the professional obligations of a structural engineer to provide a robust and safe solution. Data on flood levels for 50 years is examined, looking at the changes in flooding frequency and hence return period for the most severe floods.

Temporary works in place during construction

Saint-Denis, France

© Michel Denancé

The Lucie Bréard Footbridge – in situ reuse

43 Creating an accessible connection to the East of the Stade de France

While planning minimal new constructions to reduce costs and carbon emissions, the Paris 2024 Olympics represented an opportunity for the host municipalities to create better connections between existing neighbourhoods and the Olympic venues. Among other projects, the replacement of a footbridge non accessible to persons with reduced mobility and an unreliable moveable bridge with a new accessible pedestrian and cycle crossing over the Canal Saint-Denis was meant to link the Stade de France to the residential areas Francs-Moisins and Bel-Air.

Keywords: In situ reuse, reuse, bridge reuse, reused steel, steel footbridge, footbridge

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In situ bridge reuse

Instead of demolishing the two bridges and build a complete new one, the design team proposed to reuse the 52 m-long, 13 m-wide existing deck and part of the foundations of the former moveable bridge to form the main span of the new footbridge. The idea was motivated by CO_2 benefits, as well as by the additional comfort and uses enabled by the in situ reuse of a 13 m-wide deck. The reuse strategy was also designed to hedge the risk associated with steel supply in the context of Spring 2022.

Visual inspection and non-destructive tests carried out on welds confirmed that the structure was in good condition. Due to its reuse as a footbridge and to its rare use during its previous 20-year service life, risks associated with fatigue were discarded. The few corroded areas were repaired.

A new parapet has been installed along the whole project, creating visual consistency between the new span and the newly fabricated ramps and stairs. The 280 tonne bridge was installed in two days using a barge and self-propelled modular transporters.

The availability of extensive as-built documentation as well as constant support from the project client contributed to the success of in situ reuse within a tight programme. The Lucie Bréard Footbridge opened to the public one month before the Paris 2024 Olympics, matching an ambitious goal in terms of CO_2 emissions.

Bridge lifting and rotation © Sernavision/Razel-bec

View of the bridge soffit © Michel Denancé

London, United Kingdom


Outside view of the AVA footbridge span

AVA Footbridge: design for manufacture

44 Improving productivity

The development of the AVA Footbridge was motivated by a clear mandate to improve productivity in the delivery of footbridges across the rail network. Traditional footbridge designs frequently failed to meet Network Rail's objectives of minimising capital expenditure (CAPEX), reducing installation time, and lowering carbon emissions, thereby presenting significant challenges to their 'Access for All' program. This initiative aims to install hundreds of footbridges across the United Kingdom in the coming years, either to enhance accessibility at stations or to replace level crossings.

Keywords: Footbridge, stainless steel, manufacture, modular, pre-loaded bolts, railwaye

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Manufacture-led design process

The article will explain how the concept has been developed to follow manufacturing processes for thin stainless-steel sheets: laser cutting, folding and bolting assembly. This, in turn, required us, the design team, to be creative in the formation of efficient sections and transfer of forces at each splice.

The intention was to use flat laser cut stainless steel sheets, from which all sections could be created on demand, to increase accuracy in production, control production time and optimise quantities, including waste. The structure has no hot rolled sections; the most practical sections were folded channels, flats, and angles, based on a module length following typical sheets' dimensions to maximise neesting and minimise waste. We also explored the use of composite sections made by bolting plates together with preloaded bolts to form elements with thicker flanges. This enabled the creation of more efficient sections, hence allowing us to reduce the weight of the structure.

High-quality modular and adaptable footbridge

The result is a high-quality footbridge, designed as a product, modular and adaptable to stations. It demonstrates the potential of rethinking structural design to embed manufacturing constraints.

Aerial view of the Albi footbridge with the Saint-Cecile cathedral in the background

The Albi Footbridge

45 A new link in an heritage context

Albi (France), a city with a rich and tumultuous history, earned UNESCO World Heritage status for its historic center in July 2010. It is within this context that the creation of a cyclo-pedestrian footbridge, cantilevered over a 19th-century railway viaduct, was conceived.

Keywords: historical; aesthetics; structural concepts; planning; rehabilitating, reusing and transforming existing structure

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The viaduct, still in service today, is an entirely masonry structure of great coherence. The footbridge, made entirely of steel, is attached to it and subtly interacts with the existing structure in its design. More than just an addition, the whole project results in a new composition that possesses its own architectural and landscape quality. In terms of use, the footbridge provides a direct link between the city center and the peripheral neighborhoods, as well as a series of balconies beneath the arches of the existing viaduct, inviting people to pause and explore the built and landscape heritage of Albi.

Ney and Partners, along with its partners, won a design competition in 2013, and after a challenging journey, the project is now set to be delivered to the people of Albi.

Downstream view of a belvedere

Upstream view of belvedere

Dornierbrücke, Wangen i. Allgäu, Germany. Photo: Daniel Gebreiter / schlaich bergermann partner

Returned To A Natural State

46 Two timber-concrete-composite bridges

The 2024 state garden exhibition in Wangen im Allgäu saw the redevelopment of a former spinning mill and its industrialised and later neglected surroundings into an area for local recreation, and at the same time return them into a more natural state. Several bridges were built as part of the garden exhibition. A pair of twin bridges cross the rediscovered wetlands of the river Argen with a single span of approx. 35 m. Located only a short distance from one another, building the same design twice seemed an obvious choice, yet each bridge posseses and shares with its site a unique character.

Keywords: footbridge, bridge family, concrete-timber composite, integral bridge, sustainability, over water

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Re-claiming nature

The idea of re-claiming nature extended to the bridge design. First, untreated timber was chosen as primary material from a pool of materials investigated. Secondly, the bridges initially served construction traffic only to be "returned" to their permanent use as pedestrian and cycling crossings. This established an immediate relationship with the evolving site, where nature was quick to reclaim the riverbanks and surroundings.

For the structure, glued laminated beams act in composite with the concrete deck. At the abutments, the concrete wraps around the structural timber and continues monolithically into the foundations. Like an inlay to the concrete and away from the moist abutments, the timber is carefully protected from the elements. Fully integral, longevity is all but assured.

Life-cycle assessments continously performed throughout the design process and upon completion showed very favourable results when compared to similar span bridges.

Zeppelinbrücke, Wangen i. Allgäu, Germany Photo: Conné van d'Grachten

Nancy Pauw Bridge, Banff, AB, Canada

Nancy Pauw Footbridge

47 An 80 m clear span shallow arch in Canada's oldest national park

The Nancy Pauw Bridge clear spans over 80 m across the pristine Bow River in Banff National Park – Canada's oldest and most visited. The desire was for a bridge which was graceful, unobtrusive, and natural, fitting in with both the beautiful surroundings and the town's defined 'Rocky Mountain' theme as this was to be a high-profile civic structure, with up to 10,000 users per day. Environmental concerns, both permanent and during construction, were paramount during the project.
The bridge was required to clear span the river and temporary shoring was not allowed. A low profile was required with minimum slopes for user accessibility, and minimal ramping on either side to mitigate impact on the park lands while maintaining adequate clearance for flood conditions.

Keywords: aesthetics; design build; timber; arch; glulam; footbridge; steel-timber hybrid; shallow compression timber arch; tuned mass damper; long-span

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Solution

The solution resulted in a shallow, glulam timber arch superstructure, with a depth to span ratio of 1:20. To resolve the significant thrust demands, 5 – 1.2 m diameter augured concrete piles were cast 10.0 m deep at each abutment. Tapered weathering steel “haunches” were anchored to the abutments both to add stiffness and to protect the timber from the river. The most challenging aspect of slender bridge design is vibration performance; it was difficult to accurately predict the natural frequencies, and they were close together, even compounding each other. A customized central Tuned Mass Damper (TMD) was used, consisting of a simple mass of steel plates on a carriage suspended from cables stretched to four points on the glulam girders. The TMD was adjusted to tune it to both walking (1.9 Hz 1st vertical) and jogging (2.4 Hz 1st torsional) frequencies. In the first case the mass moves vertically, and in the other it moves laterally, efficiently suppressing the large accelerations experienced initially in both modes. Ultimately, the structure remains as a somewhat “lively” bridge, but comfortable for most users.

The challenging design constraints set forth by The Town of Banff led to a truly ‘first of its kind’ structure, and as a result, a pedestrian crossing shown in the Town’s master plan from nearly 110-years ago became a reality. The new footbridge crossing is now prized as a beautiful accent in this most picturesque setting and is a popular connector for both townsfolk and tourists. The bridge has received several international awards for engineering innovation, including the Supreme Award from the Institution of Structural Engineers.

Footbridge Riviera in Brno

48 New city promenade

The footbridge was built in the city of Brno, Czechia, and connects the Riviera outdoor swimming pool and the adjacent Brno exhibition grounds, where the main obstacle is the newly built large city ring road. The total length of the footbridge is 284 m, including access walkways. The superstructure is guided among treetops and carefully placed in surrounding space.

Keywords: promenade; spine beam; double curved; concrete hinge.

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Double curved

The superstructure consists of a prestressed concrete spine beam with a height of 0.9 – 1.7 m, which is supplemented by transverse ribs as a bearing element in the transverse direction. The longest span is situated across the city ring road with 47 m length. The width of the superstructure is 6.7 m and the footbridge thus creates a generous connection with the main Brno recreational area. The horizontal alignment of the footbridge respects the complex terrain and thus creates smooth curves of the structure with a small radius of curvature. The superstructure is supported on central slender piers with a one-way concrete hinge that resists all torsion actions. At the further piers near abutments, the pot bearings are designed. The footbridge is prepared for future development that will incorporate a junction at the footbridge walkway for a new path from an aerial tramway station.

Special attention was paid to lighting of the walkway that is incorporated into the handrail and additional LED stripes are installed underneath the superstructure that can change RGB color.

Way to exhibition area

Double curved spine beam

Oslo, Norway

The Culture Bridges in timber and stone

Lilleakerbyen Bridges: Three complimentary spans

49 **Summary**

Lilleakerbyen is a district on the west side of Oslo that straddles the Lysaker river. Over the next decade the area will transform into a vibrant and sustainable neighbourhood where people can work, live and relax. The redevelopment includes new bridges over the river to connect the community and embrace this natural asset. Through an international design competition a team of COWI and Moxon designed three distinct bridges that were all selected by developer Mustad Eiendom.

Keywords: Footbridge; Oslo; timber; stone; steel; sustainability; fabrication; context

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Each bridge responds to unique structural and functional demands while meeting the challenges of its specific site. The family of bridges feature distinct materials: timber, stone and steel, that address requirements while bringing innovation, identity and connectivity to this emerging district.

The first two bridges in the series, known as the Culture Bridges, lie at the heart of the new masterplan, midway between two waterfalls, where the riverbanks are steep and rich in vegetation. The crossings will serve to connect the district's main cultural hubs, responding to both their role as vital links within the new neighbourhood, which will span both sides of the Lysaker river, and the natural features around them.

The northernmost Culture Bridge is a straight timber span of 40 m, elevated above the riverbank with landings at varying heights. The use of timber as the load-bearing structure Is designed to reduce weight, foundation requirements, and environmental impact.

The southernmost Culture Bridge, nestled deep within the river valley, reads as an extension of the natural landscape in materiality and form. The primary structure is an assembly of regionally sourced stone blocks strung together to form shallow arching beams, offering a contemporary design in a timeless material.

The Cycle Bridge follows a dynamic S-shaped trajectory, providing an accessible gradient to connect two banks that are over 4 m different in height. The meandering path provides cyclists and pedestrians with shifting perspectives of the river, encouraging users to engage with the natural surroundings.

The Cycle Bridge in Stainless Steel

Italian Bridge over the River Plessur

50 Bicycle and Pedestrian Bridge

The new bicycle and pedestrian bridge over the river Plessur relieves traffic congestion in the Welschdoerfli street and provides better access to the old town of Chur for non-motorized traffic. The superstructure of the bridge consists of the S-shaped curved bridge girder and the arch that spans diagonally above the bridge deck. The roadway girder is supported by inclined suspender ropes, which are attached to the arch and the laterally protruding corbels. The overhang of the corbels is variable, so that a sufficient clearance height is ensured at every suspender rope. The result is an extremely slender and filigree bridge structure.

Keywords: arch bridge, steel bridge, integral bridge, curved bridge, micropiles, deep foundation, bicycle and pedestrian bridge, inner-city structure, suspender ropes

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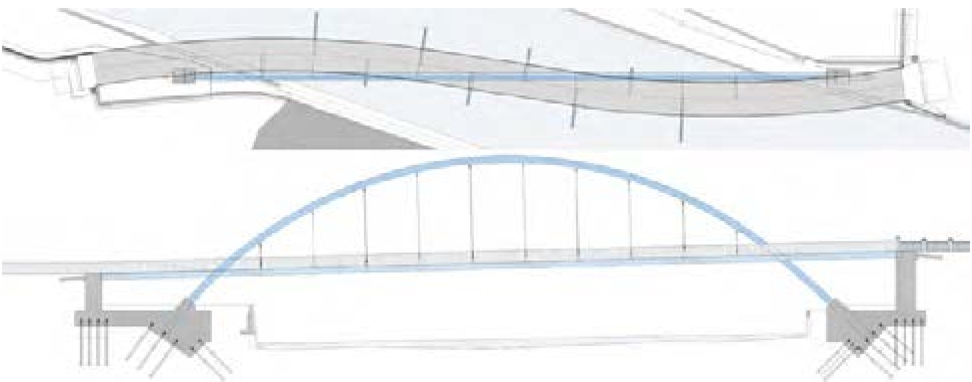
Structural concept and design

The roadway girder with a total length of 77 m and a usable width of 3 m is supported by a total of 10 ropes. In the middle of the span, the arch protrudes 9.5 m above the roadway, where the arch has a span of 62 m and a total arch rise of 14 m. Both the arch and the roadway girder have a triangular cross-section, with a side length of the equilateral arch cross-section of 70 cm and a cross-section height of the bridge girder of just 50 cm. The present bridge concept was determined as the winning project in the context of a project competition, that combines both urban planning and design aspects in a convincing solution.

A total of 175 tons of structural steel were used, of which 70 tons were used for the arch and 105 tons for the roadway girder. For the abutment structures, a total of 430 m^3 of reinforced concrete was casted and micropiles with a total length of 540 m had to be drilled. Both the arch and the bridge girder are monolithically connected to the abutment structures, so that no expansion joints and bridge bearings are required. The assembly concept was adapted to the available mobile cranes on the one hand and to the local conditions on the other hand, in particular the limited space available and the proximity to the Rhaetian Railway.



Plan view and longitudinal section of the bridge

The Curved Ribbon © DR. SCHÜTZ INGENIEURE

Curved ribbon in Speyer New Pedestrian and Cycle Bridge „Am Priester-seminar“ in Speyer

51 A New Bridge in Speyer-South

The new bridge in Speyer-South enhances connectivity between neighborhoods within the “Social City” development area and provides a safe, barrier-free link to the city center. Designed as a flowing, sculptural band, it integrates seamlessly into its surroundings, offering effective noise protection and a strong architectural identity. With its elegant curvature, two-tone railings, and integrated lighting, the structure sets a landmark for sustainable urban mobility and contemporary bridge design.

Keywords: pedestrian bridge, urban design, Speyer, bike path, integral structure, curved form, LED lighting, barrier-free, concrete, railing, sustainability, low maintenance, noise reduction, aesthetics, infrastructure

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Speyer's New Pedestrian and Bicycle Bridge: Enhancing Connectivity with Elegant, Sustainable Design

In June 2023, the city of Speyer completed a barrier-free pedestrian and bicycle bridge over the heavily trafficked B39, connecting the new "Am Priesterseminar" development and the Vogelgesang district with the city center. As part of the "Social City Speyer-South" urban development program, the bridge strengthens internal connectivity and urban integration. It spans the highway as a curved concrete band, embedded in green strips that enhance its noise-reducing function through closed side walls.

The arch-shaped structure conveys both lightness and solidity, making a bold yet subtle architectural statement. Minimalist design elements, railing bars without posts, and a two-tone color scheme reinforce the concept of a flowing ribbon.

Curved ribbon in the Darkness © Landry

Integrated linear LED lighting highlights the dynamic form even at night. Built as an integral reinforced concrete structure with low construction height, the bridge allows for gentle ramp gradients of under 4% in accordance with DIN 18024. It is low-maintenance, sustainable, and meets high aesthetic and functional standards.

With a clear span of over 11.60 m, a width of 3.50 m (expanding to 4.00 m in curves), and seamless alignment, it links existing and planned cycling and pedestrian routes – functional, safe, and visually

Shanghai, China

Tianli Bridge. View from the NW

This is (not) a bridge, it is a stage on a tripod

52 The paper explores how site-specific conditions can inspire the adaptation of generic structural models into context-sensitive forms. Our Tianli Pedestrian Bridge project over the Diangpu River in Shanghai exemplifies this approach. The site presents complex constraints: Jiahe Park lies to the northeast, elevated rail lines and the future Meilong Highway to the northwest, and a layered urban development on the southwest, formerly a cemetery, comprising landscape areas (DLC), office buildings (Jacques Ferrier Architecture), commercial spaces, and a cultural center (Tadao Ando).

Keywords: Interdisciplinarity, contextual design, urban landscape, spatial experience, stainless steel, Shanghai.

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Although a pedestrian path will be integrated into Meilong Highway, a flow analysis revealed significant limitations: congestion along narrow sidewalks, circulation conflicts near the office tower, and disconnection between green spaces. These conditions led to the tripod scheme: three arms converging at a central elevated plaza over the river.

Beyond resolving circulation, the bridge creates a civic space offering views and engagement with the surroundings. The design develops from the plaza through key stages: attractor locations, access levels, structural geometry, materiality, and landscape integration. Although construction is on hold, the project illustrates a method for designing small-scale footbridges where contextual factors (pedestrian flow, views, materials, and light) are as vital as structural demands in shaping spatial experience.

Some general views of the footbridge

Footbridge over the highway / Ticino River

53 Context

The municipalities of Gorduno and Arbedo-Castione, located north of the city of Bellinzona (acknowledged as UNESCO World Heritage Sites), are separated by the A2 highway and the Ticino River. Situated at the foothills of the Alps, the Ticino flows through the lower Leventina Valley before reaching Lake "Maggiore".
In this section, the river is channelized and passes through a landscape characterized by a rich variety of vegetation, designated for recreational and sports activities.

Keywords: footbridge, aesthetic, conceptual design, landscape, landmark, lighting

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Brief Description

The commissioning authority aimed to create a visually appealing and functional structure spanning the highway and the extensive conservation and settlement area of the Parco Golenale, located at the confluence of the Ticino and Moesa rivers.

The proposal to situate a footbridge connecting the towns of Gorduno and Arbedo-Castione, near the SBB intermodal hub in Castione, originated from our design studio. Encouraged by strong community support, the municipality opted to forgo a public design competition and directly commissioned the project to Masotti & Associati SA.

The structure is fully integrated into the surrounding landscape and includes the redesign of pedestrian pathways within the floodplain area. The overall objective is to enhance the appeal of non-motorized transport, both for recreational use and for everyday mobility needs (i.e., home, school, work).

The considerable span of 270 meters, combined with various constraints (technical, environmental, and economic), led to the development of a restrained and efficient structure made of weathering steel. The design features clean, functional lines that meet the diverse project requirements. The need to provide direct access from the walkway to the lower floodplain area is addressed through a structural concept based on a trestle configuration with two parallel box girders.

Wrocław, Poland

Examples of damage to pedestrian bridges: span displacement from supports – the bridge deck lies in the river. Right photo: uncontrolled settlement of a pier due to scouring of the riverbed.

Building Footbridges over Flood-prone rivers

54 How to build pedestrian footbridges over mountain rivers prone to dynamic flood phenomena

In September 2024, a massive flood occurred in the southern part of Poland. The flood wave devastated many mountainous areas, damaging buildings and transportation infrastructure. Over 11,000 buildings and several hundred bridges were destroyed or damaged. Pedestrian footbridges were particularly vulnerable to the flood waves due to their very low transverse stiffness.

Keywords: damages, flood, footbridges, design.

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This paper presents the fundamental mechanisms behind the destruction of such structures and proposes guidelines for designing pedestrian footbridges and bridges in mountainous areas prone to dynamic flood phenomena. The pictures below (Fig. 1) show some of many examples of typical damage forms.

Examples of damage to pedestrian bridges: uncontrolled settlement of a pier due to scouring of the riverbed.

Crossing along the bank of the Thames

Dukes Meadows Footbridge: A light touch link along the Thames

55 Summary

Dukes Meadows Footbridge is a new pedestrian bridge in Chiswick, West London, positioned beneath the Grade II listed Barnes Bridge. It joins two previously disconnected sections of the Thames Path encouraging recreation and sustainable modes of travel.

Keywords: footbridge; Thames; tidal; truss; steel; sustainability; fabrication; context

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The distinct alignment, span configuration and consequent structural form directly respond to complex geometric constraints. The result is an elegantly efficient structure that sits comfortably below Joseph Locke's historic Barnes Bridge. This bridge is very much 'part of its surroundings', expressing a connection between context and bridge. The design challenges it overcame include: a wide tidal range exacerbated by frequent flooding, close proximity to a nature reserve, live railway and listed structure and competing stakeholder requirements.

A light touch approach to the sensitive site supported a 'vision of sustainability' encompassing both longevity and climate resilience. During the prolonged design stage of this bridge, the way we considered carbon in our structures evolved significantly. It was an early example of carbon benchmarking at key milestones, using methods designed specifically for this project that are becoming industry standard. This process reduced the bridge's carbon footprint while influencing future designs by the team and their peers.

A much-needed connection

Lohmar, Germany

Block girder bridge 'Wehrweide' by Peter Bergmann

A new generation of timber bridges in Europe

56 Summary

The transport sector significantly contributes to global CO_2 emissions. To combat this, measures like promoting cycling and pedestrian traffic are being implemented worldwide. One effective strategy is improving cycling paths, often involving the requirement of bridges. Using modern timber constructions for these bridges is supplementing sustainable way to further reduce CO_2 emissions.

Three European projects highlight this: pedestrian and cycling bridges in Frankenberg (Eder), a bridge over a highway for the 2024 Paris Olympics, and a railway station bridge in Zwolle, Netherlands.

Keywords: timber bridge, block laminated glulam beams, wooden design, bloc girder, hybrid structure, concrete slabs, stepped cross section, spruce and Douglas glulam, sustainability, living bridge, protected timber, Passerelle le bourget Paris, Passerelle Zwolle, Brücke Frankenberg

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New cycling bridges in Frankenberg (Eder), Germany

As part of the comprehensive modernization program "Frankenberg 2020," the 60-meter-long block girder bridge "Wehrweide" represents the central element of the new cycling traffic concept and was the initial spark for an entire family of bridges. As a hub of the new attractive cycling traffic axis, it creates – now completed by the two sister bridges "Ederdorf" and "Wildpark" of the same construction type – short, safe, and nature-oriented connections between living, working, and leisure.

New cycling and pedestrian bridge in Paris, France for the Olympic games 2024

Following a successful competition entry with our French partners Exploration Architecture and AIA Life designers for a "Design and build" project of a bicycle and pedestrian bridge for the Paris 2024 Olympics, this bridge has been realized as part of infrastructure improvements in 2023 and 2024. Spanning the French A1 highway, the bridge connects the Media Village and Sports Complex in Le Bourget. It is based on a simple and cost-effective but iconic design that ensures durability and low maintenance due to thoughtful structural wood protection.

An elevated street for the train station Zwolle in the Netherlands

The "Passerelle" in the Dutch city of Zwolle is one of the largest European timber bridges. Designed as an elevated street the bridge features a deck area of over 1,200 m^2 and has a park-like layout combining greenery with paved walkways and recreational areas. The main structure consists of four parallel glue laminated timber beams, which support the cross-laminated timber decking that is protected by redundant waterproofing layers. All exposed components are made of steel or concrete to ensure a lifespan exceeding 100 years in an urban setting.


Passerelle le Bourget/Paris (FR) by Michel Denance


Passerelle Zwolle (NL) by Tobias Tebbel

Hampton Footbridge, COWI / Moxon

Low-embodied carbon Footbridges

57 Decarbonising guidance and principles

Foot and cycle bridges help to reduce greenhouse gas emissions from surface transport, and contribute health, economic and safety benefits. The transition to a low-carbon economy requires designers to also understand and reduce their embodied carbon. The best practice guidance sets out the carbon reduction hierarchy: build nothing > build less > build clever > build efficiently. The Net Zero Bridges Group was formed to help bridge designers understand how these principles can be applied to their work. It evaluates carbon data, gives guidance on carbon calculation, and defines low carbon benchmarks.

Keywords: Sustainability; active travel; embodied carbon; Net Zero; decarbonisation.

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Build nothing / build less

The circular economy promotes preservation, reuse and refurbishment ahead of recycling: this is "building nothing". Reuse maximises value while minimising embodied carbon, as with the High Line in New York. Examples of component reuse include the wind turbine blade girders of "BladeBridge", reuse of surplus steel sections, and designing for future reuse, such as removable piles. Building less can include reducing the extent of a bridge, or optimising its use of materials, as in efficient designs such as Hampton Footbridge and Bracklinn Falls Footbridge. Lightweight, efficient designs also lead to savings in substructure volume, cost and embodied carbon.

Build clever / build efficiently

There are hard limits to the emissions reductions this can achieve. Recent projects such as the Lower Thames Crossing low-carbon footbridge design competition show a need to "build clever" or "build efficiently", adopting high-performance and/or lower embodied carbon materials. Although there are options for lower-carbon steel and concrete, timber bridges, such as Parkufersteg; advanced composite bridges; and new stone bridges may offer radically reduced embodied carbon. Pioneering footbridges act as a lower-risk test-bed where new technologies can be introduced prior to wider and more impactful adoption.

Bracklinn Falls, Cake Engineering / BEAM Architects

Parkufersteg, Miebach / Moxon

Of Dykes and Bridges – A tribute to the archetypal Dutch dyke

58 Three bridges in Hoorn

This paper explores the challenges of designing three bridges in Hoorn, NL, by Ney & Partners. These are not bridges in the classical sense, but rather “land art” that bridge the gap between the historical Friese Omring Dyke and the 21st-century Oever Dyke at the modern waterfront. In doing so, they mark the transition between the old and the new, with the sharp lines of the historical dyke inspiring the design, while the Oever Dyke represents contemporary engineering principles. The bridges blend naturally into the landscape as if they have always been there.

Keywords: historical context; landscape design; land-art; user experience; nature inclusive design; in-situ concrete shell

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The inverse dyke

At the heart of the design lies an inversion of the classic dyke profile, resulting in an "inverse dyke": a walled passage cantilevering from the Oever Dyke dunes and hovering close to the historical Friese Omring Dyke. This spatial gesture reinterprets the landscape and offers a tactile, immersive experience. Steel grating panels form the pavement between bridge and dyke, subtly detaching the structure from the land. This separation turns the transition from past to present into a tangible experience, reinforcing the site's cultural and historical significance.

The bridges are cast in in-situ concrete with a shell-shaped form that ensures stiffness and structural efficiency. This typology creates a recognisable family of bridges with adaptable dimensions. Several challenges were overcome with innovative solutions, including 'Federlamelle' bearings, self-compacting concrete, and an integrated drainage-retention layer. The robust concrete walls require no maintenance and feature a coarse wooden texture that helps the bridge blend into the landscape. Inside the shell, a boardwalk, native vegetation, and rustic fencing complete the setting, anchoring the bridges gently into the landscape.

Ultimately, these bridges demonstrate how engineering can engage with heritage and landscape, while providing contemporary solutions for urban mobility and public engagement.

Re:Crete footbridge made of reused cut concrete blocks (© SXL).

Reuse in Footbridge design

59 Challenges and opportunities

The construction sector faces growing pressure to reduce environmental impacts, particularly from material-intensive structures like bridges. While circular strategies such as reuse have gained traction in building design, they remain under-explored in bridge engineering. This paper investigates the potential of reuse in footbridge design, presenting a typology of reuse strategies and discussing the associated opportunities, challenges, and environmental impact through conceptual and built examples.

Keywords: reuse, circular economy, design, life cycle assessment, steel, concrete

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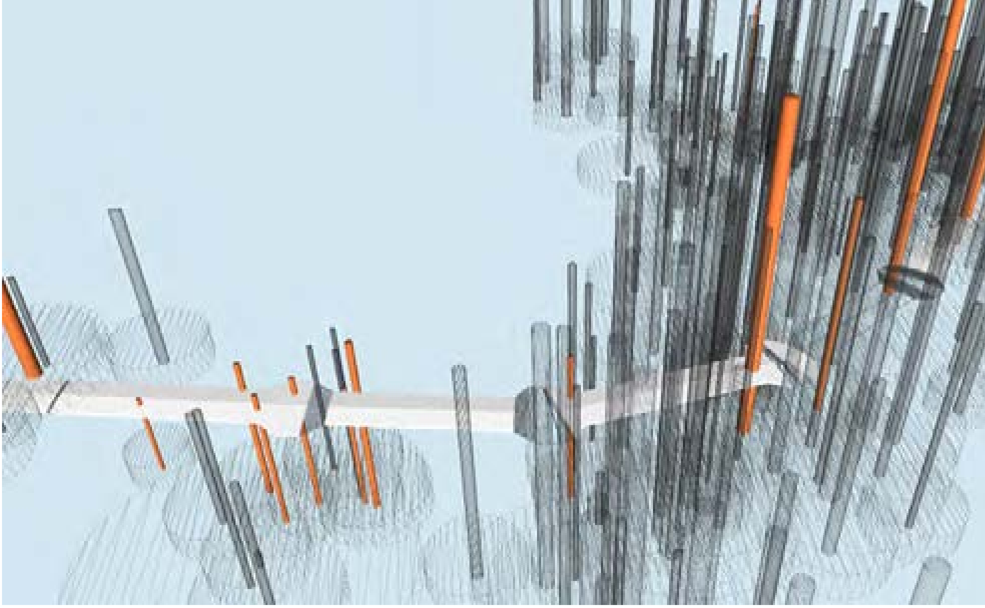
Reuse of bridges and structural components

The Lucie Bréard footbridge in Saint-Denis demonstrates how a 20-year-old steel swing bridge was successfully repurposed as a pedestrian and cycling bridge. By reusing the main span and adapting its structural system, the project achieved a 50 % reduction in embodied carbon compared to a new crossing. Similarly, the Re:Crete footbridge in Switzerland was built using cut concrete blocks from a demolished building. Its geometry, based on a compression-only arch and internal post-tensioning, enabled a structurally efficient design with minimal material intervention. Compared to conventional alternatives in concrete and steel, it achieved a 65 – 80 % reduction in embodied emissions. These and other reviewed examples illustrate the practical and environmental potential of reuse. At the same time the review shows that many structures are dismantled after only 10 to 20 years of use, well below their intended service lives. This calls for a design culture that anticipates future reuse and enables disassembly. Beyond performance and aesthetics, footbridge design must now also respond to material circularity and carbon targets.

Lucie Bréard footbridge, rotation of the swing bridge © Sernavision/Razel-Bec

Lucie Bréard footbridge (© Michel Denancé)



Vancouver, Canada

Forest-Sensitive Footbridges

60 Three Recent Projects From Vancouver's North Shore

This paper explores a 'forest-sensitive' design approach through three recent projects on Vancouver's North Shore: the Casano-Loutet Pedestrian and Bicycle Overpass, Spirit Trail Lynn Creek Crossing, and Spirit Trail McCartney Creek Crossing. We trace our journey from viewing trees as obstacles to embracing them as design generators. Empathetic digital tools responses to forest complexity with greater precision. Our approach reveals how contextual constraints can become sources of engineering elegance, resulting in footbridges that respect their surroundings while creating meaningful connections to place.

Keywords: Forest-sensitive design; biophilic design; context-driven design; digital tools; LiDAR; point clouds; visualization; place-making; user experience; design thinking

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Casano-Loutet Pedestrian and Bicycle Overpass

Currently under construction, this 78-meter composite box girder bridge carries a multi-use path across the Trans-Canada Highway. The north approach loops around a century-old western redcedar's 18-meter critical root zone, illustrating how a single significant tree can generate both pathway alignment and structural form decisions.

Spirit Trail Lynn Creek Crossing

Completed in 2023, this 52-meter steel tied arch connects two parks with minimal environmental impact. High-definition LiDAR scanning located hundreds of trees along approach pathways, while strategic design choices – weathering steel arches below the forest canopy, specialized lighting and drainage – protect the creek's sensitive salmon habitat.

Casano-Loutet overpass approach curves around a significant western redcedar tree

Spirit Trail McCartney Creek Crossing

In conceptual design, this project represents our most advanced forest-sensitive approach. Pre-concept terrestrial LiDAR scans created a digital "sandbox" for exploring structural options while evaluating forest sensitivity through automated clash detection. Construction methodology became central to concept development, with digital modeling enabling nuanced evaluation of design tradeoffs in this densely forested ravine.

Spirit Trail Lynn Creek Crossing's weathering steel arch nestles below the forest canopy

Vila Real, Portugal

Footbridge for rehabilitation of a city center

61 Over a steep river gorge

The old city centre is not alongside the vibrant streets leading to the University because a deep gorge separates the old quarter from the new city. The old city developed between the gorges of two rivers merging at the tip of a promontory, and the resulting “cul-de-sac” became little more than a lovers meeting place. It’s great to have such a place, but proximity to the University and to the new city needs to be established, bringing pedestrians to the old city and encouraging sustainable mobility. Rocky slopes provide favourable conditions for an arch bridge, smartly inverting the geometry of the arch formed by the slopes and the river below.

Keywords: urban rehabilitation, sustainable mobility; landscape observation; form dramatization

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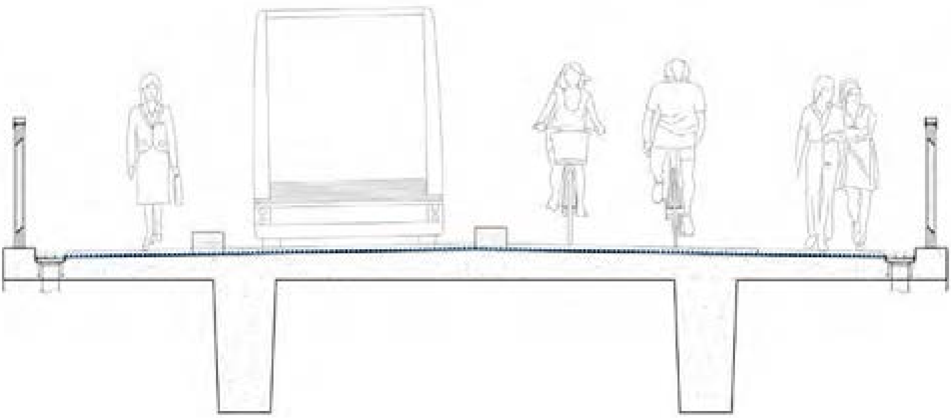
The bridge

The structural solution is the result of the confluence of a variety of factors: distance to cover and possibility of intermediate support, loads to be supported, structural materials to be considered, free widths and heights to be satisfied, local geology and construction process to be adopted in view of the local access conditions.

The bridge deck is at a height of about 75 m above the waters of the Corgo River, and the slopes of the gorge are rocky and very steep. The arched structural solution is the most suitable, certainly from the point of view of integration into the landscape and less disturbance to nature. An arch spanning 230 m and 40.2 m high supports 6 columns which, together with other 5 columns on the slopes, sustain a deck 339 m long.

The depth of the gorge is impressive and is dramatized by the inclination of columns, causing a feeling of vertigo which, however, is counterbalanced by the secondary segmented arches formed by each pair of columns and deck.

The deck is practically horizontal and contains two lateral sidewalks 1.5 m wide each, one cycling path 2.1 m wide and one 2.4 m wide path for a back and forth small and sustainable electric mobility vehicle. This footbridge may well become a landmark in the rehabilitation of the ancient and admirable city of Vila Real.



Cross-section of the bridge deck

Luebeck, Germany

Elevation view to the north

Stadtgrabenbrücke Lübeck

62 A new bridge for the historic city centre of Lübeck

As the capital of the Hanseatic League, Lübeck was one of the most important cities in northern Europe in the 13th and 14th centuries, and thus Lübeck's old town has been a UNESCO World Heritage Site since 1987. The bridge was commissioned in 2021, in order to relieve the existing entrances to the old town peninsula. In order to preserve the protected view of the old town, a sensitively fitting city footbridge was created in the nature conservation area of the moat. The structure therefore symbolises a link between the future and the past which, due to its central location, will be used by tourists and residents alike.

Keywords: smart integration; minimalistic elevation; new materials; structural concepts; mixed use; accessible design; aesthetics; cityscape; UNESCO World Heritage Site; nature reserve;

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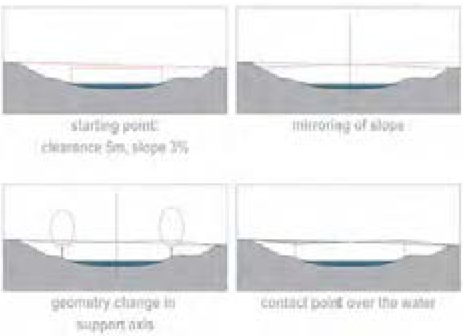
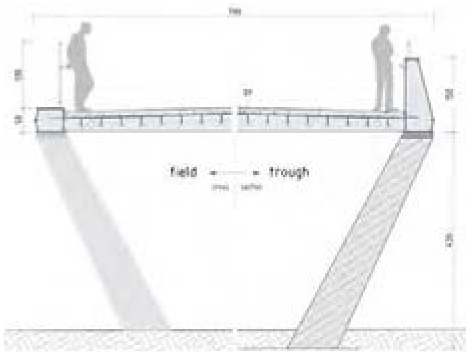
Urban design and construction

The Bridge spans the city moat on the way from the main railway station to the peninsula of the old town of Lübeck. Under the strict conditions of a minimum 5 m clearance above water, a gradient of 3 % towards the old town island ensures accessibility. The total length of the integral three-span structure is 65.9 m, with a central span of 35.9 m and a slenderness of L/72. The main supporting structure consists of two external box girders, which are haunched below deck at one end of the central span and form a trough together with the deck above the other intermediate support. The bridge deck has a generous width of 6.5 m between railings and is designed for pedestrian and bicycle traffic. It comprises an ortho-composite slab supported by a regular arrangement of cross-beams.

Due to the carbon fiber-reinforced composite rods, a concrete slab thickness of just 12 cm is sufficient and high-maintenance waterproofing is not required. The monolithic connection between supports on either side of the bridge using steel plates and the clamped steel girders in the abutments eliminate the need for expensive bearings. The steel structure itself is permanently protected against corrosion by thermal zinc-spraying. The Stadtgrabenbrücke thus meets all the modern requirements in terms of statics, durability and low maintenance.



Derivation of geometry



Cross sections

Mobile Bridge Berlin Plötzensee, 2022

63 A minimalistic kinematic approach

The bridge connects two parts of an extensive prison area (JVA Plötzensee and JVA Charlottenburg in Berlin). It allows for the save and barrier-free transfer of inmates from one building to the other. As the bridge would conflict with over-height transport events on the street below it was required to be partly moveable. The program requested an increase of clearance height above the street from 5,5 m to 9.0 m on a width of around 7m. The operation would occur only a few times per year, so the mechanism should be low-tech, low-maintenance and easy to operate for unskilled staff. The design process led to the insight: no need for a lifting bridge, it would suffice to raise the floor! This led to a considerable (and competition-winning) reduction of structural weight, moving mass, mechanical parts and electric power.

Keywords: Footbridge, enclosed, covered, lifting bridge, mobile, movable, foldable, steel

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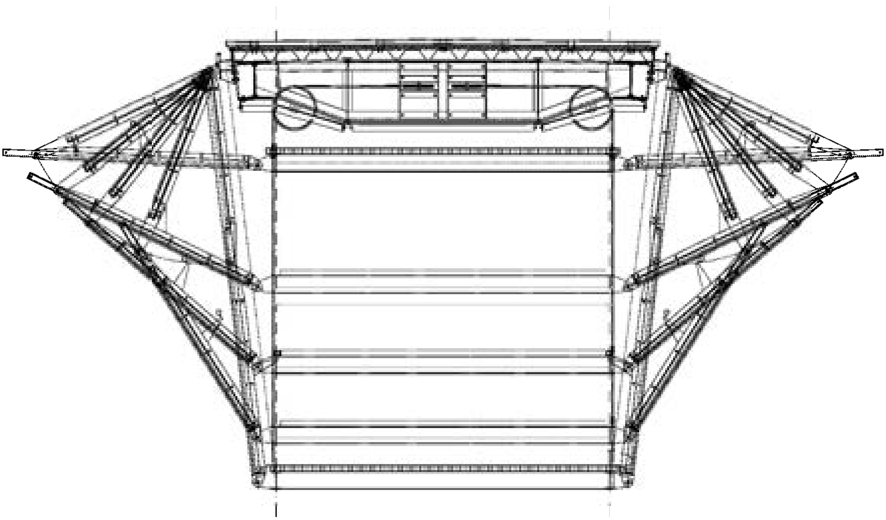
Structure and mechanics

This design feature allows for the upper chord of the primary structure, to remain fixedly in place across the entire length of the bridge – without roof joints, nor movement joints. Only a small portion of the structure and about 5 % of the total weight is moved, which not only greatly simplifies the lifting technology but also gives the bridge a lightness unparalleled among mobile bridges.

The four-chord truss with a total length of 56 m has a central span above the street, that works primarily via cantilever from either side (negative moments above the supports). Only the top chord (HEB340) runs across the 9 m wide central opening, taking some positive bending moment.

For the lifting technology, a simple and robust solution was chosen: when the deck is raised, the façade folds outward via triple hinges of the inclined hangers. This folding process is passive; the kinematics are fully defined by the position of the hinges, by rotation stops and the inclination of the façade (the dead weight pushes slightly outward) thus eliminating the possibility of snap-through or blockage at the lower dead center. The lightweight deck is lifted simply at its four corners with electric winches.



Colorado Springs, CO, USA

Park Union Bridge

64 Designed by Diller Scofidio + Renfro in collaboration with Engineer of Record, Arup, the Park Union Bridge opened to pedestrians in July 2021. Connecting the U.S. Olympic and Paralympic Museum (USOPM) to America the Beautiful Park and a bucolic 25.8-kilometer pedestrian and cycling greenway, the bridge leaps 76 meters over 13 active train tracks. The superstructure comprises a unique “rip curl” geometry, dubbed for its cresting design. The bridge’s stressed skin structure simultaneously acts an arch and a truss. Forming an asymmetrical portal, the Park Union Bridge frames views in both directions.

Keywords: 3D modelling; aesthetics; minimized impact; steelwork; innovation; offsite fabrication; community investment; new landmark; masterplan; connection

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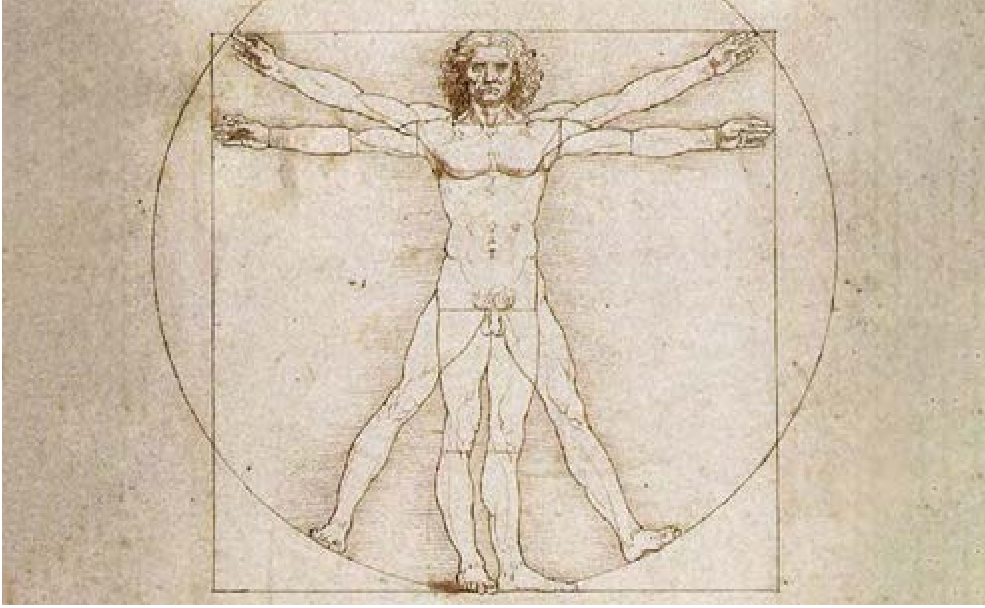
From bridge inception, the design team leveraged their parametric 3D work environment to communicate visually and explain crucial aspects of the bridge behavior among themselves and with key collaborators. The team collaboratively massed, rationalized, and managed the steelwork 3D model in Rhino with a Grasshopper parametric plug in. All analysis was completed in Oasys GSA, which linked parametrically to the 3D steelwork model. The view inside the bridge demonstrates the close relationship between architecture and bridge engineering.

The Park Union Bridge was a significant investment for this area and was financed by a combination of bonds from the City of Colorado Springs and private donations. A testament to the generosity and advocacy of the people of Colorado Springs, the bridge serves as both a destination and a critical connection.

Welcoming a national and international audience, the Park Union Bridge, integral to the USOPM, demonstrates how midsize American cities can combine new and existing assets to resuscitate a struggling downtown core. The structure is an outstanding achievement in bridge design and engineering, producing an icon for the City of Colorado Springs that unifies their Southwest Downtown masterplan.

London, UK



When Theory becomes Form: Moving on From Modular Man

65 Critical learning for change

With this paper we look to the past to alter behaviours for more inclusive outputs, to inspire collective and shared techniques for a common and critical purpose, and to find optimism.

The case for making connections is well understood; fostering links between communities and providing protected places for all, wildlife included. These connections become catalysts for education, economic growth, employment opportunities and social benefit. But are we designing with outdated requirements, established from silos of information, with a restricted view of the impact and the purpose? If so, are we as an industry doing all we can?

Keywords: Adaptation, regenerative, networks, social benefit, theory, optimism, efficiency, innovation, inclusive

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Blind spots and pioneers

While recognising the significant achievements and pioneering influence of theorists and designers before us, we will identify blind spots in current thinking and the limitations they have in our current world. With good humour and relevance to our 2025 venue, we look to Le Corbusier for learnings. His Modular Man (like Leonardo di Vinci's Vitruvian Man) sought to find beauty, purity and efficiencies that would guide design for better outcomes.

Healthy interrogation and interpretation

Critical learning from the past is key to moving forward. Having interrogated the Modular Man – the title speaks for itself in limitation – we aim to build on that vision and suggest new techniques and tools. These tools should enable truly regenerative thinking with solutions that empower all people, protect our fragile ecology, and adopt a highly respectful and integrated touch.

Modular Man, Le Corbusier on the Unité d'Habitation of Berlin, 1958

Bedburg Castle Park Footbridges, Germany

66 **"Senseful integration"**

The town of Bedburg is located in the Rhineland at about 40 km west of Cologne, in the North Rhine-Westphalia Region of Germany. Its "castle park", in the city historical centre, provides a beautiful small urban forest to walk, cycle or stroll along the meander of the Erft River that needs to be further connected to the old city hall area and its local castle and church. In the international competition to design two small pedestrian and cycling bridges in the "Schlosspark," our structural engineers and architects team combined its creativity to propose the original winning solution. The design is currently moving into the detailed planning phase, with construction expected to begin in the summer of 2025. This paper will provide an in-depth look at the design essence and its development.

Keywords: Footbridges within historical and natural landscape, architecture and structure integration, Delicacy, simplicity and allure, peace and nature, sense of place, time and light, moiré effect, Corten steel

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Small cities and landscape parks also deserve beautiful bridges...

The two bridges, of a similar design, are intended to create new path connections to opening up the castle park landscape towards Bedburg city centre and the old City Hall. Two very particular places, almost lost in a peaceful forest park, with waters meandering like a couple in love, are the setting for two small bridges for pedestrians and cyclists. The romantic ambiance calls for bridges of utmost simplicity, with a silk-like structure that ensures attention remains on the surroundings. Subtle details invite gentle, thought-provoking reflections, enhancing the tranquil and intimate atmosphere. They establish new precious links, offering expressive spaces with a quality of experience. The use of corten steel reinforces the identity of the landscape and historical site by echoing the local brick colours and patterns. The distinctive railing pattern and the slender structure of both bridges create a vibrant, seamless experience unified as a single work of art above the water.

Far from trends, the freedom found in being unique and the sense of non-existence when harmonized with the local nature inspired the creation of an “in situ” design for both bridges, as if they were “Geschwister”.

Competition rendering, Light and material study (Rawlight)

Competition rendering, Landscape integration (Rawlight)

Final state of bridge

Footbridge Hirschen – An ultrathin bridge in UHFB

67 As part of the Churerstrasse expansion, a new pedestrian bridge is being built near between Lachen and Altendorf to improve safety for non-motorised traffic. The 60 m long, 3 m wide arch bridge made of UHPC complements the historic Maillart bridges from 1940. Thanks to its lightweight material, it weighs only a third of a conventional concrete bridge, easing transport, assembly, and foundation work. The four prefabricated elements, each weighing 25 t, were installed at night using two cranes. The span over the SBB tracks is 40 m.

Keywords: aesthetics; UHFB; new materials; Robert Maillard; building above the railway

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As part of the expansion project for the Churerstrasse between Altendorf and Lachen, a new pedestrian bridge is being built on the lake side of the existing road overpass at Hirschen. This serves to increase safety for non-motorised traffic.

The new bridge construction has a total length of around 60 metres and a usable width of 3.0 metres. It is being built as a three-hinged arch bridge in the style of the neighbouring twin bridges by Robert Maillart and complements the existing bridge ensemble in a considerate manner. These two separate bridges were built in 1940 as his last bridges. Due to excessive subsidence, they were each connected in 1953 with the help of a tension strip under the tracks and thus stabilised.

The materialisation of the new bridge was intensively examined together with the Canton of Schwyz, the SBB and the monument preservation authorities. UHFB (cement-bonded ultra-high-performance fibre building material) proved to be the ideal choice.

This innovative material consists mainly of fine-grained mineral aggregates (silica dust, quartz sand), cement and steel fibres. When mixed with water and a plasticiser, a concrete-like mass is achieved that enables the production of very thin components. Following the example of R. Maillart from 1940, the intention with this project was also to realise a structure that was as light and material-saving as possible.

The arch over the double track of the SBB with a span of 40 metres must be able to be built within two short night closures of the Zurich–Chur railway line. The bridge was therefore divided into four elements and prefabricated. The four components, each weighing approx. 25 tonnes, were assembled with the help of two mobile cranes in tandem lift.

The lightness of the bridge achieved with the use of UHFB – it weighs only a third of a normal concrete bridge – allows easier transport and assembly and also minimises the foundations in the existing poor subsoil.

View of the suspended pedestrian bridge "Punetta" along the walking direction

"Punetta" bridge over the Hinterrhein River

68 A light and efficient slow traffic bridge

The "Punetta" bridge, affectionately known as the "little bridge" in Rhaeto-Romanic dialect, is an important infrastructure addition for the municipalities of Bonaduz and Domat/Ems and, at over 300 meters long, is not necessarily what you would expect from a "little bridge". The bridge over the Hinterrhein is not only an important connection for local slow traffic, but also expands the local recreation area for both municipalities. It extends the footpaths and cycle paths that connect the surrounding villages and improves the connection to the city of Chur.

Keywords: foot- and cyclebridge; cost-effective; efficient; light; minimal intervention in existing structure; prefabricated; embedding in existing; optimized workflow

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The Punetta Bridge is suspended under the upstream carriageway console of the existing Hinterrhein Bridge (highway bridge). This design resulted in minimal intervention in the existing structure and required only a few minor adjustments to the bridge.

To ensure flood safety, two side ramps were required. These ramps connect the bridge with the existing footpaths and cycle paths. The width of the pedestrian and cycle path between the suspensions is 2.4 meters. The clear height varies from 2.5 meters to around 8 meters.

The bridge is suspended with steel cables that are attached to the underside of the existing bridge deck. The suspension points are spaced 2 meters apart. The walkway surface consists of prefabricated concrete slabs inserted between the steel frames.

The suspended bridge construction offers an efficient, cost-effective solution for a pedestrian and cycle connection. The minimal intervention in the existing infrastructure, combined with the use of prefabricated concrete and steel elements, makes it an innovative and sustainable addition to the region's transportation path connection. The completion of the bridge in winter 2023 represents an important milestone in the development of the region's mobility infrastructure and strengthens its connectivity and tourist appeal.

Side view of the bridge "Punetta" attached to the existing highway bridge deck on the upstream side

The complex structural geometry of Lille Langebro in Copenhagen presented challenges when considering thermal effects.

Rigorous analysis of differential temperature effects in footbridges of complex form

69 Summary

Temperature effects, both uniform and differential, can in many instances be quite important in the design of footbridges, particularly those with complex geometry or that are movable. There are many examples where problems have occurred, yet research in this area is relatively limited. The codified rules are quite crude and difficult to apply to unusual structural forms.

Keywords: Analysis, temperature, thermal effects, first principles, Lille Langebro Copenhagen.

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Approach

An approach based on the application of computational methods has been developed that now allows an envelope of effects to be taken, providing greater confidence that the worst possible conditions have been modelled. This work is carried out in addition to the checks that are made using the simplified rules in the standards. It allows the influence of site conditions and structural geometry to be rigorously modelled.

This paper discusses an evolution of the new approach with reference to project examples including the Lille Langebro swing bridge in Copenhagen and Royal Victoria bascule bridge at Silvertown. It is concluded that some of the uncertainty in structural behaviour can be addressed by use of the new techniques. Recommendations for further development and research are provided.

Waterloo, Canada

Investigated pedestrian bridge

Fatigue Loading Analysis of Pedestrian Bridges at High Volume Transportation Hubs

70 The research presented in this paper focuses on the fatigue analysis of pedestrian bridges under cyclic pedestrian loads. In the presented analytical study, high volume pedestrian load events are simulated, corresponding with the arrival of trains at a busy public transportation hub. Train volumes and arrival frequencies are varied, and the transportation software PTV VISSIM is used along with a bridge influence surface to simulate pedestrian traffic flow and establish the load effect ranges and frequencies needed for fatigue assessment.

Keywords: fatigue loading; traffic simulation; public transportation hubs; pedestrian bridges

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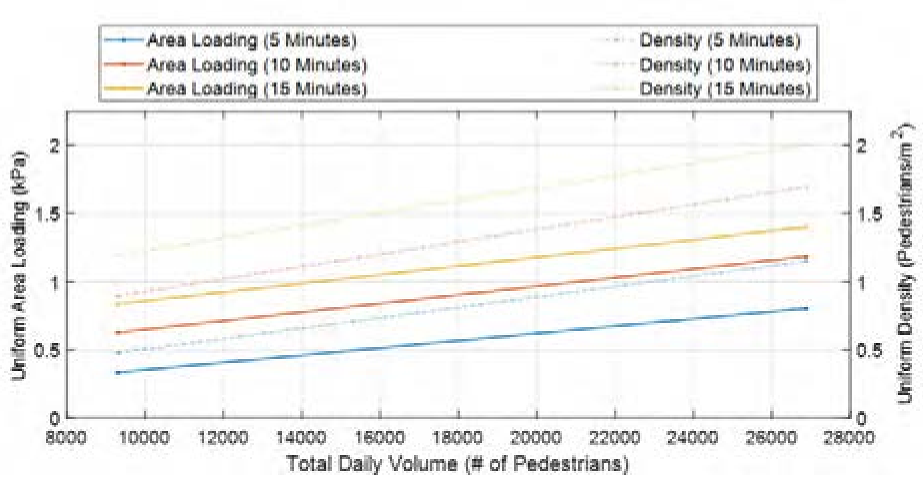
Pedestrian bridges serve as important pieces of infrastructure in urban environments, facilitating the safe movement of people across busy roads and other barriers. With the growth of cities, increase in urban density, and therefore the continuous growth of pedestrian traffic, understanding the structural integrity of pedestrian bridges under the full range of possible loading conditions is of critical importance. In this paper, the fatigue performance of a pedestrian bridge at a high volume transportation hub is assessed. The example used in the study is a train station at the outskirts of Toronto, Canada, which is connected by a pedestrian bridge to a nearby parking facility. Due to traffic volume uncertainty, the Canadian CSA S7-23 pedestrian, cycling, and multiuse bridge design guideline takes the approach of establishing a design stress range below which the fatigue life can be assumed adequate over the service life regardless of traffic volume. The results of this study show that the CSA S7-23 design stress range, which corresponds with a cyclic live load of 0.85 kPa, is on the safe side for the investigated structure. That said, the simulations presented in this paper provide insight into future scenarios where fatigue damage due to pedestrian crowds could be sufficient to warrant closer attention.



Uniform area loadings and densities for investigated bridge

Bridging Heritage and Nature

71 Cycling through the Heath

The wooden bicycle and pedestrian bridge of “Fietsen door de Heide” spans 294 meters and seamlessly integrates into its natural and cultural surroundings. The design harmonizes with the landscape, featuring entrances and exits that blend with the terrain through gentle ramps. Fine-meshed wooden beams and columns pay homage to the region’s mining heritage, evoking the intricate frameworks of historical mining infrastructure. Elevated views from the bridge celebrate the area’s natural beauty, offering users an experiential journey through the heathland. Accommodating both bicycle and pedestrian traffic, the bridge fosters a shared space designed with careful attention to safety and convenience.

Keywords: Bicycle and pedestrian bridge, shared space, Mechelse Heide, environmental harmony, sustainability, wooden construction, prefabrication, mining heritage.

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Sustainable Construction

Sustainability is a cornerstone of the project, utilizing locally sourced, wood species such as preserved softwood for the walls. The bridge deck is made in concrete for added safety. Detailed wood construction optimizes lifespan, minimizing environmental impact and supporting local forestry industries.

Constructing the bridge in the remote and varied topography of Mechelse Heide presented unique challenges. The design features double-curved frames that align with the ground's undulations and spans of 3 meters, except at the intersection with the "Weg naar Zutendaal", where a 15-meter span was necessary. The road was significantly narrowed to both increase safety and reduce the central span, improving feasibility, reducing construction costs and resulting in 50 % of the road area being given back to nature. Additionally, the design minimizes the needed deforestation. Prefabrication of the bridge elements was prioritized to ensure the construction phase on-site could proceed quickly, as we were only allowed to construct the bridge outside of the breeding season. Innovative planning ensured materials were transported and assembled without disrupting the environment.

Integrating Design, Heritage and Sustainability

The bridge's development embraced principles of rehabilitating and transforming existing structures, preserving historical character while adding new cultural significance. By drawing inspiration from the region's mining past and using local materials, the bridge stands as a symbol of continuity and renewal.

The wooden bicycle and pedestrian bridge in Mechelse Heide exemplifies the integration of functional design, cultural heritage, and sustainability. It addresses themes of environmental harmony, user cohabitation, innovative engineering, and the challenges of remote construction. The project showcases interdisciplinary collaboration and problem-solving, offering a relevant case study for future pedestrian and bicycle infrastructure. This bridge highlights how modern infrastructure can respect and enhance its surroundings while meeting contemporary demands.

Huerfanos footbridge – Santiago, Chile

Aspects of the Design and Construction of Chilean Footbridges

72 Chilean Footbridges

As part of intermodal mobility, pedestrian bridges play a fundamental role in urban and interurban connectivity, enabling safe and efficient movement for pedestrians across obstacles such as highways, rivers, or railways. In Chile, their design and construction must comply with a range of technical and regulatory requirements, including structural safety, aesthetics, functionality, and sustainability, as outlined in the Manual de Carreteras.

Keywords: historical; mobility; dynamics; structural concepts; vibration

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Aspects of the Design and Construction

Over the years, various design typologies and material choices have been explored in the construction of Chilean footbridges. From traditional reinforced concrete to the increased use of timber, these choices reflect a growing emphasis on sustainability and adaptability. Furthermore, universal accessibility has become a critical focus, ensuring that footbridges cater to users of all ages and abilities, including those with mobility impairments. This involves the incorporation of features such as gentle slopes, non-slip surfaces, and appropriately designed handrails. Another key consideration in the design of Chilean footbridges is their seismic resilience. Given the country's location along the Pacific Ring of Fire, seismic activity is a constant threat, making robust structural detailing and advanced engineering techniques essential. This paper provides a critical analysis of the historical evolution of Chilean footbridge design and construction, examining how changing priorities, technological advancements, and regulatory updates have influenced their development. Special attention is given to recent innovations, such as the adoption of advanced vibration monitoring systems, which help detect potential structural issues early, thereby extending the lifespan of these vital infrastructures. Additionally, the paper discusses the implications of new slope criteria for accessibility and the challenges of maintaining structural integrity in the face of seismic events.

Sint-Agath-Berchem footbridge, Brussels, Belgium

Bridges deemed impossible

73 Restrictions

Sometimes the need for a new bridge exists, but restrictions in budget or building space apply which make building a bridge seem near to impossible. We find that looking beyond common solutions often leads to unforeseen possibilities.

Keywords: restrictions; budget; environmental vulnerability; spatial integration; bridge design; aesthetics; regulations.

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Solutions

Our paper will take a closer look at several completed bridges that at one point were thought to have never been possible within the restrictions that applied. Projects will include a weathering steel footbridge across the railway tracks at Brussels Sint-Agatha-Berchem station where the client wanted a bicycle bridge but got a footbridge with elevators instead, which was much more suitable for the location.

Another project will look at a different problem, surrounding natural and cultural heritage in Australia. The bridge in Perth over the Swan River goes over Herrison Island, which is of great importance to the local Noongar people. The design is tailored to be effective yet integrated in the landscape.

Other projects will illustrate solutions to a wide range of restrictive situations or regulations. For instance: how we came up with an elegant yet very low budget design by bypassing the process of the formal tender process and designing in close collaboration, closely examining the materials and constructions techniques for cost reductions.

Small freestanding footbridge, Ankeveen, the Netherlands

Brussels, Belgium

Two Footbridges In Tokyo: Case Studies On The Relation Between Form And Structure

74 Two new Footbridges in Tokyo

The paper presents two footbridge projects recently constructed in Tokyo, Japan, with focus on the architectural and technical challenges associated with the structural forms particular to each project.

Keywords: steel bridges, structural concepts, form-finding, seismic design, footbridges in Tokyo

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Toranomon Pedestrian Deck

The first footbridge in Tokyo is located at the newly developed high-rise complex Toranomon and serves as an open plaza, spanning 35 meters in length and 20 meters in width between two buildings. The structure is a simply supported box girder with a folded plate geometry in the bottom flange. The piers, made of multi-faceted non-standard cross sections, are designed for ductile plastic behavior and thus limit the horizontal reactions to the substructure in case of extreme earthquakes, resulting in exceptionally slender columns. The paper discusses the design of the plastic behavior of the, including the physical loading cycle test of the scaled model.

Shiokaze Bridge

The second footbridge, the Shiokaze bridge, is situated in the coastal park in Odaiba, an artificial island in the Tokyo bay, connecting two sides of the park which are separated by the water. In plan, the deck alignment is gently curved towards the seaside to achieve a smooth transition to the primary undulating walkways of the park. The chosen bowstring arch typology is efficient for the 56 meters span length and suitable for the limited clearance under the deck. The form of the arch is determined through form-finding, eliminating unfavourable bending moment due to the geometric variation of the hanger angles. The paper discusses the process of form-finding and its materialization.

The Shiokaze bridge

Footbridge in Vinaroz, Spain © Roland Halbe

Pedestrian-cycle Footbridge in Vinaroz, Spain

75 A bridge that dialogues with the sea

The footbridge that has been recently built in the town of Vinaroz in Castellón, Spain, has a span of 60 m with a 15 cm thick deck. This degree of slenderness has not been achieved by ambition, but as one of the most tangible results of a coherent design and conception process.

The structural system of the new Vinaroz footbridge is a stress ribbon, which gives a very expressive and slender footbridge bridge that is respectful with the beautiful mediterranean surroundings.

Keywords: Footbridge; stress ribbon; steel prestressed; concrete; micropiles; prefabrication, Vinaroz, Vinaròs

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A stress ribbon bridge

Cervol River is about 63 m wide at its mouth and is flanked by a retaining wall at the south side, and by a rock embankment at the north side. The challenge was to propose a solution minimally invasive while respectful with the surroundings. A study of solutions was carried out in which several variables were considered, such as cost, aesthetics, environmental impact, visual impact, urban and landscape integration, constructability and degree of prefabrication. For hydraulic and environmental reasons, the best option was to design a structure without supports in the riverbed, which could be a reasonable approach since the span was not too large.

Finally, a stress ribbon bridge with two asymmetrical spans was chosen as best compromise of all the parameters, with special highlight on the simplicity and low visual impact.

The footbridge has a total length of 84 metres and a span of 60 metres, of which 50 metres correspond to the strict span of the stress ribbon.

The deck is the functional part of the footbridge and it is divided on 3 m for cyclists and 2 m for pedestrians. Users stand on prefabricated reinforced concrete slabs 5.12 m wide, 75 cm long and 12 cm thick. These concrete slabs work as unidirectional beam elements supported on two 700 mm wide, and 30 mm thick high strength steel plates coated for aggressive marine exposure.

As conclusion

Vinaroz footbridge is a infrastructure that is already part of the city image and it was a very well received by the public.

This footbridge is a good example of how a rational method of conception leads to a coherent design, which, in this case is also light, minimalist and integrated.

Footbridge over R1 expressway in Banska Bystrica, Slovakia

76 **Bridges that connect communities**

The footbridge is located at the entrance to the city of Banska Bystrica in the central part of Slovakia. It connects urban areas divided by R1 expressway and the local road junction. The complicated location with many constraints led to the design of a suspended steel structure with a pylon and one-sided suspension. Cyclists and pedestrians use shaped ramps to overcome obstacles and reach the Hron River on the eastern side. The footbridge with spans 13.06 + 24.69 + 22.90 + 76.30 + 22.26 + 24.69 + 13.06 m is fixed in concrete abutments at both ends.

Keywords: urban; aesthetics; structural concept; suspension; integral; steel; dynamics; damping

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Footbridge Concept

The superstructure comprises a steel box girder, which maintains a constant height of 0.75 m. The clear width on the footbridge between the railings is 3.0 m, extending from 3.0 m to 3.5 m in the ramp sections. In the main span, the superstructure is supported along the outer edge by 26 hangers.

The two suspension cables are anchored into the top of the 24.4 m high inclined steel pylon and through the system sockets into the steel superstructure. The pylon is stabilised by two cables that are fixed to concrete blocks with ground anchors 25 m long. Both ramps are supported by three steel piers, which function as hinged columns, and are fixed into the concrete abutment. All elements of the substructure are founded on drilled piles 0.9 m in diameter, which are embedded in a layer of dolomites.

The dynamic calculation incorporated into the design has revealed that the footbridge is sensitive to pedestrian-induced vibrations. To ensure the footbridge can be used comfortably, two custom-made 1000 kg dynamic vibration dampers have been installed in the main span of the structure.

The footbridge's character is enhanced at night through the use of LED spotlights, reflectors and strips. The fundamental constraints of the site have resulted in the design of a logically formed footbridge structure that creates a significant element in the urbanised landscape.

Aerial view

Night view

Completed 106 m Hybrid Bridge, Uganda

Bridging the Unsurmountable in Uganda

77 Cut Connectivity and Context

The result of devastating flooding in 2020 caused by the immensely powerful, topography shifting Mubuku River, two mountain communities in the Kasese District of western Uganda were cut off from each other: Isolating the two communities from education, health, and economic opportunities. The loss of more than a dozen community members' lives (newborns to elderly) also added to the dire situation. The nearest safe crossing became a perilous 2.6 km journey to a bridge that was also damaged by the flooding. The two communities put out a call for assistance to build a safe bridge across the seemingly unsurmountable river with its changing limits.

Keywords: Remote location, long-span, cable-supported, parametric, humanitarian

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A Long Span Solution

Engineers without Borders responded and agreed to partner with HDR to support the communities. A key part of the call to action for the ambitious bridge was engaging footbridge engineers familiar with cable supported trail bridge design and rudimentary construction methods: Critical aspects for a bridge in a remote location and capable of bridging a seemingly unsurmountable river.

This paper will highlight the technical approaches applied to meet the community's vision for a safe and practical footbridge across one of Uganda's most powerful and unpredictable rivers. A solution leveraging a pragmatic design and meeting a very modest construction budget to quickly reconnect two communities. The effectiveness of a broad range of technical approaches necessary to address the challenges of a very remote location, including innovative methods combining simple field survey measurements with state-of-the-art raw satellite data will be presented. Although the final design and detailing of the hybrid suspension-suspended bridge spanning 106 m was based on basic cable-supported fundamentals, the design solution was improved parametric design tools to meet budget and schedule challenges.

This paper is a structural engineer's perspective of the team's journey from concept to completion of the bridge in less than two years: A safe solution for vulnerable communities in a rural and remote area of Uganda that also provided an enriched experience for all those involved in the bridge design.

View on the new appearance of the historic sea lock and the new bicycle bridge.

Reitdiep bridge as add-on

78 Zero tolerance for addon bicycle bridge

A more than a 100 year old historic sea lock normally seems not very adaptive to big interventions, let alone a complete new foot / bicycle bridge. Nonetheless, this was the question for the Reitdiep lock as part of 'De Nieuwe Waterwerken'. Designing a 62.5-meter bridge went beyond engineering – a new foot and bicycle bridge had to respect heritage while adding value. Commissioned by the Province of Groningen and Waterschap Noorderzijlvest, and designed by NEXT architects and H+N+S, the project is a layered approach in its context, its history and transforming a technical intervention into a meaningful public space.

Keywords: bridge design, bascule, historical; heritage; aesthetics; structural concepts; tolerances, bicycle and pedestrian bridge, interdisciplinary

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Adding another layer

The bridge design carefully considers the monumental lock, the intended recreational use, and the site experience. The bridge deck is aligned parallel to the existing bridge, seamlessly fitting into the lock's structure. The positioning of the bridge and its approaches is elaborately defined in respect to the existing structure, respecting valuable historic elements. Old and new elements complement each other. The slender bridge and approaches redefine the appearance of the lock and gives new meaning to the entrance of the village. In this way, the story of the lock and the differentiated composition of the complex can be experienced from different perspectives and at different speeds. Both from land and from the water.

Zero tolerance on all levels

Structural and architectonic details of the Reitdiepbridge are aligned with the lock's layout, ensuring synchronized opening and closing with the existing bascule bridge. The engineering and manufacturing of the steel bridge and its mechanism had to work like clockwork. The success is in the details and which started in the early design phases. Despite its modest size, the bridge is highly labor-intensive due to its high complexity and challenging design, requiring a great deal of expertise and craftsmanship per kilogram of steel.

Creil, France

A Landscaped Walkway in the City – Perspective of the Future Northern Forecourt

Low-carbon walkway over the railway

79 In anticipation of high-speed rail introduction in the area, Creil City Council plans to enhance its railway station with a new neighborhood-spanning footbridge to ensure urban connectivity, platform accessibility for Persons with Reduced Mobility, and integration with the Multimodal Exchange Hub.

Keywords: Footbridge, Low-carbon, Minimalist, Railway, Long-span, Sustainability, Multimodal, Frugal, Bicycle, EMC2B : Energy, Materials, Climate, Carbon, and Biodiversity, Dynamic Analysis

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Egis and AREP proposed a streamlined, minimalist, and low-carbon 220-meter-long footbridge offering passersby an open dialogue with nature while providing protection. The architecture emphasizes clear, transparent, and lightweight designs, enhancing pathway readability and creating an open dialogue with nature while providing protection. The steel structure highlights the city's industrial heritage with a precisely dimensioned retroussé truss beam that spans large distances. The beam's flanges extend without ties above platforms, allowing passenger access to stairs.

This includes an optimized structure with a 25% reduction in weight, a 45% improved carbon footprint, and an 11% optimization of the structure's carbon weight compared to conventional designs. The project includes a 550 m^2 photovoltaic park producing 110 MWh annually and features 54% local tree species.

The proposed footbridge successfully addresses the objectives of urban connectivity, accessibility, and sustainability. This project sets a benchmark for future infrastructure developments in the region, promoting sustainable and efficient design practices eco-design approach and addressing major ecosystem challenges for a virtuous response. The structure honors the industrial past and projects a post-carbon future, addressing environmental challenges such as energy, materials, climate, carbon, and biodiversity.

Minimalist, and legible architectural signal

The Padre Anchieta Footbridge

80 An engineering solution for the improvement of urban mobility in Tenerife

The Padre Anchieta pedestrian bridge in La Laguna emerges as a unique solution to address urban mobility issues in an area with high pedestrian and vehicular traffic. Designed through a competition organized by the Cabildo de Tenerife, the winning proposal by FHECOR features a 100-meter-diameter metallic ring that facilitates pedestrian movement while minimizing conflicts with vehicular traffic. The ring is complemented by multiple access points to enhance pedestrian connectivity. The project faces technical challenges such as assembling large modules and coordinating with existing traffic.impacts.

Keywords: structural concepts; planning; aesthetics; steel; urban context.

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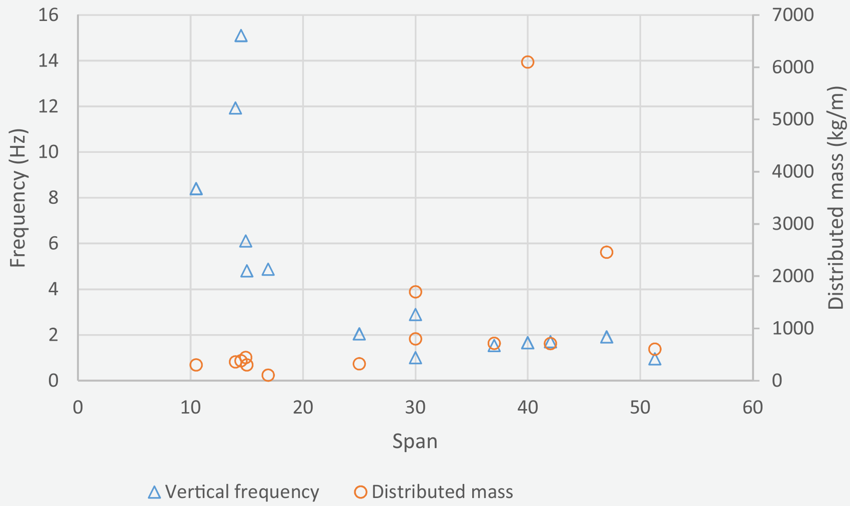
The concept of a ring for the footbridge is unique yet compact, as it represents a closed structure, without a beginning or end, allowing access from multiple points without compromising the overall design. Additionally, a classical structure supported by columns was chosen, as the challenge was to design the ring and the connecting ramps effectively, providing formal unity to the entire ensemble with minimal "structural effort," meaning an optimized use of materials. The ring's shape and its relative eccentricity in relation to the oval-shaped traffic roundabout made it possible to support the ring at a series of points. Moreover, it was understood that the very formalization of a 100-meter-diameter steel ring would bestow the project with the distinctive character typical of major engineering works designed appropriately.

This footbridge exemplifies the essential role of civil engineering in solving urban mobility issues and creating high-quality public spaces. Projects of this kind would not be possible without effective collaboration and teamwork. The combination of knowledge, skills, and efforts from each group has been crucial in addressing the complexity of the project.



Porto, Portugal

Characteristics of existing footbridges

Load models and response assessment of lightweight footbridges

81 Dynamics of short span footbridges

The dynamic design of pedestrian bridges has advanced considerably over recent decades, but challenges remain concerning load models, pedestrian-structure interaction, and user comfort. These issues are particularly relevant for lightweight footbridges. Through a simplified study based on typical pedestrian dynamics, this work explores the definition of load models and the relevance of pedestrian-structure interaction for high-frequency footbridges, evaluating its impact on the structural response. Additionally, the suitability of peak acceleration as a comfort indicator is examined.

Keywords: Lightweight footbridge; dynamics; vertical vibration; pedestrian-structure interaction; serviceability

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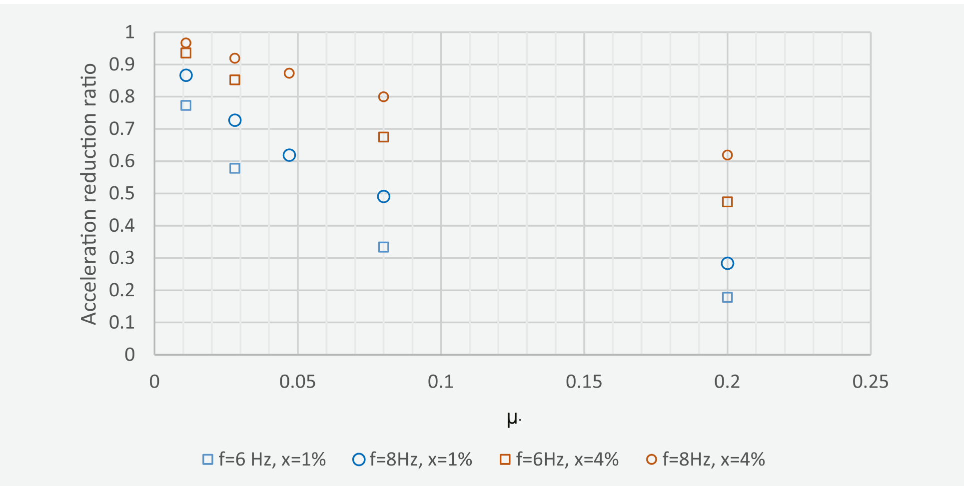
Load models and pedestrian-structure interaction for lightweight footbridges

Based on the observed characteristics of footbridges, a distributed mass ranging from 70 kg/m to 500 kg/m is considered. Spans of 10 to 25 m are targeted, with natural frequency greater than 5 Hz. Damping ratios of 1% to 4% are considered.

Assuming the footbridge modelled as a single degree of freedom system, and a walking resonance at 1/4th the fundamental frequency, it is concluded that, even for significant damping, the non-consideration of resonance in the high harmonics is very unconservative.

From a frequency domain modelling of the footbridge interacting with a pedestrian characterised by an average frequency of 3.5 Hz and damping ratio of 20%, it is shown that pedestrian-structure interaction is determined above all by the pedestrian mass-tructure ratio μ. It also depends on the footbridge damping, decreasing with the increase of footbridge frequency. This interaction is very significant for high values of μ and low damping ratios. Conversely, it can be neglected for mass ratios μ lower than 5% and damping ratios greater than 4%.

To assess comfort in short-span footbridges, there is a need to explore different metrics, such as the 1s-running root mean square acceleration defined by the ISO 10137 standard.



Pedestrian-structure interaction vs mass μ.

Williams Crossing

82 A new Footbridge across the Arkansas River

As part of the City of Tulsa's vision for the improved Zink Dam area, schlaich bergermann partner and MVVA were commissioned to design a pedestrian bridge over the Arkansas River. It was to replace an old truss bridge that was in need of major repair. The 440m long Williams Crossing is supported by eleven 36m long arch spans and an approach span. The semi-integral bridge was designed with extremely slender, deck-stiffened arches made of weatherproof steel plates. The minimalistic and optimized structure quickly became a new landmark for Tulsa and generated euphoric reactions from users and residents and even national media attention.

Keywords: formfinding, optimisation, integral structures, realized theory, stringent structural concept, minimalism

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A tribute to Robert Maillart

Williams Crossing provides a connection to “Gathering Place,” an immense park designed by Michael Van Valkenburgh Associates, as well as links to the River Parks and Midland Valley Trails. The bridge is designed for both pedestrian and cyclist access and offers opportunities to stop and enjoy the dramatic river views with seating and lookout areas along the bridge deck.

The deck stiffened, plate arch structure is the first of its kind in the United States, its purely formfound geometry allows for optimizing every members dimensions to an absolute minimum. The arch cross section consists of a continuous polygonal 80 mm thick steel plate that is kinked at the spandrel locations. The tops of the slender spandrel plates are connected through a steel tie plate that is integrated and part of the 45 cm thick composite bridge deck.

Decisive for the realisation of the minimized structure was a holistic construction sequence. As non-uniform loads could not be taken by the sole steel-structure, temporary tie-beams and bracings had to be used for the installation of the steel arches and until the completion of the concrete deck. To eliminate the need for formwork, the concrete portion of the composite deck consists of 15 cm thick prefabricated elements.

Weathering steel was the preferred material chosen for the entire bridge structure. In combination with the semi-integral bridge approach – bearings and joints are only located at the abutments – maintenance efforts for this structure should be kept to a minimum.

Williams Crossing was designed as a tribute to Robert Maillart’s 1933 Schwandbach Bridge near Bern, probably the most beautiful ancestor and role-model of integral deck-stiffened arch bridges. Its form obviously shows the theoretical background for realizing integral, form-optimized structures.

Footbridge over railway station in Cheb

83 New Footbridge over 39 railway tracks

The new footbridge over the railway station track in Cheb is located in the position of the old steel footbridge, which had to be taken down due to its unsatisfactory technical condition. The footbridge is situated in a complex area where it crosses 6 local roads and 39 rail tracks. The footbridge is designed as a prestressed concrete structure supplemented by a pair of steel pylons with semi-radial cables supporting the longest span of 87 m and the total length of the structure is 397 m.

Keywords: incremental launching, cable stayed, prestressed concrete, steel pylon

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The piers are formed in cross-section by V-shaped columns which are connected by a wall up to a level of 1.8 m below the upper surface of the pier. The cross-section of the footbridge is formed by a symmetrical parapet cross-section of H shape with a total height of 2.0 m. The parapets are angled outwards and their upper surface is at a height of 1.25 m above the level of the walkway. On the inner side of the footbridge, LED strips are installed to illuminate the walkway. The pylon cross-section is designed as a welded box with internal diaphragms. The pylon reaches a height of 13.75 m including the height of the parapet.

Incremental launching

The superstructure was produced in the casting yard and the individual segments were incrementally launched over the entire track together with the already installed pylon, which is an integral part of the superstructure.

Thorough dynamic and static loading tests were performed with very good correspondence with numerical models.

View over central part of footbridge

Brussels, Belgium

Bikeramp Spoor Noord, Ney & Partners © Gilles Alonso

Overcoming Elevation

84 The Spatial Challenges of Footbridge Design

Bridges connect people, serving a purpose beyond simply overcoming physical obstacles. However, before overcoming these obstacles, there is often another challenge in bridge design: addressing the height difference to reach the bridge level. Given the increasing scarcity of available public space and the growing diversity of stakeholders involved, public authorities face challenges in project planning. We discuss how the design process is influenced by a wide range of user feed-back (cyclist unions, stakeholders or individuals with disabilities). This paper explores different solutions for this challenge, in 5 footbridge projects by Ney & Partners.

Keywords: space, planning, overcoming elevation, cycle comfort; accessibility, inclusive design, cycle ramps, challenging environment, stakeholders.

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Urban and landscape contexts

The first category focuses on projects where more space is available, with an emphasis on integration into the surrounding landscape and enhancing user comfort. Examples include the Bikebridge in Menen and the Krugerbrug in Hoboken. The second category examines projects in contexts with limited space, primarily in urban environments, such as the Reepbrug in Kortrijk and the Salangaan Bridge in Vilvoorde. For the last project we look at the specific case of Bikeramp Spoor Noord in Antwerp, where, despite a challenging environment, an innovative yet comfortable solution was successfully implemented.

The paper aims to offer practical insights for improving inclusivity, safety, and comfort in the design of footbridges and cycle bridges, enhancing pedestrian and bicycle connectivity in both urban and natural environments. Through these case studies, the paper demonstrates how thoughtful design and spatial and integration planning can optimize the user experience for pedestrians, cyclists, and people with mobility impairments, while also addressing site-specific constraints such as topography, traffic flow, and environmental impact.

Krugerbridge Ney & Partners
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Salangaanbridge, Ney & Partners
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The Swiss Society for the Art of Engineering

The Swiss Society for the Art of Engineering is pleased to support the Footbridge Symposium 2025 – an event that explores engineering art from the perspective of pedestrian bridges.

Pedestrian bridges are much more than functional structures. They connect spaces and people – with ease, with elegance, and often with a boldness in their artistic independence. In these structures, creativity in engineering becomes particularly visible. Because their components are experienced up close and at a walking pace – and are often tactile – footbridges provide an interesting field for exploring structural possibilities, aesthetic expression, and contextual design. Moderate live loads allow greater design flexibility. This should be used consciously to design an realise engineering works of high quality that add value to their context.

Conceptual and creative design work is a central part of engineering practice, one that deserves special cultivation. Documenting outstanding works of engineering that express this principle is an important way of raising awareness.

Since its founding in 1995, the Swiss Society for the Art of Engineering has been committed to making the cultural value of engineering creations visible. We are convinced that understanding the history behind a structure – whether it's a 19th-century wooden bridge or a novel suspension design – allows you to see it in a different light. Knowledge of construction, origin, and cultural context broadens our perspective – and transforms it.

Through excursions, exhibitions, lectures, publications, walking paths, and books for our members, we promote the exchange and dissemination of knowledge about both contemporary structures and historical buildings. These existing works are part of our built identity. The Swiss Society for the Art of Engineering therefore invites all those who are interested to join this network – to strengthen and carry forward the culture of engineering construction. The Footbridge Symposium 2025 offers an ideal platform for this.

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