European Council of Civil Engineers

Footbridges

Small is beautiful

ECCE

Editor and copyright owner: **ECCE**
European Council of Civil Engineers

Registered office: **One Great George Street, Westminster**
London SW1, United Kingdom

Publisher: **Grafika Soča d.o.o., Nova Gorica, Slovenia**
October 2014

Designed and printed by: **Grafika Soča d.o.o., Nova Gorica, Slovenia**
tiskarna@grafika-soca.si

Proof-reading and translations: **Amidas d.o.o., Ljubljana, Slovenia**
Hugh Brown, lecturer

Cover page photographs: The Rialto Bridge, Venice, Italy
The Bridge of Peace, Tbilisi, Georgia

Each ECCE National member organization is responsible for the choice and quality of photographs in their contribution.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Footbridges

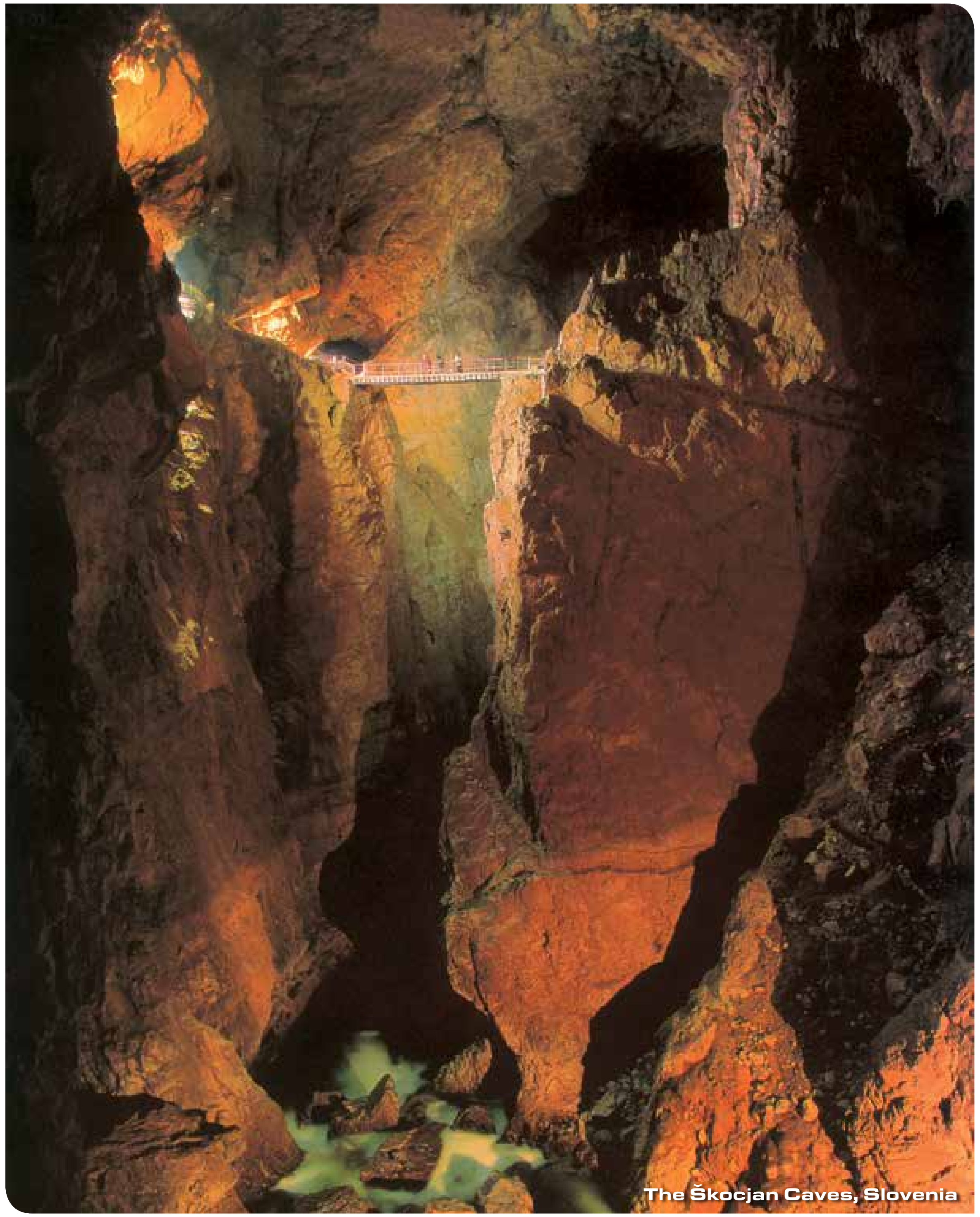
Small is beautiful

ECCE - European Council of Civil Engineers
2014

Contributions from the following countries

* Country not being ECCE member
** The contribution of JSCE-Japan Society of Civil Engineers as guest

FOOTBRIDGES - SMALL IS BEAUTIFUL

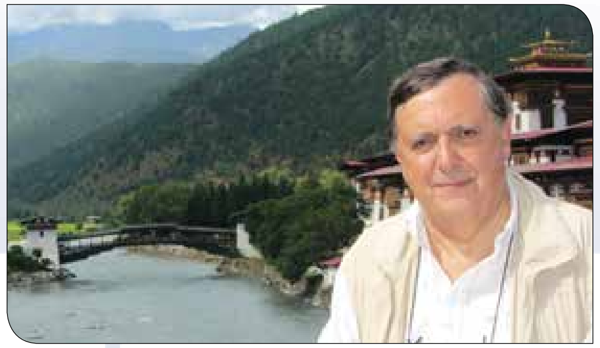


The Škocjan Caves, Slovenia

Editors in single countries

1.	**CROATIA**	Zvonimir Sever, Aleksej Dušek
2.	**CYPRUS**	Andreas Constantinides, George Demetriou
3.	**CZECH REPUBLIC**	Alois Materna, Jiří Stráský
4.	**ESTONIA**	Tiia Ruben, Alar Just, IvarTalvik
5.	**FRANCE**	Georges Pilot
6.	**GERMANY**	Carsten Ahrens
7.	**GREAT BRITAIN**	Melissa Zanocco, Brian Duguid
8.	**GEORGIA**	Iuri Svanidze, Mirian Kalabegishvili, Malkhaz Bediashvili, Nodar Medzmariashvili
9.	**GREECE**	Aris Chatzidakis, Vassilis Economopoulos
10.	**HUNGARY**	Gabor Szöllössy
11.	**IRELAND**	Murt Coleman
12.	**ITALY**	Nicola Monda, Massimo Mariani, Enzo Siviero, Michele Culatti, Luca Guido, Fabrizia Zorzenon
13.	**LATVIA**	Helena Endriksone
14.	**LITHUANIA**	Vincentas Stragys
15.	**MALTA**	Ruben Paul Borg, George Cassar, Vincent Cassar
16.	**MONTENEGRO**	Nebojša Djuranović, Miloš Knežević
17.	**POLAND**	Wlodzimierz Szymczak, Janusz Rymsza, Malgorzata Skowronek
18.	**PORTUGAL**	Fernando Branco, Renato Oliveira Bastos
19.	**SLOVENIA**	Gorazd Human, Viktor Markelj, Branko Zadnik
20.	**SPAIN**	José Francisco Sáez Rubio, Jesús Gómez Hermoso
21.	**TURKEY**	Tugrul Tankut
22.	**JAPAN (as guest)**	Prof. Fumio Masubuchi, Mr. Mitsuo Iso, Ms. Kyo Tekenouchi, Mr. Mikio Matsui, Mr. Naoichi Kuroshima

ECCE President's introduction



A pedestrian bridge is the best symbol for the art of Civil Engineering. It represents the simplest and most elegant structure to pass an obstacle, to reach the unknown side, or simply to go on with our lives of discovery. To build a pedestrian bridge means to face the challenge of connecting what is separated, or to eliminate the existing obstacle. And when it is finished, people passes and enjoys, but rarely looks at that shy engineer that, in the border of the river, looking at the bridge, says proudly "I was able to do it".

This is the life of the civil engineer, working mostly in the shadow, he is proud to eliminate most of the existing natural and living problems, making the world a better place to live.

In tribute to this symbol represented by the Pedestrian Bridges, the European Council of Civil Engineers decided to promote this book where nice examples of Pedestrian Bridges are illustrated, keeping a memory of the elegance of these structures, and simultaneously thanking the Civil Engineer, in the border of the river, for his notable achievement.

Fernando Branco
ECCE President
Oct. 2012 - Oct. 2014

Editor's foreword

The book you are holding is the second book prepared by the European Council of Civil Engineers (ECCE) on the subject of cultural and technical heritage in civil engineering and architecture.

This time the task of the working group under the aegis of the ECCE – known as Task Force Civil Engineering Heritage – was to undertake as comprehensive as possible a review of the achievements of human expertise in the construction of bridges specifically intended for pedestrians. This task was not chosen at random. Instead, it had a specific objective. Although footbridges are usually smaller structures (there are exceptions), their planning and execution require a great deal of expertise in the fields of both construction and architecture. Few construction projects involve such creative interaction between construction engineer and architect from the outset. Today it is almost impossible to imagine the creation of a new pedestrian bridge without their fruitful cooperation. Such cooperation requires both of the participants in the process to hone and refine the concept of the other.

A cooperation agreement between ECCE and JSCE was signed by ECCE President Fernando Branco, ECCE President Elect Wlodzimierz Szymczak and JSCE President Takehito Ono in Lisbon on 30 May 2013.

The present book is the result of the teamwork of individual working groups in more than 22 ECCE member states. Together, we selected more than 200 footbridges for inclusion in this book, regardless of their date of construction or their size. The result is an interesting collection of footbridges selected by the working groups in individual ECCE member states. Few other books offer such a varied selection of fascinating pedestrian bridges in one place. The book is complemented by a review of 17 footbridges in Japan, prepared specially for this book by the Japan Society of Civil Engineers (JSCE). The Japanese contribution is the fruit of cooperation between the ECCE and the JSCE.

It is no coincidence that the cover of the book features two very different bridges that are separated by more than four centuries. The first bridge on the cover is the Rialto Bridge in Venice, perhaps the most recognisable pedestrian bridge in the world. It is particularly important for our profession because its construction (completed in 1591) was the result of a public competition to choose a design for the bridge. This competition, which lasted several decades, was one of the first of its kind in the world. This is still a highly significant fact today. The other bridge on the cover is the Bridge of Peace in Tbilisi, Georgia (built in 2010), whose name includes a word that is loaded with meaning. Even with their names, bridges can symbolically communicate messages that are increasingly important for today's civilisation.

The Footbridges – Small is Beautiful project involved more than 60 contributors in 22 countries in the preparation of the individual articles and numerous photographs. They include the members of the editorial committee, whose invaluable advice helped give this book its final shape.

I would like to express my sincere thanks to all the contributors, without singling anybody out by name, for their creative and fruitful cooperation, and for the patience required during the preparation of material for this book.

Particular thanks are due to Fernando Branco, the current ECCE President, and Wlodzimierz Szymczak, who will take over from him as ECCE President in October 2014, for their understanding and assistance in the realisation of this major book project. The same acknowledgement goes to all the members of the ECCE Executive Board and the members of the Task Force Civil Engineering Heritage 2010–2012 and 2012–2014.

Finally, thanks are due to Professor Enzo Siviero of the Università IUAV di Venezia for generously agreeing to review the introductory chapter on the history of bridge-building.

Gorazd Humar
Editor- in-Chief
and
ECCE President
in mandate October 2010 - October 2012

Claude Monet (1840–1926)

Le Pont Japonais *(The Japanese Bridge)*

Some notes on the history of bridge structures

Written by Gorazd Humar, B.Sc.C.E., ©

Review: prof. Enzo Siviero, Faculty of Architecture, Venice

Hradeckega Footbridge in Ljubljana, Slovenia, 1867

The article that follows does not aim to describe the entire history of construction, or more particularly of bridge-building, since it does not cover the whole of the historical period in which bridges have been built. The text is a compilation of the author's independent research and a number of his studies relating to the history of bridge-building. It also includes material that the author presents to students in his lectures on the history of construction at the University of Maribor's Faculty of Civil Engineering. The text also contains significant statements and findings from numerous researchers of the history of construction. The author has combined their findings into the overall context of the article according to the logic of their development over time and their importance, and according to his own judgement, so that the text before you can tell the story, supported by historical facts, of the development of bridge-building expertise up to the beginning of the twentieth century.

Some statements and findings are dealt with in more detail because of the interesting points they raise, and serve to make the varied history of construction even more interesting. Why can't the history of construction, and particularly the history of bridge-building, be read like a thrilling novel? The many famous builders and engineers who have built bridges have supplied more than enough reasons to suggest that it can. So let us begin...

The oldest bridges were almost certainly made of wood

We do not know when and where the first bridges appeared. Even so, it is not difficult to imagine what they looked like. They were almost certainly made of logs and would have served to allow people to cross streams or small rivers. The short lifespan of wood, however, means that none of these earliest bridges have survived.

The first wooden bridges that we know of were built by marsh-dwellers who built their dwellings on wooden piles or stilts driven into marshy ground, forming small settlements. Life in such settlements was safer because access was difficult and enemies were easier to spot. The lives of the marsh-dwellers were centred round hunting, fishing and agriculture and they travelled using simple dugout canoes.

Marsh-dwellers' settlement

The first pile-dwellings of the marsh-dwellers were built in the large wetland area south of Ljubljana, the capital of Slovenia, in the first half of the fifth millennium BC, in other words at the end of the Stone Age. People continued to live here throughout the Copper Age and right up until the second millennium BC, which is known as the Middle Bronze Age. Similar pile-dwellings have also been found in other countries: Austria, Switzerland, France, Germany and Italy.

Archaeologists have discovered the remains of a larger settlement of this type in a marshy area close to the city of Ljubljana in Slovenia. Judging by the wooden piles preserved in the marshy soil, it is possible to estimate that a wooden bridge around 400 metres long and supported by piles once led to the settlement. This bridge did not only serve for access, it was part of the defences of this settlement in the middle of the marsh. Several thousand years later the city of Venice developed using this same principle of protection against enemies by building on water, though of course in an entirely different manner.

Venice was also built as a settlement on water

Stone was the basic construction material of ancient civilisations

Only a few of the bridges built by ancient civilisations have survived to the present day. These stone structures are a silent testimony to the bridge-building expertise of our ancestors thousands of years ago. Stone was the most commonly used construction material after wood, above all because of its advantage over other natural materials. Stone suitable for building was always available and it could be shaped as required. Its greatest advantages, however, were its strength and durability. This is the reason why of all the bridges built by our ancestors, only stone bridges have survived.

The oldest stone bridges

The first stone bridges were naturally somewhat primitive. Bridging an obstacle was most often done using flat stone slabs whose length did not exceed 2.5 metres. These were supported in a simple manner by other stones placed in the bed of the stream or river to act as piers. One of the best known bridges of this kind in Europe is the simple stone "clapper bridge" called the Tarr Steps, in the Exmoor National Park in England.

Tarr Steps – clapper bridge in England

It is not known exactly when this simple but effective bridge was built, but it is believed to date from around 1000 BC. The bridge is 55 metres long and has 17 spans consisting of stone slabs.

A bridge made of stone slabs is also known to have been built in Sichuan province in China in around the year 1040 BC. The Venetian merchant and traveller Marco Polo (1254–1324) mentioned large bridges built of stone slabs in his writings on China.

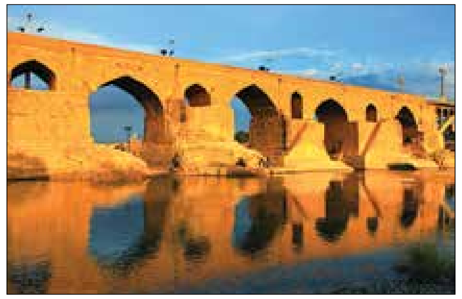
Also interesting are the techniques used to bridge gaps in the Mycenaean culture of ancient Greece. One famous example is the gate at the entrance to the citadel of Mycenae in the Peloponnese, known as the Lion Gate. A huge stone lintel weighing 15 tonnes and measuring 4.5 x 2.0 x 0.8 metres was placed over the gate. The shape of this lintel is interesting in that it is slightly thicker in the centre, where the loads are greater. The golden age of Mycenaean culture lasted from 1400 BC to 1100 BC.

The Lion Gate in Mycenae

Stone and, later, brick also predominated in the other constructions of the ancient civilisations that developed in the warm and fertile landscapes of Mesopotamia along the Euphrates and Tigris rivers and on the river Nile. Less well known but no less developed civilisations also inhabited

The great Ziggurat of Ur

Babylon



Dezful bridge

Acropolis in Athens

the area of the river Ganges in present-day India and the Yangtze river in China.

By far the best-known stone structures are the famous pyramids of Egypt and the Assyrian architecture of Mesopotamia. The best-known brick structures are the city of Babylon and the Great Ziggurat of Ur.

The Egyptians were not just good builders. Even today we are unable to explain how the enormous quantities of stone used to construct the pyramids were broken and transported from the quarries of Aswan. Another interesting fact is that the Great Pyramid of Cheops, built in around 2700 BC, is the largest stone structure ever built in the history of humankind. In terms of the quantity of stone used to build it, it is only exceeded by the Great Wall of China. The Great Pyramid of Cheops, whose base measures 233 x 233 metres and which stands 146.6 metres high, was built using around 2.6 million cubic metres of stone.

Yet the findings of archaeologists who have studied the civilisations of the ancient world show that the first to use arches as structural elements were the inhabitants of Mesopotamia – the Babylonians and the Sumerians. The arch bridge over the Euphrates at Babylon built by Nebuchadnezzar II may have only stood for a few centuries, but it served as an important model for the subsequent development of bridge-building. This bridge had several arches and a total length of 390 metres.

Via the Phoenicians, who carried knowledge of construction techniques from Mesopotamia and the Nile Valley to the shores of the Mediterranean, the art of building in stone spread rapidly towards Europe. At this point we must also mention the civilisation of the Sassanids, a Persian dynasty who ruled in the fourth century BC. The world's oldest surviving stone bridge dates from this period. Six hundred metres long and resting on massive piers, its load-bearing structure consisted of irregular arches. Another bridge built by the Sassanids was the bridge at Dezful, notable for its pointed arches and a series of smaller arches that served to reduce the weight of the bridge.

The art of construction in stone advanced significantly in ancient Greece. The Greeks gave stone new forms and structural characteristics. Unlike the civilisations that came before them, they worked the stone with iron tools. It is in ancient Greece that we find the first traces of rationality in construction and the origin of a variety of architectural styles of increasing richness. The Greeks succeeded in bringing the working of stone to a level that was practically faultless. Another characteristic of ancient Greek civilisation was that stone was not only used in the construction of temples but also in many other structures that are today familiar to us all, such as theatres, hippodromes, stadiums, baths, and so on.

In Roman times the arch becomes the principal structural element

Colosseum in Rome

Some sources claim that the arch was first developed as a structural element by the Etruscans, who lived in the Apennine Peninsula (present-day Italy) at the start of the first millennium BC. The origins of ancient Roman building and engineering, which gradually began to develop in the third century BC, may be considered a continuation of Etruscan construction techniques. The Romans, whose empire began to spread across the whole Mediterranean region, made good use of all the experience in building in stone acquired by earlier civilisations.

The arch, the most characteristic Roman structural element, quickly established itself in structures of every kind. The Romans began to use it in all the large and important structures of their empire, including aqueducts with multiple tiers, roads, bridges, amphitheatres, arenas, triumphal arches, and so on.

Thanks to the durability of stone and the impressive solidity achieved by the Romans, a very large number of structures from this period have survived to the present day. It is also thanks to the Romans, who brought the stone arch to a higher stage of evolution than any civilisation before them, that the use of the arch as the principal structural element spread throughout the Mediterranean and the greater part of Europe.

The Pons Cestius (Ponte Cestio) in Rome

The Romans were also familiar with a form of concrete, known as Roman concrete (concretum), which was mainly used as a filler in stone structures.

From the writings of Vitruvius (Marcus Vitruvius Pollio, a classical Roman author who lived at the time of Julius Caesar and the Emperor Augustus in the first century BC), we know that the Romans made concrete from a mixture of lime, volcanic ash from Baiae (a resort town across the Bay of Naples from Mount Vesuvius), pieces of stone and crushed brick. The lime and ash, which is a type of volcanic tuff called pozzolana, were mixed in a ratio of one to two. Among the most famous structures made from Roman concrete is the aqueduct that ran from the hilly Eifel region in Germany to what is today the city of Cologne. Built between AD 70 and AD 90, this ovoid-section aqueduct carried water for 77 kilometres, for the most part underground.

Tests of Roman concrete conducted by the Swiss scientist Adolf Voellmy found that it had a breaking strength of 110 kg/cm^2.

Roman concrete was also used in the construction of the famous Trajan's Bridge over the Danube in Serbia.

With the fall of the Western Roman Empire towards the end of the fifth century AD, the use of Roman concrete was forgotten. More than a millennium would pass before engineers once again discovered a binder that could harden underwater.

The Romans often used light materials as filler in order to reduce the weight of structures. This technique was used above all in the case of bridges and aqueducts. The most commonly used filler was volcanic tuff quarried below Vesuvius. Among the famous structures to use this material are the Baths of Caracalla, the Baths of Titus and, most notably of all, the Pantheon in Rome.

Today we know that while the Romans brought the construction of arches and bridges to a remarkably high level of sophistication, they did not master the mathematical methods needed to calculate loads. In most cases they built their arches on the basis of experience and empirical models.

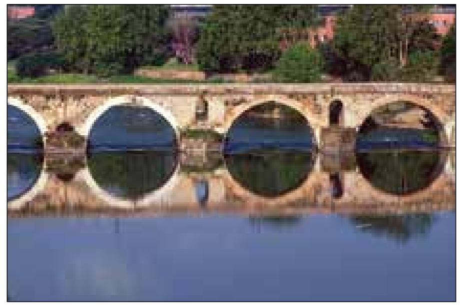
The stone arch is developed to perfection in ancient Rome

Vulci bridge in Toscany, Italy

It is no surprise that a large number of bridges built by the ancient Romans have survived 2,000 years to the present day. More than 300 bridges from Roman times are still standing today in various parts of Europe. What is the secret of their long life and their remarkable durability?

The ancient Romans, who learnt the skill of building arches from the Etruscans, developed the arch – the load-bearing structure of every stone bridge – to the point of perfection, despite the fact that they did not have the engineering knowledge we possess today.

The development of the bridge form, in particular the increase in the spans of bridge arches, took place according to entirely empirical methods. The Romans accumulated a great deal of experience in this field, since they built bridges throughout their empire, which extended across half of Europe. Bridges from the days of ancient Rome are remarkable for two of the basic characteristics of their construction. The first notable characteristic of Roman bridges is the form of the arch. This represented a line in the form of a perfect semicircle. Very few bridges had arches that deviated from this semicircular line. The second characteristic is more enigmatic, yet it was this that enabled the majority of bridges built by the ancient Romans to survive for an extraordinarily long time. The stone blocks used to build the arches were put in place without the use of mortar in the gaps between them. In geometrical terms, the blocks were cut with such accuracy that each block fitted closely to its neighbour. This, of course, required tools of sufficiently good quality with which to work the stone. For this reason, the quarrying of stone was a highly developed activity in ancient Rome. The Roman quarry (Cava Romana) at Aurisina near Trieste in Italy dates back around 2,000 years and is still operating today.



The Pons Milvius (Ponte Milvio) in Rome

The largest number of bridges built in ancient Roman times and still standing today are to be found in the city of Rome itself. All of them once served to carry important Roman roads across the river Tiber. Perhaps the most characteristic example of the Roman method of bridge-building is the Pons Milvius (Ponte Milvio), built in 109 BC as part of the Via Flaminia. The majority of large bridges from that time are named after the emperors who ordered their construction. The best-known Roman bridge outside present-day Italy is the Alcántara Bridge over the river Tagus in Spain. This bridge boasts the largest arch (with a span of 30 metres) of any surviving bridge from ancient Roman times. Sadly the bridge with the largest arch built by the Romans has not survived. This was the bridge at Narni in Umbria, the largest arch of which had a span of 34.75 metres.

The Pons Fabricius (Ponte Fabricio) in Rome

The bridge over the Nera at Narni – at the point where the Via Flaminia turns towards Ancona – was built by the Roman emperor Augustus. The bridge is known to have had four large arches, the larger two of which had spans of 20.5 metres and 34.75 metres respectively, while the smaller two both had spans of 15.75 metres. An interesting technical detail is that the piers of the largest arch were at two different heights. It is not known exactly when the bridge fell down, but poor foundations were the reason for its collapse.

The Pons Fabricius (Ponte Fabricio) in Rome commissioned by Lucius Fabricius in 62 BC. The bridge survives almost intact in its original form. Because of the high waters of the River Tiber the bridge has had to be restored several times. In the second century AD the frontal walls, which were originally of travertine, were bricked over. Because of the nearby Jewish ghetto the bridge was also known in the Middle Ages as the Pons Judaeorum.

The Pons Cestius was the second bridge to link the little island in the middle of the Tiber with the river's right bank. It was built in 46 BC. It has partly fallen down and been rebuilt many times. Only the central arch has remained of the original bridge. The bridge was completely restored in 1892.

The Ponte Sant'Angelo in Rome

FOOTBRIDGES - SMALL IS BEAUTIFUL

Some notes on the history of bridge structures

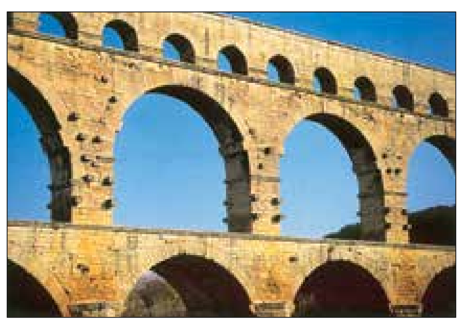
Traian's Column in Rome, Italy

The inhabitants of Rome call the remains of this bridge the Ponte Rotto (Broken Bridge). When it was built (between 181 and 179 BC) it was called the Pons Aurelius. It is the oldest Roman stone bridge. It was reconstructed several times, especially in the Middle Ages. The bridge was destroyed by the high waters of the Tiber, and only one of the arches has survived, hence the bridge's current name.

The Ponte S. Angelo is probably the most beautiful bridge in Rome. The Emperor Hadrian had it built in 133/134 AD. The Pons Aelius, as it was known at the time, led to Hadrian's mausoleum on the left bank of the Tiber. Only the three central arches have remained of the original structure. The bridge was completely renovated in the Middle Ages. During the period of the Roman Baroque, Lorenzo Bernini had the idea of placing ten statues of angels with symbols of the Passion on the bridge.

Trajan's Column is unique and one of the best preserved monuments of Ancient Rome in the City of Rome. The column, which is 39.87 metres tall including its base, is made of 25 blocks of marble 3.5 metres in diameter. The outer surface of the column is covered from top to bottom in reliefs showing scenes from the war with barbarian Dacia (the eastern part of the Roman Empire) in 101-103 AD and 107-108 AD. The various images from this war (waged by the Emperor Trajan (who ruled from 98 AD to 107 AD) wind round the column right up to the top. Approximately 2500 human figures are depicted on the column. One scene shows Trajan's Bridge over the Danube at Kladovo, built by Apollodorus of Damascus. The bridge had stone foundations and piers, while the main span was made of wood. It was built between 103 and 104 AD. The column is hollow. A spiral staircase leads to the top, where a statue of St Peter has stood since 1587.

All the bridges built in ancient Roman times that have not survived to the present day fell victim either to floods or to erosion of their foundations.



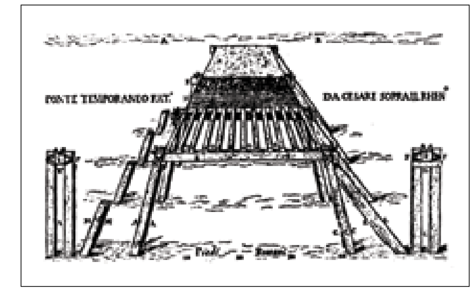
Pont du Guard, France

The Romans also built numerous aqueducts, following similar principles to those used in the construction of bridges. We need only mention here two of the most characteristic surviving Roman aqueducts. The most imposing Roman aqueduct of all is the granite-built aqueduct in the Spanish city of Segovia. Hardly less imposing is the Pont du Gard, an aqueduct bridge in the Provence region of France. The complexity and difficulty of these feats of engineering gives us pause for thought even today.

The fall of the Roman Empire towards the end of the fifth century AD also represented the end of the construction of large bridges throughout Europe for a very long time.

Roman wooden bridges

The Romans did not only build stone bridges, however, since this was not always possible. As a rule, they only built stone bridges where they were able to find a sufficient quantity of high-quality stone in the vicinity to cut into stone blocks. The Romans built bridges across almost the whole of present-day Europe. These bridges allowed the Roman legionaries to cross rivers quickly, and this is why they were so important. They became part of the defences of the Roman Empire, which survived intact until the end of the fourth century AD.



Caesar's Bridge over the Rhine in Germany

It is understandable that wooden bridges from ancient Roman times have not survived to the present day. In many places, however, it is still possible to discover the remains of the wooden piles driven into the riverbed in places where bridges once stood.

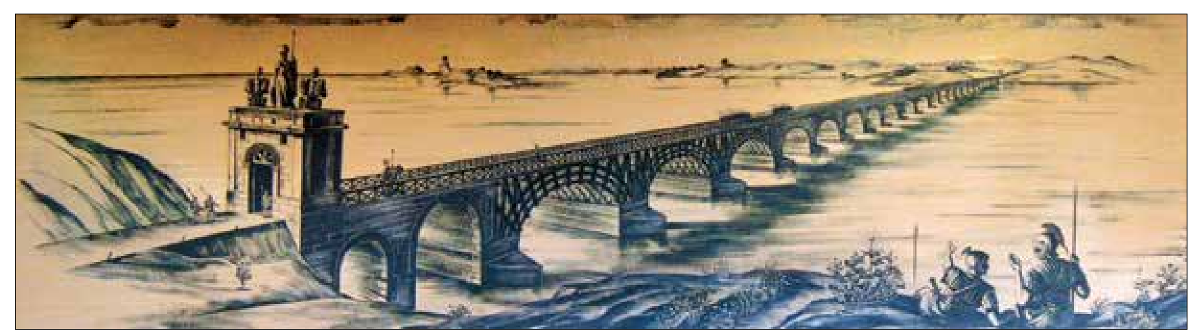
One of the best-known wooden bridges from ancient Roman times was the Caesar's Bridge over the Rhine in present-day Germany. This was a massive wooden bridge built of thick logs and beams, joined together by wooden treenails and thick ropes. The bridge served as a model for the bridge built for the Walt Disney Pictures film The Chronicles of Narnia: Prince Caspian on the river Soča in Slovenia in 2007.

The "Beruna Bridge" over the Soča near Bovec in Slovenia – part of a film set, 2007

Another even better known famous Roman bridge was of course the famous Traian's Bridge over the Danube on the border between Serbia and Romania. This was built by Apollodorus of Damascus, one of the greatest bridge engineers ever to have lived. The bridge is named after the Emperor Traian, who reigned from 98 AD to 107 AD, and was a remarkable achievement not only in terms of its construction but also because of its size. It was 1,135 metres long and its central section had 18 spans measuring 51 metres. An interesting technique was used for the foundations of this bridge: rubble was poured into the Danube to serve as a base for the masonry piers. The distance between these immense piers, which stood 52 metres apart, was bridged by the arched wooden superstructure supporting the roadway.

Owing to the short lifespan of the wooden structure, the bridge has understandably not survived to the present day. All that is left today are some remnants of the stone piers.

Trajan's Bridge over the Danube



The bridge form undergoes many changes in the early Middle Ages and Renaissance

Rouen Cathedral, France
Supporting structure

The first changes in bridge-building and, above all, the construction of large buildings and churches, came with the Gothic period, in the first century of the second millennium. This style is perhaps best known in the case of religious architecture, when churches slowly began to change from the predominant Romanesque style to the new Gothic style. Church buildings became taller and their naves grew wider. Gothic architecture developed an exceptionally beautiful, elegant and refined style that is still admired today. We need only think of the famous cathedral of Reims, or of Notre-Dame in Paris, construction of which began 1163 and was only completed two centuries later.

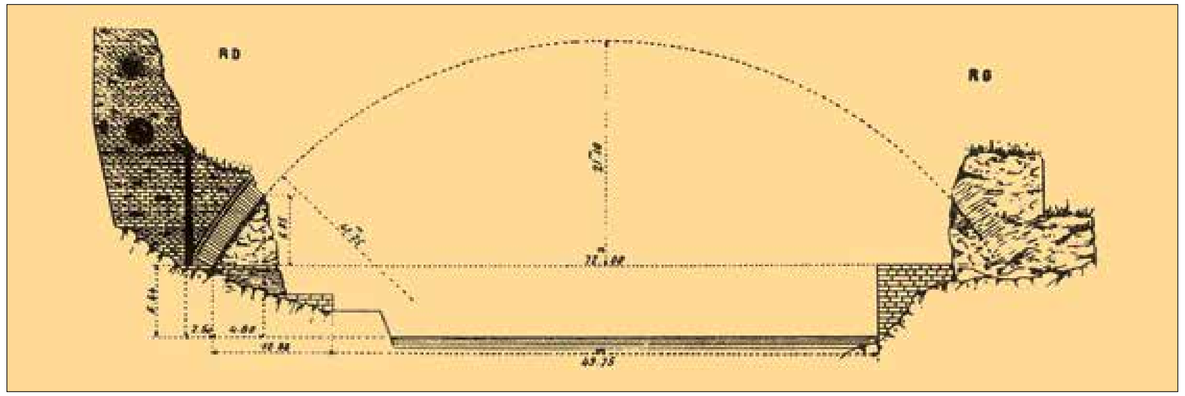
Changes also took place in bridge-building, above all in the shape of the arches, which became increasingly flattened and began to achieve greater and greater spans. A notable bridge from the early part of this period is the bridge at Avignon in France, built between 1177 and 1185. This bridge was characterised not only by its great length but also by the flatness of its main arches, which was remarkable for the period. The biggest arch had a span of 34.8 metres. This in itself represented a major change in comparison to the bridges with semicircular arches built in ancient Roman times. Bridges were becoming increasingly slender and elegant. A large section of the Avignon bridge was pulled down in 1385 by order of Pope Boniface IX – for reasons of defence. The well-preserved remaining section of the bridge at Avignon can still be admired today.

Avignon bridge, France

Ponte Scaligero in Verona, also known as the Ponte Vecchio. Built between 1354 and 1356. At that time it had the longest span in the world (48.70 m)

Other important advances in bridge construction were made in the fourteenth century, in the early Renaissance period. This period, which drew inspiration from the rich heritage of the art of bridge-building in Roman times, is characterised by the construction of a number of interesting bridges. The Devil's Bridge or Old Bridge (Pont Vieux) at Céret in the French Pyrenees, built between 1321 and 1339, had a single arch with a span of 45.45 metres. Just a few years later, in 1356, it was overtaken by an arch bridge in Verona, Italy, which had a span of 48.70 metres. Again just a few years later, in 1377, a stone arch bridge was built over the river Adda near Trezzo in Italy with a span measuring a full 72 metres, an incredible achievement for that time. Although it was demolished just 40 years later, this bridge held the record for the largest span right up until 1903 (!) when the Adolphe Bridge, with an opening of 84.65 metres, was built in Luxembourg.

Scaligero bridge in Verona, Italy



Trezzo sull'Adda Bridge (Italy)

The bridge over the river Adda at Trezzo was built between 1370 in 1377 by order of Bernabò Visconti, the Lord of Milan. A fortified bridge, it provided access to the castle by the town. On 21 December 1416, barely four decades after it was built, the bridge was destroyed by the condottiero Carmagnola, in the service of the Duke of Milan, Filippo Maria Visconti, during a siege.
The bridge at Trezzo was notable for its very low span-to-rise ratio (3.4 to 1), giving the arch a very flat profile, and for the fact that the arch was built of a single course of stone blocks. The remains of the initial section of the arch still survive today.

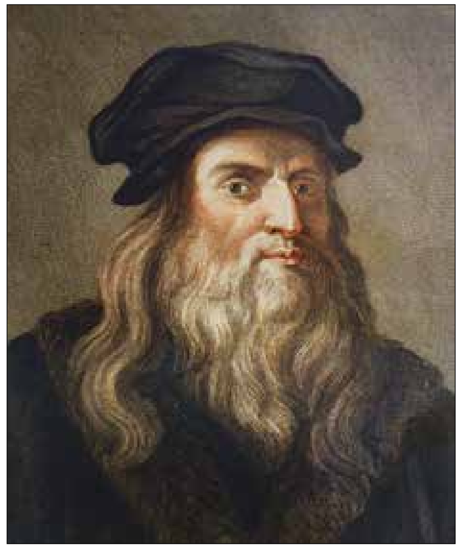
Trezzo sull'Adda Bridge, painting from 1898

The bridges of the Middle Ages already differed significantly from Roman structures in the way that stone was used as the basic construction material. Bridges were becoming increasingly rational and slender. The faster development of science during the Renaissance (with notable advances in fields such as mathematics, statics, mechanics of solids, geometry, etc.) also contributed to the development of bridge-building and the construction of other arched or vaulted structures such as domes.

Foremost among the giants of human intellect who contributed to the development of engineering and construction – and therefore bridge-building – was Leonardo da Vinci (1452–1519), who studied the problem of the pressure of the arch on abutments.

Leonardo da Vinci was a genius: a multifaceted inventor and artist, he also turned his attention to a great number of engineering problems, in particular with regard to the construction of military fortifications. Other ideas included designs for navigation canals and systems of dams and sluices.

Leonardo also researched the principles of construction of large arch bridges One of his best-known works is a sketched design for a large arch bridge with a span of 240 metres across the Golden Horn in Istanbul, which he drew between 1502 and 1503. The plans are said to have



Leonardo da Vinci (1452–1519)

Leonardo da Vinci's sketched design for a bridge over the Golden Horn in Istanbul

been commissioned by Suleiman the Magnificent, the Ottoman sultan. Although the project was never realised, the study for the Golden Horn bridge may be understood as a synthesis of Leonardo's great knowledge and engineering expertise.

Leonardo also drew up plans for pontoon bridges, bridges with mechanisms that enabled them to rotate, and even a two-storey bridge (1487–1488).

Galileo Galilei (1564–1642) is considered the father of the science of the resistance of materials. The first person to use static calculations to solve the problem of arches was, however, the French mathematician Philippe de La Hire (1640–1718), who was the first to use a funicular polygon to determine forces in arches.

Ponte Santa Trinita in Florence – its shape represents a decisive change in the form of the arch structure

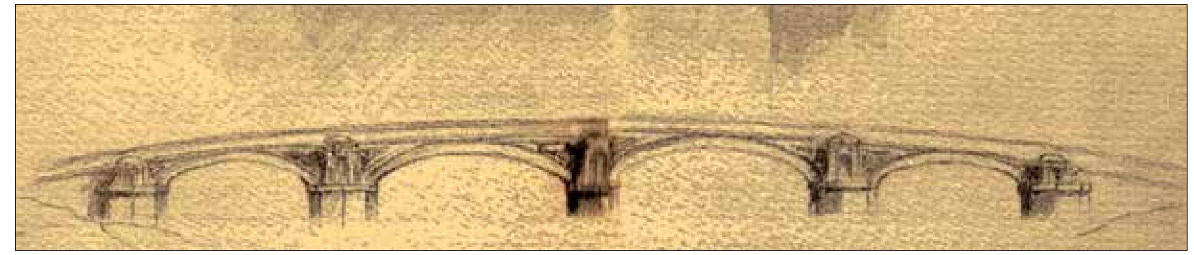
Particularly interesting among Renaissance bridges is the Ponte Santa Trinita in Florence. This bridge features very flat arches and an additionally curved form of transition from arch to piers. The form of the arches is strongly emphasised by archivolts (projecting edges at the front of the arch).

The bridge was commissioned by Cosimo de' Medici, the ruler of Florence, and built by the distinguished architect Bartolomeo Ammannati. It was completed in 1569. The arches of the bridge had a line that had never been used before and in fact this bridge represented an entirely new understanding of the line of the arch, which was no longer

The Ponte Santa Trinita in Florence, Italy

FOOTBRIDGES - SMALL IS BEAUTIFUL

Some notes on the history of bridge structures



Michelangelo's sketched design for a bridge over the Golden Horn in Istanbul

semicircular. The new line of the lower curve of the arch (known as the intrados) was almost that of a catenary, the theory of which had been furthest developed at that time by Michelangelo and Ammannati. The clear openings of the Santa Trinita bridge are 26.75 metres + 29.20 metres + 26.75 metres, while the span-to-rise ratio of the arches is 6 to 1.

Bridges of the Ottoman Empire in the 16th century

The Old bridge (Stari most) in Mostar Bosnia and Herzegovina, 1566

Two of the most interesting and characteristic products of the school of bridge-building brought to such a pitch of perfection by the great builder of mosques and bridges Mimar Sinan (1490–1588) are the bridge over the Neretva at Mostar (1566) and the bridge over the Drina at Višegrad (1577). Both are located in present-day Bosnia and Herzegovina.

Several large bridges were also built in present-day Turkey and Greece during the period of the Ottoman Empire. Among the most interesting bridges in Turkey is Sinan's bridge over the Kizilirmak, while in Greece the Bridge of Arta over the Arachtos is also very interesting.

Historical sources prove that the architect Mimar Sinan was in contact, via friends, with Venetian bridge-builders, in particular with Andrea Palladio. The bridge over the Neretva at Mostar, also known as the Old Bridge, was in fact built by Sinan's pupil Mimar Hayruddin. The biggest difficulty in the construction of this bridge was the torrential river Neretva flowing beneath it, which meant that Hayruddin somehow had to construct the arch without the benefit of scaffolding standing in the riverbed. Mostar's Old Bridge is notable for the remarkable elegance of its stone arch, which has a span of 28.7 metres. It has a very singular shape and is not pointed as was the custom in Ottoman architecture.

An interesting feature of the bridge in Mostar remained hidden from view right up until 1955 when engineers carrying out repairs discovered, on drilling into the arch structure, that a large part of the interior of the bridge is hollow. Two parallel rectangular cavities were discovered on either side of the bridge. Their purpose was to reduce the weight of the bridge superstructure above the stone arch.

The Višegrad bridge over the Drina river. Built by Mimar Sinan in 1577.

Ivo Andrić (1892–1975) The winner of the 1955 Nobel Prize in Literature.

This is the first known example in the history of bridge-building of the construction of a bridge with apertures to reduce weight in the interior of the bridge. From this point of view the Old Bridge in Mostar represents a particularly interesting chapter in the history of civil engineering. It was built in the last year of the reign of Suleiman the Magnificent.

Entirely different but no less interesting is the bridge over the Drina at Višegrad (Bosnia and Herzegovina). This bridge was built in 1577, just a few years after the bridge in Mostar, and some authors claim that it was built by the architect Mimar Sinan. Construction in the channel of the Drina was a complex process that lasted six years, but the result was probably the largest bridge ever built in the Ottoman Empire. The bridge boasts a remarkable harmoniousness of form, especially in the arch openings, which rhythmically increase in size from the two banks towards the centre of the bridge.

The bridge, including access ramps, has a total length of 328 metres, while the openings have spans ranging from 10.7 metres to 14.79 metres. The bridge became widely known thanks to the novel The Bridge on the Drina by Ivo Andrić, the winner of the 1955 Nobel Prize in Literature.

The Rialto Bridge in Venice

The wooden Rialto Bridge before it was destroyed by fire

Andrea Palladio's design for the Rialto Bridge

The Rialto Bridge in Venice, which was completed in 1591, is probably one of the most famous and most visited footbridges in the world. Its construction was a process that dragged on for decades. The first proposals for a new bridge to replace the earlier wooden bridge, which had been destroyed by fire, appeared in 1503. The search for an acceptable solution for the new bridge was renewed in 1550. In a move of great significance for the history of construction, a public competition was held to find an architectural solution. The committee responsible for the competition was presided over by the salt merchants' guild, who held special privileges regarding the sale of salt on the bridge. The competition to select the most suitable new solution for a bridge over the Grand Canal is one of the earliest public architectural competitions in history. The competition criteria specified that shops should be placed on the bridge (as before) and that the bridge opening should be sufficiently large to allow the Doge's barge to pass through it unobstructed. Another important condition for the designers of the bridge was that it should be made of stone, to ensure that it did not share the fate of its wooden predecessor. Entries were submitted by several of the most prominent architects of the period – which was also known as Venice's Golden Age. Shortly after this, as a result of the discovery of America and the rerouting of maritime traffic across the Atlantic, Venice slowly began to stagnate.

Among the most famous architects to submit a solution was the renowned Andrea Palladio. Yet while his pro-

posed solutions in the classical style were architecturally wonderful, they contained one significant defect. Palladio planned a bridge with several arches, a solution that would have considerably impeded the dense boat traffic along the Grand Canal.

The situation was interrupted decisively by the Venetian senate, which on 7 January 1588 ruled that Venice's main navigable canal must be bridged by a single arch. The most suitable proposal was that submitted by Antonio da Ponte. His design was for a stone arch bridge with a span of 28.8 metres. This was not a particularly large span for the time. Many bridges in Europe already had considerably larger spans (e.g. the Ponte Scaligero in Verona, built in 1356, the largest arch of which a span of 48.70 metres).

On the other hand it should be remembered that the Rialto Bridge was built on very poor foundations from the geological point of view. The constantly waterlogged soil of Venice was unable to offer sufficient support to withstand the enormous horizontal forces generated by stone arch bridges. Antonio da Ponte skilfully solved this problem by placing the foundations of the bridge on a very wide area determined by a great number of wooden piles driven vertically into the ground.

The Rialto Bridge has another distinguishing characteristic. It has three separate walkways for pedestrians: a larger one in the centre and two narrower ones on either side of the bridge. Between the walkways are two rows of little shops, which give the bridge its characteristic appearance.

The Rialto Bridge is 22.1 metres wide and is probably still the widest footbridge in the world today. For some centuries it was also the only bridge over the Grand Canal in Venice.

The Rialto Bridge as drawn by Canaletto

The Rialto Bridge today

Other bridges in Venice

The Bridge of Sighs in Venice

Venice is justifiably known as the city of bridges. An enormous number of large and small bridges connect the streets and alleys of this city built in a lagoon. The great majority of the 431 bridges in Venice today date from the golden age of the Most Serene Republic of Venice – "La Serenissima". The number of new bridges built in Venice over the last two centuries can be counted on the fingers of one hand. Practically all the bridges of Venice are arch bridges. In most cases the arches are of white Istrian stone, while the superstructure is either brick or stone. The bridges of Venice are particularly identifiable by their unique parapets, which in the great majority of cases are of stone. These give the bridges their characteristic "Venetian" shape.

Undoubtedly the best known and most photographed bridge in Venice after the picturesque Rialto Bridge is the small but highly decorative Bridge of Sighs (Ponte dei Sospiri). It connects the Doge's Palace with Venice's once notorious New Prison. This is not a normal bridge with foundations on the seabed or abutments on the banks of a canal or river. It rests on the walls of the two neighbouring buildings and spans the canal that flows between them. From this point of view it is not even a true bridge but rather a bridge-like passageway between two buildings.

The Bridge of Sighs in Cambridge, 1831

According to legend, the bridge gained its name because of the deep sighs of the prisoners who crossed it on their way from the Doge's Palace to the prison on the other side. Before they descended into their dark prison cells below the ground, they would sigh as they crossed the bridge and caught their last glimpse of Venice. Legend also has it that the famous adventurer Giacomo Casanova was among those to cross the Bridge of Sighs on his way to prison – before famously escaping.

Today such aerial passageways are also known as skywalks. It might not be unreasonable to assert that the Bridge of Sighs was the first passageway of this kind in the world. Bridges of the same name can be found at the universities of Oxford and Cambridge in England, although these were built later and differ in style.

The Bridge of Sighs in Oxford

Venice's many bridges include a somewhat less well known small bridge in an out-of-the-way location that goes by the rather racy name of Ponte delle Tette (literally: Bridge of Tits). The bridge was given this name for a reason. Believed to have been built in the fifteenth century, it stands not far from the Rialto Bridge, in an area that was officially designated a red-light district. According to one version of the story, the bridge got its name because prostitutes would stand at the windows of a house by the bridge and display their breasts to attract business. According to another story, which may well also be true, the authorities tacitly encouraged women to bare their breasts in the house by the bridge in an attempt to stem the rising tide of homosexuality, viewed as a social problem in the Venice of the fifteenth and sixteenth centuries. The aim was therefore to "convert" men to heterosexuality. Whatever the truth of the matter, it is certainly an original name for a bridge.

The Ponte delle Tette is not the only bridge in Venice to have an unusual name. We have already mentioned the Bridge of Sighs. There is also the Ponte della Paglia (Bridge of Straw) near the Doge's Palace. This is where straw was unloaded for the pallets of the prisoners in the nearby cells.

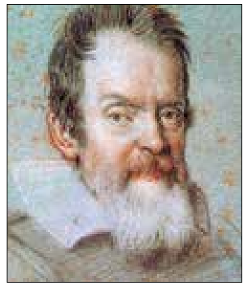
Then there is the Ponte dei Pugni (Bridge of Fists), on which youths from various districts of the city would display their fighting skills.

We could certainly find many other bridges with curious names too, since every bridge in Venice has its own history and its own story. Unsurprisingly, the bridges of Venice have inspired many writers and poets: Dante, Casanova, Mark Twain, Lord Byron, the Croatian writer Predrag Matvejević, and many others. It would seem that the myths surrounding some of Venice's famous bridges have developed out of the interesting stories that have been spun about them.

The Bridge of Tits today. It was renovated and widened in 1847.

The Bridge of Straw (Ponte della Paglia) in Venice

The foundations of modern structural mechanics are laid in the 17th and 18th centuries



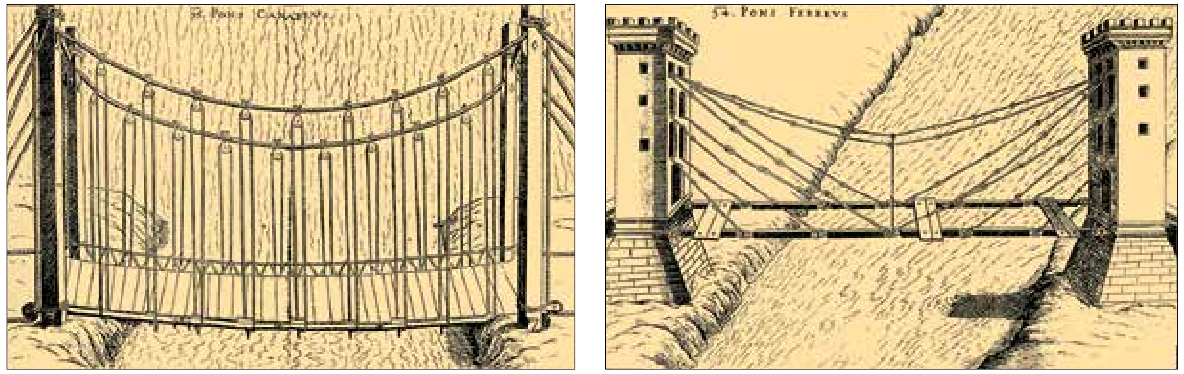
Galileo Galilei (1564–1642)

As mentioned earlier, the construction of the Santa Trinita bridge in Florence in 1569 represented a true turning point in the understanding of structural mechanics and, consequently, the line of the arch. The new line of the flattened arch establishes an entirely new understanding of the interplay of gravitational and other forces in the bridge structure. The arch has long since ceased to be the semicircular form used in ancient Rome. It has become increasingly flattened, but the most important thing is that the line of the arch of the Santa Trinita bridge is very close to a catenary, in other words a curve that increases its curvature as it moves from the centre of the arch towards the abutments. In this way the horizontal forces in the centre of the arch are increasingly transformed into vertical forces in the pier or abutment.

The research by Ammannati, the builder of the Santa Trinita bridge, into the interplay of forces in a catenary was successfully continued by one of the fathers of modern mechanics, Galileo Galilei (1564–1642), who was not only famous as an astronomer. As well as establishing the laws of falling bodies, Galileo attempted to determine the path of projectiles. He established that the path of a horizontally thrown object is a perfect parabola. In 1638 he succeeded in proving that a parabolic trajectory corresponds to a catenary. Essentially, the interplay of forces in an arch bridge structure of catenary shape is similar to that in a falling projectile.

Also dating from this period is the first known proposal to build a bridge suspended on chains. This was the work of the Croatian inventor and engineer Faustus Verantius (also known as Faust Vrančić or Fausto Veranzio). His work Machinae Novae, published in 1595, contained his idea for a bridge suspended from chains. This was the first predecessor of a system for the construction of suspension bridges that was widely used in later centuries and is still used today.

Plans for suspension bridges by the Croatian inventor Faustus Verantius (Faust Vrančić), 1595



Of enormous importance for the further understanding of structural mechanics was the research conducted in the seventeenth century by Robert Hooke (1635–1703). He discovered the law of elasticity – known as Hooke's Law – which is still valid today.

The most solid foundations of modern structural mechanics were, however, laid by Sir Isaac Newton (1642–1727). He presented his research in his 1687 work Philosophiæ Naturalis Principia Mathematica, condensing it into the laws that we know today as Newton's laws. Newton's discoveries opened the way to further development of the science of construction.

A crucial turning point in the history of bridge-building came when Jean-Rodolphe Perronet (1708–1794) established the École des Ponts et Chaussées (School of Bridges and Roads) in France in 1747. This school provided the basis for the construction of bridges according to the engineering principles of statics, strength of materials, mechanics and other parallel sciences that contributed, in a scientific manner, to the introduction of new construction principles in bridge-building that were supported by calculations. Perronet's contribution to the further development of bridges is of inestimable importance. With the help of the findings of his school, he entirely changed the shape of the arch as the principal load-bearing element of the bridge. He flattened the arch to a remarkable degree and in doing so did away with all previous conceptions of arch design in bridge structures.

Robert Hooke (1635–1703)

Jean R. Perronet (1708–1794)

Comparison of progress in bridge-building from the Roman era to the 18th century, when J.R. Perronet distinctly modernised the form of the arch and changed the role of bridge piers.

In the picture are the Pont de la Concorde, designed by Perronet, and the Pons Milvius in Rome. Around 1800 years separate the building of these two bridges. While semicircular arches and thick piers were typical of Roman bridges, Perronet's stone bridges had very shallow arches and slender piers, which among other things allowed more water to pass under the bridge

The problem of the dome of St Peter's in Rome and the beginning of modern civil engineering

Michelangelo Buonarroti (1475–1564)

Leaving aside Perronet's school, it could be argued that the real beginnings of a serious scientific, engineering-based approach to construction using complex mathematical and physical principles can be noted in the approach to the problem of cracks in the dome of St Peter's Basilica in Rome. The procedures introduced in the search for a way to repair the dome in 1742 may be considered the beginning of modern civil engineering, and in particular of structural statics in the sense in which we still understand it today.

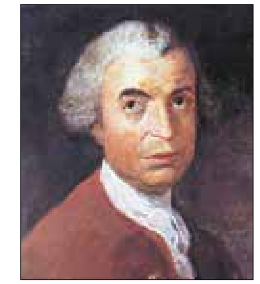
Following the death of the chief architect of St Peter's in 1546, the task of building the great dome of what was then the biggest church in the world fell to Michelangelo Buonarroti (1475–1564). After extensively revising the original plans, Michelangelo built a wooden model of the dome that still survives today. The dome was eventually completed, using Michelangelo's unfinished plans, by his successors, the architects Giovanni della Porta and Domenico Fontana.

The dome of St Peter's is constructed in two layers or shells. Within the two shells are spiral stairs leading to the top of the dome. The dome has a diameter of 42.59 metres, while its apex is 101 metres above the ground.

The dome of St Peter's in Rome

FOOTBRIDGES - SMALL IS BEAUTIFUL

Some notes on the history of bridge structures



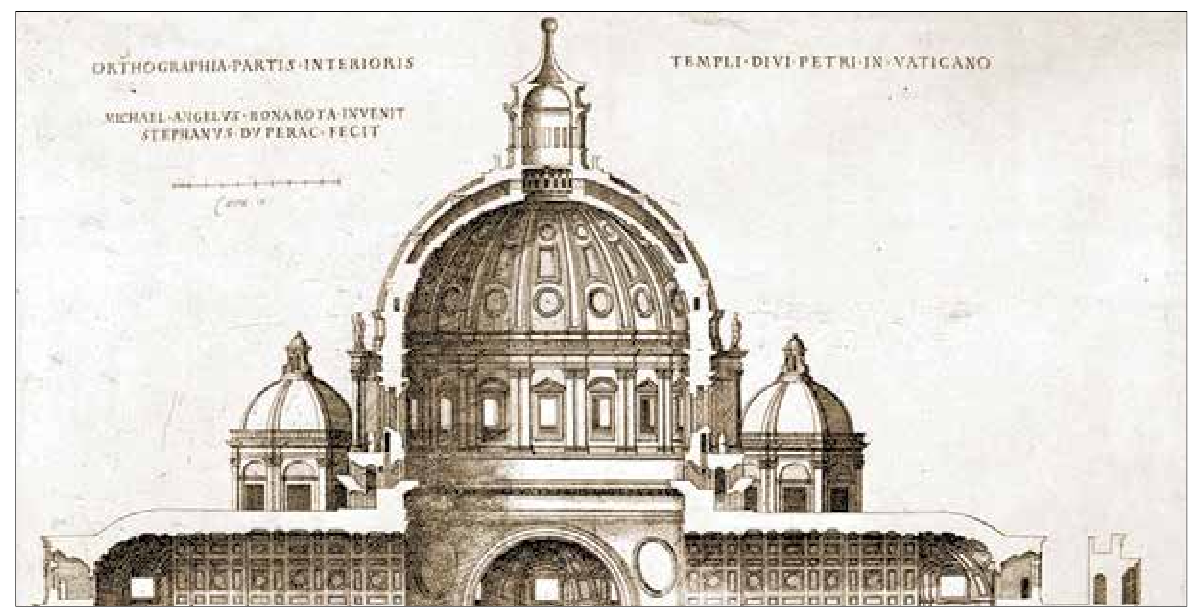
Ruđer Josip Bošković (1703–1770)

The first cracks in the dome were observed in as early as 1686. Pope Innocent XI therefore commissioned two architects to assess the state of the dome. Their work lasted several years but did not produce any successful solutions.

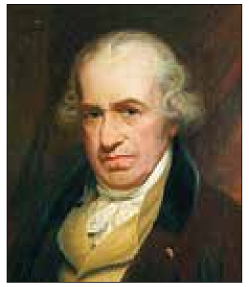
In late 1740 Pope Benedict XIV appointed a committee of three mathematicians to address the problem of the cracks in the dome, which were causing considerable concern in the Vatican. The members of the committee were R. Boskovich (1703–1770), F. Jacquier (1711–1788) and T. Le Seur (1703–1770). The approach adopted by the three mathematicians was a revolutionary one for the time. Instead of resorting to the established rules of construction, they addressed the problem from the point of view of the theory of statics. Using this theory they formulated a mathematical model of the formation of the cracks and, on the basis of these findings, looked for ways to repair the dome. They used diagrams to determine the interplay of forces in the dome and arrived at a model that explained why the cracks had formed. Even so, their theory and the findings based on it provoked great opposition from a large number of experts.

Modern theoretical construction science has since fully vindicated their findings. Because they addressed the problem of the dome in a theoretical and scientific manner, their work may be reasonably described as one of the first foundations of modern civil engineering. Naturally, their findings also found an immediate and direct response in bridge-building, where mathematical principles were increasingly being applied. As a result, bridges were become increasingly slender, and their spans were gradually beginning to increase in size. As already mentioned, the most notable proponent of these modern principles in bridge-building was the French engineer Jean-Rodolphe Perronet.

Cross-section of the dome of St Peter's in Rome



A brief historical overview of the development of iron bridges



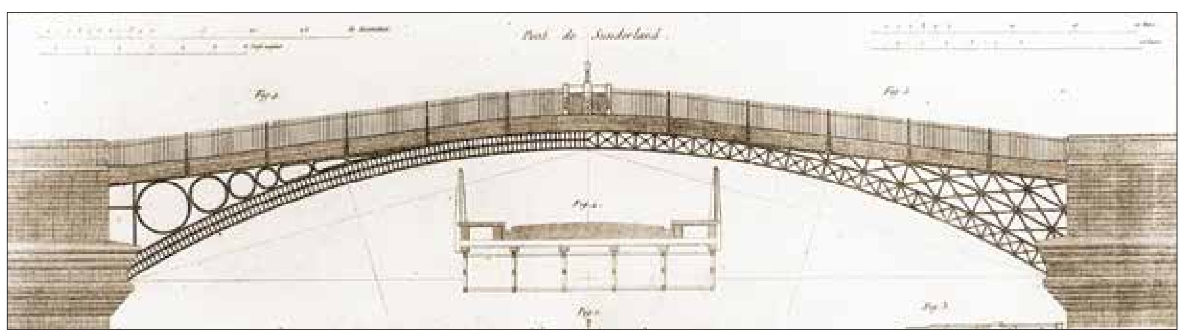
James Watt (1736–1819)

The cast-iron bridge in Ironbridge, England, built in 1779 and still standing today, was the first cast-iron bridge in the world. Span 30 metres.

Everyone familiar with the history of bridge-building knows that the first iron (or rather cast-iron) bridge was built in 1779 near Coalbrookdale in the English county of Shropshire. This cast-iron arch bridge with a span of 30 metres over the river Severn represented a new development in bridge-building at a time when practically all bridges were still built of stone, brick or wood. It opened a new era of iron and, later, steel bridges which seemed to offer practically limitless possibilities. The bridge over the Severn was both product and harbinger of the imminent Industrial Revolution, which brought with it many important technical achievements, particularly in late-eighteenth-century and early-nineteenth-century England. Among them were the invention of the steam engine (James Watt, 1736–1819) and the building of the first steam locomotive, followed, in 1825, by the opening of the first steam railway, between Stockton-on-Tees and Darlington. The cheapness and competitiveness of cast iron in comparison to other construction materials led to an unprecedented boom in iron structures, including bridges, in the early nineteenth century, first in England and then throughout Europe. We should, however, be aware that cast iron was a construction material with certain limitations. It has good compressive strength but is much less able to withstand tensile and bending stresses. It is also characterised by relatively low elasticity, in other words it is highly brittle. These characteristics were not ideal for bridge structures, which is the reason why the great majority of cast-iron bridges were arch bridges, in which compressive stresses predominate. Bridge-builders took advantage of the special characteristics of cast iron to build what were, for the time, bold bridge structures with large spans and arches with very small heights or rises.

The Wearmouth Bridge, built across the river Wear in Sunderland, England in 1796, was one of the boldest cast-iron bridge structures ever built. With a span of 71.9 metres, it was at that time the biggest single-span bridge in the world (apart from the stone bridge at Trezzo in Italy built in 1377, which had a span of 72 metres and was demolished in 1416), yet it was only three-quarters the weight of the bridge over the Severn at Ironbridge. In 1854 Robert Stephenson strengthened the bridge with three additional arches made of wrought iron. Today a steel arch bridge with a span of 114 metres stands in the same position.

The Wearmouth Bridge in England, 1796

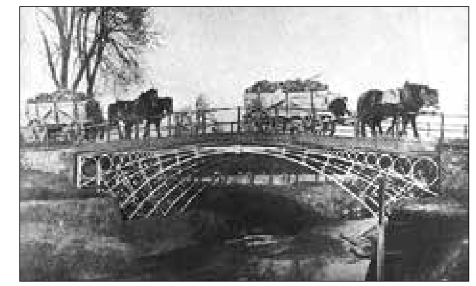


One of the largest and most beautiful bridges from the first era of cast-iron bridges stands in Dublin, Ireland, and is still in use as a pedestrian bridge today. Built in 1810, this single arch bridge over the river Liffey has a total length of 42 metres. It was cast in Coalbrookdale, in England, in the same foundry as the Iron Bridge over the Severn. The majority of cast-iron bridges of the period were cast in this foundry, including a small cast-iron bridge in Jamaica that was transported there in pieces by ship.

The largest arch bridge ever to be built of cast iron was built in London in 1819. This was the Southwark Bridge over the Thames, with three arches, the largest of which had a span of 73 metres. Today a bridge of the same name but with a somewhat different structure stands in the same position.

The use of cast iron in bridge-building quickly spread from England across the whole of Europe and became particularly popular in Germany. In 1791 a scaled-down replica of the Coalbrookdale Iron Bridge was built in the castle park at Wörlitz. The first large cast-iron bridge suitable for heavy cart traffic to be built in continental Europe was the bridge at Laasan in Silesia (today Łażany, Poland), built between 1794 and 1796. Unfortunately this bridge was blown up by the retreating German army in 1945. In 1802 a fine arch bridge was built in the park at Charlottenburg near Berlin, although it had a smaller span than the Iron Bridge

The cast-iron Liffey Bridge (or Ha'penny Bridge) over the river Liffey in Dublin, built in 1810)



Cast-iron bridge at Laasan, today Łażany in Poland, 1796

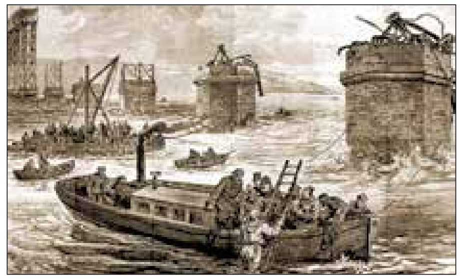
The Pont des Arts in Paris, the first cast-iron bridge in France, 1804

The Hradecky Bridge in Ljubljana, Slovenia. Cast-iron tubular arch bridge, 1867.

over the Severn. Nevertheless, this interesting structure became a model for the majority of later cast-iron bridges. A number of cast-iron bridges were also built in France. The nine-arch Pont des Arts was built over the Seine in Paris between 1802 and 1804. Its total length is 155 metres.

The first generations of cast-iron bridges were made from solid casts rather than from hollow or tubular casts as were used in later generations of cast-iron bridges, among them the Hradecky Bridge in Ljubljana, Slovenia.

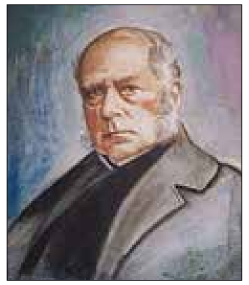
In the first half of the nineteenth century and beyond, cast iron was widely used in structures of all kinds, particularly railways and pedestrian bridges, because of its low cost. Cast-iron structures began to be used in numerous bridges, where however the poor mechanical properties of cast iron, particularly its brittleness and poor tensile strength, soon came to the fore. This led to numerous railway accidents and bridge collapses. The first major disaster (known as the Dee Bridge Disaster) occurred in 1847 on the river Dee in England, when the bridge structure fractured at the joints. One of the most famous and tragic bridge collapses occurred in 1879, when the railway bridge over the Firth of Tay in Scotland collapsed as a train was passing over it during a violent storm (the Tay Bridge Disaster). The train plunged into the water, claiming the lives of its 75 passengers. It was this event, which saw fracture failures in the cast-iron sections of the structure, that sealed the fate of cast-iron bridges. Following the Norwood Junction railway accident in 1891, their construction was effectively prohibited.



The Tay Bridge in Scotland collapsed in 1879 during a storm with winds of more than 100 km/h. The train that was crossing the bridge plunged into the waters below, claiming the lives of all 75 passengers.

And yet it was not only accidents and disasters that put an end to the use of cast iron in the building of bridges. Technological development and new inventions in the mid-nineteenth century also played their part. After 1840 wrought iron was increasingly used in structures instead of cast iron. A little later rolled iron also began to be used. Both materials had incomparably better characteristics than cast iron for building bridges. Rolled iron, in particular, had a more homogeneous load-bearing capacity and had good tensile strength as well as compressive strength, which was a big advantage in comparison to cast iron.

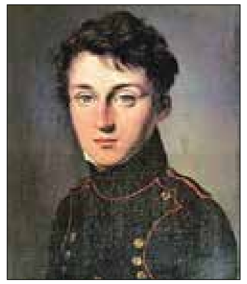
Henry Bessemer (1813–1898) caused a revolution in the production of iron with his invention, in 1856, of the Bessemer converter, which opened the way to the manufacture of high-quality steel. The use of steel in the second half of the nineteenth century and beyond represented a true revolution in all kinds of construction, including shipbuilding.



Henry Bessemer (1813–1898)

Nevertheless, the widespread use of cast iron in the construction of arch bridges (in particular) right up until the end of the nineteenth century is not surprising, since despite its numerous disadvantages the use of cast iron was dictated by its low price.

The development of hinges in bridge structures



Claude-Louis Navier (1785–1836)

Let us begin this section by considering the role or function of hinges in a bridge structure. In structural statics theory, a hinge is a structural element which does not transmit a bending moment (the bending moment in the hinge is therefore expressed as M=0), but which can transmit axial forces, i.e. compressive, tensile and shear forces. The use of “moment hinges” contributes to the statical determinacy of a structure. It is particularly useful in bridge structures with high temperature stresses and those in which partial deformation or subsidence of the foundations is possible. A hinge allows partial and limited rotation and movement of individual parts of the bridge structure without affecting the bridge’s load-bearing capacity. This most frequently occurs as a result of temperature changes or changes in the loading of the bridge.

When was a hinge first used in a bridge structure as a structural element? One of the first to consider the theoretical basis of the hinge was the French engineer Claude-Louis Navier (1785–1836). An important step towards understanding the role of hinges was taken with the construction of the Pont d’Arcole in Paris in 1854. This bridge, which stands near Notre-Dame cathedral and spans one arm of the Seine, was built by the retired engineer Alphonse Oudry (1819–1869) and his partner Nicolas Cadiat. The bridge was built from a combination of rolled iron and wrought iron, rather than cast iron, and had a span of 80 metres. The rise of the arch was just 6.12 metres – evidence of the remarkable boldness of the structure. Although the arch did not contain a hinge at the crown of the arch, the arch was extremely slender at this point and therefore flexible. The height of the arch at the crown was just 38 centimetres. This design allowed the two halves of the bridge to withstand the slight rotations and movements that mainly occurred as the result of temperature changes. Thanks to its slenderness or flexibility, this part of the bridge structure could be said to perform the role of a hinge. At the same time the Pont d’Arcole was the first bridge to span the Seine without the use of intermediate piers. The builders of the Pont d’Arcole may, however, have gone too far with the slenderness of their arch, since on 16 February 1888 the bridge suddenly sagged by 20 centimetres. Additional strengthening of the bridge was carried out immediately, before more serious damage could occur.

The Pont d’Arcole in Paris, built in 1854. The bridge structure has since been somewhat altered and modernised.

The technical solution adopted by Oudry was an attempt to reduce the effect of temperature changes on the internal forces in the arch and limit its deformation. In terms of statics the bridge may be defined as an elastic arch that is fixed at both ends and has, at its centre, a kind of hinge that allows moderate rotations and in this way relieves the static loads on the bridge structure as a whole.

J. A. Charles Bresse (1822–1883)

With its bold slenderness and original structural concept, the Pont d'Arcole led directly to the introduction and use of the first hinge in the next generation of iron bridges.

A further important theoretical step that contributed to the introduction of hinges in bridge structures (particularly those made of iron) was taken by the French engineer J. A. Charles Bresse (1822–1883). He tested his theory by means of measurements on existing bridges in France and obtained results of considerable consistency. This was the best proof of the practical applicability and validity of his theory.

The invention of hinges and their use in iron bridge structures

The hinge of a large steel bridge

The first bridge-builders to put the theory of hinges in bridge structures into practice were the French engineers Couche and Salle. In 1858 they built a wrought-iron railway bridge to carry the Paris–Creil line over the Saint-Denis canal. The bridge consisted of two sections: a horizontal lattice truss structure and, below it, an iron arch on which the truss structure rested. The arch, which had a span of 45.16 metres and a rise of 4.71 metres, was built as a two-hinged arch, with the hinges naturally located in the abutments. Originally the engineers wanted to build a three-hinged arch, but owing to the insufficient height of the arch structure at the crown they had to abandon this idea. Nevertheless, the bridge caused a sensation in engineering circles with its statically pure and technically accomplished structure. Above all, Bresse's theory of the elasticity of iron arches was now confirmed in practice.

Assembling of the Quebec steel bridge, 1919

Shortly after this, between 1862 and 1864, a large iron bridge was built near Koblenz in Germany. This was the first bridge in the world to consist of a truss or lattice arch structure resting on supports via hinges. The German engineer Heinrich Gerber (1832–1912) became renowned for his use of hinges in bridge structures (to begin with these were mainly iron bridges). In 1864 he successfully patented a technical solution for the road bridge over the Main at Hassfurt, which was completed in 1867 and which used hinges in the truss structure. This was the first prototype of a structure that is still known today as a Gerber beam. The bridge over the Main was also the first modern steel bridge, since until that time iron bridges had mainly been made of cast, wrought or rolled iron. The length of Gerber's two-hinged beam was 37.9 metres. The bridge was later demolished and thus has not survived to the present day.

The door was now open for the generalised use of hinges in the construction of bridges (particularly iron bridges). Soon after this hinges also began to be used in the construction of solid bridges, whether of stone or, later, of concrete.

Application of the hinge to the Hradecky Bridge in Ljubljana (1867)

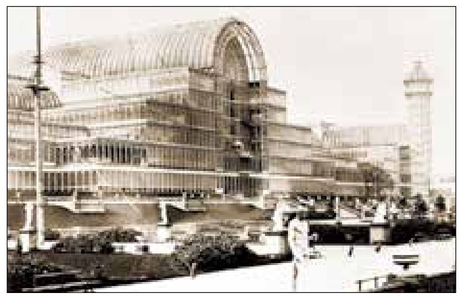
Just a few years after Couche and Salle built the first hinged bridge, the Austrian engineer Johann Hermann successfully used this technical solution in the construction of the Hradecky Bridge. He knew why a hinge was necessary and he also knew where to put it – in the centre (i.e. at the crown) of the arch of his new footbridge in the centre of Ljubljana (Slovenia). He was clearly well aware of the role and function of the hinge in his planned new cast-iron structure. The Hradecky Bridge, built in 1867, was one of the first bridges in Europe and indeed the world to incorporate what was, for the time, a revolutionary structural element. At the time of its construction (1867) it was also the only cast-iron tubular arch bridge to incorporate a hinge.

These facts make the Hradecky Bridge unique in the world. From this point of view it may be considered an early representative – if not indeed the oldest representative – of an important stage in the development of engineering expertise in bridge-building.

Iron bridges break the record for length of span in the 19th century

In the second half of the nineteenth century iron and steel broke the records previously held by other construction materials used to build bridges. This period saw the construction of famous bridges such as the Garabit Viaduct (G. Eiffel, 1884) and, most notably, the Forth Rail Bridge over the Firth of Forth in Scotland (1889). The latter had

Firth of Forth railway bridge in Scotland, 1889



Crystal Palace in London, 1851

two main spans of 521 metres – an astonishing achievement for the time. Iron and steel made rapid and triumphant progress in bridge-building. Steel was increasingly used in the construction industry, particularly after 1856, when Henry Bessemer devised a process for producing high-quality steel, and now became the material of choice for the construction of large structures. In the late nineteenth and early twentieth centuries, numerous public buildings – railway stations, museums, exhibition halls, etc. – were built using a combination of steel and glass.

One of the most famous buildings to characterise the developmental possibilities and potentials of the Industrial Revolution is without a doubt the Crystal Palace, built in London in 1851 by Joseph Paxton. This huge building, the ground plan of which measured an incredible 615 x 150 metres, was built in just 17 weeks and was almost entirely constructed of iron, steel and glass. It was built to house the Great Exhibition of 1851, the first international exhibition of the products of industry. With its magnificent exterior and endless expanses of glass on an iron skeleton, the Crystal Palace heralded a new technological era in construction and represented a complete break with traditional construction methods. More than any other building in the world, it expressed the great potential of iron and steel as materials in every field of construction. Iron continued its triumphal march in the construction of large bridges for the rapidly developing railway network in Europe.

Shortly after the Great Exhibition, the Crystal Palace was dismantled and moved from its original location in Hyde Park to a new location in London. It stood there until 1936, when it was destroyed by fire, after which the few surviving sections were demolished.

The Pont Alexandre III in Paris, 1900

It is perhaps less generally well known that a similar fate was originally planned for the Eiffel Tower, which was built for the 1889 Exposition Universelle in Paris. The original plan was to dismantle the tower once the exhibition was over. Fortunately, however, this did not happen. The Eiffel Tower still stands in Paris today, as the city's most recognisable landmark and one of most important attractions.

Steel bridges can also be beautiful, as is demonstrated by a highly ornate bridge located in the very centre of Paris. The Pont Alexandre III was built in 1900 as a symbol of Franco-Russian friendship in the year of the Exposition Universelle in Paris. It is named after Tsar Alexander III, whose son Nicholas II laid the bridge's foundation stone. The numerous figurative and decorative elements of the bridge were created by the greatest French artists of the day and skilfully incorporated into the bridge, a low steel arch structure of bold design with a span of 100 metres. Many people consider it the most beautiful bridge in Paris.

Decoration on the Pont Alexandre III

Concrete began its victorious advance at the end of the 19th century

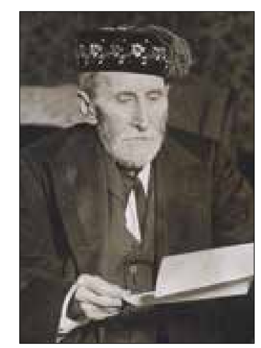
Concrete is today an almost ubiquitous construction material. It is practically impossible to imagine any modern structure without it and we encounter it at every step. Its main advantages are that it can be prepared simply and quickly, it is relatively inexpensive and it has an adequate lifespan or durability.

The history of the use of concrete is actually very interesting. As mentioned earlier, the first to use it were the ancient Romans, who called it concretum. The dome of the Pantheon in Rome, built in around 126 BC, is still the largest unreinforced concrete dome in the world.

This hemispherical dome has a diameter of 43.40 metres. It is built from extremely light concrete containing volcanic tuff, chosen because of its lightness. The Roman concrete used to build the Pantheon has proved its durability, since the dome is still standing and its magnificent structure remains an inspiration to modern construction science.

In 1756 the British engineer John Smeaton (1724–1792) pioneered the use of a hydraulic binder, in other words a mortar which will also set underwater. This marked the start of a new era in the history of civil engineering. The first hydraulic mortars, baked at a high temperature, were made of lime. With the invention of Portland cement in 1844 (thanks to a chance discovery by the British engineer Isaac Charles Johnson, 1811–1911), this type of cement gradually began to be used in bridge-building. Up until the middle of the nineteenth century all bridges had been built using lime mortar. Now, however, this material gradually began to disappear from bridge-building. After 1890 cement was used exclusively as a binder.

Interior view of the Pantheon dome in Rome, 126 BC



The British engineer Isaac Charles Johnson (1811–1911), the inventor of Portland cement

The use of concrete meant the gradual end to thousands of years of stone bridge construction in Europe

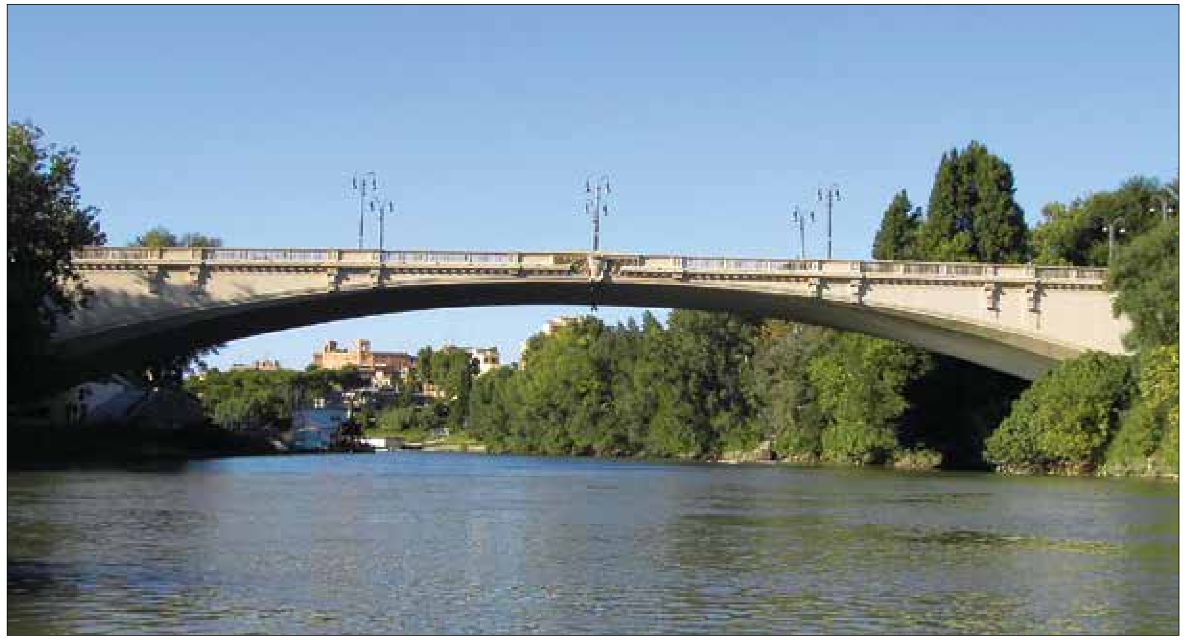
With a main span of 85 metres, the bridge at Solkan (Slovenia) boasts the largest stone arch of any railway bridge in the world.

The use of cement as a basic binding material immediately found its place in bridge-building. The aqueduct built over the river Yonne in France in 1870 had several concrete arches, the largest of which had an opening of 40 metres. Yet although their march had now become inexorable, concrete bridges were still in their infancy. Bridge-builders still preferred the tried and tested method of building stone bridges, and continued to develop the use of stone as a construction material to the limits of its possibilities.

Steel bridges also began to provide competition to stone bridges, although these were not widely used in Austria and Italy in the late nineteenth and early twentieth centuries. In view of the widespread opposition to the construction of steel bridges on railway lines, the railway companies in Austria and Italy gave priority to solid stone arch bridges. As a result, this period also produced some of the largest and most beautiful stone railway bridges. The crowning achievement of a path of development followed by thousands upon thousands of stone bridges built over the course of two millennia came in 1906 with the construction of the largest stone arch in the world.

That year saw the construction of the last great stone bridge: the railway bridge over the river Soča at Solkan in Slovenia. This bridge, whose stone arch has a span of 85 metres, still graces the valley of the Soča and is still used by railway traffic today. Construction of this imposing bridge took place between 1904 and 1906 and the demanding project concentrated all the bridge-building expertise accumulated by the engineering profession in the construction of stone bridges. The bridge still boasts the largest stone arch of any bridge in the world.

The Ponte del Risorgimento in Rome. The first concrete bridge to achieve a span of 100 metres. Built in 1911.



In the last two decades numerous stone road bridges with even longer spans have been built in China, although these are not bridges in the true sense of the word but simply viaducts across a valley, since they do not cross a major river – usually the biggest obstacle in the construction of a bridge. The largest stone viaduct in China is the Danhe Bridge, which has a main span of 146 metres. It is, however, a representative of a different technological era from that of the great stone bridges of the late nineteenth and early twentieth centuries.

The construction of the railway bridge over the Soča at Solkan also marks the end of the long era of stone bridges. The predominance of concrete as a cheaper material that is also more suitable for bridge-building put an end to a venerable tradition, lasting several thousand years, of unique and today unrepeatable structures.

The first concrete bridge with a span of 100 metres was built in Rome between 1910 and 1911. This was the Ponte del Risorgimento over the Tiber, built using a system patented by the Belgian engineer François Hennebique and justly considered the first herald of the unstoppable march of concrete in bridge-building.

Large stone bridges had become monuments overnight. A new era of reinforced concrete and, later, prestressed concrete now began, and still continues today. How we view this era today may best be summed up as follows: we may build concrete bridges, but our hearts are still loyal to the imperishable beauty of stone bridges.

The further development of bridge-building in the twentieth and twenty-first centuries and up to the present day is another story. The best way to interpret it is the review of numerous bridges, particularly pedestrian bridges, that follows this article. This book is living proof that bridge-building knowledge is still evolving and will certainly continue to do so in the future.

Literature and sources

1. **Bednarski M. Cezary:** *The "Chained" Bridge, Footbridge, 2011*
2. **Cortright Robert:** *Bridging, Bridge Ink, Oregon, USA, 1998*
3. **ECCE** *– European Council of Civil Engineers: Civil Engineering Heritage in Europe 18th – 21st Century, Grafika Soča d.o.o., Nova Gorica, ECCE, 2009*
4. **Graf Bernhard:** *Brücken, die Welt verbinden, Prestel, München, 2002*
5. **Humar Gorazd:** *Kamniti velikan na Soči (The Stone Giant on the Soča) Založba Branko, Nova Gorica, 1996*
6. **Humar Gorazd:** *Zmajski most (The Dragon Bridge), Založništvo Pontis in Založba Branko, Nova Gorica, 1998*
7. **Humar Gorazd:** *World Famous Bridges in Slovenia, Arch '01, Presses des Ponts, Paris, 2001*
8. **Humar Gorazd:** *Hradeckega most v Ljubljani (The Hradeckega Bridge in Ljubljana), Gradbeni vestnik, letnik 62, Ljubljana, 2013*
9. **Kurrer, K. E. Kahlow, A.:** *Arch and vaults from 1800–1864, 1998*
10. **David J. Brown:** *Brücken, Callwey Verlag, München, 1994*
11. **Mariani Massimo:** *Consolidamento delle strutture lignee con l'acciaio, DEI srl, Tipografia del Genio Civile, Roma, 2004*
12. **Melan Joseph:** *Der Brückenbau, II. Band, Franz Deuticke, Leipzig und Wien, 1920*
13. **Pauser Alfred:** *Entwicklungsgeschichte des Massivbrückenbaues, Österreichischer Betonverein, Wien, 1986*
14. **Prade Marcel:** *Les Ponts – Monumentes Historique, Editions BRISSAUD – Poitiers, 1986*
15. **Pržulj Milenko:** *Mostovi, Udruženje, "Izgradnja", Beograd, 2014*
16. **Séjourné Paul:** *Grandes voûtes, Tome I-VI, Imprimerie Vue, Tardy-Pigelet et fils, Bourges, 1914*
17. **Siviero Enzo:** *Ponteggiando, il prato casa editrice, Padova, 2009*
18. **Straub Hans, V. Halász Robert:** *Zur Geschichte des Bauingenieurwesens, Die Bautechnik, Berlin, 1960*
19. **Tonković Kruno:** *Masivni mostovi, Građenje, Školska knjiga, Zagreb, 1979*
20. **ZÖIAV:** *Zeitschrift des Österreichischen Ingenieur und Architekten-Vereines, H-2, Wien, 1868*

St John Nepomucene - Svatý Jan Nepomucký

Protector against floods and also protector of bridges

Statues, monuments and inscriptions are not a very common phenomenon on bridges in general. Only a few bridges can boast this type of decoration, which can give a bridge a special importance. The ancient Romans used to build stone tablets into their bridges, usually to commemorate the ruler responsible for its construction. By virtue of their function, bridges were structures on which rulers and others liked to place monuments or divine symbols. No-one could cross the bridge without observing the symbol on it.

Erecting statues or commemorative symbols on bridges reached the height of its popularity in The Middle Ages. Perhaps the richest and most beautiful bridge from this point of view is the Charles Bridge in Prague, built over the Vltava in the early 15th century. Today over 30 statues and sculptures stand on the 516-metre-long bridge, transforming it into a true art gallery.

The old Roman bridge (built 133-134 AD by the Emperor Hadrian) leading to the Castel Sant'Angelo in Rome was completely renovated during the Roman baroque period, by

The Charles Bridge in Prague

FOOTBRIDGES - SMALL IS BEAUTIFUL

St John Nepomucene

Lorenzo Bernini, who placed on the bridge ten statues of angels with symbols of Christ's Passion.

A feature of both these famous bridges is that their statues are life-sized. Even in the Middle Ages the designers of bridges knew that such proportions create proper symmetry in the traveller crossing the bridge and do not destroy the harmonic balance with the bridge structure itself.

Of all the monuments on bridges in Europe the most common are statues of St John Nepomucene (Jan Nepomucký in Czech language).

In order to explain why the image of this saint is almost always found on bridges, we need to go far back in time to the 14th century. John Nepomucene was born around 1330 in Pomúk in Bohemia and later became Bishop of Prague. According to legend, he recovered from a serious illness in his youth thanks to the prayers of his pious parents. To show their gratitude for his recovery they sent him to Prague to enter God's service. There he became a famous preacher and many of those who heard him changed their way of life as a result. King Wenceslas IV invited him to his court, where he became the queen's confidant. As the result of a dispute with the king, who wished to subject the Bohemian church to his sway, John Nepomucene fell into the king's disfavour. His position was worsened by the fact that he refused to betray to the king what the queen had told him in the confessional. The king had him imprisoned and

FOOTBRIDGES - SMALL IS BEAUTIFUL

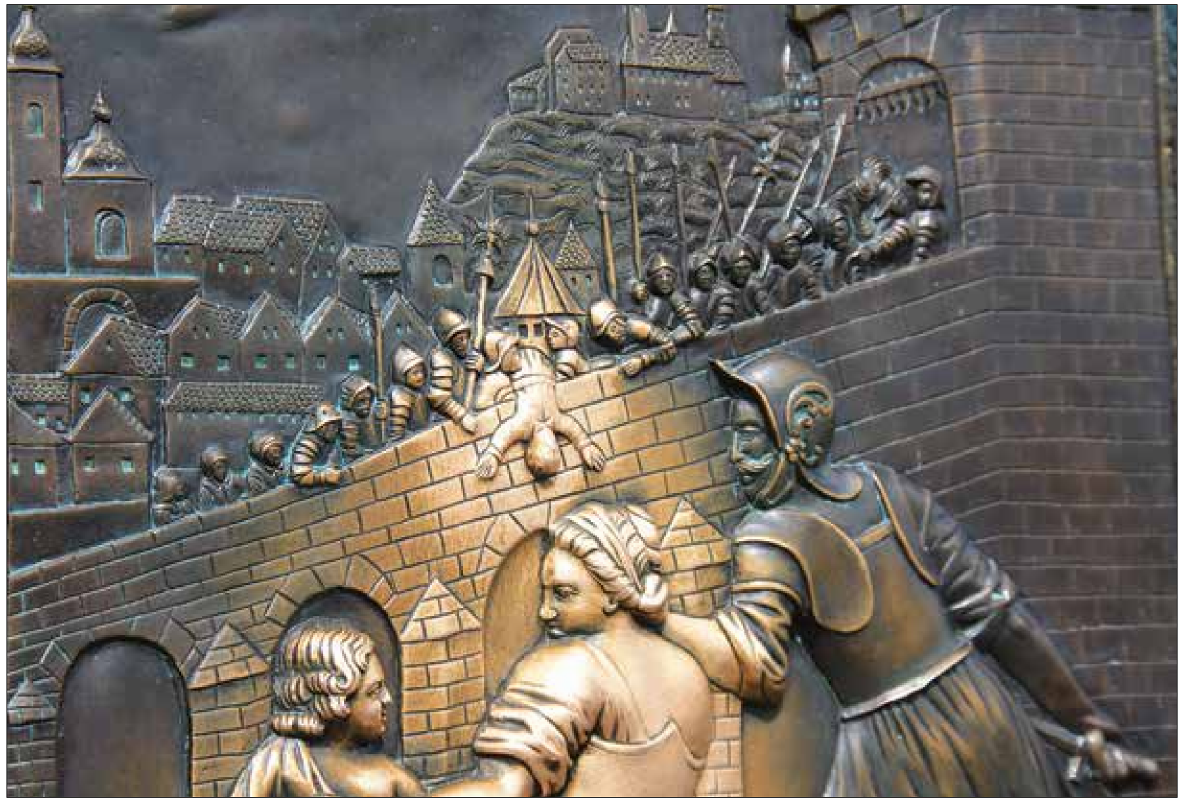
St John Nepomucene

tortured. On 20 March 1393 he had him tied in a bag and pushed from the Charles Bridge into the icy waters of the Vltava, where he drowned. According to popular rumour, as the bag was sinking to the bottom of the Vltava a halo with five stars, which symbolised the martyr, rose to the surface.

After his tragic death the martyr John Nepomucene became a model for the protection of the sanctity of the sacrament of confession. His fame spread greatly during the Catholic Reformation and in 1729 he was proclaimed a saint. Because of the manner of his death he was popularly held to be a protector against floods, while his infinite and unyielding commitment to the secrecy of the confessional also gave him the role of protector against slanderous tongues.

For these reasons statues of St John Nepomucene mainly appear on bridges, with the result that indirectly he has also become the patron saint of bridges. In 1683 a bronze statue of the saint was placed on the Charles Bridge in Prague, at the point where he was thrown into the water. Later, statues of the greatest Czech saint appeared on bridges all over Europe.

Detail from the bronze plaque on the Charles Bridge showing the moment when St John of Nepomuk was thrown from the bridge



FOOTBRIDGES - SMALL IS BEAUTIFUL

Contributions from European countries

A beautiful bridge is a symphony

Johan Wolfgang von Goethe
(1749–1832)

Bosnia and Herzegovina

The Latin Bridge
(Latinska ćuprija)

- **Sarajevo, over the river Miljacka**
- 1565, renovated in 2004
- Famous as the site of the assassination of Archduke Franz Ferdinand in 1914

Text by: Gorazd Humar
All photos: Gorazd Humar

The Latin Bridge is a wonderful, harmoniously designed bridge in the classical style that stands in the centre of Sarajevo. Centuries earlier, a wooden bridge stood on this site. The first stone bridge was built in 1565 by Ali Ajni-Beg, an influential citizen of Sarajevo. The bridge was given the outlines of its present form during reconstruction work carried out between 1798 and 1799. Some years earlier it had been almost entirely destroyed by floodwaters. The bridge is characterised by two relieving openings or "eyes" above the piers in the middle of the river. These openings even appear on the coat of arms of the city of Sarajevo.

The Latin Bridge got its name from the fact that the city's Catholic population lived on the other side of the bridge. This district was known as Latinluk – the Latin quarter. The bridge is most famous, however, for an event that took place just beside it and that changed the course of world history.

It was here that on 28 June 1914 Gavrilo Princip assassinated Archduke Franz Ferdinand, the heir to the Austro-Hungarian throne, and his wife Sophie. This was the spark that triggered the conflict between Austria-Hungary and Serbia and led to the outbreak of the First World War. A museum commemorating this event still stands by the bridge today.

From 1918 until 1992 the Latin Bridge bore the name of the assassin Gavrilo Princip and was known as the Princip Bridge.

The present appearance of the Latin Bridge dates from the reconstruction that took place between 2003 and 2004.

Bosnia and Herzegovina

The Old Bridge
(Stari most)

- **Mostar**
- 1557–1566
- Stone arch bridge, span 28.7 metres
- Built by Mimar Hayruddin, a pupil of the famous Ottoman architect Mimar Sinan
- Hollow interior structure, first of its kind
- Destroyed in 1993, rebuilt in 2004

Text by: Gorazd Humar
All photos: Gorazd Humar

The architecture of Mostar, with the Old Bridge at its heart, is among the most beautiful and characteristic in the whole of Bosnia and Herzegovina. The Ottoman architecture that dominates the city also includes the Cejvan Cehaj Mosque, Mostar's other architectural jewel. Mostar's old town centre developed on the two banks of the river Neretva, which are linked by the Old Bridge.

The challenge of bridging the wild river undoubtedly inspired the master architect Mimar Hayruddin, who sought a solution that would enable him to span the Neretva with a single arch and without a central pier in the river itself. The result was an extraordinary stone arch structure, built by special order of the Turkish sultan Suleiman the Magnificent (1492–1566).

Construction of the bridge is believed to have begun in 1557 and was completed in 1566, the last year of Suleiman's reign. We do not know what means were used to support the bridge during construction of the stone arch, but the torrential nature of the Neretva rules out the possibility of a supporting structure standing in the riverbed. We are, however, able to identify the quarry near Mostar which supplied the hand-cut stone that was used to build the arch. The bridge was mentioned several times by the seventeenth-century traveller Evliya Çelebi, in words full of emotion and enthusiasm: "It is like a rainbow soaring up to the skies, extending from one cliff to the other." Later on he adds: "I, a poor and miserable slave of Allah, have passed through sixteen countries, but never have I seen such a high bridge."

The Austrian writer Robert Michel, who dedicated a special monograph to the Old Bridge, compared it to the Rialto Bridge in Venice, saying: "Were we to have to choose the most beautiful bridge in the world, we would probably choose the Old Bridge in Mostar." He compared the structure to petrified crescent moon or a gigantic gull turned to stone in mid-flight.

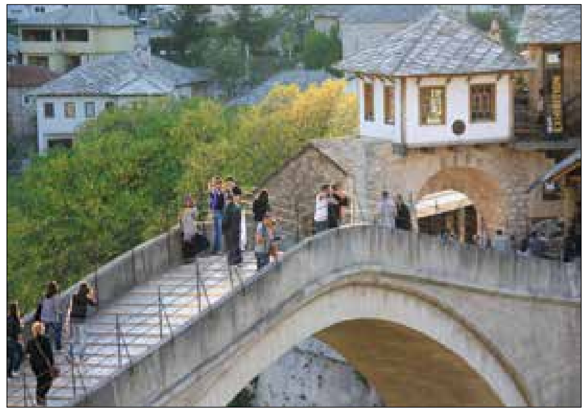
The curve of the supporting arch differs from the humpbacked arch typical of Ottoman architecture like that of the famous bridge over the Drina at Višegrad, while it is also different from the semicircular shape used by the Romans. Its form is closest to an ellipse or oval – quite an unusual shape for the time. Hayruddin also achieved something else with the basic dimensions of the arch. The thickness of the arch in the centre, where the structure is thinnest, was a full 77 centimetres. The upper edge of the supporting arch has a projecting edge – the archivolt – that emphasises the line of the arch through the effect of shadow. The relatively steep deck of the bridge, into which stone ribs are built to prevent slipping, is particularly interesting.

The bridge's biggest secret was discovered by chance almost 400 years after it was built. While drilling into the bridge structure during restoration work in 1955, engineers discovered two hidden cavities in the interior of the arch. The purpose of these two parallel box-like cavities, divided by a supporting wall and covered by stone slabs, was to reduce the weight of the bridge structure above the supporting

arch. The discovery of these cavities increased the historical value of the bridge. This structural solution gave the bridge a special value from the static point of view, to go with its unique shape. This "other" value of the bridge may be less well known, but from the point of view of the historical development of bridges it is worthy of particular consideration. Without a doubt this is the oldest known example of a hollow bridge in the history of bridge-building.

Mostar's Old Bridge experienced the most difficult moments in its history during the terrible war that raged in Bosnia and Herzegovina from 1991 to 1994, claiming an enormous number of human casualties. The Old Bridge did not survive the war. The equivalent of 200 shells per inhabitant fell on Mostar during the fighting. On 9 November 1993, following two days of artillery bombardment and 92 direct hits, the bridge gave way and went crashing into the Neretva. The memory of one of the greatest architectural feats in human history was washed away by the river.

In 2003, under the aegis of the World Bank and with the help of donations from numerous European countries and Turkey, work began to rebuild the bridge in its original form. The new Old Bridge was officially opened on 29 September 2004, and its resplendent beauty once again adorns the city of Mostar. At the same time it has become an involuntary monument to human foolishness and the senselessness of the war in Bosnia and Herzegovina.



FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Gorazd Humar

The Old Bridge (Stari most), Mostar

Croatia

Footbridges of Dubrovnik

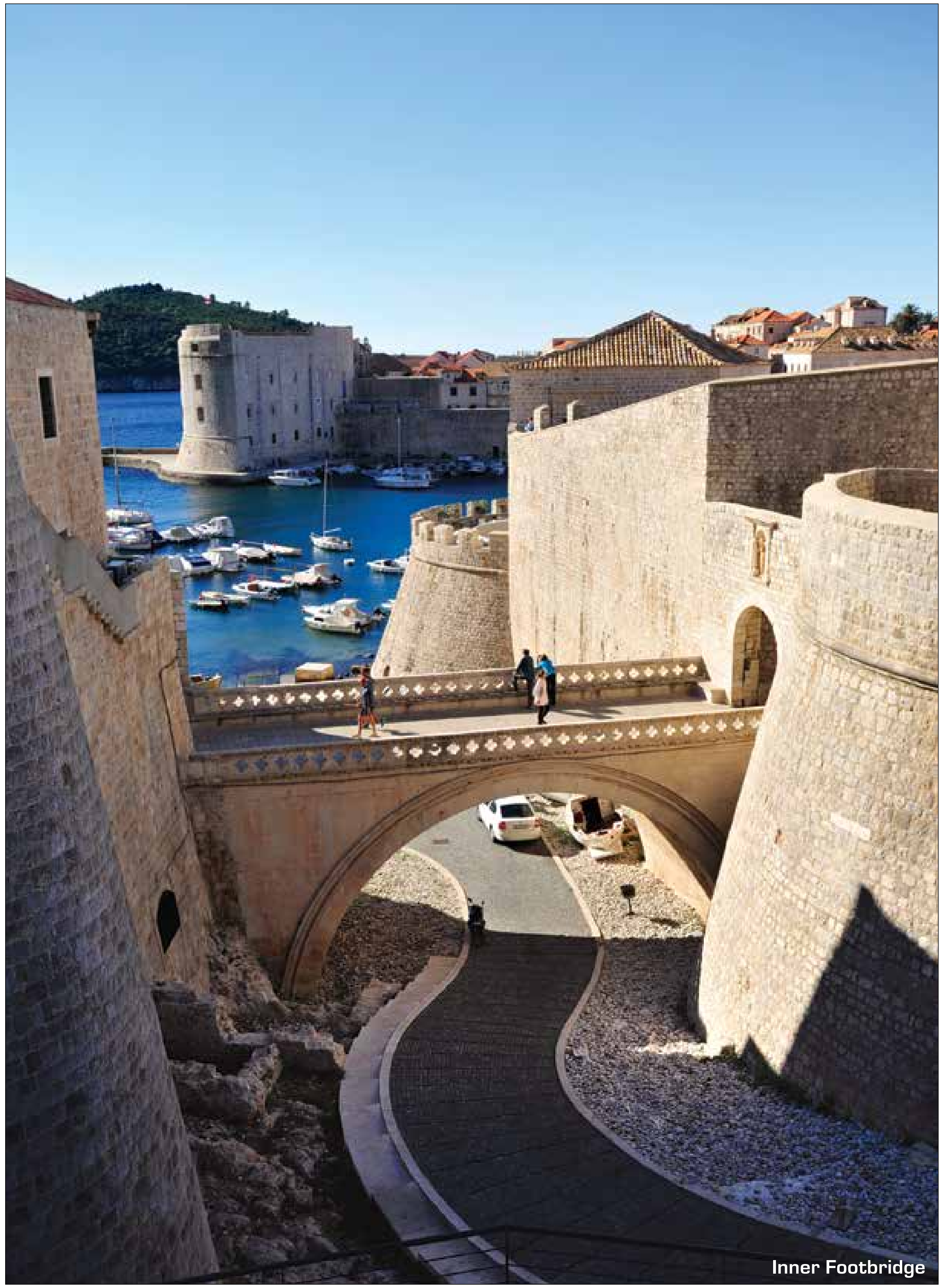
- **Dubrovnik**
- 1397–1538
- Access bridges to the walls of Dubrovnik
- Outer bridges extended by a wooden drawbridge

For more than eleven centuries, until the beginning of the nineteenth century, the city of Dubrovnik (Latin: Ragusa) was a republic, defending its survival and freedom primarily through diplomacy but also by building city walls and other fortifications. The Dubrovnik city walls run uninterruptedly for 1,940 metres and represent a unique example of fortification architecture. Today they are an internationally recognised monument. The process of constructing the walls and fortifications continued for centuries. In the fourteenth century the people of Dubrovnik dug a moat in front of the Pile Gate, on the west side of the city. In the fifteenth century they did the same on the east side.

Entrance to the Old Town is through the Pile Gate on the west side, via a two-arch stone bridge and a wooden drawbridge. This stone bridge underwent numerous changes and transformations over the course of the centuries. The original bridge built by military engineer Giovanni da Siena between 1397

Pile Footbridge

FOOTBRIDGES - SMALL IS BEAUTIFUL



Inner Footbridge

and 1398. This was a stone bridge with a single arch. In the mid-fifteenth century the town ramparts were expanded, a new Outer Pile Gate was built and the moat was widened, all of which demanded the construction of a new three-arch stone bridge. This bridge was built in 1474 to the plans of the Dubrovnik master builder Paskoje Miličević, using stone from the island of Korčula. The decorative stone elements were made by Marko Andrijić, a stonemason from Korčula. In the year 1533, the original stone arch of the bridge, the one connected to the Pile Gate itself, was demolished and replaced by a wooden drawbridge. The work was completed in 1538, thereby giving the bridge its present form.

At the time of the republic and up until the mid-nineteenth century (by which time Dubrovnik was under Austrian rule), the wooden bridges at the Pile and Ploče gates were drawn up at night. The mechanisms for lifting the wooden bridges are still visible today. During reconstruction work in 1937 the original gates underwent restoration and the existing concrete bridge was replaced by a wooden one which can no longer be drawn. Following construction of Put iza Grada, the "Way behind the Town", between 1896 and 1899, and excavations beneath the Minčeta Tower, the moat under the Outer Pile Gate and the bottom parts of the bridge were filled in. On passing through the gate, one enters an area with a paved road and a stone staircase which was carved in 1923 by the renowned Croatian sculptor Ivan Meštrović.

In order to bridge the moat under the Inner Ploče Gate, it was decided in 1449 to construct a single-arch stone bridge (today known as the Inner Ploče Gate Bridge) corresponding in style to the bridge in front of the Outer Pile Gate. This bridge was designed by Paskoje Miličević and built by the stonemasons Đuro Utišenović, Radoje Grubačević, Radoslav Radovanović and Vlado Bogojević.

Further on, one passes along the walls of the Revelin Fortress to the Outer Ploče, constructed in 1466.

In 1479 another moat was dug to the east of this gate and the Outer Ploče Gate Bridge was built over it, once again to a design by Dubrovnik's master builder Paskoje Miličević. A wooden drawbridge and a two-arch stone bridge continue on to the Outer Ploče Gate.

The bridges are in the Gothic-Renaissance and decorated Gothic styles, recognisable by the quatrefoil motif on the bridges' parapets.

Inner Footbridge

F O O T B R I D G E S - S M A L L I S B E A U T I F U L

Footbridges of Dubrovnik

Ploče Footbridge

FOOTBRIDGES - SMALL IS BEAUTIFUL

Ploče Footbridge, Dubrovnik

Croatia

Footbridge over Jazine Bay

- **Zadar**
- 1962
- Links the old and new parts of Zadar
- Steel bridge, total length 152.2 metres

The first bridge across the harbour in Zadar opened in 1928. It was 153 metres long and 7 metres wide, had a roadway and footways, and opened in the middle to facilitate the passage of ships into Jazine Bay. It was destroyed in 1944 during an Allied air raid.

On 21 December 1949 a temporary pontoon bridge on steel oil drums was anchored at the same location. Crossing the bridge during strong south winds or gales was no easy matter. The pontoon bridge could also open up to let ships through.

Finally, on 12 May 1962, the present steel bridge was opened for use: 152.2 metres long and 6 metres wide, it connects the newer districts of town with the peninsula. It is the busiest pedestrian crossing in Zadar, designed for pedestrian traffic only. At its centre, the bridge has a structure that is designed to open in order to let ships through. Its mechanism, however, was only functional on the day of the final inspection. Jazine Bay has been cut off from the port of Zadar ever since.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Croatia

Pedestrian suspension bridge over the Drava

- **Osijek**
- 1980
- Main span 209.5 metres
- Famous Osijek landmark

The pedestrian suspension bridge over the river Drava in Osijek was built in 1980 and almost as soon as it was completed it joined the co-cathedral as one of Osijek's most famous and beautiful landmarks. The 209.5 metre bridge is a single-span suspended structure. Load-bearing steel cables (Ø 60 mm) are stretched across two steel pylons 30.2 metres high and anchored into reinforced concrete anchorages on either side of the bridge at an axis-to-axis distance of 56.4 metres from the pylon axis. The foundations of the pylons consist of a reinforced concrete chamber supported by eight reinforced concrete piles with a diameter of 1,500 mm and a length of approximately 22.0 metres. The precast reinforced concrete deck, with a total width of 8.0 metres, is suspended on staying cables (Ø 20 mm) attached to the main load-bearing steel cables. The total width of the pedestrian footway is 5.0 metres.

Croatia

Skradinski Buk Footbridge

- **Skradin**
- 1985
- Situated in the Krka National Park in central Dalmatia
- Built at the foot of the largest travertine waterfall in Europe
- The second-oldest hydroelectric power station in the world (1885) lies below the Skradinski Buk waterfall

The Krka National Park is located in central Dalmatia, downstream of Miljevci and just a few miles north-east of Šibenik. It covers the area along the river Krka, which rises at the foot of Mount Dinara near Knin and flows through a 75-kilometre gorge. It covers an area of 142 square kilometres, including 25.6 square kilometres of water surface. The Krka has seven travertine waterfalls and owes its beauty to its many natural karst phenomena.

The Krka National Park was created in 1985 and is famous for its large number of lakes and waterfalls. Skradinski Buk is the largest travertine waterfall in Europe. It consists of a series of travertine cascades forming more than 17 "steps".

The width of the cascades ranges from 200 to 400 metres, the total height difference is 45.7 metres and the waterfall covers a total length of approximately 800 metres.

A footbridge has been built across the foot of the waterfall. It is 100 metres long and 1.8 metres wide and is built of wood in order to fit into its surroundings.

Below the Skradinski Buk waterfall is the world's second-oldest hydroelectric power station – the oldest plant of its kind in Europe. Completed in 1885, it was opened just three days after the world's oldest hydroelectric power station at Niagara Falls.

Croatia

Vršić footbridge over the gorge of the Pazinčica

- **Pazin**
- 1993
- Main span 87.5 metres
- Prestressed superstructure with a box cross-section

Pazin Cave is the most picturesque example of natural forces at work on the karst terrain of the Istrian peninsula. Beneath the walls of the thousand-year-old Pazin Castle, right on the border between "grey" and "red" Istria, the river Pazinčica – the largest sinking stream in Istria – disappears underground and does not re-emerge until it reaches the valley of the river Raša.

The Vršić bridge was built as a pedestrian bridge over the gorge of the Pazinčica. It was constructed in 1993.

The total length of the bridge is 115.5 metres, while the bridge superstructure has a length of 87.5 metres. The total width of the bridge is 8.1 metres.

The bridge is a prestressed superstructure with a box cross-section measuring 2.15 x 5 metres at the ends and 2.15 x 3 metres in the middle.

As well as connecting Pazin's pedestrian traffic with the Pazinka factory, the bridge serves to carry a main sewer pipe over the gorge.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Croatia

Footbridge over the Sava

- **Martinska Ves**
- 2002
- Main span 145 metres
- Suspension bridge

This pedestrian suspension bridge 177.8 metres in length and with a main span measuring 145 metres stands in the village of Martinska Ves, a small urban centre on both sides of the river Sava near Sisak. As the bridge is about 4 metres wide, it can accommodate one-way motor vehicle traffic, but this traffic will be restricted to smaller vehicles only.

The bridge links the two halves of the village, whose residents previously had to use ferries to reach the shop, school, clinic and church. The bridge is a reinforced concrete cable-stayed structure with two A-shaped pylons of a height of a little over 20 metres. The main cables pass over the pylons and are anchored into separate reinforced concrete blocks situated on the river banks.

Croatia

Memorial Footbridge

- **Rijeka**
- 2002
- A monument to the Croatian fighters who fell in the Croatian War of Independence
- Extremely thin slab spanning a canal

The Memorial Footbridge is located in the very centre of the city of Rijeka, on the canal separating the old town centre from the former port. Besides serving as a pedestrian crossing over the canal, this footbridge is also a monument to the Croatian fighters who fell during the Croatian War of Independence. It is a place of memory and of social encounters. The Memorial Bridge is designed as an extremely thin slab spanning the canal and has a distinctive L-shape. Definition of the public space is achieved entirely through the built structure, which at the same time had to be recognisable as a memorial structure.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Croatia

Footbridge over the river Vuka

- **Vukovar**
- 2013
- Known as the Friendship Bridge
- Steel arched trussed structure

The footbridge over the river Vuka in Vukovar (known as the Friendship Bridge) was built in 2013 as an extension of Vukina Ulica, a street running perpendicular to the river, with the aim of providing a pedestrian link between Vukovar and the village of Olajnica on the opposite bank of the river. It is a steel truss arch bridge with a span of 31.2 metres and a total length of 46.94 metres. The total width of the superstructure is 4.4 metres, of which 3.0 metres is footway. The substructure consists of two reinforced concrete abutments, each with foundations on four drilled piles with a diameter of 0.8 metres. The reinforced concrete deck is supported by the bottom edge of the main girders, which in structural terms are arched steel truss girders acting as simply supported beams, with an axis-to-axis distance of 3.8 metres in the abutment axes and 3.0 metres in the bridge axis. The height of the arches in the bridge axis is 3.5 metres.

Croatia

Footbridges in the Plitvice Lakes National Park

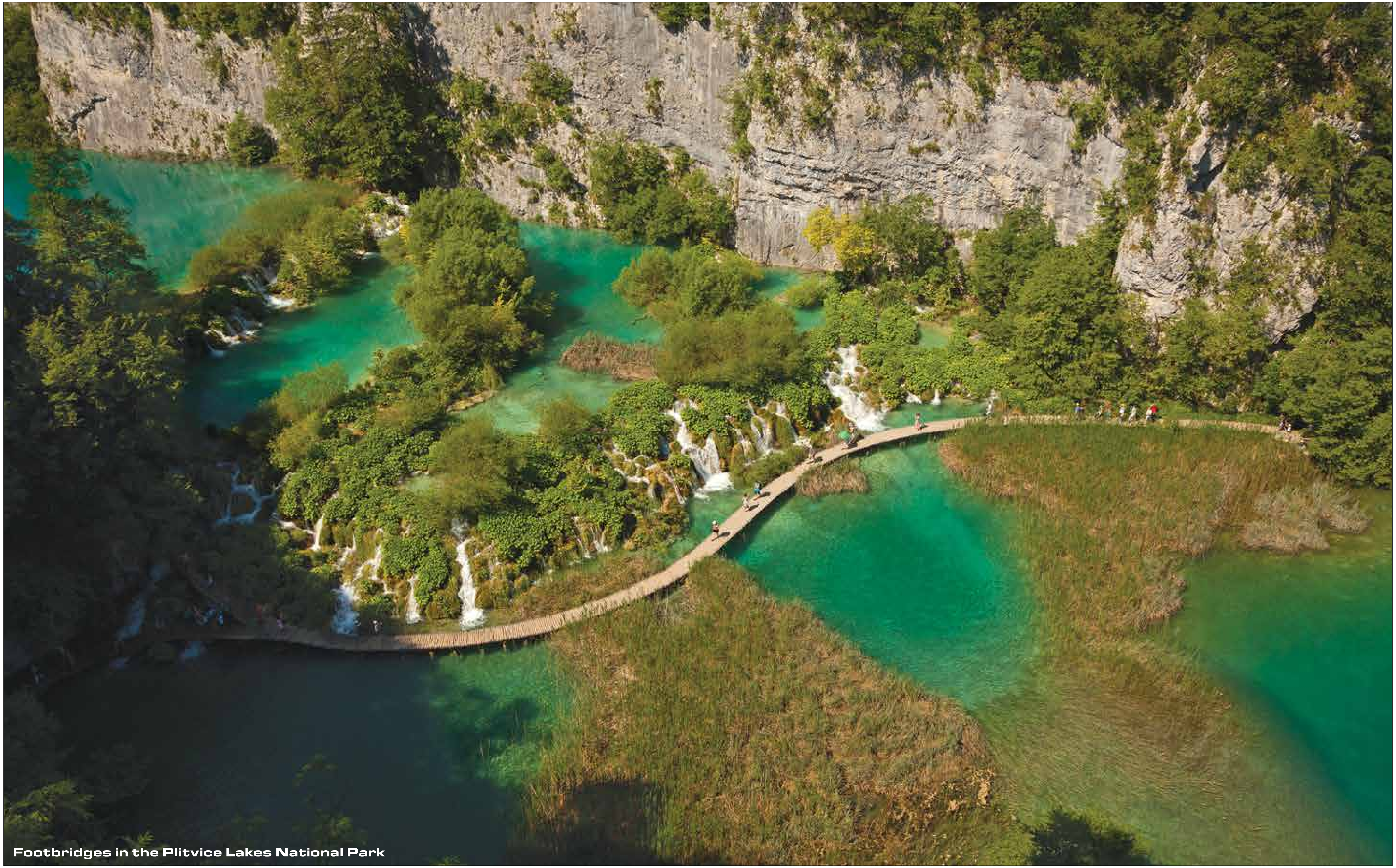
- **Plitvice**
- From 1949
- UNESCO World Heritage Site from 1979
- Series of 16 lakes
- Miles of small wooden footbridges crossing the National Park

The Plitvice Lakes were declared a national park in 1949 and constitute the largest and oldest national park in Croatia. With its vast forests, the natural beauty of its lakes and waterfalls and its rich flora and fauna, the Plitvice Lakes National Park became, in 1979, one of the first natural sites in the world to be added to the UNESCO World Heritage List.

The wealth and splendour of the water is probably the first thing most people think of when they first come into contact with the Plitvice waterfalls. A series of 16 lakes are fed by the many small rivers and creeks surrounding them and are interconnected by cascades and waterfalls. One of the most notable features of the Park are the travertine barriers that have formed over the course of tens of thousands of years.

The most attractive part of the national park consists of an eight-kilometre stretch of lakes and waterfalls, linked by tourist trails. The largest waterfall is 72 metres high. An intricate network of small wooden bridges and paths keeps visitors in close contact with the lakes and waterfalls.

Nestled between the trees and the water, the narrow footpaths and bridges foster friendly encounters between those who come to enjoy the untouched natural beauty. Indeed, it looks as though none of the trees have been disturbed and the lakes have always been turquoise and transparent.


Footbridges in the Plitvice Lakes National Park

Cyprus

Photo: Sophia Lambrianidou

Paphos Castle Footbridge

- **Kato Paphos**
- 13th century
- Access bridge to the castle
- Rebuilt in the 16th century

The bridge has three small semicircular arches and spans the moat, giving access to the castle.
The bridge was built in the Ottoman period and is believed to have been rebuilt for the existing castle in the late sixteenth century.

Photo: Xristakis Sazeides

Elia Footbridge

- **Near the village of Fini**
- 17th century
- The smallest of the three medieval Venetian bridges in Cyprus
- Rebuilt in the 16th century

A pointed arch bridge with an opening of 5.5 metres and a width of 2.5 metres. The bridge was built using irregular blocks of stone and river pebbles. The arch is faced with squared limestone blocks.
A clay plaque with an engraved cross is affixed to one side of the bridge. The bridge deck is paved with cobblestones from the river.
The Elia (Olive Tree) Bridge is one of the three medieval Venetian bridges in Cyprus, the other two being the Tzelefos Bridge and the Roudia Bridge. It is the smallest of the three bridges.

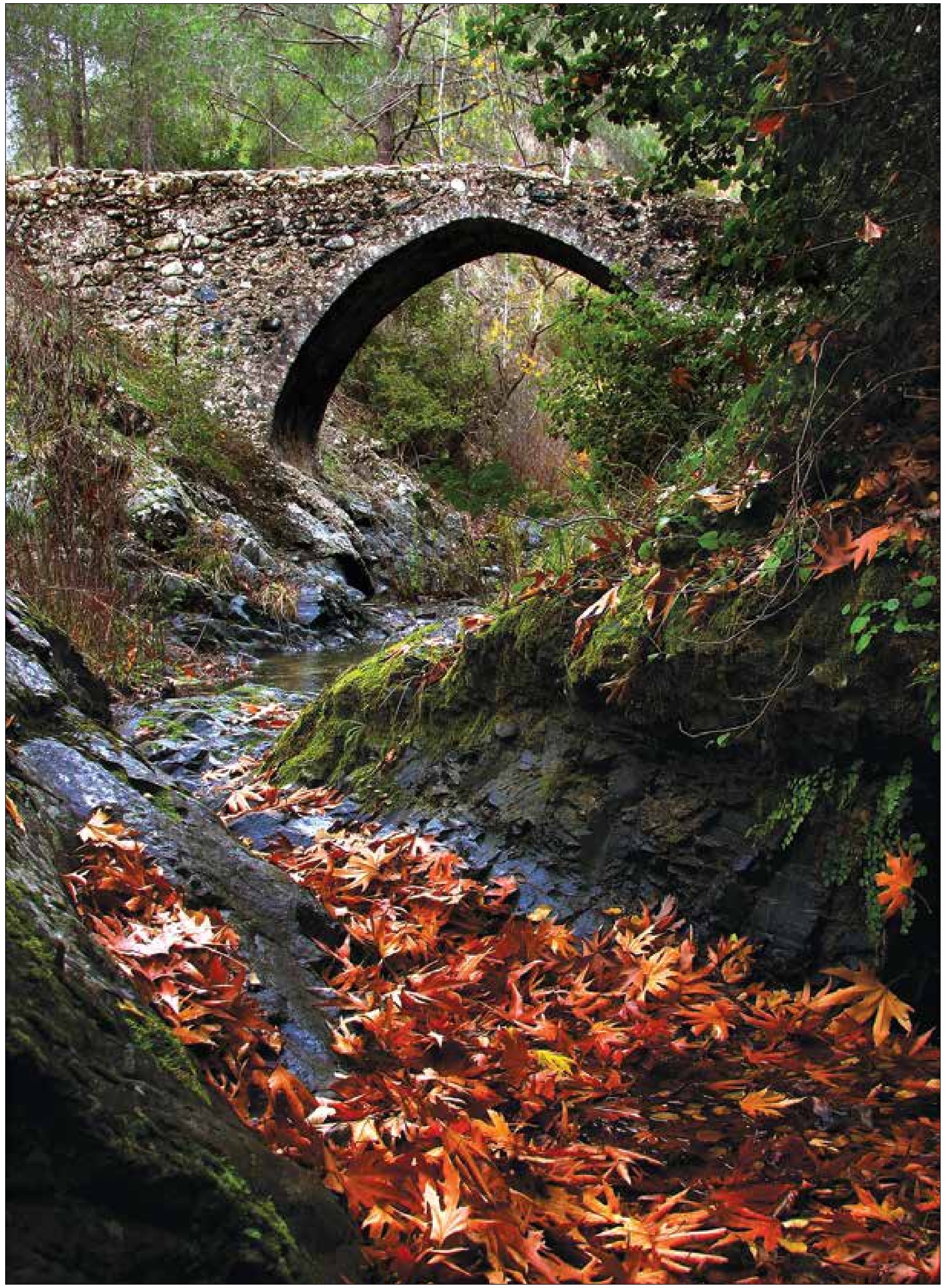


Photo: Xristakis Sazeides

FOOTBRIDGES - SMALL IS BEAUTIFUL

Cyprus

Tzelefos Bridge

- **Paphos Forest, near the village of Agios Nikolaos**
- Built between 1489 and 1571
- Arch span 10.7 metres
- Built while Cyprus was under Venetian rule

The bridge has an arch opening of 10.7 metres. The width of the pavement is approximately 2.5 metres.

The bridge is made of irregular stone blocks and faced with bricks. The original pavement of cobblestones from the river still survives. The Tzelefos Bridge stands on the river Diarizos, near the village of Agios Nikolaos in Paphos Forest in Cyprus. It is an ancient bridge built during the period of Venetian rule in Cyprus (1489–1571) to allow camel trains to transport copper and other materials from the Troodos Mountains to the port of Paphos for export.

Photo: Xristakis Sazeides

Photo: Soteres Anastasi

Cyprus


Photo: Xristakis Sazeides

Skarfou Footbridge

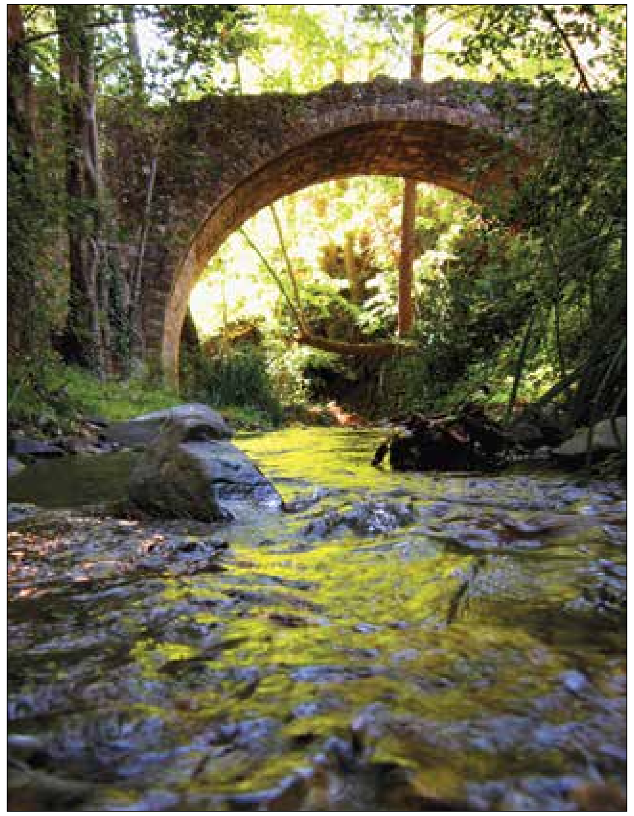
- **Paphos**
- 1618
- Provides access to a watermill
- Built by the Venetians

The bridge consists of a semicircular arch with an opening of 8.5 metres. The bridge is built of roughly cut limestone blocks. Squared limestone blocks were used for the arch facings.

The deck is 2.75 metres wide and still preserves the original pavement made of cobblestones from the river.

A stone slab on the outside of the arch is engraved with a cross and the year 1618.

The Scarfou Bridge is located close to the village of Simou in the Paphos district of Cyprus. The bridge was built by the Venetians in 1618 and stands next to an old watermill, once used by the local inhabitants to mill wheat.



Tris Elies Footbridge

- **Tris Elies village**
- 17th century
- Built during the period of Venetian rule
- Engraving with a cross on the bridge

Photo: Anastasia Kouri

The bridge was built using irregular blocks of stone and river pebbles. The arch is faced with squared limestone blocks.

An inscribed stone slab with an engraved cross dates the bridge from the seventeenth century.

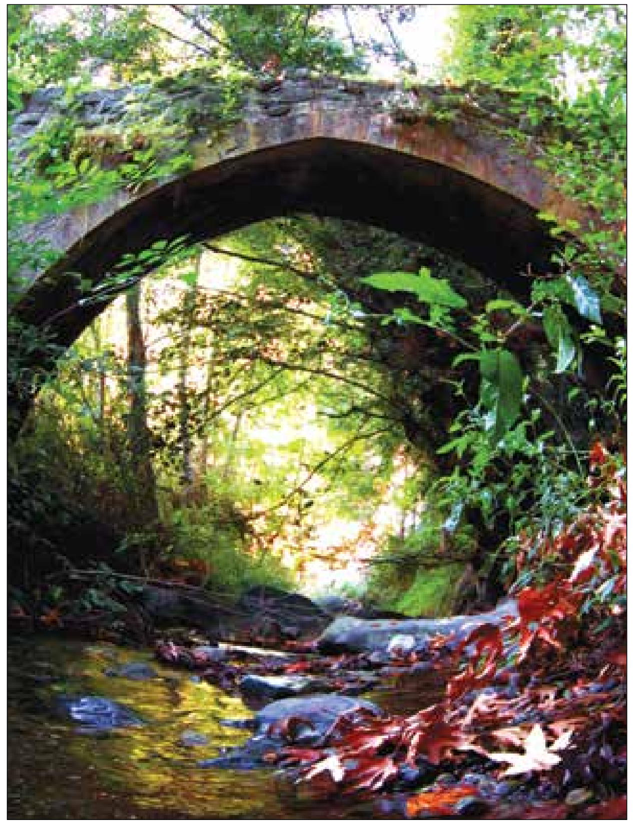
The Tris Elies Footbridge was built in the period of Venetian rule.

Cyprus

Kaminaria Footbridge

- **Kaminaria village**
- 18th century
- Single arch made of local stone

Photo: Anastasia Kouri



The bridge is built from local stone and consists of a single pointed arch resting on two large rocks on either bank of the river.

Domino Footbridge

- **Limassol**
- 1996–1997
- Coastal footbridge
- One of the longest footbridges in existence


Photo: Anna Ionidou & Nikos Akathiotis

This wooden bridge passes over the ancient port of Amathus, which is now under the sea.

The bridge is made of iroko wood and connected to the supporting structure by means of galvanised metal flanges.

The bridge is 650 metres long and 2 metres wide.

The footbridge is located in the Amathounta area of Limassol and forms part of a two-metre-wide walkway along the Limassol seafront which extends for 4.5 kilometres.

The bridge was built between 1996 and 1997.

Cyprus

Photo: Charis Solomou

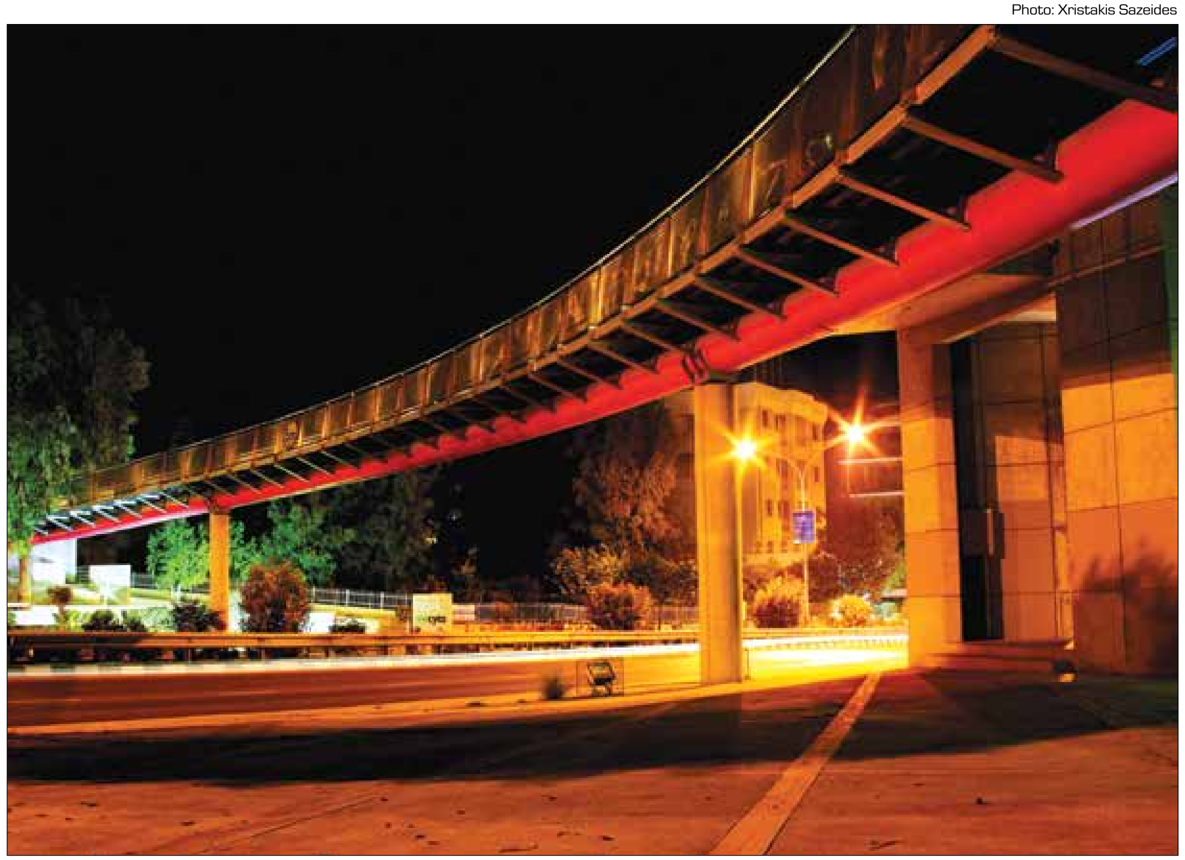
Cyta Footbridge

- **Nicosia**
- 2003
- Metal tube — main supporting element
- Access ramps for disabled users and those with reduced mobility

The bridge structure consists of a curved metal tube supported by concrete columns. The bridge is 1.5 metres wide, spans a distance of 37 metres and has an opening of 70 metres.

Access to people with disabilities or reduced mobility is provided by a 12 metre ramp at the south end of the bridge and a 17 metre ramp at the north end. The Cyta Footbridge is located on Limassol Avenue, in Dasoupolis, Nicosia and connects the Archbishop Makarios III High School with the police road safety park.

Photo: Xristakis Sazeides



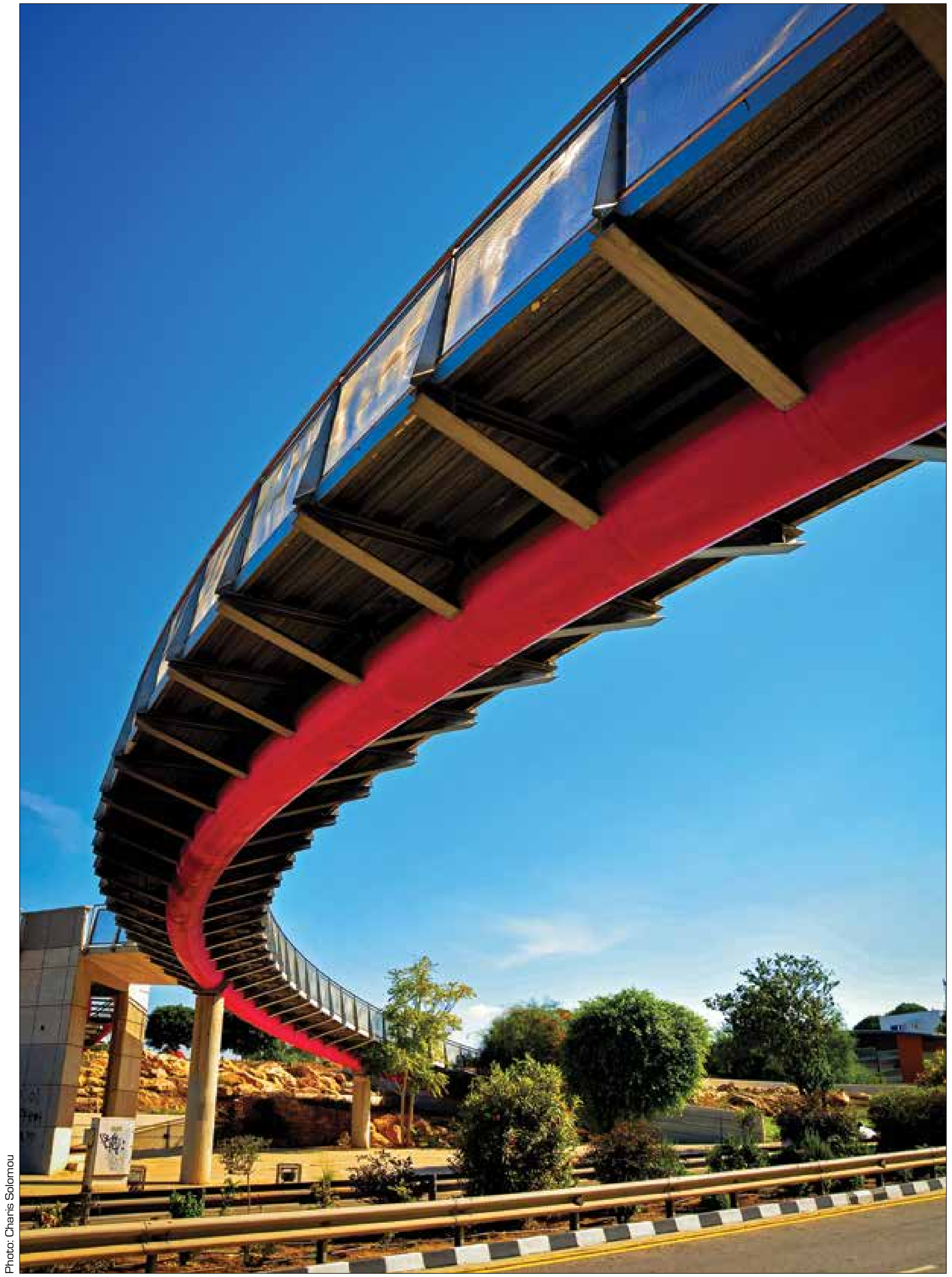


Photo: Charis Solomou

Cyprus

Photo: Sophia Lambrianidou

Agios Athanasios Footbridge

- **Limassol**
- 2007
- Fitted with an antiseismic shock absorber device and tuned mass dampers
- Cable-stayed bridge with a single span of 50 metres

The Agios Athanasios Footbridge is a cable-stayed bridge with a clear span of approximately 50 metres.

Pylons of a height of approximately 12 metres support the cables over the centreline of the bridge deck. The cables are fixed to the pylons and spread to the sides of the deck in a fan-shaped pattern. The railings are set at a slope, in line with the cables.

The bridge deck consists of three parallel steel pipes of a diameter of 300 millimetres, which are linked to a grid of 3,000 steel blades of an aerodynamic wing-shaped design. The plane grid is stiffened by diagonal tube trusses.

The deck of the bridge is made of fibreglass.

The bridge support on the north abutment is fixed in a longitudinal direction, while the support at the south end contains elastomeric bearings providing a longitudinal degree of freedom.

A shock absorber device is placed in the centre position in order to control the risk of seismic action. Tuned mass dampers are also installed below the deck to increase the damping of the bridge.

Cyprus

Photo: Charis Solomou

Pedieos River Footbridge

- **Nicosia**
- 2010–2012
- Built of wood, steel and concrete
- Deck covered with highly durable African timber

The transverse bridge is 65 metres long and connects the two banks of the river Pedieos. The two sides of the bridge are also connected to ramps measuring 85 metres and 45 metres respectively.

A second 350-metre bridge runs along the river and passes underneath the transverse bridge.

The average width of the bridges is 3 metres.

The materials used for the construction of the bridges are wood, steel and concrete. The bridge decks are made of hard durable timber (from Equatorial Africa).

The deck is supported by steel members which carry the load onto the piers. These are made of steel at the top and reinforced concrete at the bottom.

The handrail is made of galvanised iron wire and stainless steel.

The footbridge is part of the Pedieos flood plain pedestrian/bicycle path linking the municipalities of Strovolos and Lakatamia and covering a distance of 2.5 kilometres. It was designed by the Cyprus Town Planning and Housing Department.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Cyprus

Agia Kyriaki Footbridges

- **Kato Paphos**
- 2010–2012
- Built over a famous archaeological site
- Facilitates access to the archaeological site for disabled visitors and those with reduced mobility

The bridges have metal frames and wooden decks in order to provide elasticity in movement and to allow the best possible view over the archaeological site while causing minimal interference with the surrounding landscape.

The bridges are 350 metres long and 2.05 metres wide. Their height ranges from 5 centimetres to 3 metres.

The materials used were wood for the deck and handrails and metal for the frame.

The footbridges are located at the archaeological site near the church of Agia Kyriaki in Kato Paphos.

The main purpose of their construction was to facilitate access to the archaeological site for people with disabilities or reduced mobility. The development of the footbridges also represents a pilot project in the island of Cyprus.

The archaeological site is most famous for a column known as St Paul's Pillar situated near the church. Local legend has it that in the year AD 45 St Paul was tied to this column and scourged with "forty lashes less one". Today it is considered one of the most accessible tourist destinations in the Paphos region.

Photo: Chrisanthos Pissarides

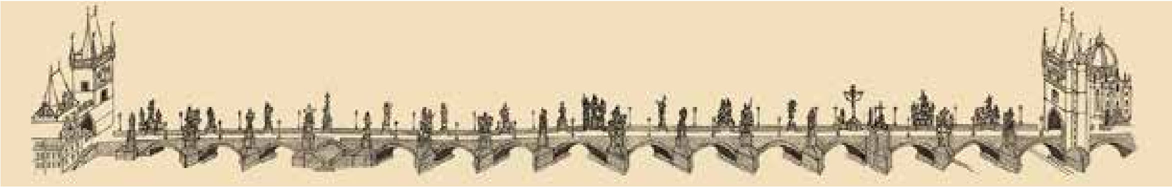
Czech Republic

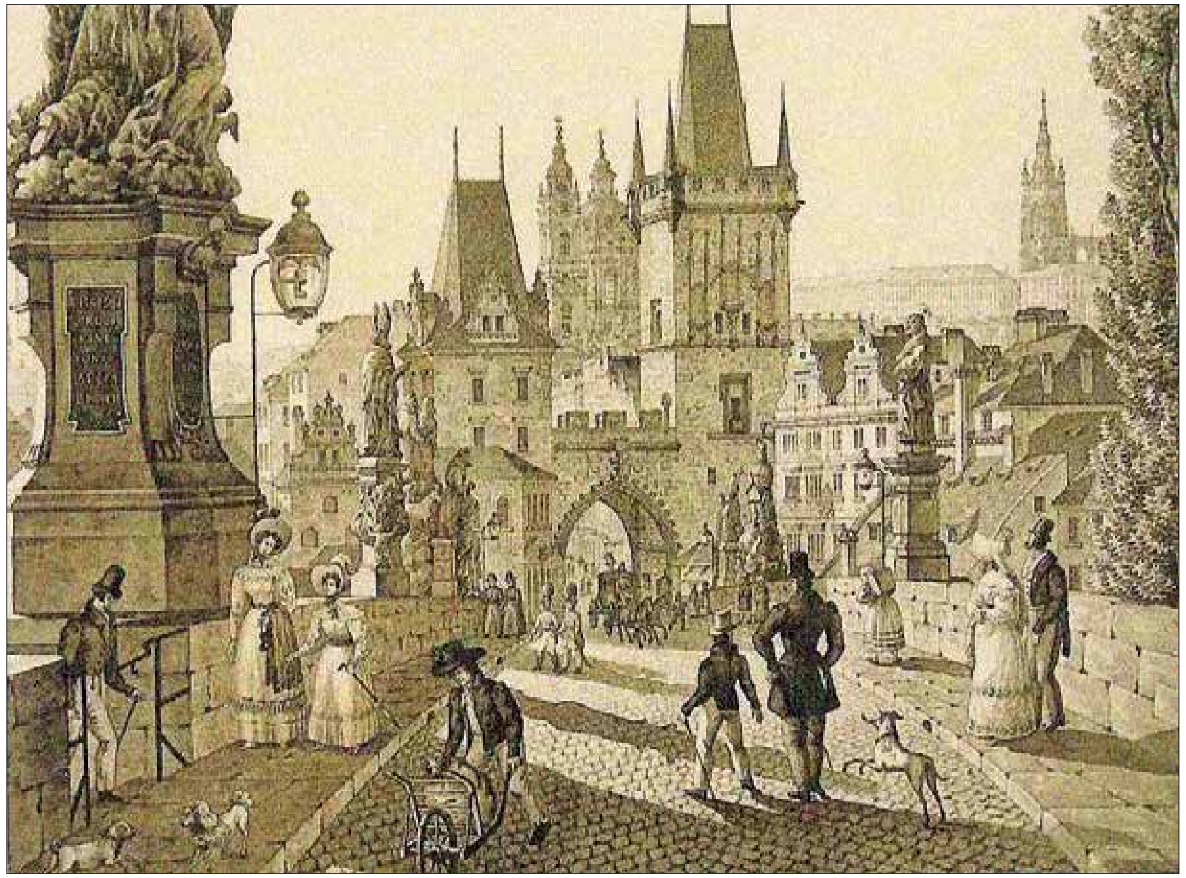
The Charles Bridge
(Karlův most)

- **Prague, over the river Vltava**
- 1411
- UNESCO World Heritage Site
- The most famous bridge in Prague, with a very rich history; also notable for the numerous statues on the bridge
- Pedestrian-only since 1978

The Charles Bridge in Prague is a national cultural monument, one of the first to be included in the list of UNESCO World Heritage Sites. It is also an important tourist attraction offering a fine view of the unique silhouette of Prague Castle and the surrounding Hradčany district. It lies on the historic Royal Route, once used by the kings of Bohemia during coronations.

From Knights of the Cross Square (Křižovnické náměstí) in the Old Town, the Charles Bridge spans the Vltava, crossing the tip of Kampa, an island in the river which can be accessed via steps from the bridge Island, and passing over the Čertovka canal to the Malá Strana (Little Quarter) side, where it is protected by two bridge towers. It stands on the site of the earlier Judita Bridge, a stone bridge in the Romanesque style which was completely destroyed by a flood in 1342. The foundation stone of the new Gothic bridge was laid by Holy Roman Emperor and King of Bohemia Charles IV on 9 July 1357. Work is believed to have been completed in 1411. The first builder was the master stonemason Otto. Following Otto's death, construction continued under the direction of Petr Parléř. The bridge incorporates the Old Town Bridge Tower, which was completed in 1395. The bridge has experienced ten large to catastrophic floods over the course of its history, all of which caused major damage to its structure, including the collapse of sections of the bridge. The 1890 flood destroyed three entire spans. These were subsequently restored to their original appearance, but with lightened arches. The foundations of the new piers stood on a load-resistant base and were built with the help of caissons. The last flood to hit the bridge occurred in 2002. Fortunately, the bridge survived this flood without damage, although the water level reached a height of around 8 metres above its normal level. The bridge's better resistance to this flood was due in particular to a modification to the bridge's foundations and structural modifications to the bridge deck (an integrated reinforced concrete slab). As well as by natural disasters, the bridge has been affected by human activities. Many historical events have affected its appearance and frequently damaged it. The greatest damage was caused by a Swedish invasion in 1648, and by fighting in the revolutionary year of 1848. The finishing touch was given to the bridge in the late seventeenth century with the construction of pedestals above the cutwaters of the bridge piers, on which baroque sculptures were placed. This gave the Charles Bridge its current unmistakable appearance. Between 1883 and 1905 a horse-drawn tram operated on the bridge, using two sets of rails, one for each direction. Three years later the horse-drawn trams were replaced by electric trams. The rails were removed from the bridge in 1914. In 1866 the oil lamps dating from 1723 were replaced with gas lights. Since 1978, the Charles Bridge has only been used as a pedestrian bridge.





The more recent history of the bridge is marked by a series of repairs and renovations, beginning with the complete renovation of the bridge deck which took place between 1965 and 1974. The bridge structure is subject to significant stresses caused by temperature fluctuations over the course of the year. This results in cracks, which extend through masonry joints as well as through the facing stone. The penetration of water into these cracks and the deposition of ice in winter can seriously damage the stonework. The main goal of the renovation was the insertion of waterproofing layers in the bridge structure. Waterproofing had not previously been incorporated into the bridge. Together with the new insulation, it was decided to insert a reinforced concrete slab which would serve as a base for the new system of layers in the bridge deck and at the same time reinforce the bridge in the horizontal direction (an important reinforcement during floods, when the tops of the arches are subjected to considerable horizontal force). This slab was placed on top of the historical Gothic marl filler.

Regrettably, however, it soon became evident that the repair did not satisfy the demands. Thermal dilatations of the reinforced concrete slab, which was firmly joined to the breast walls, pushed the stone parapet outwards, causing it to lean. This process was accelerated by the penetration of rainwater into the contact area between the insulation and the parapet, and by freezing in winter. The waterproofing material (asphalt IPA sheet) was unable to provide the necessary permanent waterproofing. It was therefore decided to carry out a complete repair of the bridge deck and parapet.

The envisaged repairs included full restoration of the waterproofing layer, replacement of damaged stones in the parapet and restoration of the balustrade to its original position. The bridge is still only open to pedestrian traffic, with the exception of maintenance vehicles, which are necessary for the operation, maintenance, monitoring and repair of the bridge. The waterproofing intervention was guaranteed to be effective for thirty years. Repair work took place between 2007 and 2010. Current operation and maintenance of the bridge show that the last phase of repairs can be considered to have been successful. The next phase of repairs will include repairs to the entire facing of the bridge. This will take place in stages.

All stones that do not meet the physical-mechanical characteristics required for their structural function, particularly in the arch areas, will be replaced. Constant and regular maintenance of the bridge is a fundamental condition for the permanence of the bridge structure and its survival as an indispensable part of Prague's heritage.

Photo: Gorazd Humar

The Charles Bridge (Karlův most), Prague

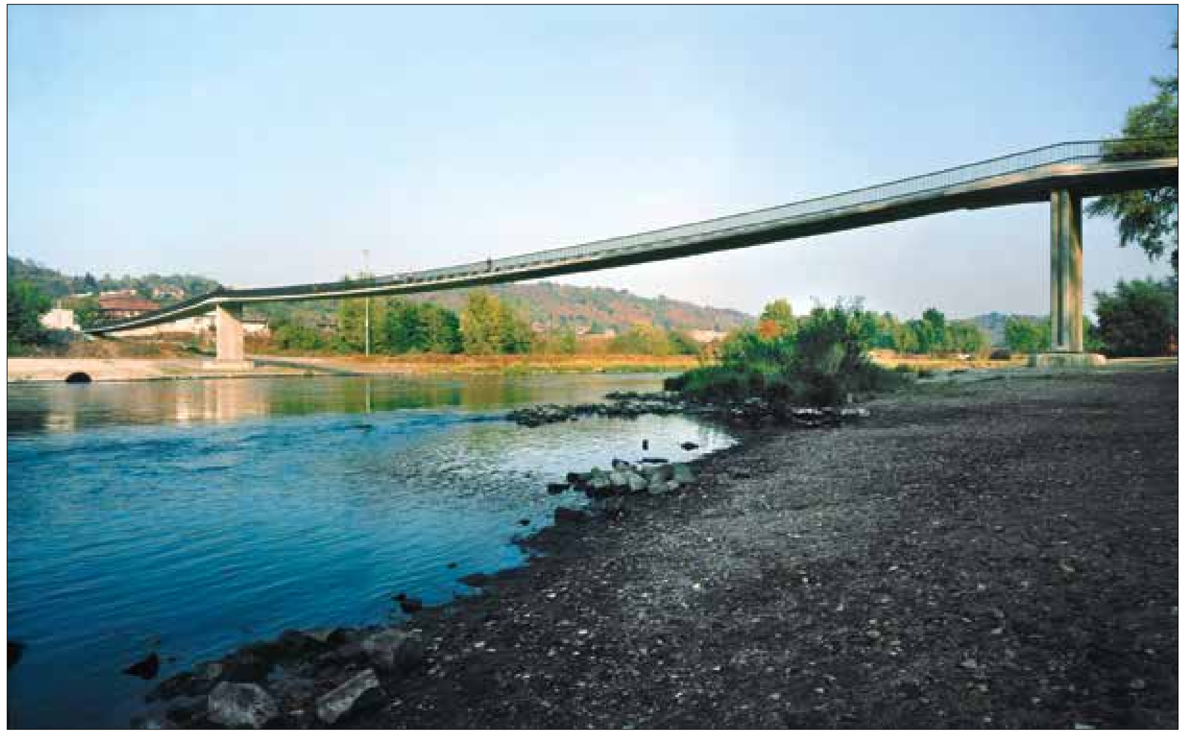
Czech Republic

Bridge over the Vltava

- **Prague-Troja suburb**
- 1983–1984
- Flooded in 2001 without any damage
- Good results in dynamic tests

This bridge, which has a total length of 261.20 metres, crosses the Vltava in Prague-Troja, a suburb to the north of Prague. It connects Prague Zoo and Troja Palace with the sports facilities situated on Emperor Island and with Stromovka Park.

The bridge has three spans measuring 85.50 metres, 96.00 metres and 67.50 metres respectively; the sags at mid-spans are 1.34, 1.69 and 0.84 metres respectively The stressed ribbon is formed by precast segments and cast-in-place saddles (pier tables) connected to intermediate piers. Concrete hinges at the bottom of the piers allow rotation of the



bridge in a longitudinal direction. The horizontal force from the stressed ribbon is resisted by wall diaphragms and micropiles.

Following the casting of the end abutment, the solid segments were positioned on neoprene pads situated in the front portion of the abutments. The first halves of the main cables were then pulled across the river and tensioned to the design stress. The cables were supported by steel saddles situated on the piers.

The segments were then erected using a mobile crane. The segments were positioned on the main cables and shifted along them into the design position. The segments of the side spans were erected first, followed by the segments of the main span.

Once all the segments had been erected, the second halves of the bearing cables were pulled and tensioned to the design stress. In this way the structure reached the design shape. The steel tubes that form the ducts in the joints between the segments were then put into place, and prestressing cables were pulled through the deck.

The reinforcing steel of the troughs and saddles was positioned and the joints, troughs and saddles were cast. The side spans were cast first, followed by the central span and saddles. The saddles were cast in formworks that were suspended on the already erected segments and supported by the piers.

The static assumptions and quality of the workmanship were also checked by a static and dynamic loading test. In 2001, when Prague was hit by an exceptional flood, the pedestrian bridge was totally flooded. Careful examination of the bridge after the flood confirmed that the structure had suffered no structural damage.

The bridge has met with a positive response from the public and no problems with static or dynamic performance have been reported to date. The dynamic tests confirmed that is not possible to damage the bridges by excessive vibrations caused by people (e.g. in a case of vandalism) and that the speed of motion caused by people is within acceptable limits.

The bridge was designed by Jiří Stráský and Ilja Hustý and built by Dopravni stavby & Mosty, Olomouc.

Main technical characteristics:

Stressed-ribbon bridge – length: 261.20 metres;
span lengths: 85.50 + 96.00 + 67.50 metres; width between the railings: 3.00 metres

Loading test

Czech Republic

Bridge across Swiss Bay at Lake Vranov

- **Vranov**
- 1991 – 1993
- Main span 252 metres, a world record for footbridges at the time of construction
- Award for Outstanding Structures 1994 – FIP [Fédération Internationale de la Précontrainte], XII Congress in Washington DC

This suspension bridge, built in 1993, is located in a beautiful, wooded recreation area where Lake Vranov was created by a dam in the 1930s. The structure replaced a ferry service carrying people between a public beach on one side the lake and accommodation, restaurants and shops located on the other side. The structure was also designed to carry water and gas lines.

A very slender deck of a depth of just 0.40 m is suspended on two inclined suspension cables over three spans measuring 30, 252 and 30 metres. The cables run across steel saddles situated at the diaphragms of the concrete pylons and are anchored in anchor blocks. The pull from the cables is transferred into the ground by rock anchors. The anchor blocks and abutments are connected by prestressed concrete ties.

To stiffen the structure against the effects of the wind load, the deck is widened from mid-span toward the pylons. The deck is suspended at its outer edges on hangers that are perpendicular to the longitudinal axis. It was assembled from precast segments of double-tee cross-section, stiffened by diaphragms at the joints. The 3-metre segments have a variable width corresponding to the variable width of the bridge deck. The two end segments are solid. Steel pipe conduits for gas and water lines were placed on the outer overhangs, which are not mutually connected. The deck was post-tensioned by four internal cables that are led through the whole deck and anchored at the end segments. The vertical and horizontal curvatures allow stabilisation of the structure by stiffening the external cables situated within the edges of the deck; the cables pass across the expansion joints and are anchored at the end abutments.

The deck is supported at both ends by two multi-directional pot bearings situated on the pylon diaphragms. Horizontal force due to wind is transferred by steel shear keys.

The main cables are formed by 2 x 108-15.5 mm diameter strands grouted in steel tubes. To eliminate tension stresses in the cement mortar of the suspension cables, the deck was temporarily loaded before the cables were grouted. The load was created by radial forces caused by the tension of the external and internal cables temporarily anchored at the abutments. The suspension cables are fix-connected with the deck at mid-span. The hangers are formed from solid steel rods of 30 mm diameter and pin-connected to the deck and main suspension cables.

The inclined pylons have an A-shape with curved legs connected by top and bottom diaphragms. The legs of the pylons were post-tensioned by draped cables to balance the bending stresses due to the curvature of the legs. During erection of the structure, the pylons were supported by pins; following erection the pylons were cast in the footings. The anchor blocks protruding above the grade were post-tensioned to the anchor foundation slabs, where the rock anchors are anchored, by prestressing rods.

The bridge forms a partly self-anchored system in which the arched deck is suspended on the cables and is flexibly connected with the abutments that, in turn, are mutually connected with the anchor blocks by prestressed concrete tie rods.

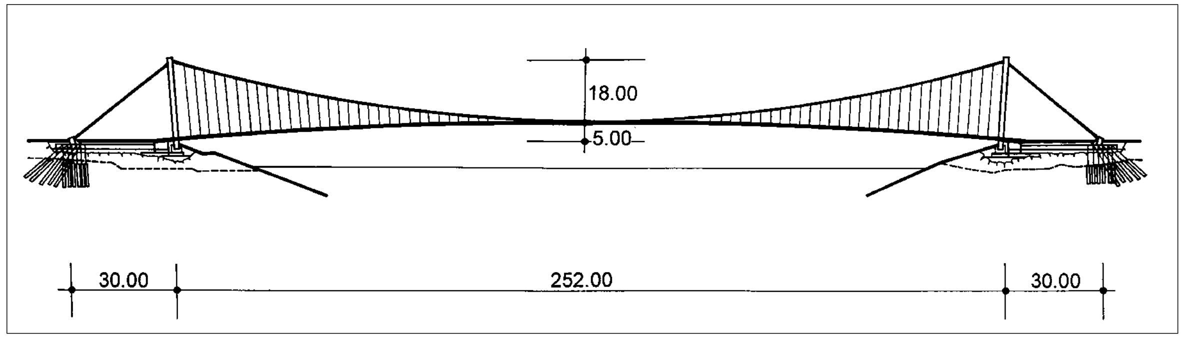
Construction of the bridge began in spring 1991 and was completed in spring 1993. Due to the recreation season from June to mid-September and severe winter conditions, construction work could only be carried out in the spring and autumn months.

Although the structure has a very slender deck, users feel no unpleasant motion of the bridge either when walking along it, or when standing and observing the surroundings. The bridge is widely used not only for crossing of the bay but also as a meeting place and for bungee jumping.

The bridge was designed by Jiří Stráský and built by Dopravni stavby & Mosty, Olomouc.

Main technical characteristics:

Suspension bridge – total length: 312.00 metres;
span length of the suspension cables: 30.00 + 252.00 + 30.00 metres;
deck length: 252.00 metres;
width between the railings: from 3.40 to 6.60 metres



FOOTBRIDGES - SMALL IS BEAUTIFUL


Bridge across Swiss Bay at Lake Vranov

Czech Republic

Bridge over the Vltava

- **České Budějovice**
- 2005–2006
- Structure of the year 2006, Czech Republic
- Bridge of the year 2007, Czech Republic

This footbridge in České Budějovice connects the historic town centre with a new residential area. The bridge consists of a tied arch inclined to one side and anchored to a composite deck. The arch has a span length of 53.20 metres and a rise of 8.00 metres and is formed by a steel pipe; the suspenders are formed from I-shaped steel members. The deck is formed by two edge pipes mutually connected by a truss floor beam and a composite deck slab. The steel structure is supported by a short cantilever protruding from the end diaphragm. To resist bending moments, the diaphragms are supported by a pair of piles. The steel structure was assembled on temporary towers. When the towers were removed, the composite deck slab was cast.

The bridge was designed by Stráský, Hustý a partneři s.r.o. of Brno and built by JHP Mosty of Prague.

Main technical characteristics:

Arch bridge – length: 64.5 metres;
span length of the arch: 53.20 metres;
width between the railings: from 3.52 metres

Czech Republic

Bridge over the river Svratka

- **Brno**
- 2007
- Award for Outstanding Structures 2010
  FIB - International federation for structural concrete. III Congress in Washington DC
- 2008 Footbridge Awards in the aesthetics medium-span and technology medium-span categories

This pedestrian bridge connects a newly developed business area (the Spielberk Office Centre) with the old town centre. It is situated in the vicinity of a new international hotel and prestigious office buildings. An older, multiple-span arch bridge with piers in the river stands nearby It was clear that the new bridge should also be an arch structure, but a bold span without piers in the riverbed was required. Due to the poor geotechnical conditions, a traditional arch structure capable of resisting a large horizontal force would be too expensive. It was therefore decided to built a combination stressed-ribbon and arch structure. Both ribbon and arch are assembled from precast segments of high-strength concrete and were erected without any temporary supporting structures. The smooth curves characteristic of stressed-ribbon structures allowed a soft connection of the bridge deck with both banks.

The deck of the bridge is formed by a stressed ribbon that is supported by a flat arch. Since both the stressed ribbon and the arch share abutments, the structure forms a self-anchored system that stresses its footings with vertical forces only. Because the riverbanks are formed by old stone walls, the abutments are situated beyond these walls. The abutments are supported by pairs of drilled shafts. The abutments serve as arch footings, stressed ribbon anchor blocks and struts. The rear shafts are stressed by tension forces while the front shafts are stressed by compression forces. These forces balance the tension and compression forces originating in the stressed ribbon and arch. The abutments function as compression struts transferring the tension force from the stressed ribbon into the compressed arch.

The arch has a span of 42.90 metres and a rise of 2.65 metres, giving a span-to-rise ratio of 16.19:1. The arch is formed by two arms that are further apart at the crown and merge at the foot. The 43.50-metre stressed ribbon is assembled from 1.5-metre segments. In the middle portion of the bridge the stressed ribbon is supported by low spandrel walls whose depth increases with the fall of the arch. At midspan the arch and stress ribbon are connected by 2 x 3 steel pins that transfer the shear forces from the ribbon into the arch. The stressed ribbon is carried and prestressed by four internal cables consisting of 12 monostrands of 0.6" diameter grouted in PE ducts. The segments are of variable depth with a curved soffit. The stressed ribbon and arch were made from high-strength concrete with a characteristic strength of 80 MPa.

The arch was assembled from two arch segments that were temporarily suspended on erection cables anchored to the abutments. Next, the midspan joints were cast and the erection cables were replaced by external cables that tied the abutments. Then the spandrel walls were cast and the segments were erected. The segments were successively positioned on the arch spandrel walls, and then on the external cables. The internal cables were then pulled through the ducts and tensioned. Finally, the external cables were removed. In this way, the required geometry of the deck was obtained. After casting the joints between the deck segments, the cables were tensioned up to the design stress and, as a result, the deck was prestressed.

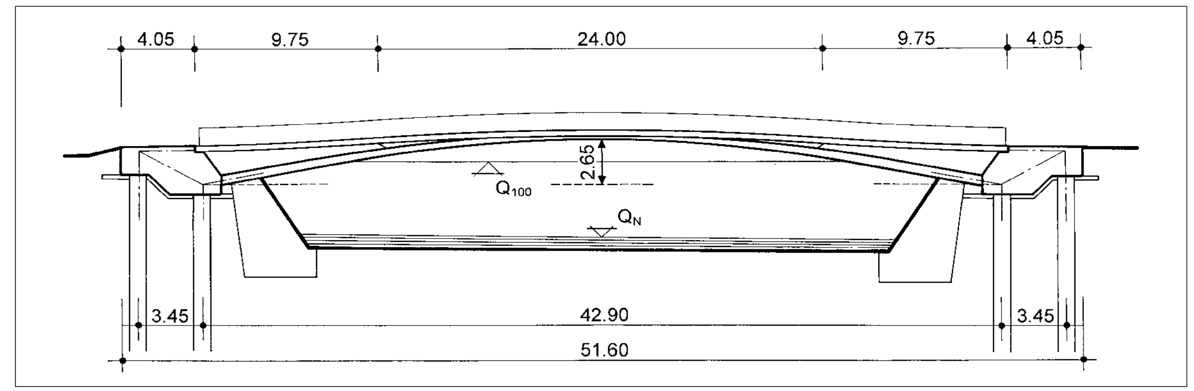
Although the bridge is very slender, it is very stiff and no unpleasant sensation is noted by users standing on or walking across the bridge. The static function and quality of the workmanship were checked by means of a loading test, during which lorries were positioned at various points on the deck.

The construction of the bridge started in February 2007 and was completed in September of the same year. The new structure has been well received by the public.

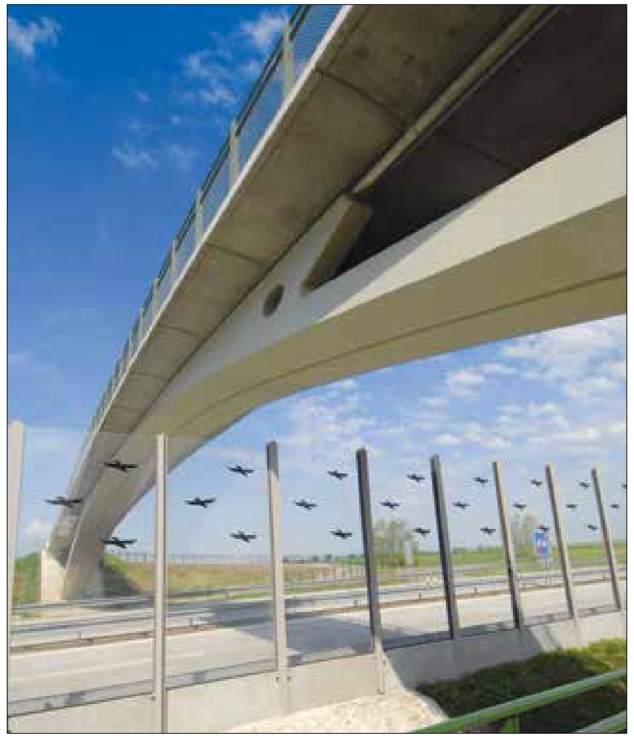
The bridge was commissioned by CTP Invest, s.r.o., Czech Republic, designed by Stráský, Hustý a partneři s.r.o. of Brno in collaboration with Studio Acht of Prague and Rotterdam, and built by SKANSKA DS, Division 77 Mosty, Brno.

Main technical characteristics:

Stressed-ribbon bridge supported by arch – length 51.60 metres,
stressed ribbon length 43.50 metres,
arch span length 42.90 metres;
width between the railings 3.00 metres



Czech Republic



Bridge over the R3508 expressway

- Olomouc
- 2010
- Extremely slender structure
- Arch span length 64 metres

The bridge crosses the R3508 expressway near the city of Olomouc. The bridge is formed by a two-span stressed ribbon supported by an arch. The 76.50-metre stressed ribbon was assembled from precast 3.00-metre segments supported and prestressed by two external cables.

The precast deck segments and precast end struts are made of high-strength concrete with a characteristic strength of 80 MPa. The cast-in-place arch is made of high-strength concrete with a characteristic strength of 70 MPa. The external cables are formed by two bundles of 31 x 0.6" diameter monostrands grouted inside stainless steel pipes. They are anchored at the abutments and run over saddles formed by the arch crown and short spandrel walls.

Steel pipes are connected to the deck segments by bolts located in the joints between the segments. At the abutments, the cables are supported by short saddles formed by cantilevers that protrude from the anchor blocks. The stressed ribbon and arch are connected to each other at the centre of the bridge. The arch footings rest on drilled shafts while the anchor block foundations consist of micropiles.

The bridge was erected in several stages. After the piles were placed, the end struts were erected and the arch footings and anchor blocks were cast. The arch was cast in a formwork supported by light scaffolding. When the concrete of the arch had sufficient strength, the external cables were assembled and tensioned. Then the precast segments were erected. Once the forces in the external cables had been adjusted, the joints between the segments were cast, after which the external cables were tensioned up to the design stress.

The structural solution was developed on the basis of tests and a very detailed static and dynamic analysis. Great attention was also paid to analysis of the buckling of the arch. The stability analysis proved that the structure has a sufficient margin of safety. Although the structure is extremely slender, no unpleasant sensation is noted by users when standing on or walking across the bridge. The bridge was built in 2007.

The bridge was designed by Stráský, Hustý a partneři s.r.o. of Brno and built by Max Bögl a Josef Krýsl, k.s., Plzeň.

Main technical characteristics:

Stressed-ribbon bridge supported by an arch – length 83.00 metres,
stress ribbon length 76.50 metres,
arch span length 64.00 metres;
width between the railings 3.50 metres

Czech Republic

Bridge over the D1 motorway

- **Bohumin**
- 2010
- Single-pylon cable-stayed bridge
- Bridge of the year 2011 - Czech Republic

This bridge, which is used by both pedestrians and cyclists, has a curved plan of a radius of 220 metres. The motorway, currently under construction, is located in the north-east of the country and the bridge will be the first flyover on the way from Poland.

The bridge has two spans of 54.937 and 58.293 metres respectively and is suspended from a single pylon situated in the area between the motorway and local roads. The bridge deck is fixed into abutments formed by inclined front walls and rear walls forming anchor blocks.

In the preliminary design stage, a deck of an effective width of 6.00 metres was suspended from two inclined planes of stay cables. The deck was formed by a slender deck slab stiffened by transverse diaphragms and edge girders protruding above a sidewalk. The stay cables were anchored to anchor blocks situated outside the edge girders.

Due to heavy bicycle traffic, the city of Bohumin required the pedestrian and bicycle pathways to be separate. The deck was therefore modified. It is formed by a central spine girder with asymmetrical cantilevers carrying the pedestrians and bicycles. To balance the load, the shorter cantilever is solid, while the longer is formed by a slender slab stiffened by transverse ribs.

The pylon is formed by two inclined columns of two-cell box sections tied by top and bottom steel plates connecting the boxes' central webs. The boxes are filled with concrete that was pressed from the bases of the columns to their tops. The stays are anchored to the central webs.

To reduce the torsional stresses due to the dead load, the deck was cast in two stages. First the central portion of the deck supported by stay cables was cast. Once this had been suspended from the stay cables, the end sections were cast. The structure was then prestressed by continuous cables situated in the central web. The forces in the stay cables, together with the forces and the layout of the prestressing cables, balance the effects of the dead load.

Although the bridge is very slender it is very stiff, and no unpleasant sensation is noted by users when standing on or walking across the bridge. The static function and quality of the workmanship were checked by loading tests, during which lorries were positioned at various points on the deck.

The construction of the bridge that was completed in fall 2010 is very stiff and comfortable to users.

The bridge was designed by Stráský, Hustý a partneři s.r.o. of Brno and built by SKANSKA DS, Division 77 Mosty, Brno, Czech Republic.

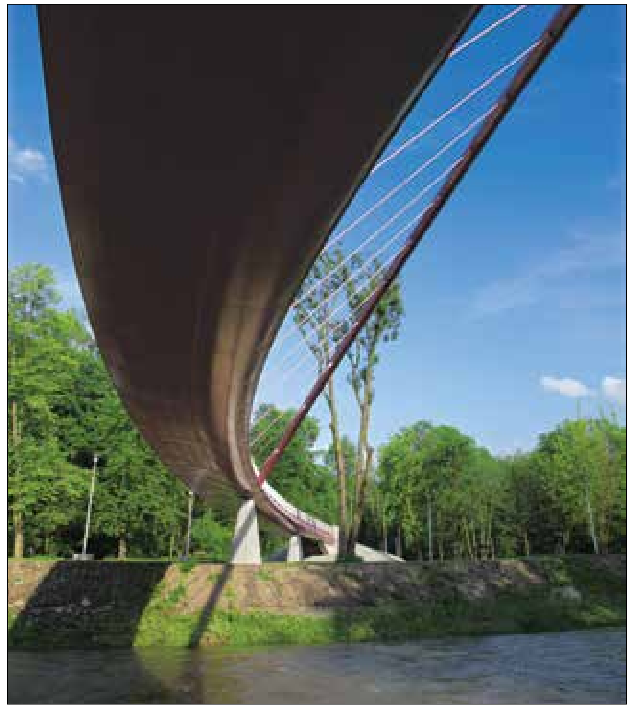
Main technical characteristics:

Cable-stayed bridge – length 113.23 metres,
span lengths 54.94 + 58.29 metres;
width between the railings 2.25 + 3.00 metres

Czech Republic

Sport Bridge over the river Olše/Olza

- **Český Těšín/Cieszyn**
- 2011–2012
- Connecting Český Těšín and Cieszyn
- The bridge has a curve of 100 metres
- Total length 95.40 metres



A pedestrian bridge over the border river Olše/Olza connecting Český Těšín on the Czech side and Cieszyn on the Polish side. In view of existing pedestrian and cycling paths and the level of the river during floods, bridge has a horizontal curve radius of 100 metres and a maximum slope of 5.70 %.

The pedestrian bridge is formed by a curved box girder of four spans measuring 17 + 45 + 18 + 13 metres. In the main span bridging the river (on the inside of the curve) the girder is stiffened by an inclined arch. The arch's vertical rise is 6.75 metres, its inclination is 30° and the inclination of the suspenders is 45°. The box girder, which has an asymmetrical cross-section, is fixed into the abutments and forms a composite with a 120 mm thick concrete slab. The box girder is stiffened by curbs that protrude above the sidewalk surface. The external cables anchored to the abutment wings are led through these curbs. The cables are composed from monostrands.

The composite box girder, which has a width of 4.375 metres and a depth of 0.903 metres, has a markedly asymmetrical cross-section

so that its shear centre is as close as possible to one side suspension. The box section is stiffened by diaphragms at intervals of 3.00 metres. The transverse position of the piers corresponds to the asymmetrical cross-section.

The arch has a parabolic shape and is formed by a steel pipe of 457 mm diameter. The pipe's thickness of 25 mm increases to 40 mm at the foot of the arch. The pipe is filled by C30/37 concrete that was pressed from the arch foot to the crown. The arch pipe is welded to cone base plates of a thickness of 200 mm.

The horizontal component of the arch force is transferred from this plate into the whole section by a locally stiffened bottom plate and by diagonal stiffeners.

The composite deck slab is fixed into the abutments together with the steel girder. The abutments and piers stand on drilled piles with a diameter of 900 mm. The piles, measuring 8 to 10 metres, are driven into claystone. The relatively short pile length means that the substructure has good transverse stiffness.

When the piles, abutments and piers were completed, the steel deck and arch were erected. Due to the possibility of flooding, the structure was erected on temporary towers that were supported by a truss structure bridging the riverbed.

Since during construction the structure experienced not only transverse and vertical deformation but also distortion of the deck, great attention was devoted to determination of camber and the positioning of the supports.

Because the supports had to allow horizontal movement and deck distortion, the erected girder was not supported but suspended on towers. The girder was assembled from six segments of lengths ranging from 12 to 18 metres. The arch was assembled from three segments of lengths ranging from 10.50 to 18.80 metres.

During tensioning of the cables, the structure moved transversally into the designed position. Subsequently, the neoprene bearings were engaged and the piers' temporary supports were removed.

The bridge was analysed as a geometrically non-linear space structure by ANSYS simulation software. Global analysis was performed on a space bar model, while complex details were analysed on a 3D model consisting of a shell and solid elements.

Stability and dynamic analyses of the structure were also important part of the design. The arch stability was checked for possible imperfections and for wind load and progressively increased live load. In view of the fact that the first torsional frequency is smaller then 1 Hz and since the bending frequency is close to the pace frequency, the structure was checked for vibration. The analyses proved that the structure has a sufficient margin of safety and that vibration of the structure caused by people or the action of the wind does not cause discomfort. Design assumptions and the quality of the workmanship were verified by static and dynamic loading tests.

The bridge was designed by Stráský, Hustý a partneři s.r.o. of Brno, and built by EUROVIA CS of Prague.

Estonia

Photo: Jaak Nilson

Viljandi suspension bridge

- **Viljandi**
- 1879 - original bridge
- 1995 - renovated
- Steel pylons, cables, main beams, cross-beams, handrails
- Timber deck
- A symbol of Viljandi

This 50-metre suspension bridge in Viljandi spans a valley in the castle park. The original bridge was built in 1879 by Felser & Co. of Riga for a different location in the grounds of Tarvastu Manor. In 1930 the lord of the manor presented the bridge to the town of Viljandi and it was re-erected in its present location, where it has become a symbol of the town and a popular attraction for visitors and locals alike. The pylons are original but the cables and deck have been renovated several times, most recently in 1995.

Photo: Alo Karu

FOOTBRIDGES - SMALL IS BEAUTIFUL

Estonia

Keila-Joa Suspension Bridges

- **Keila-Joa, Harju County**
- 1890 — older suspension bridge
- 2013 — bridges renovated
- Older bridge – 28-metre span
- Younger bridge – 19.8-metre span
- The older bridge is protected as a cultural monument

Photo: Tiia Ruben

The landscape garden at Keila-Joa Manor was designed in 1844 by Count Alexander von Beckendorff. The garden was reconstructed in 1890 under the guidance of the architect Winkler. The longer of the two suspension bridges (today protected as a cultural monument) was built towards the end of the nineteenth century.

The area of the garden containing the two suspension bridges currently belongs to the State Forest Management Centre.

The bridges are close to Keila-Joa waterfall, a popular attraction which is particularly beautiful in spring and winter. The waterfall is 60–70 metres wide and 6 metres high.

The suspension bridges were renovated in 2013.

Materials: pylons, cables, main beams and cross-beams, handrails (steel), deck (timber)

Photo: Tiia Ruben

Estonia

Photo: Olev Mihkelmaa

Kasari Old Bridge

- **Matsalu National Park, Lääne County**
- 1904
- The longest concrete bridge in Europe when completed
- Used as a footbridge since 2000
- Total length 308 metre, 13 spans of 21.4 metres, width 6.5 metres

This 308-metre reinforced concrete bridge spans the river Kasari. It was designed and built by the French-Swiss company Monicourt & Egger. It consists of 13 arches with spans of approximately 21.4 metres. The reinforced concrete arches are supporting on piers made of hewn granite blocks that also serve as icebreakers.

Construction took place between January and September 1904. On completion, the bridge was the longest reinforced concrete bridge in Europe.

The bridge is paved with cobbles and was used for motor traffic until 1990.

Since being renovated in 2000, the bridge has been used as a footbridge. The bridge is attractively illuminated at night.

Photo: Olev Mihkelmaa

FOOTBRIDGES - SMALL IS BEAUTIFUL

Estonia

Devil's Bridge

- **Tartu**
- 1913
- First generation of concrete arch bridges in Europe
- Very popular footbridge in Tartu
- Length 20 metres, width 2.5 metres

Photo: Ivar Talvik

This single-span arch bridge is an elegant example of a concrete bridge from the early twentieth century. It was commissioned by the authorities in 1913 to mark the 300th anniversary of the Russian Imperial House of Romanov. It is situated in the very heart of the university city of Tartu and spans a road in the fortress hill area, a favourite location for romantic walks for locals and tourists alike.

Photo: Jaak Nilson

Estonia

Tartu Arch Bridge
(Tartu Kaarsild)

- **Tartu**
- 1957–1959
- Span 57 metres
- Arch width 1 metre
- Arch rise 8 metres

All photos: Jaak Nilson

This footbridge over the river Emajõgi was built between 1957 and 1959 on the foundations of an old stone bridge destroyed during the Second World War. It is a single-span concrete bridge, with a central tied arch, concrete hangers and separate 2.25-metre walkways on either side of the arch.

Estonia

Nõmme Footbridge

- **Tallinn**
- 1986
- Used by pedestrians, cyclists, joggers and skiers
- Total length 72 metres
- Main span 30 metres, width 3 metres

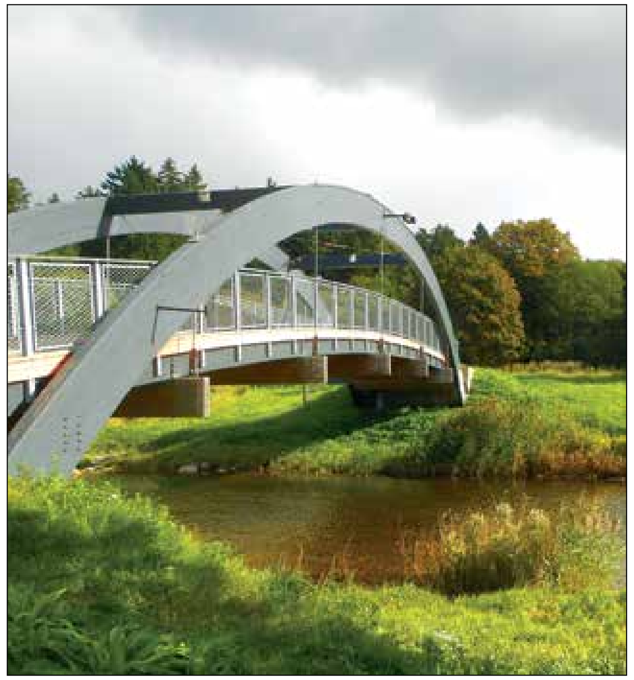
Photo: Alar Just

Nõmme is a green district mainly consisting of private houses surrounded by large areas of forest. Founded by Nikolai von Glehn in 1878, today it forms one of the administrative districts of Tallinn. This steel frame bridge connects the hillsides on either side of the road and provides a convenient crossing for pedestrians, cyclists and skiers. Mente et manu – with mind and hand – is the motto of Tallinn University of Technology. The bridge is located near the university campus and was designed by Johannes Aare and Valdek Kulbach. Jogging, cycling and skiing students are the most frequent load combinations for this bridge. The triple-span continuous main beams and inclined supports are made of thin-walled steel sections. The deck is located on the bottom flange of the beams, which serve also as handrails and safety barriers. The deck slab is made of trapezoidal steel sheeting and covered by concrete.

Lükati Ski Bridge

- **Tallinn**
- 2005
- Used by skiers in winter
- Length 36 metres, width 4 metres
- Parallel glulam arch ribs

Photo: Tiia Ruben



The main load-bearing structure consists of two parallel glued laminated timber (glulam) arch ribs, while the deck is suspended from steel hangers. The bridge provides a safe and convenient crossing for skiers in a recreational area in the suburbs of Tallinn.

Estonia

Photo: Andres Brakman

Photo: Erik Konze

Vaida Footbridge

- **Vaida, Harju County**
- 2007–2008
- Total length 124 metres
- Main span 62 metres
- Longest wooden span in Estonia

This cable-stayed wooden footbridge spans the main Tallinn–Tartu road (E265). The load-bearing structure, made of glulam beams, is supported by steel tension bars. The pylons are made of Comwood, a special glulam element with 12-sided polygonal hollow cross-sections. The bridge is an attractive landmark located above the busiest traffic route in the country and a good demonstration of the possibilities of large-scale wooden structures. The 62-metre main span is the longest span of any wooden structure in the country. The bridge deck is made of solid wood and paved with asphalt. The bridge is designed to Eurocode standards to carry a traffic load of 4.0 kPa and a service vehicle with two axle loads of 40 kN and 80 kN.

Photo: Tiia Ruben

Bridge at the Estonian University of Life Sciences

- **Tartu**
- 2008
- Span 27.7 metres
- Width 2.5 metres
- Depth of beams 1.32 metres

This single-span beam bridge creates a straight connection from the ground floor of the main building of EULS to the neighbouring sports hall, crossing a small stream. The aim of the designer was to create a modern natural landscape around the modernist blocks of the university buildings. The beam bridge, with its minimalist form, was chosen because it is unobtrusive and does not hide the buildings or the view.

The main structure consists of two reinforced glulam beams with a cross-section of 200 x 1320 millimetres. The deck is supported by the lower flange of the beams, which also form a safety barrier for pedestrians. The glulam beams are reinforced by steel bars glued into the grooves of the beam section. The reinforcement, which is placed in both compression and tension zones, increases bending resistance by up to 1.3 times and also increases bending stiffness so as to satisfy the deflection limits. All steel details are cut into the timber, both for aesthetic reasons and in order to protect them against the effects of the environment. The deck consists of boards nailed together to form a diaphragm, providing lateral stiffness.

Estonia

Vallikraavi Footbridge

- **Pärnu**
- 2010
- Span 31.5 metres
- Outstanding glulam structure of the year in 2010

The Vallikraavi footbridge spans the moat in Pärnu, a favourite summer resort in Estonia. The deck lies atop a low-rise arch and the lighting design makes the bridge attractive at night. The arch is made of glulam timber with a steel tie rod. In 2010 the bridge won a national award as the outstanding glulam structure of the year.

All photos: Reio Avaste

Estonia


Photo: Andrus Kõresaar

Seaplane Harbour Footbridges
(Estonian Maritime Museum)

- **Tallinn**
- 2011
- Total length of footbridges 210 metres
- Width 2.5–4.0 metres
- Winner of major EU award in 2013

The hangars in the Tallinn Seaplane Harbour are the most important engineering landmark in the region (designed and built by the Danish company Christiani & Nilsen Ltd in 1916/17). They are thought to be the first large-scale

reinforced concrete shell structure in the world. The building consists of three main reinforced concrete shells measuring 36.4 x 36.4 metres (average thickness 8–12 cm).

Renovation of the hangars was carried out between 2009 and 2012 (architectural project by KOKO Architects, engineering and technical project by Karl Õiger and Heiki Onton) with the aim of transforming the hangars into a home for the Estonian Maritime Museum.

The architects came up with the idea of a two-level space that would create an impression of the underwater world and the world above the water without actually flooding the hangars. This "two worlds" solution is distinguished by special lighting that creates a visual impression of the split-level space inside the hangars.

Visitors view the exhibits from "sea level" using the 210-metre steel footbridge that passes through the hangar.

A second footbridge marks the radius of the arc of the reinforced concrete shell.

Photo: Andrus Kõresaar

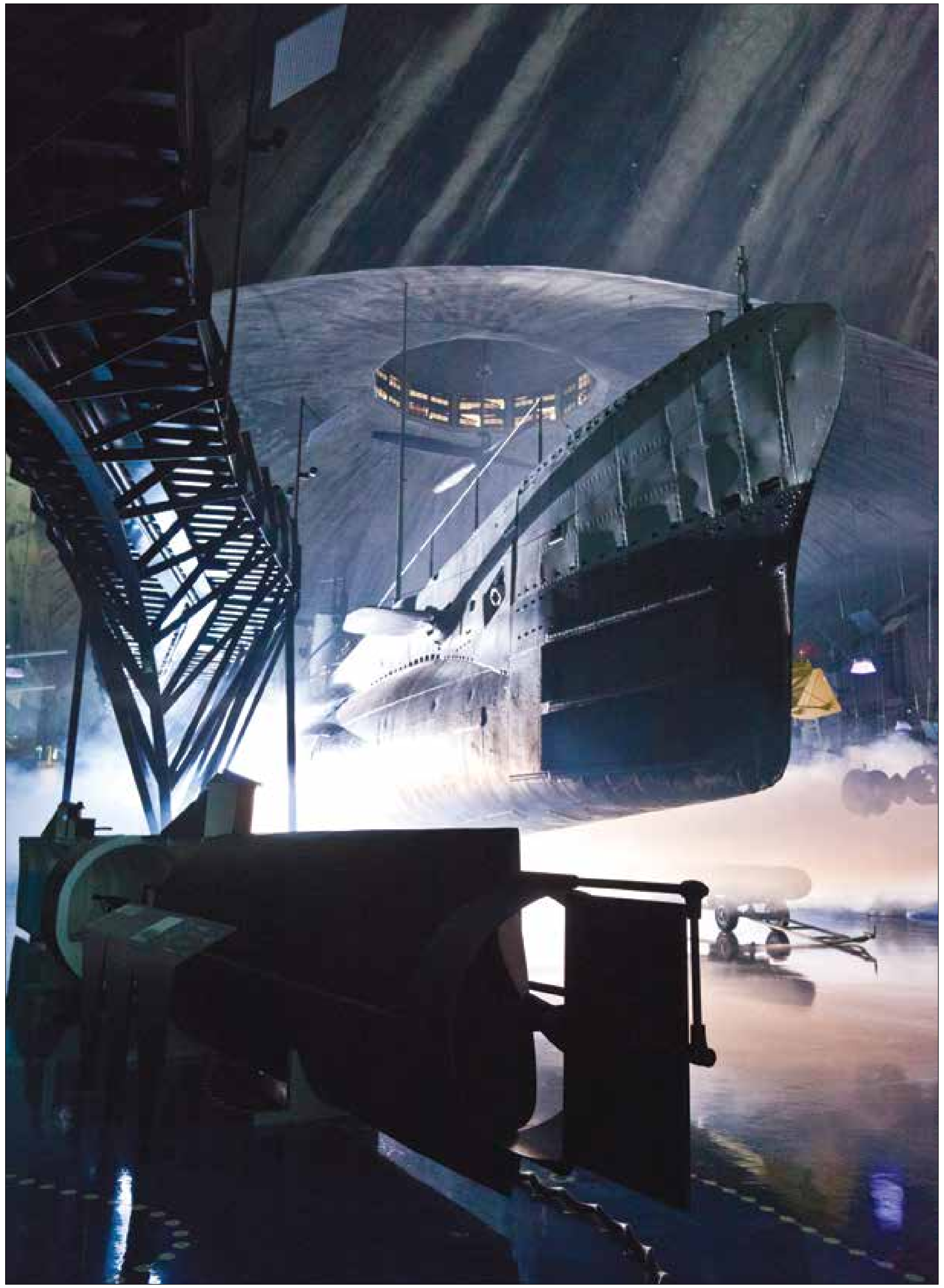



Photo: Andres Teiss

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Andrus Kõresaar

Seaplane Harbour Footbridges, Tallinn

France

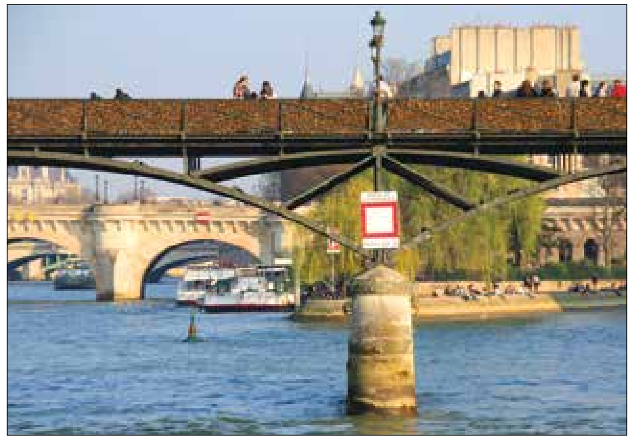


Photo: Gorazd Humar

Arts Bridge
(Pont des Arts)

- **Paris**, over the Seine
- 1804
- One of the most beautiful bridges in Paris
- The first cast-iron bridge in France
- Reconstructed 1981 – 1984

Text by Jean-Louis Bordes

The Pont des Arts is a pedestrian bridge over the Seine in Paris. It is located at the heart of one of the world's most magnificent urban sites, inscribed on the UNESCO World Heritage List. It links the central square (cour carrée) of the Louvre Palace including its Renaissance wing – known as the Palais des Arts during the First Empire – to the Institut de France, home of the Mazarin Library (Bibliothèque Mazarine) and the French Academy, the latter founded in 1635 by Cardinal Richelieu. When standing near the middle of the bridge, one can enjoy the amazing urban scenery. Upstream are the towers of Notre Dame Cathedral, downstream the Eiffel Tower, and all around the domes of monumental buildings, the legacy of nine centuries of French history.

The deck of the bridge is 11 metres wide and an inviting place to stroll. The footbridge is a meeting place which inspired the song "Le Vent" (Si par hasard, sur l'Pont des Arts…) by Georges Brassens, who warns ladies of the mischievous wind whipping up their petticoats.

The Pont des Arts is also a monument to engineering history. It was the first metal bridge in France (1801–1804), built some years after the famous Iron Bridge near Coalbrookdale in England, the first cast-iron arch bridge in the world (1779). The site was chosen by Napoleon, then First Consul, who wanted the world to know of France's importance.

Louis Alexandre de Cessart and his pupil Jacques Lacroix Dillon originally designed the structure with nine cast-iron main arches each with a span of 16.80 metres. The arches were made of circular arc trusses hinged at the key with transversal strut bars acting as sway braces. Overlapping longitudinal arcs connect the main arches over each pier. Several types of joints, including dovetails, double-members and key pins, were used to assemble the structure in order to avoid drilling into the cast iron. The piers were of masonry. The wooden decking is horizontal.

Unfortunately, however, the cast iron of the original structure proved too brittle to resist shocks. In 1970, having being damaged several times by barges colliding with it, the bridge was closed in 1970 for safety reasons. It was reconstructed "identically" between 1981 and 1984. Although the number of arches was reduced to seven, the appearance of the original bridge was preserved. The new bridge was opened on 27 June 1984 by Jacques Chirac, then mayor of Paris.

Main technical characteristics

Structural type: 7 steel arches, spans 22 metres
Total length: 155 metres
Width: 11 metres (present bridge)
Geographical coordinates: 48°51'30"N 2°20'15"E
Designers: Louis Alexandre de Cessart and Jacques Lacroix Dillon (1804) Louis Arretche (1984)
Contractor: Entreprise Morillon Corvol Courbot EMCC

FOOTBRIDGES - SMALL IS BEAUTIFUL

Arts Bridge


Photo: Jean-François Coste


Photo: Jean-François Coste

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Gorazd Humar

Arts Bridge (Pont des Arts), Paris

France

All photos: Jean-François Coste

College Footbridge
(Passerelle du Collège)

- **Lyon**, over the Rhône
- 1844
- A tragic accident occurred during construction
- Main span 109.70 metres

Text by Jean-François Coste

The Passerelle du Collège is the oldest surviving crossing of the Rhône in the centre of Lyon.

It takes its name from the Collège-lycée Ampère, formerly the Great College of the Jesuits under the Ancien Régime, which stands on the right bank of the river.

The footbridge was built in response to pressure from the inhabitants of the left bank, who had no public high school. The bridge allowed students from the left bank to cross safely, without having to make a detour to cross the Pont Morand or Pont Lafayette.

Although the Rhône Bridges Company was reluctant to follow up the official request of 1840, it was instructed on 28 May 1842 to start construction of a three-span suspension footbridge with steel cables over the Rhône, as specified by the département's chief engineer M. Cailloux.

With the bridge nearing completion, a tragic accident occurred on 7 December 1844. A bolt holding

a cable in its sheath broke. The deck collapsed, the contractor M. Santil died and eight of the 25 workers were drowned. The work restarted rapidly and the footbridge was opened to pedestrians in early September 1845.

An imperial decree of 6 October 1860 mentions that the toll was abolished following the repurchase of the concession by the French State.

In 1944 the German Army dynamited the footbridge. The suspension cables were broken, the deck collapsed and the piers were severely damaged, as were the carved statues of two lions which marked the entrance to the bridge. The footbridge was rebuilt exactly as it was, except for the statues. It was reopened to pedestrians in September 1945.

A full restoration was carried out in 1986 and in 1987 the wooden deck was replaced with aluminium plates with anti-slip cladding.

Despite the footbridge's eventful history, traffic on the Passerelle du Collège is still intense and it is used every day by pedestrians and, more recently, bicycles to cross the Rhône between the old and new city centres.

Main technical characteristics

Structural type: suspension bridge – 3 steel spans: main span 109.70 metres; side spans 42 and 46 metres
Total length: 198 metres
Width: 4 metres (3.50 metres usable)
Geographical coordinates: 45°45'41.00"N 4°49'48.00"E
Built: August 1843–September 1845
Designers: Cailloux, Garella
Contractor: Santil (1844) and Société Arnodin (1985)

France

Alibert footbridge Photo Lucien Pliskin

Canal Saint-Martin Footbridges
(Passerelles du Canal Saint-Martin)

- **Paris**, over the Canal Saint-Martin
- 1825–1860
- Represent the development of iron and steel bridge construction in the 19th century

Text by Lucien Pliskin

The Canal Saint-Martin in Paris was built in order to create a bypass of the Seine at low water, facilitating navigation through Paris, and to develop industrial activities on its banks.

Its construction was decided in 1802 by Napoleon Bonaparte, then First Consul. Later on, as Emperor, Napoleon issued the order to commence work on the basis of a project by the civil engineer Pierre-Simon Girard. Construction was postponed several times owing to financial difficulties, but was completed in 1825.

The canal crosses numerous streets in the north-east of Paris, so several bridges and footbridges had to be built in order to re-establish the connections between them.

The footbridges crossing the Canal Saint-Martin include, from south to north, the Douanes (or Temple) footbridge, the Alibert footbridge, the Richerand footbridge and the Grange-aux-Belles footbridge. They are separated from each other by a distance of between 300 and 500 metres. Their spans range from 30 to 35 metres and their width from 2 to 2.5 metres.

Built between 1860 and the end of the nineteenth century, these footbridges are a veritable museum of steel bridge construction. Due to the variety of approaches employed, they clearly illustrate the progress of nineteenth-century bridge building:

- the Douanes footbridge (also known as the Temple footbridge) consists of a three-ribbed arch on masonry supports. Each arch rib
is made up of 8 curved cast-iron sections joined by bolts.
- the Grange aux Belles footbridge consists of a three-ribbed arch on masonry supports. Each arch rib is made up of 7 curved cast-iron sections joined by bolts.
- the Alibert footbridge consists of a two-ribbed arch on masonry supports. Each arch rib is made up of curved steel sections joined by rivets.
- the Richerand footbridge is a rigid frame bridge consisting of two parallel girders with masonry supports. Each girder is made of soldered steel plates.

These footbridges enhance the canal surroundings and evoke the spirit of nineteenth-century Paris. The ships and barges going up and down the canal increase the appeal of the area for tourists.

Grange-aux-Belles footbridge Photo Lucien Pliskin

Temple footbridge © Mairie de Paris DVD Photo Christophe Belin

France

Buttes-Chaumont Footbridge
(Passerelle des Buttes-Chaumont)

- **Paris**, Buttes-Chaumont Park
- 1867
- Built by Eiffel et Cie

Text by Georges Pilot

All photos: Georges Pilot

This suspension footbridge, 65 metres long, is located in the Buttes-Chaumont Park in north-east Paris. It is one of the very few suspension bridges built by Eiffel et Cie still in use today.

The resources of the Buttes-Chaumont area had been exploited since 1789, mainly through underground mining, for the production of gypsum and construction stone. This activity continued until 1860, leaving a devastated landscape in its wake.

Later on, as part of the rebuilding of Paris during the Second Empire (1852–1870), Napoleon III decided to transform this desolated area into a 25-hectare park. Buttes-Chaumont Park was inaugurated in 1867 to coincide with the International Exposition of 1867

The lower part of the park comprises a lake with, at its centre, an island rising to a height of 30 metres and topped by the Temple de la Sibylle.

The park was created under the direction of Jean-Charles Alphand, Ingénieur des Ponts et Chaussées, who was in charge of preparations for the International Exposition, along with the engineer Eugène Belgrand, the architect Gabriel Davioud and Paris's chief gardener Jean-Pierre Barillet-Deschamps.

The footbridge, built in 1867, passes eight metres above the level of the lake and allows pedestrians to reach the island. It is suspended from two pairs of twin steel cables, each of which supports a steel girder and a wooden deck.

The Buttes-Chaumont footbridge was used as the model for a similar bridge in Cairo Zoo, also built by Eiffel et Cie.

France

The Debilly Footbridge and the Army and Navy Halls during the 1900 Exposition Universelle

Debilly Footbridge
(Passerelle Debilly)

- **Paris**, over the Seine
- 1899–1900
- Historical monument of Paris
- Has inspired several film-makers

Text by Jean-François Coste

In order to accommodate visitor traffic across the Seine during the Exposition Universelle of 1900, the Exposition's General Commissioner, Alfred Picard, approved the construction of a footbridge opposite the Avenue Albert de Mun, to join the Army and Navy Halls to the exhibition recreating old Paris.

This footbridge was originally designed to be dismantled after the Exposition but was saved when the City of Paris acquired it in 1902. In 1906 it was moved about 200 metres upstream towards the Pont de l'Alma and relocated opposite Rue de la Manutention.

It was originally known as the Passerelle de l'Exposition Militaire and then as the Passerelle de Magdebourg. In 1906 it was given the more dignified name of Passerelle Debilly to honour Jean Louis Debilly, a general of the First Empire who was killed at the Battle of Jena in 1806.

The bridge was designed by the engineers Jean Résal, Amédée Alby and André-Louis Lion. Résal was a professor at the École Polytechnique and, with Alby, was also responsible for designing the Pont Alexandre III, built in 1900.

With its steel arches and total length of 120 metres, this footbridge is a typical example of a steel structure from the early twentieth century, along with the Eiffel Tower. The central arch, 75 metres long, is supported by piers and hinged to the two side arches, 22.50 metres long, which are anchored to the abutments by vertically hinged truss rods to balance the arch thrusts. The stone abutments on the banks are decorated with dark green ceramic tiles giving the impression of waves.

Despite the bridge's history, in 1941 M. Bluyssen, president of the Society of Modern Architects, declared that the footbridge was a "forgotten accessory of a past event". Fortunately the Debilly footbridge was eventually included in the French register of historical monuments (1966) and once again saved from destruction.

It was repainted in 1991 and its decking was restored with tropical hardwoods.

In 1989, a few days after the fall of the Berlin Wall, a German diplomat working for the secret services of the German Democratic Republic was found dead on the footbridge. It transpired that the footbridge had been used as a discreet meeting place for East German agents during the Cold War.

This event prompted Brian de Palma to set a dramatic scene of his thriller Femme Fatale (2002) on the bridge. The footbridge has also inspired other film-makers such as Patrice Leconte, who made Girl on the Bridge starring Vanessa Paradis in 1999, and appears in the video for the song "L'amour fou" by the singer Jenifer

All colour photos Jean-François Coste

Main technical characteristics

Structural type: 3 steel arches: main span 75 metres, other spans 22.5 metres
Total length: 120 metres
Width: 8 metres
Geographical coordinates: 48°51'45"N 2°17'49"E
Designers: Jean Résal, Amédée Alby and André-Louis Lion
Contractor: Daydé et Pillé

France

All photos Jean-François Coste

Léopold Sédar Senghor Footbridge
(Passerelle Léopold-Sédar-Senghor)

- **Paris**, over the Seine
- 1999
- Winner of France's highest architecture award in 1999
- Reopened in 2000 following resolution of technical problems

Text by Jean-François Coste

The Passerelle Léopold-Sédar-Senghor, formerly known as the Passerelle Solférino, is a footbridge over the Seine in Paris linking the Musée d'Orsay and the Jardin des Tuileries.

The original cast-iron bridge in this location was built in 1861 and opened by Napoleon III. This bridge was dismantled in 1961 because damage to its structure had made it vulnerable to impacts from barges. It was replaced by a temporary footbridge replaced that was demolished in its turn in 1992.

The present footbridge was designed by the architect and engineer Marc Mimram. It was built between 1997 and 1999 and crosses the Seine in a single 106-metre span resting on double abutments (one high one low) on each riverbank. The supporting structure consists of two steel arch ribs assembled from curved sections and secured by transverse braces.

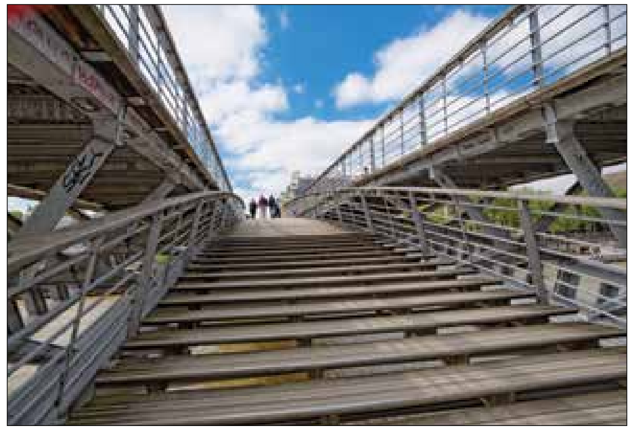
The bridge supports an asymmetrical deck with accesses from both the high and low quays meeting at a central opening. The deck planking and stairways are made of finely grooved azobé, an exotic hardwood.

The steel structure represents a unique design and an innovative engineering solution that won Marc Mimram the Prix de l'Équerre d'Argent, France's highest architecture award, in 1999.

The footbridge was officially opened by the Minister of Public Works and the Minister of Culture on 15 December 1999. During the inauguration a gust of wind caused the single-span to sway and the Minister of Culture slipped on the deck planking. The bridge was immediately closed. This event led to questions being raised about the stability of the bridge. Lateral displacement was measured by having more than 100 people dance to a rhythm that would maximise the sway. Eventually the sway was significantly reduced by dampers positioned under the deck and the footbridge was reopened in September 2000. Anti-slip strips were added to the planking prevent pedestrians from slipping.

The footbridge was renamed the Passerelle Leopold-Sédar-Senghor on October 2006, in memory of the Senegalese poet and statesman Leopold Sédar Senghor (1906–2001), the first African member of the French Academy.

Today the footbridge is famous for the padlocks that lovers leave on its railings.



Main technical characteristics

Structural type: Steel arch consisting of two parallel ribs joined by transverse braces, span 106 metres,
Total length: 140 metres
Width: 11–15 metres
Geographical coordinates: 48°51'43.00"N 2°19'29.00"E
Designer: Marc Mimram
Contractor: Quillery/Eiffel Construction Métallique

France

Photo: Mairie de Laroin

Laroin Footbridge (Pyrénées-Atlantiques department)
(Passerelle de Laroin)

- **Laroin**, over the river Gave de Pau
- 2002
- Innovative structure
- A bridge with carbon-fibre cables
- Design and construction: Freyssinet International, Soficar

Text by Georges Pilot

This cable-stayed footbridge is an innovative structure using carbon-fibre cables. Crossing the river Gave de Pau, it provides direct access a water sports centre.

The footbridge comprises a single 110-metre span supporting a deck consisting of transverse steel beams and prefabricated concrete slabs 2.5 metres wide and 10 centimetres thick.

The deck is supported on either side and at its extremities by four carbon-fibre cables attached to the deck beams. Compared to steel cables, carbon-fibre cables are lighter (one quarter of the weight), stronger and more durable. The cables are supported by two 20-metre pylons, each of them linked to a backstay anchored in a concrete foundation.

A special device was developed in order to facilitate the maintenance and eventual replacement of cables.

The bridge was designed and built by Freyssinet International & Cie, using cables supplied by Soficar.

Photo: Nono64, Wikipedia

France

Photo: Xavier Langlois

L'Estellier Footbridge (Alpes-de-Haute-Provence department)
(Passerelle de l'Estellier)

- **Over the river Verdon**
- 2004
- The bridge elements were transported by helicopter
- Assembled in difficult mountain conditions

Text by Georges Pilot

Located in the dramatic landscape of the Gorges du Verdon, the 45-metre Passerelle de l'Estellier footbridge spans the river Verdon. It is the only river crossing for pedestrians.

The Verdon is a river in south-eastern France with a total length of 175 kilometres. The section between Castellane and the Pont du Galetas, a distance of around 20 kilometres, is considered by many to be the most beautiful river gorge in Europe. Just six metres wide at its narrowest, the river is hemmed in by cliffs rising to heights of between 250 and 700 metres. This popular tourist destination is visited by numerous hikers, who follow hiking trails along the river, in particular the Martel trail and the vertiginous Inbut trail. Hikers use the Passerelle de l'Estellier to cross the river.

This footbridge is a steel arch comprising a three-dimensional structure with a V-shaped cross-section.

The construction site has no road access so the footbridge was manufactured in sections in the workshop before being transported by helicopter and assembled on site.

The bridge was designed by the architect Dominique Putz. The structural engineer in charge of the project was Alain Ranvier.

France

Photo: ConstruirAcier website

Simone de Beauvoir Footbridge
(Passerelle Simone de Beauvoir)

- **Paris**, over the Seine
- 2006
- The 37th bridge in Paris
- One of the first structures built according to Eurocode 3

Text by Noël Richet

The newest bridge in Paris – the thirty-seventh in total – is the Passerelle Simone de Beauvoir, the fourth crossing of the Seine for pedestrians and, more generally, non-motorised traffic. Equidistant from the Pont de Tolbiac and the Pont de Bercy, this bridge connects the front of the François Mitterrand Library (the main site of the Bibliothèque Nationale de France) on the left bank of the Seine to the Parc de Bercy on the right bank. Spanning between the Quai François Mauriac and the Quai de Bercy, it improves access to the banks of the Seine while creating a new vantage point from which to contemplate the river and its environment. Since its inauguration on 13 July 2006 it has been used as a venue for a variety of events.

The total length of the footbridge including the access ramps is 304 metres. The main section (over the Seine) comprises a free span of 190 metres. The bridge is 12 metres wide and 6 metres high (3.20 metres at the ends of the central lens). The steel structure weighs 1,600 tonnes, with the main crossing weighing 1,100 tonnes (including 550 tonnes for the central lens). The steel grades used are S355K2G3, S355N and S355 NL (NF-EN 10025), with a maximum thickness of 15 centimetres. The oak planking of the deck has a total area of 4,000 m².

Commissioned by the Department of Roads and Transport of the City of Paris, the bridge was designed by the architect Dietmar Feichtinger. Supervision of the project was entrusted to a consortium consisting of Dietmar Feichtinger Architectes and RFR SAS. Construction was carried out by Eiffel Construction Métallique, Joseph Paris and Soletanche Bachy. The steel was supplied by Dillinger Hütte GTS of Germany, which delivered 70% of it (including the thicker plates) to Eiffel's site in Lauterbourg (Alsace). The remaining 30% was supplied by Duferco Clabecq of Belgium, which delivered it to Eiffel's various subcontractors.

The bridge was one of the first structures designed according to Eurocode 3.

The bridge was manufactured almost in its entirety (95%) at Eiffel's Lauterbourg site. The central lens, a major part of the bridge (650 tonnes, length 106 metres, width 12 metres), was transported down the Rhine from Lauterbourg to Rotterdam. From there it travelled by sea to the mouth of the Seine and then up the river to Paris. It was then hoisted into position in its final location (between midnight and 3.00 a.m. on the night of 28 January 2006). Manufacturing and on-site work began in June 2004. The work was completed in June 2006. The final test under dynamic loading (known as a "crowd test") took place on 10 July 2006 under the supervision of technical assessment body CSTB.

Photo: Georges Pilot

Photo: ConstruirAcier website

France

Three Countries Footbridge

Three Countries Footbridge
(Haut-Rhin department)
(Passerelle des Trois Pays)

- **Huningue**, over the Rhine
- 2007
- World's longest-span pedestrian bridge
- Winner of the 2008 Deutsche Brückenbaupreis

Text by Bernard Raspaud

Passerelle des Trois Pays (or, in German, the Dreiländerbrücke) is a bridge that lies within a few hundred metres of three different European countries: France, Germany and Switzerland. It crosses the Rhine between the towns of Huningue (France) and Weil am Rhein (Germany).

The bridge was designed by the Franco-Austrian architect Dietmar Feichtinger in association with the consulting firm Leonhardt, Andrä und Partner.

The structure, built between 2006 and 2007, holds the world record for the longest span of any bridge for pedestrians and cyclists.

L'Arca International described it as an arch of asymmetric cross-section that transmits all the strength and technical elegance of this bridge; on the southern side lies another more slender arch that widens the visual axis; the bridge supports were designed not to block the view of the river banks.

The deck of the bridge, made of steel, is resistant to horizontal loads and contributes to structural stability.

The footbridge was the winner of the 2008 Deutsche Brückenbaupreis.

Main technical characteristics:

Span 248 metres, **total length** 346 metres.
Width 5.50 metres
Clearance 7.80 metres.
Highest point of the arch 24.75 metres
Materials: 1,012 tonnes of steel, 1,798 cubic metres of concrete, 805 metres of suspension cables.

Photo: Wladyslaw, Creative Commons Attribution 3.0

Photo: Piero d'Houin-Inocybe, Creative Commons Attribution-ShareAlike 3.0 Unported

France

All photos: Béton[s] Le Magazine

Angels Footbridge (Hérault department)

(Passerelle des Anges)

- Crosses the gorge of the river Hérault
- 2008
- The first use in Europe of fibre-reinforced UHPC
- Fitted with anti-vibration mass dampers

Text by Noël Richet

The construction of the Passerelle des Anges forms part of the development of a "Grand Site de France", listed as a UNESCO World Heritage Site, that includes the gorges of the river Hérault in the Languedoc-Roussillon region. The site, which also includes the medieval village of Saint-Guilhem-le-Désert, covers an area of 10,000 hectares and includes five communes: Aniane, Montpeyroux, Puéchabon, Saint-Guilhem-le-Désert and Saint-Jean-de-Fos. The site provides multiple resources in remarkable landscapes and is the subject of multiple protections and recognitions. Annual attendance is estimated at between 650,000 and 700,000 visitors, with peaks of up to 13,000 people per day.

An integral part of the proposed development, the footbridge provides pedestrians with safe access to the nearby eleventh-century Pont du Diable (Devil's Bridge), a protected historical monument. It spans a natural gap 70 metres wide and 10 metres deep.

The footbridge is 72 metres long, 1.80 metres wide and 1.80 metres deep, with a deck slab thickness of 4 centimetres and a weight of 144 tonnes. It uses fibre-reinforced Ultra High Performance Concrete (UHPC) and follows the Sherbrooke Pedestrian Bridge in Quebec, Canada and the Peace Bridge in Seoul, South Korea to become the first structure in Europe to use this new technology. The footbridge is living evidence of the evolution of construction techniques and forms part of a continuum with the Romanesque Devil's Bridge (eleventh century) and the nearby road bridge (early twentieth century). It is the fifth bridge on the site.

In structural terms it consists of two parallel isostatic T-beams, which also act as the railings. The material used for the bridge, Ductal® UHPC by Lafarge, was especially chosen in order to provide an elegant solution to all technical and environmental requirements.

The entire structure was prefabricated in the workshop. The footbridge is assembled from fifteen 4.6-metre segments, each weighing about 10 tonnes, prefabricated from a single mould. Each segment comprises the two beam sections and three tie members. The segments were then transported and assembled on site using a post-tensioned prestressing system. The slenderness of the bridge (which has a span-to-rise ratio of 38 to 1) required the use of mass dampers to limit vibrations. Studies, prefabrication, construction methods and prestressing were all strictly scheduled: three months for prefabrication, one month for site preparation, one week for installation and adjustment, one week for dismantling – in other words less than two months on site and less than two months for all operations.

Commissioned by the Communauté de Communes Vallée de l'Hérault, the footbridge was designed by the architect Rudy Ricciotti and built by the contractors Freyssinet and Bonna Sabla.

France

All photos: Alain Spielmann

Nanterre Harbour Footbridge
(Hauts-de-Seine department)
(Passerelle du Port de Nanterre)

- **Nanterre**
- 2010
- Bridge built in recreation area
- Total structural steel weight: 125 tonnes

Text by Jean-Paul Teyssandier

The Passerelle du Port de Nanterre spans the channel giving access to Nanterre harbour from the Seine river. Built between 2009 and 2010, it provides continuity to the footpath along the bank of the Seine.

It was designed by the French architect Alain Spielmann in association with the structural design firm Ingérop.

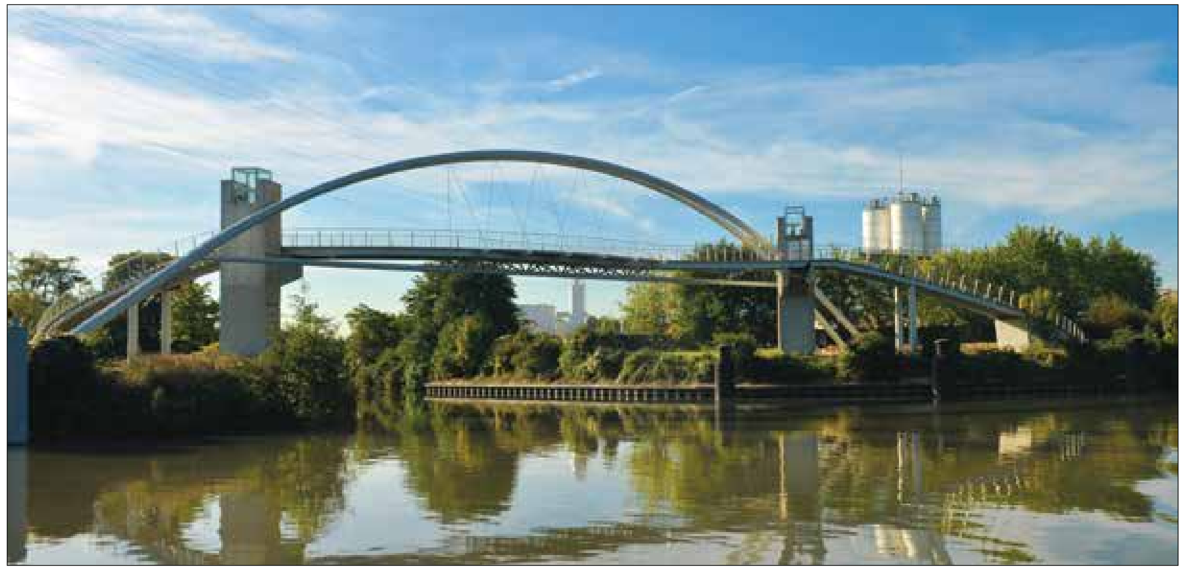
The footbridge consists of a metal bowstring arch from which an S-shaped deck is suspended between two concrete towers containing elevators.

The slenderness of the arch and the deck, associated with the robustness of the concrete towers, produces an elegant sculpture rising above the surrounding flat landscape. The curved shape of the deck provides a belvedere over the river and creates the feeling of a recreation area.

Main technical characteristics

The arch, 65 metres long and 15 metres high, is embedded at its extremities in two concrete blocks. It is formed of two metal tubes of a diameter of 610 millimetres.

The deck is composed of two metal box girders linked by cross-beams suspended from the arch and supporting the wooden planking of the walkway. It also incorporates a metal tube acting as a tie-rod for the arch.



France

Saint-Clair Footbridge

Saint-Clair Footbridge (Ardèche department)
(Passerelle Saint-Clair)

- **Annonay**
- 2011
- Glued laminated timber structure
- Hinges in galvanised steel

Text by Bernard Raspaud

The Passerelle Saint-Clair, completed in 2011, spans the D820 route départementale. It was built as part of the development of access to the town of Annonay, 50 kilometres south of Lyon.

Wood has been used in the manufacture of paper in Annonay since the eighteenth century. The bridge's designers, IGIOA SAS and B+M Architecture, wished to recall this tradition by choosing a glued laminated timber (glulam) structure.

The footbridge consists of a deck 40.30 metres long and two glulam arch ribs 28.24 metres wide and with a rise of 3.75 metres. The deck of the bridge is a reinforced concrete slab 15 centimetres thick, cast on a ribbed steel trough. The thickness of the arch ribs ranges from 1.05 metres at the supports to 0.65 metres at the crown.

Radiating fan-shaped braces connect the arch and deck. These braces are made of reconstituted welded profiles and are coated with solid wood.

The glulam arch ribs are supported by reinforced concrete abutments through galvanised steel hinges.

Construction of the bridge involved assembling two half-bridges each forming a half-span, and then joining the two half-bridges together.

Photo: A Hzami

Georgia

Georgian Footbridges in the Past

Bridges have played an important role in Georgia since the origin of human society. A review of historical materials and notable surviving examples presents us with a clear picture of the development of roads and bridges at different stages of Georgia's history. Bridge building has represented a significant aspect of engineering activity in Georgia since time immemorial. The expertise of the master bridge builders of the past has survived to the present day. A number of ancient Georgian stone bridges are still standing, although not all of them are in perfect condition. They are silent witnesses to the history of Georgian bridge building and a confirmation of the high level of technical expertise of their builders. The historian of King David IV, known as David the Builder (1084–1125), writes that King David built many bridges and paved roads.

An attractive single-span stone arch bridge stands on the river Tedzami near the old Rkoni monastery (Kaspi district). This bridge is 1.5 metres wide at its widest point.

Another beautiful single-span stone arch bridge can be found on the river Besleti, six kilometres north-east of Sukhumi. This bridge has been described in detail by many travellers and is considered a masterpiece of medieval bridge building. The bridge is built of stone with courses of flat Georgian bricks held in place by lime mortar The deck of the bridge is up to 4.7 metres wide and the distance between the supports is 13.3 metres. The crown of the semicircular arch stands 8.4 metres above the river, while the supports reach a height of 2.5 metres above the level of the water. The arch thickness ranges from 0.5 to 0.6 metres.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Georgia

Mtskheta – the ancient capital of Georgia

The Silk Road

Georgia

Pompey's Bridge

- **Mtskheta**
- Fourth to third century BC
- Today partially submerged
- Part of the famous Silk Road
- Once had two defence towers

Pompey's Bridge stands on the river Mtkvari (Kura) in Mtskheta, the ancient capital of Georgia. It is partially submerged in the waters of a man-made lake. Although the present bridge is commonly referred to as Pompey's Bridge both by the local population and in historical documents, a bridge stood on this site well before 65 BC, when the Roman commander Gnaeus Pompeius Magnus built a new bridge here. The origins of the first bridge are believed to date back to the fourth or third century BC.

In ancient times the old Georgian capital of Mtskheta lay at an important crossroads of international trade routes. Many historians mention these routes, among them Strabo, Pliny, Appian and Cassius Dio. The most famous road to cross ancient Georgia and pass through Mtskheta was the Silk Road, which began in China and crossed Georgia in the direction of the Black Sea and the Mediterranean. The road appears on the map of the ancient world drawn by the Roman geographer Castorius.

In the year 65 BC the bridge and the whole Mtskheta region became a battlefield in the war between Artag, king of Kartli (modern-day Georgia), and the Roman army commanded by Pompey.

In the fifth century AD the bridge was rebuilt by King Vakhtang Gorgasali. Its length was increased to 120 metres.

In the eighteenth century we find references to the bridge in the writings of the naturalist and explorer Johann Anton Güldenstädt. He described the bridge and the two defence towers, as well as the customs house.

In 1927 the bridge was submerged when the river was dammed to create a reservoir for the Zemo-Avchaly hydroelectric power station. From time to time it appears above the surface, depending on the water level.

Georgia

Anaklia Footbridge

- **Anaklia**
- 1 January 2012
- Europe's longest timber bridge
- Cable-stayed bridge, total length 505 metres
- Glulam wooden structure
- Assembled using the patented Hess limitless joint

Text by: Markus Golinski
All photos: Hess Timber, Germany

The original conceptual design of the footbridge envisaged a bold suspension bridge design made of steel and with a length of approximately 552 metres. In this design, the biggest span, of approximately 317 metres, would have been located in central section of the bridge. This design, however, by far exceeded the planned budget. The search therefore began for an alternative solution.

Eventually a cheaper solution involving timber was decided upon as an alternative to the steel structure. Leonhardt, Andrä and Partner (LAP) of Stuttgart (Germany), who had been chosen as planning partners, created a timber construction solution in cooperation with the German company Hess Timber. Before the design was finally approved by Georgian president Mikheil Saakashvili, several versions and suggestions had been worked out.

The final design was a multiple span system consisting of two haunched end spans of 36 metres each, six standard spans measuring 48 metres and a cable-stayed section consisting of the largest spans of, respectively, 64 and 84 metres. The total length of the bridge is 505 metres, which makes it Europe's longest timber bridge.

The cross-section of the bridge reveals a spatial timber frame construction consisting of two trussed girders which are laterally inclined to 45 degrees as well as a horizontal panel construction consisting of cross-bars and wood-based boards. The glulam sections were joined by means of standard slotted plate and dowel joints.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Georgia

Anaklia Footbridge

Originally it was planned to cover the entire timber frame structure with chestnut cladding. During assembly, however, the client was impressed by the timber frame construction and it was decided to clad the glulam elements with transparent polycarbonate plates so as to keep them visible.

Hess Timber decided to transport an entire carpenter's workshop from Germany to Georgia in order to ensure the smooth realisation of the pre-assembly process and the necessary preliminary work. Assembly was carried out by German carpenters and Georgian support workers.

Assembly of the bridge: where possible, the timber frames (produced on site) and steel parts (produced in Germany) were pre-assembled on the ground and/or on the dam raised at the assembly site. Owing to the site's special position (right beside the sea, on the river Inguri), the assembly work that took place in autumn and early winter was repeatedly affected by flooding, storm tides and violent storms.

Project data:
Owner: Georgia
General Contractor: CRP, Tbilisi, Georgia
Timber frame construction:
Hess Timber, Kleinheubach, Germany
Design: Leonhardt, Andrä & Partner, Stuttgart, Germany
Timber frame structural engineering calculations: Fast & Epp, Darmstadt, Germany
Planning of sealing details: HSW-Ingenieure, Bad Oeynhausen, Germany
Structural engineering calculations for cables, pre-tensioning and assembly:
Redaelli, Italy
Lighting design: Lunalicht, Karlsruhe, Germany
Structural engineering calculations and manufacture of neoprene bearings: ALGA (Freyssinet Group), Milan, Italy.

Georgia

The Bridge of Peace

- **Tbilisi**
- 6 May 2010
- Curved steel tubular truss structure covered with glass plates
- Special illumination and light effects
- Opened by the Georgian president Mikheil Saakashvili

Text by: Gorazd Humar
All photos: Gorazd Humar

The Bridge of Peace – the name of this architecturally interesting bridge in the centre of the Georgian capital Tbilisi represents a communication that "celebrates life and peace between people". These are the words of Philippe Marionaud, the French lighting designer responsible for the bridge's special lighting effects. And indeed – the bridge is a wonderful sight not only during the day but also at night, when thousands of LED lights create a colourful and constantly changing spectacle.

These lighting effects also include the deck of the bridge, where LEDs are embedded in protective glass railings. The lights display a message that renders the periodic table of elements in Morse code scrolling along the parapets of the bridge. Along with the nearby Narikala Fortress, which is impressively floodlit, the bridge helps give Tbilisi an attractive appearance by night.

The bridge was designed by the Italian architect Michele de Lucchi, who was also the designer of some important modern public buildings in the vicinity. The elements of the steel bridge structure were produced in Italy and assembled on site. The bridge, which spans 150 metres over the river Mtkvari (Kura), links Tbilisi's old town to a new modern park on the left bank. The bridge has a very particular shape that is somewhat reminiscent of a sea creature. This effect was achieved by a special roof construction covered with glass plates.

Soon after its completion the Bridge of Peace was already established as one of Tbilisi's most important landmarks. Even the name of the bridge sends a strong signal – it is a symbol of peace in modern Georgia.

FOOTBRIDGES - SMALL IS BEAUTIFUL

The Bridge of Peace

Client: Old City Rehabilitation and Development Fund
Designer: Michele de Lucchi / **Structural design:** Favero & Milan Ingegneria Srl
Illumination designer: Philippe Marionaud
Illumination made by: Dutch Primo Exposures and RENA Electronica

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Gorazd Humar

The Bridge of Peace, Tbilisi

Germany

Chain Bridge
(Kettensteg)

- **Nuremberg, Bavaria**
- 1824, restaurated in 2010
- Oldest surviving iron suspension bridge in continental Europe
- Length 68 metres, width 2 metres
- Bridge over the old arm of the river Pegnitz

Text: C. Ahrens

The Kettensteg was built in 1824 by Konrad Georg Kuppler. It is the oldest iron suspension bridge in continental Europe. The chains and suspension rods of the Kettensteg still exist in their original state but ceased to serve their function when a supporting structure was installed in 1931. The name "Chain Bridge" derives from the system of chains, each three metres in length, from which the bridge is suspended via pylons at either end.

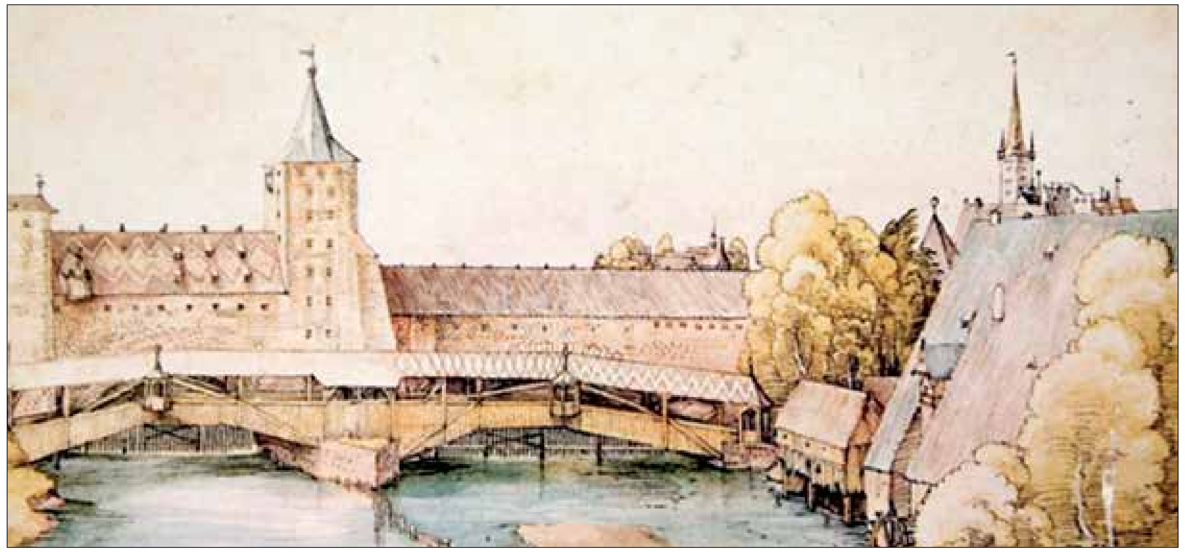
The bridge was provisionally restored in 1930. The start of the Second World War prevented its complete demolition. It continued to serve its function as a "temporary" bridge for more than six decades, until it was closed for safety reasons in 2009. The restoration of the bridge, financed by the city of Nuremburg, began in 2010. On 22 December 2010 the bridge reopened, having been restored almost to its original state. Since suspension bridges are affected strongly by vibrations, the bridge was stabilised by means of a wooden structure integrated into the footway.

Today the bridge enjoys protected status as part of the country's technical heritage and forms part of Nuremberg's "historic mile".

The bridge has a famous predecessor, which was painted by the great painter Albrecht Dürer.

Design: Konrad Georg Kuppler / **Planning:** Dr. Kreutz + Partner, Nuremberg

Albrecht Dürer, 1491



Germany

Photo: Robert Böck ©

Neuschwanstein Castle
(Marienbrücke)

- **Near Neuschwanstein Castle, Bavaria**
- 1866, later renovated
- Built 90 metres above the gorge
- No falsework was used during construction of the bridge

Text: C. Ahrens

The Marienbrücke (also known as the Pöllatbrücke) is located in the village of Schwangau, not far from the town of Füssen in Bavaria. The bridge spans the gorge of the Pöllat stream at a height of about 90 metres. Named after Marie of Prussia, the wife of Maximilian II of Bavaria, the bridge offers a wonderful view of the famous castle of Neuschwanstein.

The original wooden bridge, built in 1845, was designed to allow riders to cross the gorge. In 1866, on the orders of King Ludwig II, it was replaced by a delicate iron structure built in the Gustavsburg workshops of Maschinenbau-Gesellschaft Nürnberg Klett & Co. (a predecessor of the present-day MAN SE). The designer was the royal engineer Heinrich Gottfried Gerber.

Construction of the bridge took place using what was, for the time, a brand-new technique: the two halves of the bridge, anchored in the rock on either side of the gorge, were cantilevered outwards to meet in the middle, thus avoiding the need for falsework to support the structure during construction. Although the bridge has undergone several renovations, parts of it are still original.

Germany

Photo: © Deutscher Brückenbaupreis 2008

Three Countries Bridge
(Dreiländerbrücke)

- **Bridge over the Rhine between Weil am Rhein (Baden-Württemberg, Germany, near Basle, Switzerland) and Huningue, France**
- 2005–2006
- Steel arch bridge with one main span, length of the bridge 248 metres, width 5 metres
- Longest span: 229.4 metres – a record span length for arch footbridges

Text: Deutscher Brückenbaupreis 2008

With its record-breaking span, this bridge is a symbol of modern bridge building and a popular tourist attraction. It is well integrated into its surroundings thanks to its unusually flat arch and "invisible" abutments.

The plan of the bridge is asymmetrical and the arch is extremely flat, with a height of just 24 metres. This gives the bridge a special tension and elegance. Steel structural elements in which the flow of forces can be read take the place of the usual massive abutments and allow a smooth transition into the river bank area.

Innovative design solutions were used for details such as lighting, handrails, access steps and ramps.

Design: Wolfgang Strobel, Dietmar Feichtinger
Client: Town of Weil am Rhein in cooperation with the Communauté de Communes des Trois Frontières

FOOTBRIDGES - SMALL IS BEAUTIFUL

Three Countries Bridge

Photo: © Deutscher Brückenbaupreis 2008

Germany

Harbour Footbridge

- **Sassnitz, Mecklenburg-Vorpommern**
- May 2006–July 2007
- A balcony over the sea
- Very light and transparent bridge structure

Text: Deutscher Brückenbaupreis 2010

This new footbridge functions as a "balcony over the sea", connecting the harbour of Sassnitz to the town. It has an extremely slender profile with a height difference of 22 metres and combines form and function in a very convincing manner. The bridge is a single-ring beam suspended from eccentric cables and connected to an approach ramp. The bridge is light and transparent, with the result that the view is not obstructed at any point.

The bridge was designed and built by **Schlaich, Bergermann & Partner** of Stuttgart and was the winner of the 2010 Deutscher Brückenbaupreis.

Construction data:

Total length: 243 metres
Span: 119 metres
Ramp: 124 metres
Width: 3 metres
Height difference: 22 metres
Height of mast: 43 metres
Number of cables: 28
Weight of bridge: 320 tonnes

All photos: Wilfried Dechau ©

FOOTBRIDGES - SMALL IS BEAUTIFUL

Germany

Dragon Tail Bridge
(Drachenschwanz Brücke)

- **Gera and Ronneburg, Thuringia**
- 2007
- Wooden Stressed Ribbon Bridge
- One of the longest and most innovative wooden bridges in Germany

Text: Deutscher Brückenbaupreis 2008

The bridge was built for the 2007 Bundesgartenschau (federal horticultural show) which was held in Thuringia. It was the main attraction at the show and is today an important part of the Thüringer Städtekette, a popular long-distance cycling route.

The bridge is one the longest and most innovative wooden bridges in Germany – and indeed the world. It has won various prizes thanks to its attractively undulating deck and eye-catching piers. Its remarkable shape makes the bridge a poetic part of the terraced landscape, offering fantastic views over it.

The stressed ribbon is just 50 cm thick but has to withstand tensile forces of around 800 tonnes and is anchored at the ends of the bridge by ground anchors. By doubling and changing the width, the specific form of the ribbon helps damp high torsional vibrations. The ribbon itself is protected against corrosion by the use of wood. The handrail is also made of wood, which helped keep the costs of the bridge down.

Cost: € 1.7 million
Length: 225.5 metres – three spans of more than 52 metres each
Width: 2.5–3.8 metres
Height above ground: 25 metres

Client: BUGA Gera und Ronneburg 2007 GmbH, Thuringia /
Planning and design: Richard J. Dietrich Design Office for Engineering Architecture Munich/Traunstein

Photo: J. Dietrich ©

Germany

All photos: © Deutscher Brückenbaupreis 2012 / T. George

Flöha Bridge
(Blaue Welle)

- **Flöha, Saxony**
- 2010
- Crosses a railway and main road
- Semi-integral steel deck bridge
- Length 110.60 metres, 3 spans
- Longest span 53.50 metres

Text: Deutscher Brückenbaupreis 2012

The Flöha Bridge, also known as the "Blue Wave", crosses a busy main road and a small railway in the town of Flöha, Saxony and connects the town centre to a new district. Spatial constraints and relatively big height differences resulted in an S-shaped design.

The three-span bridge, supported by two piers, is an undulating semi-integral structure incorporating haunched beams. It is well integrated into the surrounding area.

The steel deck is anchored at the ends because forces caused by temperature fluctuations are mainly carried by the radial movements of the S-shaped structure. Thus the bridge is slender and does not require much maintenance.

The "Blaue Welle" bridge won the **2012 Deutscher Brückenbaupreis** in the footbridges category in recognition of the skilful engineering solutions employed and the economically optimised construction.

Client: DEGES GmbH, Berlin on behalf of the Free State of Saxony /
Project management: Karl Kleinhanß, Bernd Urbank, DEGES GmbH, Berlin /
Design and execution: Frank Ehrlicher, Gregor Gebert, Schüßler-Plan Ingenieurgesellschaft mbH

FOOTBRIDGES - SMALL IS BEAUTIFUL

Germany

Slinky Springs to Fame, a "bridge sculpture"

- **Oberhausen**
- 2011
- Length 406 metres, width 2.7 metres
- Main span 65.8 metres
- Awards: Stahl-Innovationspreis 2012, ECCS Award for Steel Bridges 2012

Text: C. Ahrens

All photos: Roman Mensing

The elegant pedestrian bridge across the Rhine-Herne Canal is a part of the EMSCHERKUNST 2010 project. Designed by the artist Tobias Rehberger, the bridge is a colourful ribbon wrapped in a light, swinging spiral that connects two existing parks. The lightness of the design is achieved through the minimalist structural design of the bridge. Two steel ribbons made of high-strength steel connect to inclined supports across the canal. The resulting tension force is transferred into the abutments via the outer vertical tension rods. The walkway consists of pre-cast concrete plates bolted to the stressed ribbon, to which the railings and spiral are attached. The springy synthetic pavement of the walkway, combined with the colourful rhythmisation of the concrete and coating, amplifies the dynamic experience of the bridge. Railings made of steel and cable meshes effectively add to the damping of this animated bridge.

Owner: Emschergenossenschaft / **Design:** Schlaich Bergermann und Partner /
Contractors: ARGE Stahlbau Raulf; IHT Bochum /
Cooperation: Bauplan GmbH Wagner + Partner, Gelsenkirchen; Madako, Oberhausen

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Roman Mensing, artdoc.de

Slinky Springs to Fame, Oberhausen

Germany

All photos: © Deutscher Brückenbaupreis 2014

Erba-Steg Footbridge

- **Bamberg, Bavaria**
- 2012
- Length 60 metres, main span 48 metres, height in the middle 350 mm
- Very light and elegant footbridge
- Winner of the 2014 Deutscher Brückenbaupreis

Text: Deutscher Brückenbaupreis 2014

This bridge in the UNESCO World Heritage city of Bamberg, Bavaria, has a curious, if short, history. It originally served as a temporary replacement bridge during the reconstruction of Bamberg's Kettenbrücke (Chain Bridge), which lasted two years.

In 2012 the city of Bamberg hosted the Landesgartenschau and needed a slender bridge that would fit into the context of a garden.

Both these requirements had to be fulfilled by this one bridge, which is now known as the Erba-Steg, a footbridge over the smaller left arm of the river Regnitz, connecting the island of Erba to the city.

In order to substitute the Chain Bridge over the Main-Donau Canal, a span of 60 metres was necessary. This would normally require an arch of considerable dimensions. For its use in the garden, however, the bridge had to have a very small height and had to fit neatly into the garden setting.

For this second use, the bridge was cut into two pieces. The two sections were lifted into their respective places in the garden and welded together to form a three-span bridge with a main span of 48 metres. The shorter end spans made it possible to give the bridge an extremely slender profile of just l/137, a figure that pushes the limits of technical possibilities. The bridge sets new standards of lightness, gracefulness and elegance.

Design: Johann Grad († 2013), Matthias Dietz / **Client:** City of Bamberg

Great Britain

Postbridge

- **Devon**
- 13th century
- The deck slabs weigh up to 8 tonnes each
- Protected status since 1967

Text by Brian Duguid

The oldest surviving footbridges in the United Kingdom include "clapper bridges", a simple form of bridge constructed from massive stone slabs supported by stone masonry piers. The most famous examples include the Tarr Steps in Somerset, a 55-metre bridge of 17 spans that is believed to date from around 1100; and Postbridge in Devon, a three-span bridge dating from the thirteenth century.

The deck slabs at Postbridge are reported to weigh up to 8 tonnes each. These bridges still rank as significant engineering achievements given the limited means available at the time of construction. The bridges have remained in continuous use since they were built, carrying both foot and packhorse traffic.

Postbridge is recognised for its historic significance and has been listed as a protected historical monument since 1967.

Great Britain

Mathematical Bridge

- **Cambridge**
- 1749, rebuilt in 1866 and 1905
- Historic timber footbridge
- Spans 12 metres over the river Cam
- Very efficient use of timber

Text by Brian Duguid

Few historic timber footbridges have survived. The Mathematical Bridge, which spans 12 metres across the river Cam in the university town of Cambridge, originally dates from 1749. The current bridge is actually a reconstruction to the same design, the bridge having been completely rebuilt in 1866 and 1905.

The design, by William Etheridge, uses straight timbers arranged radially and tangentially to a circular arc, giving rise to the bridge's nickname. It has been suggested that this represents a highly efficient use of the timber, and it has also been used for the timber centring for a number of masonry arch bridges. However, there is little evidence to support this supposition, and many of the timbers in the bridge are likely to carry very little load.

Although the Mathematical Bridge in Cambridge is well known, there is an essentially identical, albeit smaller, bridge of the same type at Iffley Lock in Oxford, built in 1924.

Great Britain

Kirkton of Glenisla Bridge

- **Angus**
- 1824
- The earliest surviving stayed suspension bridge in the UK
- Very slender bridge structure
- The rod stays are 15 mm in diameter

Text by Brian Duguid

This metal footbridge at Kirkton of Glenisla in Scotland, which has a span of 19 metres, is the earliest surviving stayed suspension bridge in the United Kingdom, and possibly in Europe.

It was built in 1824 by the blacksmith John Justice, roughly eight years after a series of other stayed bridges at Galashiels, Dryburgh and Kings Meadows, none of which have survived. Justice built a number of other bridges of similar design, and the surviving rod-stayed highway bridge at Haughs of Drimmie may even predate the Kirkton of Glenisla bridge by a year.

The Kirkton of Glenisla footbridge remains remarkable for the slenderness of all its elements, a feature shared by other Justice designs. Four rod stays of approximately 15 millimetres in diameter connect the bridge deck to the very thin pylons at either end of the deck. The deck itself consists mainly of one flat iron bar at each edge, from which a series of cross-ties support the deck planking.

Over time, the bridge has become twisted and deformed, but its survival at all seems little short of a miracle.

Great Britain

Maryhill House Footbridge

- **Elgin**
- Between 1850 and 1870
- Metal footbridge
- Suspension cable passes below the deck
- Very light, slender and efficient structure

Text by Brian Duguid

During the nineteenth century a number of interesting metal footbridges were built throughout the United Kingdom. Many of these were of the conventional suspension bridge type, and examples of these can be found throughout the country, often beautiful and generally highly economical.

A number of lenticular bridges were also built, of which the bridge near Maryhill House in Elgin is simply an example. The firm of Charles D. Young & Co advertised this type of bridge in an 1850 brochure, noting that it was more economical than suspension bridges because it avoided the need for pylons. Indeed, it can be thought of as an "underspanned" suspension bridge, where the suspension bar or cable passes below rather than above the deck.

There are good examples of the firm's bridges at Denham Court, near London; at Roxburgh Viaduct in the Scottish Borders region; and at Elgin. None of them are well recorded and the dates of construction are uncertain, although the Elgin bridge probably dates from between 1850 and 1870. Its span is not recorded, although it is estimated to be about 17 metres.

What sets this bridge apart, as with many other remarkable bridges of the period, is the extreme slenderness of the metal members, resulting in a very elegant, lightweight, and efficient structure.

Great Britain

Faery Bridge

- **Dunblane**
- 1911
- A significant example of pioneering structural design
- Spanning 28 metres over the river

Text by Brian Duguid

A number of innovative and significant reinforced concrete bridges were built in the United Kingdom in the twentieth century The most famous example is possibly Ove Arup's Kingsgate Bridge, built in Durham, in 1963. A number of very elegant arch designs were also built at about the same time, such as the bridge at Swanscombe Cutting in Kent, which recalls the designs of the famous Swiss engineer Robert Maillart.

Much earlier, a bridge was built in 1911 in Dunblane, which although not the most beautiful of its time, was remarkable in its form. Spanning 28 metres, it was designed and built by Considere and Partners, and may take its name "Faery" Bridge from a corruption of the term "ferro-concrete". The bridge is a deck-stiffened arch, where a thin arch element is stabilised by a stiffer deck beam, a form of construction often attributed to Robert Maillart, who used it in bridges such as the superb Töss Footbridge.

However, Dunblane's Faery Bridge predates the Töss design by roughly two decades, and was also a decade ahead of Maillart's other deck-stiffened arch bridges, built in the 1920s. It is therefore a significant example of pioneering structural design.

Great Britain

Lockmeadow Footbridge

- **Kent**
- 1999
- Length 80 metres, main span 45 metres
- Unusual twin-masted arrangement

Text by Brian Duguid

The 1990s saw an explosion of exciting contemporary footbridge design throughout the United Kingdom. Many of the bridges built were the product of high-profile bridge design competitions, often bringing far greater involvement from architects than had previously been the case. Many such bridges are notable for their striking, sometimes iconic, visual appearance. Many are also notable for their cutting-edge engineering design.

The Lockmeadow Footbridge at Maidstone in Kent resulted from all these criteria: a collaboration between engineers Flint & Neill and designers Chris Wilkinson Architects, the bridge was the winner of a design competition held by the local council. It was completed in 1999.

The bridge is 80 metres long, with a main span of 45 metres, and has an unusual twin-masted arrangement, which reduces the overall mast height required. The bridge deck, which is only 300 millimetres thick, is supported by stays from the skeletal steel masts.

The bridge incorporates a number of innovations. The footway deck uses aluminium extrusions, locked together by stainless steel prestressing bars. The balustrades consist of custom-made fibre-reinforced plastic posts supporting a stainless steel handrail and wire panels.

The bridge is a highly modern intrusion in a historic setting, but every effort has been made to minimise the visual impact of its various components.

Great Britain

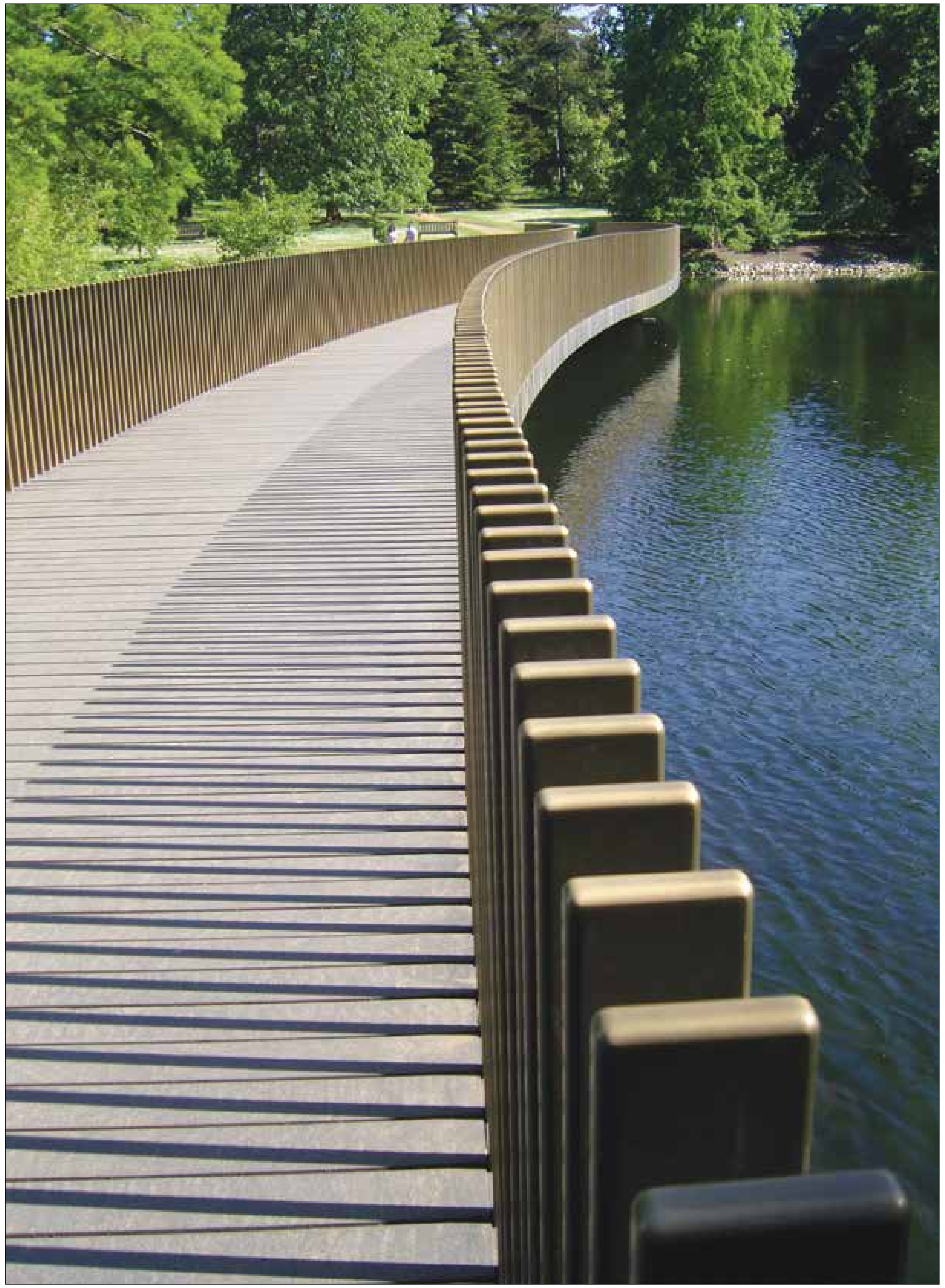
Sackler Crossing
■ **London**
■ 2004–2006
■ 70-metre footbridge over a small lake
■ Minimalist approach to architecture

Text by Brian Duguid

There are two contemporary footbridges in London's Kew Gardens, each very different from the other. One is an aerial walkway, threaded between the treetops. The other, the Sackler Crossing, crosses a small lake, and links two footpaths.

The bridge, designed by John Pawson with Buro Happold, is 70 metres long and crosses the lake in a sinuous S-curve. The structure is a steel frame supported on steel piles, but the key visible features of the bridge are the series of granite sleepers forming the deck and the 990 bronze posts forming a parapet with no continuous handrail.

The lead designer, John Pawson, is renowned for his minimalist approach to architecture, but the bridge offers a sensuous rather than a minimalist experience.



Great Britain

Halgavor Bridge

- **Cornwall**
- 2001
- Spans 47 metres across a road
- Deck made of GRP and covered with recycled rubber tiles

Text by Brian Duguid

Built in 2001 to carry a local footpath 47 metres across a busy road, Halgavor Bridge successfully marries attractive visual design to state-of-the-art engineering.

The bridge was designed by Wilkinson Eyre and Flint & Neill. It is a suspension bridge with short steel pylons inclined away from the roadway. The main suspension cables consist of galvanised steel, while the hanger cables and parapets are of stainless steel. Timber panels at the base of the parapets facilitate the use of the bridge by horses, by helping to hide the traffic from their view. Recycled rubber tiles on the deck provide a soft but robust surface for the horses' hooves.

The bridge deck consists mainly of glass-reinforced plastic (GRP), combining pultruded edge sections with sandwich plate decking, and GRP plates and diaphragms. The material is expected to be largely maintenance-free. A number of other fibre-reinforced plastic footbridges have been built in the United Kingdom in recent years, but very few have managed to combine technology with the elegance of the Halgavor design.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Great Britain

Fisherman's Bridge

- **Cumbria**
- 2009
- Simple weathering steel box girder
- 15-metre bridge mainly used by anglers
- When struck by a metal bar musical notes are sounded

Text by Brian Duguid

This tiny, 15-metre footbridge on private land in the Cumbrian Lake District is used only by the occasional angler to cross the River Duddon. It was designed by Honey Architects with Price & Myers engineers.

The bridge was built for an extremely low price and consists only of a simply supported weathering steel box girder, triangular in both cross-section and elevation. This is supported on small concrete piers at each end, to raise it above the river flood level.

The bridge parapets are a series of simple steel rods of varying length. When struck by a metal bar, these resonate with the box girder and a series of musical notes are sounded.

Great Britain

Castleford Bridge

- **Yorkshire**
- 2008
- 131 metres long, 4 metres wide
- Hardwood decking
- Offers an attractive view over the river

Text by Brian Duguid

Opened in 2008, this footbridge was built both to improve pedestrian connections and to try and encourage economic development in the small town of Castleford. Designed by McDowell and Benedetti, Alan Baxter Associates, and Tony Gee and Partners, it is 131 metres long and 4 metres wide.

The bridge crosses the river Aire in a sweeping S-shaped curve, immediately downstream of a weir. The bridge deck contains twin hollow steel box girders, one of which rises above deck level to provide a base for seating. The box girders are supported on steel legs arranged in V-shapes.

The bridge decking and part of the parapets are made from hardwood. The bridge creates an attractive space from which to admire the river, while the blend of timber and steel elements is visually very successful.

Great Britain

Forthside Bridge

- **Stirling**
- 2009
- Very unusual bridge structure
- Spans 113 metres above a railway station
- Glass panels as parapets

Text by Brian Duguid

Completed in 2009, this bridge is an unusual and adventurous development of the cable-stayed bridge type. It is 113 metres long and spans above Stirling railway station.

The bridge was designed by Gifford and Wilkinson Eyre and built by Nuttall. Each edge of the bridge is supported by an "inverted Fink truss", essentially a series of cantilevering cable-stay elements. These decrease in height from one end of the bridge to the other, with the arrangement along each edge being the reverse of the other. The masts also incline outwards at increasing angles, visually reflecting the pedestrian desire line.

The bridge deck consists of a steel monocoque formed by two diamond-shaped edge girders connected by intermediate plates. The bridge parapets are glass panels, inclined to match the angles of the masts.

The bridge is a bold and dramatic contemporary design, and forms a landmark which can be seen from Stirling Castle, high above the town.

Greece

Eleutherna Bridge, Rethymno, Crete

- **30 km SE of Rethymno, Crete**
- Circa 350 BC, Hellenistic period
- One of few surviving bridges from that period
- Built of unmortared limestone blocks

Text by: Aris Chatzidakis

The ancient city of Eleutherna was located approximately 30 kilometres south-east of Rethymno (Crete), in the foothills of Mount Ida, at about 380 metres above sea level.

Eleutherna underwent great development during the late Classical and Hellenistic periods, as well as during the later Roman and Christian periods.

As we know, ancient bridge technology progressed from the use of flat surfaces, through the use of the corbel arch, with or without centring, to the use of the arch with voussoirs. Corbelling is found in prehistoric bridges and was widely used until the Hellenistic period, when The Greeks began using arches with voussoirs.

The evidence suggests that the bridge dates from the Hellenistic period, i.e. around 350 BC, which makes it one of the very few surviving bridges from this period.

The bridge sits on natural rock, part of which is incorporated into the support of the bridge. The bridge is 9.35 metres long. Its width ranges from 5.1 metres at its east end to 5.2 metres at its west end. The width above the crown of the arch is 5.05 metres. The two sides of the bridge thus converge slightly.

The bridge is built of unmortared large limestone blocks. The blocks vary in width from 0.5 to 1.5 metres, in thickness from 0.4 to 0.7 metres, and in height from 0.4 to 0.45 metres. The corbel arch is 3.95 metres wide. The feet of the bridge are of uneven height and the base of the triangular corbel arch is horizontal. The free height of the bridge ranges from 4 metres (south) to 4.2 metres (north). The height of the isosceles triangle formed by the sides of the arch (i.e. the rise) is 1.84 metres. The angles formed by the base and sides of the same triangle are 43°, while that of the crown of the arch is 94°.

Greece

Palkida or Kalogeriko Bridge

- **Western Epirus, near the villages of Kipoi and Koukouli**
- 1814
- Stone bridge, total length 56 metres
- Three spans of 12, 14 and 16 metres
- Perfectly integrated with the landscape

Text by: Aris Chatzidakis

The Plakida or Kalogeriko Bridge is situated in Western Epirus, close to the villages of Kipoi and Koukouli, in the Central Zagori area. It was built in 1814 in order to link the banks of the river Vikos (a branch of the Voidomatis, which is a tributary of the Aoös, one of the longest rivers in Greece). The stone bridge, which has a total length of 56 metres and is 3.15 metres wide, has three stone arches with spans of 12, 14 and 16 metres respectively. The parapet consists of oblong stones set vertically at regular intervals. The bridge is particularly notable for the way it blends into the landscape. Its shape has led to comparisons with a crawling caterpillar.

The original bridge was wooden but it was later rebuilt in stone following a grant from Serafeim, the abbot of the Profitis Ilias monastery in the village of Vitsa. It was therefore named the Kalogeriko Bridge (καλόγερος, kalogeros = monk in Greek). After the year 1865, according to an inscription, it underwent structural repairs financed by Alexis and Andreas Plakidas of Koukouli, and was therefore was renamed the Plakida Bridge.

Bridges were usually named after the person or institution who financed their construction (rich benefactors, endowments such as the Ottoman vakifs, Turkish officers, ecclesiastics and so on). In some cases, two or more names were attributed to the same stone bridge, since they referred to the people who had covered the cost of repairs, when needed. Bridges were also named after villages, when they were built using funds raised in a given area.

The stone bridges that are found in the mountainous regions of Greece, particularly in Epirus, enabled essential communication between inaccessible rural areas and the principal markets of the eighteenth and nineteenth centuries: the Balkans, Austria (mainly Vienna), Turkey and Egypt. Bridges were essential to the area's economic livelihood.

Most of the bridges in Epirus were built of schist stone, while a mixture of lime, crushed tiles, water, pumice stone and dried grass were added to the binding mortar in order to make it stronger and more resistant. Construction of bridges started from both ends, with the master builders working gradually towards the keystone. The voussoirs had to be set close together in order to direct the thrust of the arch in such a way that the weight of the whole structure would be transferred to the supports. The abutments and central piers had to be bedded on stable ground, so the construction of stone bridges mostly took place in summertime, to take advantage of favourable weather conditions. A well-constructed scaffolding consisting of wooden beams was used to prepare the formed arches and removed after building was complete.

Stone bridges, like most structures of the period (religious buildings, public buildings, domestic architecture), were built by groups of local craftsmen (μπουλούκια or ισνάφια, known also as κουδαραίοι), who moved from village to another and from one region to another. Those responsible for building bridges were known as κιοπρουλήδες, kioproulides (köprü=bridge in Turkish), but they also built other buildings and included craftsmen (μάστορες, mastores) able to work in stone, wood, metal, as well as their young apprentices.


Palkida or Kalogeriko Bridge, Western Epirus

Greece

Alikianos Bridge

- **Chania, Crete**
- 1908
- The largest stone bridge in Crete
- Total length 85 metres, width 6 metres
- Designed using the graphic statics method

Text by: Aris Chatzidakis

This bridge near the village of Alikianos in the Chania region is the largest stone bridge in Crete. It has three clear spans of 20 metres each, a total length of 85 metres and a width of 6 metres. The bridge is still in use and its 5.2-metre deck supports the main road to the village.

The bridge was built in 1908 by the public works service of the autonomous Cretan State. It was designed by state engineers using the scientific knowledge and engineering manuals of the day. The chief designer is known to have studied at the polytechnic of Louvain in Belgium. Graphic statics methods of structural analysis were already in use in this period. The bridge structure is of cut stone, while the foundations are of concrete. Iron fastenings are used in places. The arches are flattened, with a span of 20 metres and a rise of 7.5 metres.

FOOTBRIDGES - SMALL IS BEAUTIFUL

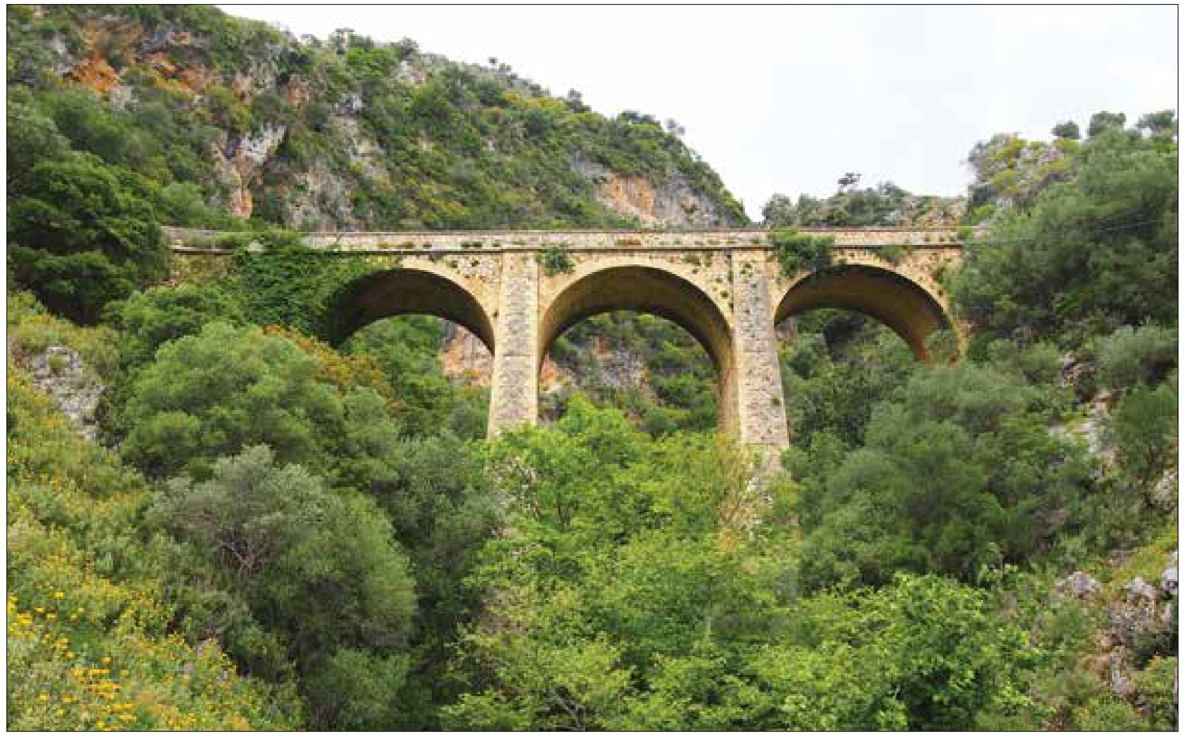
Greece

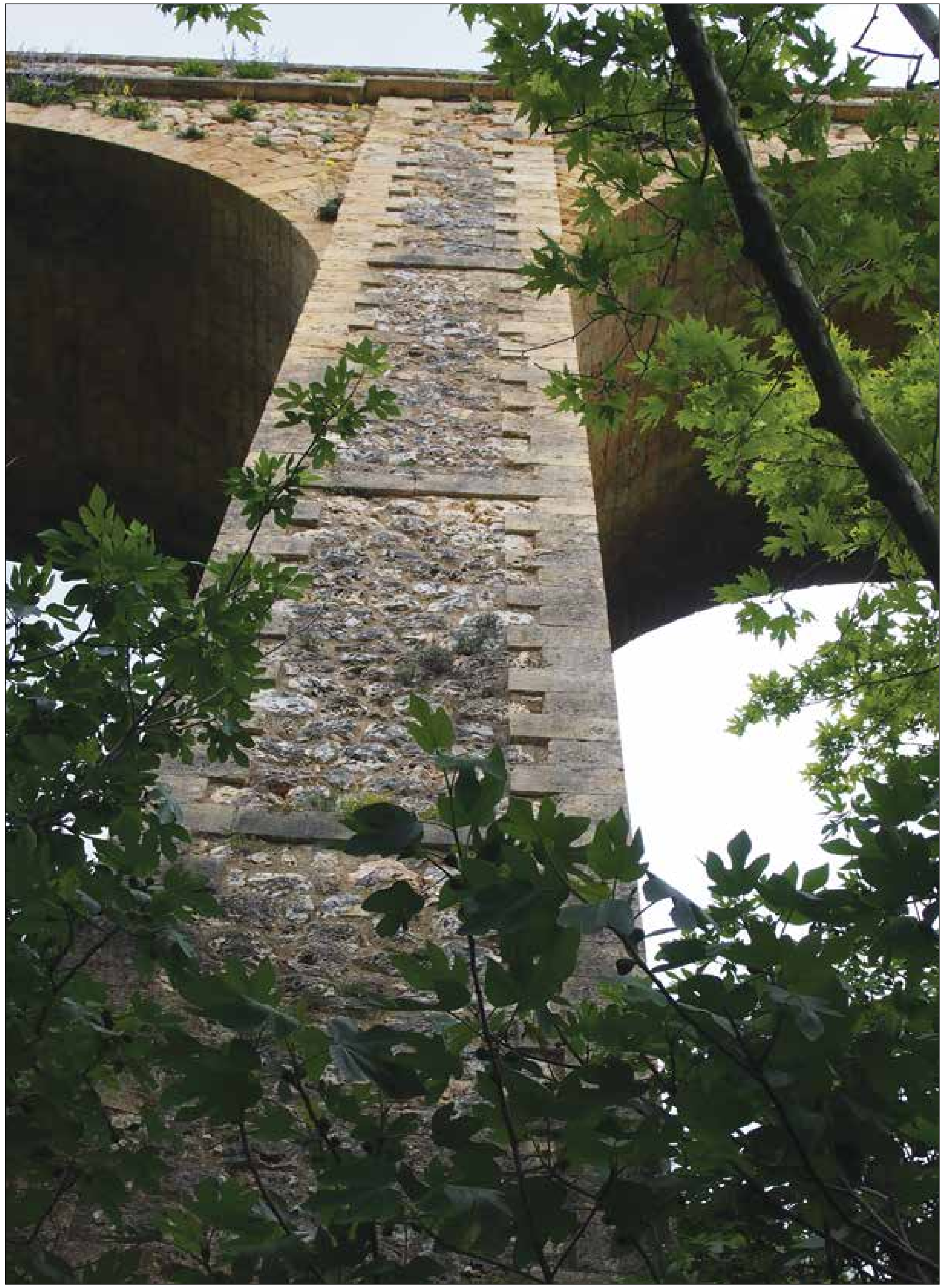
Simas Bridge

- **Rethymno**
- 1910
- 3 arches with 10-metre spans
- Built using local limestone
- Designed by the Italian engineer Figari

Text by: Aris Chatzidakis

The bridge is located on an old country road about 10 km south of the town of Rethymno and spans a small gorge. It has three semicircular arches each with a 10-metre span, a width of 4 metres and a height of 20 metres at the two central piers. The cross-section of the base of the central pier measures 3 x 8 metres. The bridge was built in 1910 by the autonomous Cretan State authorities. It takes its name from a contractor nicknamed Simas, in recognition of the successful execution of this complex construction project. The bridge was designed by the Italian engineer Figari, who held the post of chief engineer in the autonomous Cretan State. It was built using local limestone, as a public construction project supervised by state engineers. The design of the bridge is a very common one in the engineering manuals of that time and was also used for aqueduct bridges and railway bridges. The bridge is still in use today, allowing one-way traffic to pass in alternating directions, and is the only route connecting the town of Rethymno to the Amari region.





Greece

Harp Bridge

- **Athens**
- 2003–2004
- Asymmetric cable-stayed footbridge
- Height of pylon: 50 metres
- Built as part of the Athens metro infrastructure
- Shape resembles a harp

For the 2004 Olympic Games in Athens, the architect Santiago Calatrava applied his architectural and engineering talent to produce impressive structures not only for the Olympic athletics complex, but also for an impressive footbridge commonly known as the Harp Bridge, which was built as part of the Athens metro infrastructure.

The shape of the bridge resembles a harp inspired by the ancient Greek monuments and sculptures of the Classical era. Located near the Katechaki metro station, the footbridge makes it easier for metro users to cross Mesogeion Avenue.

The bridge is made of steel and consists of a single curved pylon 50 metres high from which 14 high-strength steel cables hang down to support a 94-metre deck of a width of about 6 metres, suspended over the avenue.

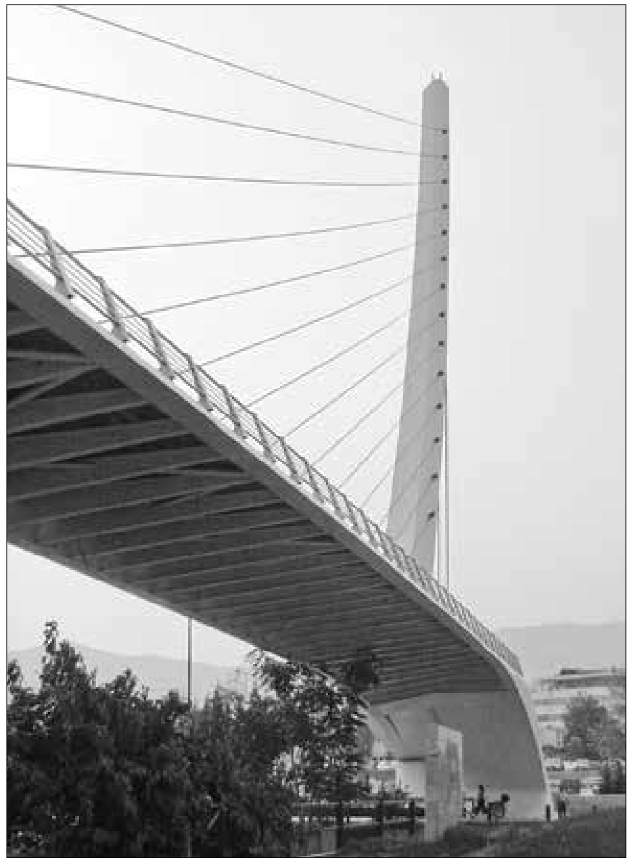
What makes the bridge unique is the arrangement of its back span. In an asymmetric cable-stayed bridge, where the main span is longer than the back span, the back span cables are generally anchored to the ground to provide the necessary stability. In most such bridges, the back span cables are angled so as to provide a horizontal force that helps the bridge's pylon resist the horizontal pull from the main span cables.

On the Harp Bridge, however, the back span cables are vertical and offer no resistance to the side-ways pull from the main span. Instead, that pull is absorbed through the curvature of the pylon as compressive thrust.

The decking is formed by short timber planks, all neatly aligned rather than staggered. These are supported by steel ribs and the whole deck is cross-braced to provide the necessary stiffness. The foot-bridge provides an attractive way for pedestrians to cross a busy junction and is already considered one of the modern landmarks of the city of Athens.

The bridge was built by the Athens-based contractor METKA.

FOOTBRIDGES - SMALL IS BEAUTIFUL



Harp Bridge, Athens

Hungary

Photo: ©Gyukics

Sárvár, the Castle Gate Bridge

- **Sárvár**
- 1810
- 11 arches
- Length 61 metres

Text by G. Szőllőssy
Source: "Hídjaink" Budapest, 2007

The first written reference to the castle dates from 1327, when it was the property of Charles I of Hungary. In 1390 King Sigismund, the future Holy Roman Emperor, gave it to a trusted member of his court's inner circle, János Kanizsai, Archbishop of Esztergom. Later it became part of the estates of Baron Tamás Nádasdy. By the end of the fifteenth century the Kanizsai family had built it into a fortified pentagonal castle around a central courtyard, flanked by residential wings and surrounded by moats. During the sixteenth century, as was the custom at the time, access to the castle was via a wooden drawbridge.

The military importance of the castle faded over time and its later owners made significant changes to the original form of the medieval castle. The most notable changes were made in the early nineteenth century by members of the House of Este, the Dukes of Modena. They filled in the moats and modernised the castle buildings in the neoclassical style. It was during this reconstruction that the eleven-arch bridge leading to the castle gate was built. The bridge is 61 metres long and 5.8 metres wide (including the parapets) and its arches have a span of 4.4 metres. A painting on a coffee cup that can be seen in the castle museum commemorates the construction of the bridge.

Since the castle has always been in use and inhabited, it has remained in perfect condition, unlike the majority of castles within the borders of Hungary.

Designer: Unknown / **Contractor**: Unknown

Hungary

Photo: ©Gyukics

Alcsút Arboretum Bridge

- **Alcsút**
- 1820
- Stands in the first English landscape garden in Hungary

Text by G. Szőllőssy
Source: "Hídjaink" Budapest, 2007

Established in 1820 by Archduke Joseph, the Alcsút Arboretum was the first English landscape garden in Hungary. As Palatine of Hungary, Joseph was the first of the Habsburgs to settle in the Kingdom of Hungary, having received land in the territory, thus founding the Hungarian branch of the Habsburg dynasty.

Today the garden covers more than 40 acres and is home to a large number of rare plants. It is popular with strollers and nature lovers. The garden surrounding the Archduke's castle was among the first of its kind in the Habsburg Empire and is notable for the richness and variety of its rare plants.

Archduke Joseph successfully domesticated around 300 plants but all that remains of his once majestic castle is a façade with a neoclassical portico. Designed by Mihály Pollack, the castle was among the largest neoclassical buildings in Hungary. The garden itself was designed by Carl Tost, a master gardener from Schönbrunn Palace in Vienna.

One wing of the castle had a stable block attached to it. This was later converted into a neo-Romanesque chapel designed by Ferenc Storno. The chapel still stands in its original form. The orangery in the garden was built to a design by Miklos Ybl. Unfortunately this once magnificent structure is now in ruins. Some of the other structures created for the arboretum are still standing, notably the footbridge. While both the designer and the builder are unknown, this bridge has survived to the present day in its original form, complete with ashlar parapets and the "J" monogram of Archduke Joseph at either end.

Hungary

All photos: ©Gyukics

Budapest City Park, Wünsch Bridge

- **Budapest**
- 1896
- Reinforced concrete arch bridge
- Built for the first underground railway in Europe
- Hungarian technical monument

Text by G. Szőllőssy,
Source: "Hídjaink" 2007

The designer, concrete engineer and entrepreneur Robert Wünsch launched the construction of the first underground railway system in Europe on 13 August 1884. The intention was for the grand opening to take place during the 1896 Millennium Festival. The 3.7 kilometre underground railway system (3.2 kilometres of which were actually under the ground) began operating on 3 May 1896.

The original terminus of the Millennium Underground Railway was at Széchenyi Bath. Since this terminus was above ground, the train left its underground section near Budapest Zoo, which made it necessary to build a footbridge over the railway. Although it has lost its original function, the bridge is still standing as a monument (the hooks that held the overhead electrical cables can still be seen on the walls of the bridge).

The monolithic reinforced concrete arch bridge – along with all the reinforced concrete structures of the underground railway – were based on Robert Wünsch's patented technique. The use of rigid beam structures represented a major breakthrough in the early days of reinforced concrete construction.

Robert Wünsch was an important promoter of this system. His solution, developed and patented in the late 1880s, was to treat the bottom surface of a reinforced concrete structure like an arch and to use reinforcement in both faces. The reinforcement in the lower face follows the shape of the arch, while the reinforcement in the upper face is horizontal.

The bridge has a span of 10.7 metres and a total width of 2.6 metres. The pedestrian walkway is 2 metres wide. Access to the bridge on the Zoo side is via a single straight stairway, while access on the City Park side is via two stairways set at right angles to the bridge. The stairways are also supported by reinforced concrete arches built using the Wünsch system. A niche between the stairways on the City Park side contains a round concrete plaque commemorating the construction of the bridge.

The Millenium Underground Railway was extended by a further two stations in 1973. During this process part of the original railroad cutting was covered over, and thus the bridge lost its function. It has, however, been preserved as a monument to the Hungarian pioneers of reinforced concrete construction.

Design: Robert Wünsch
Contractor: Robert Wünsch

Hungary

Photo: Noémi Rátkai-Szőllőssy

Zielinski Footbridge

- **Balatonföldvár**
- 1905
- Built in reinforced concrete using the Hennebique system
- Still in perfect condition

Text by G. Szőllőssy,
Source: "Hídjaink" Budapest, 2007

Szilárd Zielinski was the first president of the Hungarian Chamber of Engineers and one of the most important early promoters of reinforced concrete as a construction material. The significance of his role in popularising the Hennebique system of reinforcement is undoubted.

He was responsible for an unprecedented amount of innovative construction in many different fields of engineering. He was also involved in the design and construction of the first reinforced concrete water tower in Hungary, still in service in Szeged today.

The six-span reinforced concrete footbridge leading to the west pier at Balatonföldvár was built in 1905. The footbridge is a continuous reinforced concrete beam bridge, where each support is a square-section reinforced concrete pier. The end spans measure 15 metres and the middle spans 18 metres. The total length of the bridge is 102 metres. In structural terms the bridge consists of one longitudinal beam (cross section 35 x 40 cm) supporting a reinforced concrete slab (thickness 14 cm, width 195 cm). Reinforced concrete posts approximately 1 metre high support the original, quite beautiful wrought iron railings.

There has been no need to renovate any part of the structure, since even after more than a hundred years the bridge is still in perfect condition.

Hungary

Pál Vásárhelyi Bridge

- **Győr**
- 1969
- The first of its kind in Hungary
- Demolished before 2010

Text by G. Szőllőssy,
Source: "Hídjaink" Budapest, 2007

Photo: ©Gyukics

Up until the end of the nineteenth century, inbound traffic from Little Schütt Island (Szigetköz) to Győr was handled by ferries across the Danube. The first wooden bridge was built in 1888 using thick red pine piers and piles. The "ten-legged bridge" (as it was known) was in use for 56 years, until German troops demolished it and built a new wooden bridge with significantly greater load-bearing capacity. This new bridge, however, was blown up during the troops' retreat.

The Pál Vásárhelyi Bridge (commonly referred to as the Small Elizabeth Bridge) was a single-pylon footbridge, the first of its kind in Hungary. A steel frame with a total length of 101 metres was divided into three sections with spans of 25, 60 and 15 metres on four reinforced concrete supports. The welded steel pylon consisted of two vertical posts and upper and lower cross-girders. The "harp" consisted of two parallel pairs of suspension cables manufactured by the Hungarian Cable Manufacturing Company from material left over from the construction of the Elizabeth Bridge in Budapest, hence the name by which the bridge is commonly referred to. The bridge, which was 2.5 metres wide and weighed 90 tonnes, was supported by reinforced concrete piers. Spanning the Moson-Danube, it connected the Révfalu and Sziget districts of Győr. It was opened to the public on 16 August 1969.

An interesting episode in the bridge's history was that due to vibrations the structural frequency needed to be fine-tuned. The problem was solved by adding an additional layer of asphalt to the deck.

Since the bridge was only suitable for pedestrians, there was constant discussion about constructing a bridge that could also be used by vehicular traffic. When the necessary funding became available, the footbridge was demolished and its successor, the Ányos Jedlik Bridge, was opened to traffic in 2010.

Hungary

Photo: ©Gyukics

Salgótarján Footbridge

- **Salgótarján**
- 2005
- Steel Structure of the Year award in 2005
- Height constraints due to the railway

Text by G. Szőllőssy
Source: "Hídjaink" Budapest, 2007

This tied bowstring arch bridge with its slender tilted segmented arches and minimalist structural solutions is a very good example of the possibilities offered by steel structures. The bridge received the "Steel Structure of the Year" award in 2005.

The planned future development of the railway line imposed height constraints on the 36-metre span, while the particular conditions of the foundations also had to be taken into consideration during the design and construction of this bridge.

The bridge itself was manufactured at the facilities of the Hungarian state railway company (MÁV). The individual elements were then transported to the site, where they were assembled and lifted into place. Rather than loading the bridge sections onto a trailer, it was decided to transport them using two tow trucks, one going forwards and the other backwards.

Designer: Gábor Pál (Speciálterv Co.)
Contractor: MÁV Hídépítő Co. in 2005.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Hungary

Photo: ©Gyukics

Archaeopark covered wooden bridge

- **Polgár**
- 2007
- Main span 34 metres
- Three-hinged arch

Text by G. Szőllőssy
Source: "Hídjaink" Budapest, 2007

Gábor Medved, senior bridge engineer at Hungary's national motorway company, promoted the construction of this footbridge and provided the necessary technical expertise. Structurally designed by Lajos Szabó, this bridge pays homage to the great variety of covered wooden bridges that can be found in Transylvania.

Built between 2005 and 2006, it was opened to the public on the occasion of the grand opening of the Archaeopark on 1 May 2007. It can be found at the Polgár junction of the M3 motorway, where it spans Route 35 and connects the Archaeopark to the Hortobagy National Park. Structurally the footbridge is a three-hinged arch with a span of 34 metres and a radius of 27.5 metres.

Hungary

"Mayfly" footbridge over the river Tisza

- **Szolnok**
- August 2009 to January 2011
- Main span 120 metres
- Fitted with tuned mass dampers

Text by: Pálossy Miklós / Pont-Terv Zrt, Budapest, Hungary

A new bridge for cyclists and pedestrians over the river Tisza in Hungary was opened to traffic in 2011. The "Tiszavirág" (Mayfly) bridge creates a new link for the city of Szolnok and seems destined to become an emblematic work of art for the city. As well as the design of the bridge itself, the design competition included the reconstruction of the urban square on the right bank and the adjoining green area on the left bank in order to make the bridge fully accessible to pedestrians, cyclists and disabled users. The design competition was won by a team consisting of bridge consultants Pont-Terv and architects ADU. The winning concept was a slender, elegant, splayed arch structure, which was intended to combine a dramatic visual impact with good functionality and economic construction.

The steel arch bridge has a main span of 120 metres composed of two tubular arches splayed outwards at 60° from the horizontal and a spatial truss deck girder suspended by tie-rods. The deck consists of a steel grid covered with composite planks of wood and resin, which is a maintenance-free material. The glass panels spaced regularly along the centre line give variety to the wide homogeneous surface.

The LED lighting consists of a dotted line of lamps on the outer side of the arches, and light beams for illuminating the inner side. The illumination of the deck is provided by LED lights embedded in the handrails.

Since dynamic behaviour is a key issue in the case of slender pedestrian bridges, in-depth aerodynamic studies were carried out and four tuned mass dampers were incorporated into the deck in order to reduce pedestrian-related vibrations.

Erection on site was carried out using two auxiliary supports in the river bed. Since its inauguration the bridge has become very popular in Szolnok, and serves as a venue for various events in the city.

Main technical characteristics:

Main span: 120 m
Length: 186 m (main steel river bridge)
Total length: 320 m (including RC approach bridges)
Width: 5 m
Structural steel: 380 t
Design: Pont-Terv Zrt/ ADU Architects
Construction: KÖZGÉP Zrt

FOOTBRIDGES - SMALL IS BEAUTIFUL


"Mayfly" footbridge over the Tisza river, Szolnok

Ireland, Republic and Northern

Liffey Bridge - Ha'penny Bridge

- **Dublin**
- 1816
- Cast iron arch spanning 42 metres
- Restored in 2002
- Heritage award in 2002

The earliest known iron bridge in Ireland, the Liffey Bridge, was erected in 1816 for pedestrian traffic to connect Merchants Arch on the south quays of the River Liffey with Liffey Street Lower leading from the north quays.

The bridge is a single span cast-iron arch with an elliptical profile and consists of three parallel arched ribs spanning 42 metres between angled masonry abutments and having a rise of 3.6 metres (The span increases to about 43 metres at deck level). Each arch rib consists of six lengths of cast-iron bars of cruciform section. These are connected together at each rib joint to form two tiers of rectangular openings with chamfered surround, the depth of the opening decreasing towards the crown. The ribs are stiffened by the deck and by diagonal and normal bracing to form a truss in the plane of the intrados. The transverse cross members are of hollow circular section with a bolt passing through, and act as spacers to provide lateral stability. Cast corbels on the outside ribs carry a flat plate that supports the parapet railings.

The Liffey Bridge was cast at the Abraham Darby III foundry at Coalbroookdale in Shropshire, England and was restored in 2002. The Liffey Bridge won the Heritage Award in 2002.

Photo: Robert Cortright, USA

Italy

SOME THOUGHTS ABOUT FOOTBRIDGES

Enzo Siviero

The footbridge as a symbol of Being

Over the last two decades, the subject of the footbridge has assumed the characteristics of excellence on a worldwide level. Beginning with the solid, emotionally engaging works of Jörg Schlaich, great engineer, to whom the 'laurea honoris' in Architecture was awarded at the IUAV of Venice, to the various "authors of bridges" who have been able to direct design back towards a kind of innovation which is sometimes ground breaking in nature, defining within it new and diverse rules, even if one does not always fully share their views. Just think of Santiago Calatrava, so unique on the world scene, enough to induce me to paraphrase B.C. and A.C. from Before Christ and After Christ to Before Calatrava and After Calatrava... Actually, this change of paradigm, which has by now become commonplace, is turning out to be of great worth in terms of "humanitas". Building a footbridge means connecting people with each other and to themselves. It means making the way for people to walk on air, as it were, to reach others in whom they perhaps see a little bit of themselves. It means creating peace, friendship and love. In a few words, seeing oneself once again as part of the great "human family". In this way, we are able to look beyond others' diversity, that we may simply not understand, overcoming an atavistic gephyrophobia, which basically means fear of crossing a bridge, jumping over the fence into the unknown, in terms of "enantiodromia". Thus people will be able to identify themselves again in their own action of "subject", which is part of the "whole".

A footbridge becomes a true point of accumulation able to attract for itself. So, not simply walking across it to get to the other side, but doing so for the pleasure of feeling part of it, making it one's own, almost "wearing it"! The relationship between subject and object tends to be reversed. The bridges that lives. The bridge that speaks. The bridge that attracts you. The bridge that makes you fall in love. Continuous emotions created by the interaction of symbol and metaphor in a metaphysical way of living that goes far beyond the simple action of crossing a bridge. New urban landscapes appear, perceived directly and indirectly. New cultural dimensions emerge and become visible to all. Mental attitudes evolve toward that which is positive. Beauty will educate the world! Such are the words of Pope Francis. So this kind of footbridge where the Vitruvian triad FIRMITAS UTILITAS AND VENUSTAS finds its synthesis with special emphasis on beauty, will be able to rebuild the world within us, in all of us, as oneness in creation. Many contractors have not yet understood this in all its depth and, with inexplicable cultural blindness, are not able to grasp the exceptional added worth, in social terms, of building something "beautiful" which means going far beyond building something useful and safe, especially in an urban environment! But at the same time a certain "mental laziness" that connotes the way of planning of some engineers, who satisfied with their scientific technicalities, which they well know how to conjugate in terms of FIRMITAS AND UTILITAS, are able to express little or nothing in terms of VENUSTAS. They thus end up abdicating the historically acknowledged role of 'PONTEFICI', in its original meaning of 'bridge makers' to Architects. Well, in Italy (but not only) there are many praised exceptions, which act as catalytic examples of care taken by contractors,

FOOTBRIDGES - SMALL IS BEAUTIFUL

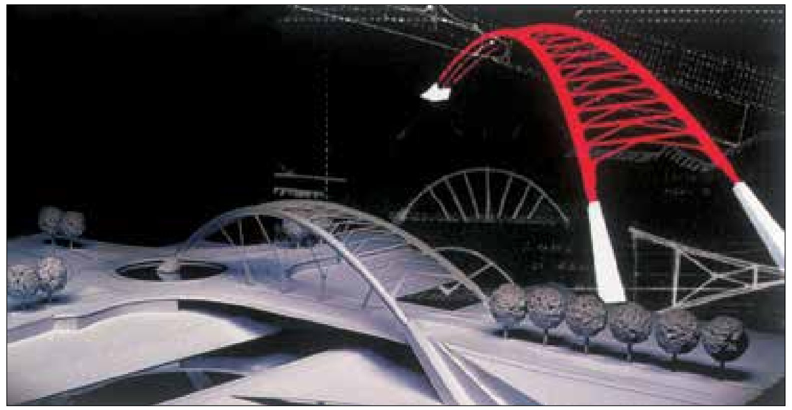
Italy

designers and entrepreneurs. In this chapter we wanted to highlight this new way of thinking which is, in truth, little known to most, to bear witness to the fact that YES, WE CAN! We therefore intend to demonstrate that 'cultured' engineering is not dead, on the contrary, it is in excellent health, but, unlike Architecture, does not receive much attention from the media. It is no wonder that the term 'Starchitect' is now widely used, while to the vast majority of people the term 'Stargineer' seems to hold no interest even though it rightly belongs in the history of building.

In compiling this chapter I have availed myself of three of my young Dphil researchers (all of them architects...but I teach Bridges at the IUAV of Venice...which, I believe, has been unparalleled in the world for over 20 years,..) Michele Culatti, Luca Guido and Fabrizia Zorzenon. Michele Culatti, expert in the evaluation, also perceptive, of the quality of infrastructure, particularly with regards to bridges and viaducts, has collaborated with me for many years drawing inspiration from various subjects such as design, landscape and anthropology. In this way he has been able to create a new field of research which is generating much interest on the part of certain contractors such as ANAS.

Luca Guido, 'man of multiform talent', is a designer, architecture critic and contemporary historian all rolled into one. Attentive to innovations in the field of the architecture of buildings, even at a young age he has been able to conjugate a way of understanding artefacts no more as mere architecture, but as interpretation of building in Vitruvian terms. He does not hold back from criticising certain trends which are certainly ephemeral and at times ethically reproachable in no uncertain terms. Neither does he censure himself for fear of 'pseudo cultural retaliation'. Such courage, in our time which is full of Don Abbondio style characters, is indeed a rare commodity, but it testifies once more to the fact that YES, WE CAN.

Fabrizia Zorzenon is my pupil not only because she obtained her degree in architecture at the IUAV, but also because of her PHD in the subject of footbridges within the course at the University of Nova Gorica. She has consolidated her cultural awareness through the considerable amount of time she has spent in the planning team I coordinate. She has recently published her doctorate thesis, contributing greatly in spreading this kind of mental attitude.



A way of life in a world to live that should permeate contractors, designers and companies alike so that our history may not be further reviled by the negligence that characterises 'non lieux'.

IL N'EST PAS PERMIT DE FAIRE LAID said Paul Sejourné a century ago. His advice was followed for little more than 50 years, and forgotten during the 70s. Let us now do our utmost so that it may be fully understood that living amongst ugly buildings means living badly. Ugliness is dirty. We absorb negative energy when we spend time in amongst ugly buildings. To sum it up 'ugliness is the denial of our being'. Beauty, on the other hand, is clean. Beauty emanates positive energy. Beauty is the highest expression of our being. Let us therefore go back to what we once were, so that beauty may triumph for everyone. And there is not a shadow of a doubt that, for their urban dimension, a "beautiful" footbridge can be the real symbol of this cultural renaissance.

Italy

Luca Guido

An Italian way to Engineering?

The projects selected for this book shouldn't deceive the reader: a few quality works are not evidence of widespread project culture, neither can we say that they sum up a wide range of contributions to the disciplines of engineering ad architecture in Italy. Each selection, each book contains exceptions which highlight the general emptiness and decay that surround them and all the opportunities that have been missed.

The best period for engineering in Italy went from immediately after the second world war to the end of the seventies. It was a good period of time because of the rebuilding that had to be done, and then the economic boom, so there were great opportunities to create works which were structurally challenging and to experiment new approaches and building technologies. The work and economic conditions of those years can never be repeated, the same goes for the liveliness of the scientific and cultural scene of the time.

In 2006, the prestigious magazine Casabella gave this title to one of its issues " The good old times of Italian Engineering" evoking, with a hint of nostalgia, the difference in quality between the current scene and the projects of the leading figures of the time such as Nervi, Morandi and Musmeci.

But what has happened more recently in Italy? What have the heirs of those great masters produced? There have been historical-critical publications and analyses by scholars such as Tullia Iori, Sergio Poretti, Valerio Paolo Mosco, all looking back on past experiences, but when it comes to actual construction it is harder to find that widespread knowledge and the ability to create a great number of works of the highest quality that characterised the second half of the last century.

To tell the truth the 1990s didn't only see the death of the leading Italian engineers, but also a change in infrastructural investments and planning strategies.

Both tendering regulations and technical building rules today do not allow for the experiments that were possible up to a few decades ago.

The latest trends sanction "an under-design style", "routine knowledge", denounced by the principal engineering projects that have been carried out: there is the tendency to build professionally correct works which are sometimes technically challenging and expensive, but which are basically impersonal when it comes to design and their place in the landscape, be it urban or otherwise.

What has caused the establishment of a merely functional way of designing has been a change in the regulation of public works which over the years has changed the role of designers, relegating them to mere consultants, with no particular contact with the contractors' administration. As a consequence of this, engineering companies, large and small, and so called general contractors have sprung up. These are interested in constructing the work mainly for the economic advantages of the contract, and are little inclined to linger over structural experimentation or aesthetic disquisitions.

The truth is that the market responds to needs created by rules: the biggest concern apparent in the regulations is not the quality of the project but simply its inexpensiveness, without realising that a project is above all a cultural act, the expression of political will, a mark that will be left in the territory, of scientific and artistic knowledge and only as a consequence the carrying out of professional or company services.

The fact that big designing structures are so impersonal and soulless reflects the impersonal attitude of contractors who stand aloof from the problems of the project and designing, confirming and favoring the belief that designing 'protagonism' should be avoided.

It is an attitude induced by the way regulations have evolved and sloth caused by inability on the part of the political classes to take on a real role of responsibility (including that of being a contractor who is interested concretely in constructing quality public works).

Another contributing factor is that is that research into the industrialisation of the building sector has created standardisation and prototypes rather than the possibility of diversification of the building process and of the final result.

The industrialisation = standardised elements equation, warmly supported in the past by many designers, has proved inadequate in automatically guaranteeing quality. Nowadays this formula seems perhaps naïve, especially if we include process automatisms in the equation. On the contrary the new frontier of the discipline of construction and architecture is in the modern parametric designing techniques and robotic construction. We are talking about new ways of imagining projects, ways that are well defined by the professional services offered by internationally renowned companies such as Balmond Studio or Gehry Technologies. These are realities that are to some extent misunderstood and not really known in Italy.

The loss of authorship when it comes to constructed works has therefore shifted the interest of researchers and has to some extent made it difficult to follow interpretative tools.

It is no coincidence that the main revolution in transportation engineering over the past twenty years is not the modern designing of a work of art but, more realistically, the Telepass system, that is the first large scale dynamic system of paying toll charges in the world, introduced by the 'Gruppo Autostrade' in 1990.

Adding to all the above, the general lack of interest in creating projects has put the spotlight on the other side of team design of the new millennium: the designer as a global star.

Having painted the picture I must underline the fact that there have been pockets of resistance to these general tendencies. These are educated, capable professionals who bear witness to the fact that not only is it possible to apply oneself to creating quality projects but it is our duty to do so. The school of Architecture of Venice, amid the general chaos, on many occasions has been able to direct the debate towards a positive outcome thanks to Enzo Siviero who transformed the (ex) faculty of architecture into a didactic laboratory that focuses on the subject of bridges, besides being a reference point for designers such as Mario De Miranda, son of the better known Fabrizio and Massimo Majowiecki. At the same time figures such as Walter Pichler, designer of the 'Ponte del Mare' (sea bridge) of Pescara, have been able to combine professional courage and business enterprise.

In any case the selection of works presented in this book should not induce its readers to draw enthusiastic conclusions about the state of Italian engineering and particularly about the effort put forth to design bridges, viaducts and footbridges.

The last few decades are full of opportunities that weren't fully exploited, in which political trends were contradictory and the demands of the administrations wasted energy in schemes that lacked structure when it came to the actual conception of infrastructures.

Furthermore the endless red tape has generated problems that have often overlapped with those relating to the project itself: noise barriers and landscape drawing have produced the terminology of mitigation and compensation almost to denounce the fact that any work will inevitably ruin the landscape to the detriment of the territory.

We must begin with the points discussed above to understand the inability on the part of legislators, often transferred to the general contractors and project managers, to view bridge infrastructures as a suitable element to include technical demands and carry out demands which relate to urban development and improvement of landscapes, creating new qualities.

In other words legislative policy has been to deal with issues concerning infrastructure projects as the sum of single problems, viewing them in a narrow, unarticulated perspective.

Essentially what has been lacking is theoretical input, intellectual curiosity, the ethical side of the discipline of construction: let us see to it that these may return to our nation's universities, administrations and political projects.

Italy

Michele Culatti

Italian footbridges: utilitas between design and landscape

Over the past few years, in Italy, interest in footbridges has grown, partly thanks to the starchitects that have turned the spotlight onto the wider subject of bridges, and partly due to the greater sensitivity that public administrations and designers have gained in virtue of the popularization of 'bridge culture'. We have realised that footbridges are works of art (so they are called in Italian tradition of construction) and that becoming the landmark of a place can add character to the environment they are built in with relatively low costs.

Nevertheless, often the effect they produce is still that of alienation from the place they are built in, or at least the place as interpreted by Marc Augè in an anthropological sense (that is a historical, identity-making, relational place), which is a definition to be taken as a necessary reference in order to comprehend the level of acceptance or rejection of space used by human beings. This alienation is usually brought about by decisions made by engineers that coupled with the designers and contractors' desire to give character to the work, tend to focus attention on the footbridge itself, in its configuration as a geometrically defined object, and give less attention to the degree of connection that can be created, on various levels, with the urban context and landscape.

But cities change: the demand on the part of the community to live in 'beauty', as opposed to the urban deterioration which is instead advancing, sheds light on the meaning of emerging issues such as urban redevelopment and regeneration that are trying to find solutions both to difficulties caused by reckless urbanisation and to the need of environmental, energy and economic sustainability. It's not just a question of public money. It is the need to take stock of what is going on in Italy that raises questions today the answers to which are difficult to predict, Italian geography has to deal with different types of networks, infrastructural and virtual, and competition has shifted from the world of industry to appeals between cities.

Within this frame of reference, the role of the footbridge became pivotal becoming the interpreter, between design and landscape, of the modification of an area we make use of.

In fact, in these two disciplinary fields, design and landscape, we can find concepts related to the study of form, function and meaning that are present in many architectures that allow for interpretation from the scale of detail to a wider one, and through which sense is given to a place, especially in so far as awareness increases that form, function and meaning are the same parameters that come into play in humans' cognitive process.

We understand therefore that ideas relating to the concept of the footbridge must by all means have a multidisciplinary and multi-objective approach, striving to meet local urban development and improvement needs whilst still taking into account humans' perceptive faculties.

Thinking in these terms means giving dignity back to architecture according to the ancient Vitruvian parameters that still hold true today. Over the past forty years, firmitas (solidity) has been given great importance in the process of building expansion that involved bridges, viaducts and footbridges while, over the past ten years, venustas (beauty) has been pushed forward as more important and today we are in the era of utilitas (usefulness). The usefulness of a footbridge (as is the case for bridges) cannot simply be considered as a way to link two land sides that clear an obstacle, but must be able to show its worth in the territory and to the community taking into account its social historical, economic, environmental and anthropological context.

Today the conceptual category of usefulness must relate to users' needs and use behaviour peculiar of design; it must be able to deal with new linguistic codes that refer to the landscape, understanding for

Italy

example the meaning of landscape quality or criticality, it must know how to build a landscape through its modification, alteration and, overcoming Italian regulations, its improvement; it must include a more multi-informed pattern in its productive process (today BIM – Building Information Modeling philosophy is gaining foothold, that from 2D and 3D moves to 4D in timing management, to 5D in cost management and 6D in maintenance management); and, as always, must connect with humans' perceptive senses.

The use of a footbridge then, is something complex and as such must deal with a number of issues that have to do for example with what functions or new end uses it should connect; what functional and ergonomic requirements should characterise it; what technological equipment it should be endowed with, such as illumination that can be adjusted in intensity and colour, solar panels, remote control, wi-fi systems to provide active communication with the users, nowadays immersed in AR (augmented reality) provided by the 3.0 Web; to what extent it should adapt to its surroundings by means of the study of consistency; to what extent it should be toned down, or hidden placing value on other surrounding elements or, conversely, to what extent should it be a monument, interpreting historical or cultural values of the area; how it should be viewed by the users from the inside and from the outside.

On this last point, it is interesting to note that what differentiates a footbridge from other bridges is not only its function – for pedestrians rather than for vehicles – but also how we perceive it.

We usually see a bridge from different directions but it tends to appeal to only one of our senses. When it is used, links between bridge and land and vice versa are created, yet the foremost sense we use is sight. With a footbridge there is a change of state: from mostly visual perception there is a greater involvement of other senses like touch and hearing. The footbridge offers a rich range of perceptions with at least three overlapping types. What comes from sight when we cross the footbridge is to experience the "infinite window ". We know we are inside an architectural work where we can experience the inside, with the weft of its structural elements, its construction details and at the same time if we turn right round we see the outside like an uninterrupted scene.

A second sense comes from the world of touch. We can stop and lean on the handrail, touch it, perceive how much heat it transmits depending on what it is made of or feel its vibrations.

Finally sound: just think of the rhythm of our steps which mingles with that of other pedestrians, the shouting of people which merges with the rustling of the vegetation on the banks of a river or with the sometimes almost imperceptible or at times deafening noise of the water or of the traffic below. At times the tension of the cables or other parts of the structure can be heard creating a real sound landscape.

Besides that, the footbridge guides us and directs us along its course. Through its form it provides information, polarizing our attention. An arched footbridge can signal the start, the middle and the end of the journey. A cable-stayed bridge can be a reference point in the area. The posts of the parapet can beat time to the regularity of the work interrupting the monotony of the crossing.

Shade from the structural parts of the bridge onto its surface can establish where people go in search of some slight sanctuary during the hottest part of the day in summer. The width of the footbridge together with the height of its surface provide the perspective depth of the crossing and dictate the distance between pedestrians.

Use reshapes the landscape or conversely the interpretation of utilitas (usefulness) connotes the system of visual scenery but at the same time gives shape to the tactile, auditory landscape always the seat of an abundance of meanings.

Still thinking of perception, this time from the outside, we can consider quantitative aspects, how much we perceive of a footbridge in terms of space due to the effect of light and shadow.

For most of the day it is in semi-darkness or in poor light that we can make out the design of the frame or the structural architecture that supports a footbridge. Therefore, shadow is what gives the sense of

Italy

depth and importance to the work, but also that which limits our perception of it. Shadow also helps temporarily carve out the other features of the surrounding area. It is this shadow that the bridge, if caught in direct sunlight, casts onto the surrounding area with enchanting or intrusive effects.

The footbridge therefore, as architecture to be crossed at low speed is a place that really appeals to the senses and for this reason designing it involves redesigning a place made of connections between parts which in their turn are then correlated with the user. It means creating layers of signs, and the more you understand how a place works , the better equipped you are to build something really useful, modulating the quality of that place.

To do that, specific knowledge of bridge techniques is not enough , but rather a cultural, multidisciplinary approach is needed, one which knows how to examine the relationship between the work and its setting. The Scuola di Ponti di Venezia has been working in this direction and thanks to Enzo Siviero, has over the last 25 years produced more than 600 theses on bridges to spread needed awareness in planning that puts an ethical search for beauty even before an aesthetic one.

Furthermore, Italy as we will see illustrated by some footbridges, has managed to bring out that creative drive which is able to create real connections with its location. Through masterly use of functional, visual and cultural relationships, in some cases, there has been the desire to produce works that today have become symbols of whole areas, as occurred with the Ponte del Mare, the footbridge which is the symbol of the Abruzzo Region.

Fabrizia Zorzenon

Footbridges as landscape design

For almost thirty years now footbridge design has been acquiring the worth and importance which for a long time has been characteristic of architectural works.

For most of the twentieth century , the quality of a bridge was judged only on the basis of its size and length. This view gave footbridges such secondary importance that they were often reduced to simple structures with beams. However, at the turn of the new millennium, a radical change of thinking caused the footbridge to be rediscovered as a “vessel of metaphors”.

Starting with authors like Calatrava, Mimram and Schlaich, at the beginning of the 1990s, an increasing number of architects and new design engineers began to see the potential behind the design of these structures so that in a short time a new generation of pedestrian bridges was born. So different from what had gone before, these structures embody the cultural revolution that in little more than twenty years has managed to profoundly change not only their day to day use, but the actual image we have of them today, both in terms of form and importance. Today, the footbridge has changed from being a simple, anonymous structure whose sole use is to clear an obstacle, to being just like any other work of architecture, something which by its very form and presence contributes to the landscape we live in. It thus acquires the importance of landscape architecture which enables it to give form to new and unexpected experiences of life, to new and unexpected places for cultural Exchange and meeting.

The reasons for this unexpected transformation did not occur by chance or because of some fad. They can be found in the way that the great European cities have addressed the ecological, social and urban crises which they have been

Italy

facing for decades. On an urban level, one response to the problems started a long period of design which, beginning with Bohigas’ plan for Barcelona (1988-1992) has seen important urban re generation in Europe, starting with the re design and reorganization of roads and squares, in fact, of all open and public spaces which are a substantial part of urban construction. These are plans whose aim could be summed up in the commonly held desire to bring the city back to its original importance as a meeting place par excellence, a place where, by interacting with others, the individual can find himself, his nature as a social being and his integral part in a wider system called society. This is a feeling that the widespread use of cars has gradually worn away over the years.

Reconstructing a city starting with urban spaces means reconsidering its entire infrastructure in ways above and beyond purely financial and technical issues which until the 1970s had been the sole concerns of every project.

From here, a new design philosophy emerged, which, in a few years, has managed to transform the footbridge from a simple infrastructure design into a real urban design or rather a landscape design. Footbridges, which are no more out of context now become structures that are morphologically integrated into the architecture of the landscape of which they are part. Bridges, which by their shape help to reassemble that nebula of fragments, typical of the contemporary condition, and create a continuous flow that twists and turns inside the urban fabric. Bridges which possess that regenerative potential present everywhere, which is conceived above all to be experienced and crossed by man. Footbridges that like rooms in the open, have the power to physically redesign the landscape and also have all the potential to become places of warmth, of social interaction, or rather spaces which can rebuild that synergy between humans and their land that makes every space into a place to be lived.

A landscape design however, involves more. Crossing a footbridge is like crossing somewhere in slow motion. Its architecture, building materials and the details of its parapet create a friction that almost without our realizing it slows us down to a halt. It is right there, when we stop that we open our eyes and look around. Suddenly our attention is aroused. Like a sponge our senses absorb everything that surrounds us. Mind and body are realigned to the present and our perception of reality, usually superficial and volatile, returns to what it was originally, charged with meaning and full of feeling. The pedestrian bridge thus brings us back to reality, makes us realize how beautiful our surroundings are and what inexcusable damage man’s ignorance in the past has caused. Bridges encourage us to open up to the world, to live and rejoice in it and be in harmony with it, they encourage us to find ourselves again as part of everything.

What the works in this book have in common is all of that. They are footbridges that do not simply go over obstacles or connect two opposite banks of a river. They are bridges that go well beyond that. They explain their nature fully by connecting, through their architecture, reality to more levels. They are bridges that even with simple shapes speak a higher language that elevates us to commune with beauty.

Italy

The Old Bridge
(Ponte Vecchio)

- **Florence (Firenze)**
- 1345
- Crosses the river Arno
- Iconic bridge of Florence
- Vasari Corridor runs over it

Text by: Gorazd Humar
All photos: Gorazd Humar

The Ponte Vecchio is one of the best-known symbols of Florence, a city famous for its art and museums. Florence is especially known for the great artists and architects who worked there, among them Leonardo da Vinci and Michelangelo.

Florence stands on the two banks of the river Arno. The unpredictable character of this river has left a deep mark on Florence. The Arno is in fact known for its sudden spates and frequent floods, which have never spared the city. In as recently as 1966, a flood devastated the city and caused irreparable damage to Florence's artistic heritage. For this reason it has also been difficult to build permanent bridges in Florence. The first bridges in the area of today's city were built in ancient Roman times. Various bridges stood here over the centuries and were constantly having to be repaired as a result of the damage caused when the level of the Arno rose.

It was not until 1345 that a more solid bridge was built: a masonry structure with three fairly shallow arches that formed the basis for the superstructure that would later be added to the bridge. In 1442 the city authorities ordered butchers with shops in the densely populated city centre to move onto the bridge. This was mainly for reasons of hygiene and to get round the problem of the unpleasant smells from the butcher's shops. The butchers could now throw waste meat and entrails straight into the water from the bridge.

The bridge now gradually began to grow wider, as brackets were built onto the outside of the bridge arches to support the overhanging shops. The overall width of the bridge thus increased considerably. The bridge was given the final form we know today with the construction of a practical addition by the architect Giorgio Vasari. By order of Grand Duke Cosimo I de' Medici, whose family ruled Florence for centuries, Vasari built an elevated enclosed passageway, today known as the Vasari Corridor, along the entire length of the bridge. This secret passageway was almost 1.5 kilometres long and enabled Cosimo to pass unmolested and unseen from the Palazzo Vecchio, the seat of government and administration, to his residence in Palazzo Pitti. In this way he could complete the journey between the two palazzi, including the crossing of the Arno via the Ponte Vecchio, in safety and secrecy.

In 1593 Grand Duke Ferdinand I ordered the butcher's shops to be removed from the bridge, because of the increasingly intolerable stench beneath the Vasari Corridor. The bridge was now occupied by shops of a "nobler" nature, and the arrival of goldsmiths gave the bridge an entirely new image.

The biggest threat to the Ponte Vecchio came in August 1944, when the retreating German army blew up almost all the bridges in Florence, including the Ponte Vecchio's famous neighbour, the Santa Trinita bridge built in 1569 by the architect Bartolomeo Ammannati. The Ponte Vecchio was spared thanks to a German officer who refused to permit its destruction.

Another interesting feature of the bridge is that its open central section offers views of both banks of the Arno: on one side towards the Uffizi Galleries and on the other, where the statue of the sculptor and goldsmith Benvenuto Cellini stands, towards the Santa Trinita bridge. The Ponte Vecchio is still the busiest point in the city of Florence today.

Italy

Bridge of the Alpini
(Ponte degli Alpini)

- **Bassano del Grappa**
- 1569 - rebuilt by Palladio
- The city's most famous sight
- The bridge structure is entirely of wood including the roof
- Destroyed and rebuilt several times

Text by: Gorazd Humar
All photos: Gorazd Humar

Few cities in the world are so closely identified with their main bridge as Bassano del Grappa, which is located roughly 50 kilometres north of Venice. Mention this wonderful little city at the foot of the Julian Alps to anyone in Italy and they will immediately think of its most famous attraction – the large covered wooden bridge that connects the two parts of the city on the river Brenta. The bridge has an extremely chequered history and has been rebuilt several times over the centuries, having fallen victim both to war and to devastating floods.

The first records of a relatively simple bridge on this site date from 1124 and 1209. A bridge stood here until 1511, when it was set ablaze by the French army. In 1567 the newly rebuilt bridge was swept away when the Brenta flooded. The city authorities then called upon one of the most important Venetian architects, Andrea Palladio, to rebuild the bridge. Palladio came up with a new design that specified that the bridge was to be covered by a wooden roof. This design still survives today and Palladio's original drawing from 1569 has been consistently followed with every subsequent rebuilding of the bridge. The next time this happened was in 1748, when the Brenta, swollen by floodwater, utterly destroyed Palladio's bridge. It was rebuilt by Bartolomeo Ferracina, who scrupulously followed Palladio's design.

The bridge was destroyed once again in 1813 during fighting with the French and was again rebuilt in its original form in 1821. It was given its current name of Ponte degli Alpini (Bridge of the Alpini) after the First World War. During the conflict the bridge was frequently crossed by Italy's Alpini regiments.

The bridge was destroyed for a third time on 17 February 1945, during some of the last fighting of the Second World War. It was rebuilt in 1947 using Palladio's plans and stood until 1966, when it was once again swept away by the river Brenta. This time the rebuilding of the bridge included a number of necessary reinforcements. This is the bridge that still stands today, an unmistakable icon of Bassano del Grappa.

Design proposal by Andrea Palladio

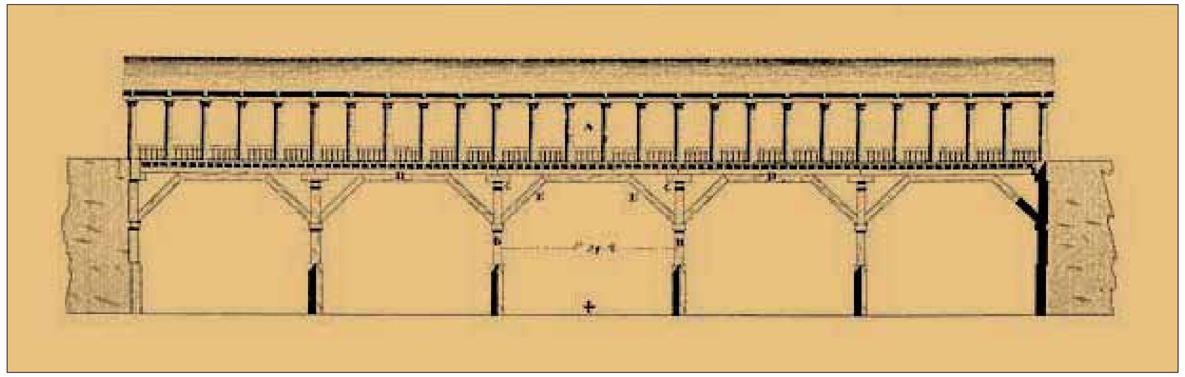


Photo: Gorazd Humar

Bridge of the Alpini, Bassano di Grappa

Italy

The Rialto Bridge
(Ponte Rialto)

- **Venice (Venezia)**
- 1591
- Probably the most recognisable footbridge in the world
- Widest footbridge in the world (22.1 metres)
- Public competition held for its construction

Text by: Gorazd Humar
All photos: Gorazd Humar

The Rialto Bridge is undoubtedly the king of Venice's bridges. It is an unmistakable icon of the beautiful lagoon city and at the same time the oldest of the four bridges that cross the Grand Canal, the city's main thoroughfare. It is 22.1 metres wide, making it the widest of Venice's 431 bridges. Another unique feature are the 24 little shops that line the bridge: two rows of them rising up in steps on one side and descending on the other.

The bridge has a rich and varied history, just like Venice itself. It was built in 1591, in the period of the city's greatest prosperity. Preparations for its construction took almost a century, beginning in 1503 when a design for a new bridge was drawn up after the previous wooden bridge was destroyed by fire. It was not until after 1550 that the plan to build a new bridge began to be taken more seriously. The city authorities held a public competition to choose a design. The committee responsible for the competition was presided over by the powerful and influential salt merchants' guild, who wanted new shops on the bridge from which to sell their salt. The public competition was one of the first in history for an important construction project of this kind, and perhaps the first ever held for the construction of a bridge. One of the conditions laid down for the design of the new bridge was that the Doge's ceremonial galley must be able to pass under it.

In 1588, after a long search for a suitable solution and numerous quarrels, construction of the new bridge was entrusted to the architect Antonio da Ponte, who designed a single-arch bridge to span the Grand Canal. The new bridge, built of white Istrian stone, was completed three years later. The biggest technical challenge was represented by the foundations of the main arch, which was squeezed between the houses on either bank of the canal. Using specially designed foundations of considerable width, Da Ponte skilfully transferred the horizontal forces generated by the arch structure into the ground via foundations supported by wooden piles.

In 1591 the Rialto Bridge was opened to traffic. The 24 stone-built shops placed on the bridge soon opened for business and a safe and broad route across Venice's main traffic artery, the Grand Canal, was thus created. Most importantly, with its single arch, the new bridge allowed boats to pass along the Grand Canal unimpeded. The Rialto Bridge is probably the most famous and most photographed bridge in the world.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Gorazd Humar

The Rialto Bridge, Venice

Italy

The Bridge of Sighs
(Ponte dei Sospiri)

- **Venice (Venezia)**
- 1602
- The second most famous bridge in Venice
- The only covered bridge in Venice
- Has inspired numerous writers

Text by: Gorazd Humar
All photos: Gorazd Humar

After the Rialto Bridge, the Bridge of Sighs is without a doubt the most photographed and most visited bridge in Venice. Not because of its size, since it is relatively small, but because of its position, its interesting design and the many stories that have been told and continue to be told about it.

The Bridge of Sighs connects the Doge's Palace with Venice's once-notorious prison on the other side of the canal, from where few ever returned. It gets its name from the sighs and groans of the prisoners who crossed it on their way to the prison and caught their last glimpse of daylight as they passed over the bridge. Among those to cross the bridge on their way to the cells was the famous adventurer and legendary lover Giacomo Casanova (1725–1798). The story of his miraculous escape over the roof of the prison after just over a year of imprisonment is perhaps the most famous story connected with the bridge.

The bridge was built in 1602 on the orders of Marino Grimani, the 89th Doge of Venice, whose coat of arms adorns the bridge. The bridge, built of white Istrian limestone, is positioned quite high up between the two neighbouring buildings – the palace and the prison – because of the danger that prisoners might escape. Even the bridge's four windows, two on either side, are covered by stone latticework. Two parallel and separate passageways pass through the bridge. In architectural terms, it is built in the baroque style. It was designed by the architect Antonio Contin. Because of the function it performed, the Bridge of Sighs is the only covered bridge in Venice and at the same time the only one not built just above the surface of the water but high up between two buildings.

Many writers have written about the bridge, among them Lord Byron and Mark Twain. The former is even credited with giving the Bridge of Sighs its name.

A thorough renovation of the Doge's Palace began in 2007. The renovation, which also included the Bridge of Sighs, was completed in 2011, and the bridge once again adorns Venice in all its glory.

Italy

Triple Bridge of Comacchio
(Trepponti di Comacchio)

- **Comacchio**
- 1634
- A bridge of unique design
- Five sets of steps lead to the centre of the bridge
- The town's principal attraction

Text by: Gorazd Humar
All photos: Gorazd Humar

Comacchio is a small town on the Adriatic coast not far from the cities of Venice and Ferrara. Owing to its numerous canals and bridges, it is sometimes known as Little Venice. This picturesque little town surrounded on almost all sides by water and marshes is also famous for a very special footbridge.

Commissioned by Cardinal Giovanni Battista Maria Pallotta in 1634, this bridge presented a very unusual challenge to its builder, the architect Luca Danese. His task was to span five canals with a single bridge while ensuring that boats could still pass along them freely, and at the same time to unite all the different paths used by pedestrians to cross the canals from various directions. The result was a bridge that in terms of its design and structure is perhaps unique in the world. Five sets of steps give access from different directions to a bridge with an interesting arrangement of arches: a unique structure that has become not only the town's most important attraction but also the principal junction in the town centre.

On the south side of the bridge two sets of steps lead up to the central section. These steps are topped by two towers. Passing under the towers, you come to the centre of the bridge, from where the bridge now branches into three completely separate directions, reached by three sets of interestingly designed steps.

Most of the bridge is built of red brick, while the central section is built of white stone transported here by ships that crossed the Adriatic from what is today the Croatian part of Istria.

The bridge attracts large numbers of visitors, but it really comes into its own once a year when the floodlights are switched on and its steps serve as the catwalk for one of Italy's most prestigious fashion shows.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Triple Bridge of Comacchio

Italy

All photos: courtesy of Studio Majowiecki

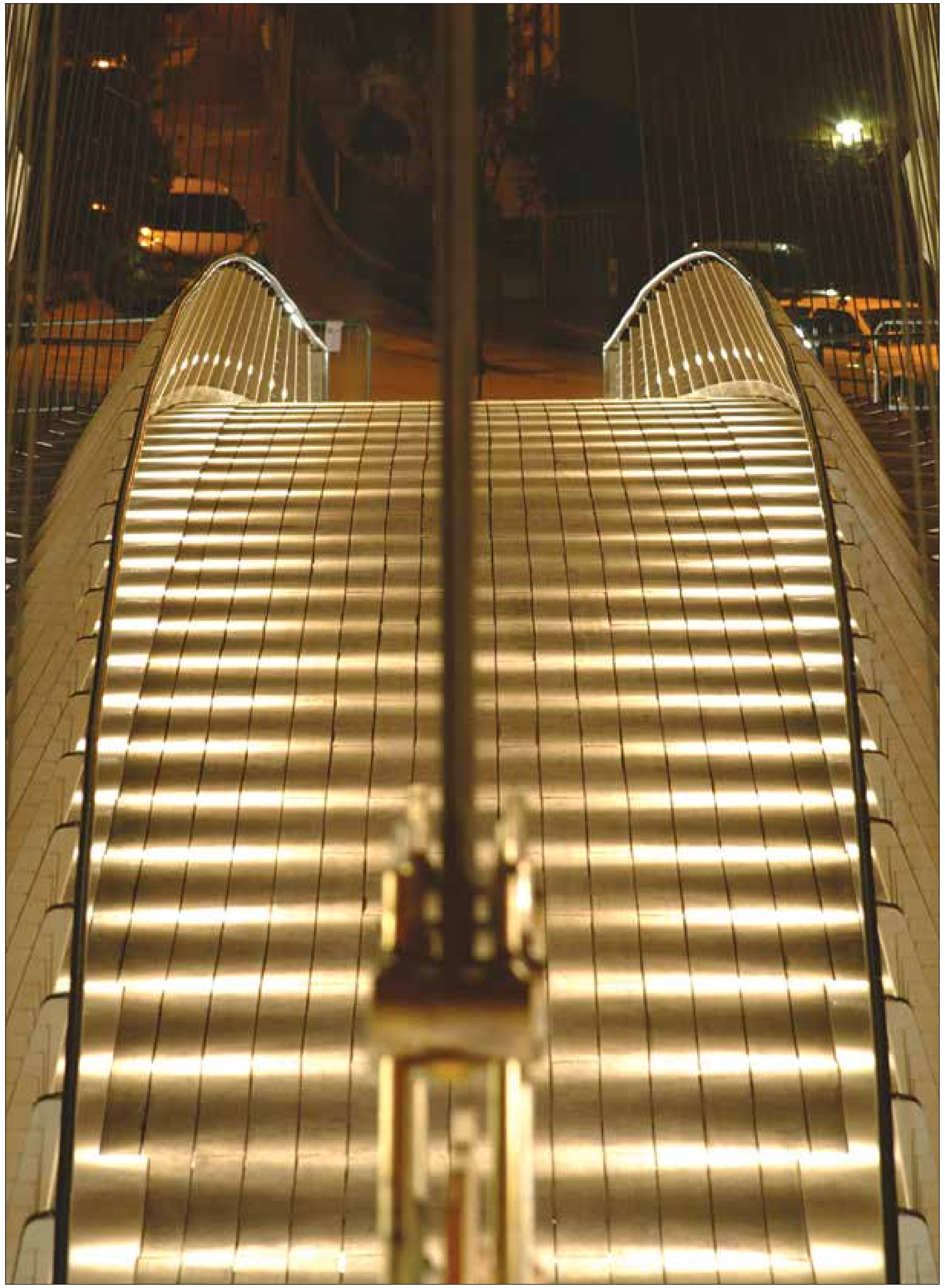
Footbridge over the Reno River
(Passerella sul fiume Reno)

- **Casalecchio di Reno**
- 2002 - 2004
- Steel suspended bridge
- A span with 98 metres
- Wooden flooring

The cycle and pedestrian footbridge in Casalecchio di Reno, designed by Massimo Majowiecki, is characterised by a linear, sharp design mark. Stretching out between the two banks of the river, like a large overturned arch, this piece of work settles into the hilly area that surrounds the river Reno. It creates a wonderful symbiosis between architecture and landscape. The structure is built within a supporting framework. The main features are the two cables, that have a span of 98 metres and a height of 15 metres. With their solidity, they precisely trace the outlines of the bridge, enhancing its lightness. The curved cables of the stabilizing system, on the other hand, are hidden at the sides of the frame, which is supported by diagonal metal girders of variable span and linked to the supporting cables by tie rods. The structure also has two big A-shaped anchoring portals that, like entryways, invite pedestrians to walk across the bridge. The wooden flooring encourages people to take their time and enjoy the beauty that surrounds them.

Client: Comune di Bologna / **Designer:** Massimo Majowiecki

The Old Bridge



Italy

All photos: courtesy of Antonio Capsoni

Footbridge over The Po River
(Passerella sul fiume Po)

- **Turin (Torino)**
- 2004
- Steel beam bridge
- Span of the bridge 100 metres
- The bridge abutments form two squares
- Meeting point above the water

Along the river Po in Turin, a slender, elegant footbridge designed by Antonio Capsoni was inaugurated in 2004. He had won the international competition that the city of Turin had tendered for the carrying out of this work. The bridge crosses the principal Italian river, creating a natural connection between the two banks of the Po and the districts that face each other on either side, in the context of a wider project of redevelopment of the landscape surrounding the river that flows through the city of Turin. This project is called 'Turin, city of waters' and has amongst its aims that of enhancing the system of pedestrian and cycle routes that connect the densely populated urban areas with the two banks of the river in order to bring a piece of nature and beauty back to the city. For this reason, the elegant and at the same time systematic shape of the bridge is based on the urban morphology of the areas around the bridge which is characterised by an alternating series of narrower parts (roads and avenues) and wider ones (squares) . These aspects of the city's arteries are reflected in the bridge's layout which widens out where the pylons are, creating areas where people can stop and maybe sit on one of the benches. In this way, the structure creates a natural extension of the road, over the river. To highlight this continuity are the bridge abutments that form two squares which create a geometrical unison between the roadway and the route along the bank of the river. Finally, by interacting with the water, the bridge becomes a crossroads that originates from the intersection between the longitudinal direction of the road and the transverse direction of the river. As it crosses the river the road widens out above the water transforming itself from a road into a square. By doing this it creates a reference point where you can stand and look at the panorama and also a place for social interaction, suspended above the water.

Client: Comune di Torino / **Designer:** Antonio Capsoni

Italy

Olympic Bridge
(Ponte delle Olimpiadi)

- **Turin (Torino)**
- 2005 - 2006
- Cable-stayed steel arch bridge
- Span of the bridge 400 metres
- Height of the arch 69 metres

All photos: courtesy of Fabrizia Zorzenon

This bridge, with its characteristic red arch, was built for the 2006 Winter Olympics in Turin. It is the work of Hugh Dutton, whose project was an integral part of the plan to build the city's new Olympic Village. Part of this project is the renovation of the historical 'Magazzini Generali', designed by Umberto Cuzzi in 1934, and the building of the new footbridge creates a pedestrian route to the ex Lingotto building, situated in front of the new village but beyond the railway line. The bridge's most characteristic feature is certainly the great arch to which the original composition of tilted cables is anchored, thus organised in order to support the long, narrow path that leads from the Olympic area to the Ling8 shopping centre. The choice of colour, like the one chosen for the arch, reflects the desire to create a strong visual reference point within Turin's landscape and urban skyline, a clear sign that can be seen from very far away that has become not only the symbol of the Olympics but also of the future of this city. Indeed, its structure, which is basic but full of meaning, was chosen to make this bridge into an icon of strength and lightness. Its slim, slender figure remind us of the elegant sequence of parabolic arches characteristic of the architecture of the MOI (Olympic Village). This has further contributed to making this bridge into the real symbol of the Olympics, as also demonstrated by the advertising slogans chosen for the event.

Client: Comune di Torino / **Design:** Hugh Dutton Associes / **Project Manager:** Hugh Dutton

Olympic Bridge, Turin

Italy

All photos: courtesy of René Riller

Bridge over the Talvera River
(Ponte sul fiume Talvera)

- **Bolzano**
- 2005 - 2007
- Steel girder bridge, span 54 metres
- Connecting the city and the museum
- Interesting night illumination

Bridges as a sculpture in the space: this is how the designers define their work. These are the two new footbridges that cross the Talvera river completing the project for the new museum of modern and contemporary art in Bolzano. Designed by KVS Berlin, that in 2001 were awarded the contract by the 'Provincia Autonoma del Sud Tirolo', the new museum is located on the outskirts of the ancient city, along an ideal route that joins the historical centre with the quarters that are part of the building expansion dating back the Mussolini's time. The two bridges were built using similar materials to the architecture of the museum building itself. They represent the materialisation of this route, but also the desire to recreate an immediate connection between art and the city. In contrast to the squared shape of the museum, the bridges were built using a combination of parallel and oscillating curves that intertwine over the river capturing the attention of passersby. A playful approach of sculptural shapes that move freely in the landscape provoking a mix of curiosity and excitement in passersby that only a work of art is able to create. At night, a cold light that illuminates the structure close to the ground and is then refracted by the glass of the handrail contributes to the effect, adding dramatic power.

Client: Provincia Autonoma di Bolzano / **Design:** KSV Krüger Schuberth Vandreike - Berlin

FOOTBRIDGES - SMALL IS BEAUTIFUL

Italy

All photos: courtesy of Michele Culatti

Rari Nantes Footbridge

- **Padova**
- 2006 - 2008
- Total lenght 75 metres
- Bycicle-pedestrian lanes on the bridge
- The shape of the bridge is inspirated by a local water bird

Designed by the Progeest firm and inaugurated in June 2009, the Rari Nantes footbridge is one of the key elements of a recently promoted project by the Paduan municipality with the goal of facilitating the use of bicycles as the best means of getting around the city. The objective of the 'Padua by Bike' project is therefore to build a vast network of bicycle-pedestrian lanes which will be able to connect the existing roads within the historical centre quickly and safely with the quarters located outside the ancient city walls. Included in the 115 kilometres of road is the new lower desk arch footbridge designed by Professor Enzo Siviero, aimed at restoring the connection between Via Isonzo and Via Vittorio Veneto at a point where the Bacchiglione river offers interesting opportunities in terms of services for the citizens. The design of the bridge draws inspiration from one of the most common 'inhabitants' of the river, the moorhen, a water bird similar to Galliformes. The entire conception of the work came from observing this animal and analysing its movements when hunting for the insects it feeds on. Regarding its geometry, the footbridge is characterised by an arch which is tilted by 22 degrees compared to the vertical and crowned on top by a bar shaped like a bird's beak that acts as a stabilizing element. With a total length of 75 metres, the bridge has a cantilever type frame that gets gradually wider, until it reaches a width of 4 metres at the top. In this way, pedestrians and cyclists are given the chance to slow down halfway across to enjoy the beautiful scenery from a vantage point, suspended between the two banks over the water.

Client: Comune di Padova / **Designers:** Lorenzo Attolico - Enzo Siviero

FOOTBRIDGES - SMALL IS BEAUTIFUL

Rari Nantes Footbridge

Italy

All photos: courtesy of Studio Majowiecki

Footbridge over the A13 motorway

- **Dozza (Municipality of Bologna)**
- 2006 - 2009
- Steel arch bridge
- Span of the bridge 100 metres
- Bycicle-pedestrian bridge
- The bridge structure is narrower in the middle

Inaugurated in 2009 and designed by Massimo Majowiecki, this cycle-pedestrian bridge was born with the goal of repairing the damage caused by the A13 motorway (Padova-Bologna) that, through its layout, caused a huge tear in the urban fabric of Dozza. For this reason, the bridge was built with the aim of recreating physical and social continuity between these two parts of the country that were painfully cut off from each other by this new highway. The reconnection is therefore brought about by means of this vital, dramatic work that becomes at the same time a symbolic memorial of the events that changed the history of the area. Two A-shaped metal structures rise up tilted away from their respective abutments to stand facing each other, above the motorway, at a point of maximum tension both statically and visually. From here, two rows of cables branch off radially to support the structure that is significantly narrower in the middle. The two facing curves that define the shape give traction to the structure that balances out the initial push produced by the struts.

Client: Comune di Bologna / **Design:** Massimo Majowiecki

FOOTBRIDGES - SMALL IS BEAUTIFUL

Footbridge over the A13 motorway

Italy

All photos: Oskar Da Riz, courtesy Textus Edizioni.

Sea Bridge
(Ponte del Mare)

- **Pescara**
- 2008 - 2009
- Cable-stayed footbridge
- Total length 466 metres, main span 172 metres
- Two separate lanes for byciclists and pedestrians

Jutting out towards the Adriatic sea, Pescara is a city rich in contrasts: on the one side, the sea and a mainly urban territory that face each other, on the other, the river with the same name, Pescara, that splits the urban fabric in two quarters which are distinct and diverse both from an architectural and from a social point of view. In this difference lies, the origin of the "Ponte del Mare" (Sea Bridge), conceived as an element which can facilitate the physical and cultural reconnection of two seemingly opposite realities, with a past which is rich in history and a future in constant growth. Designed by Walter Pichler, an architect from Bolzano, the work is the tangible expression of the desire to give unity back to the urban fabric of Pescara, recreating the continuity of its seafront. The bridge's morphology comes from this desire, two pathways that lift up from their respective banks as one to meet, ideally, in a place of physical and social reconciliation, suspended above the river. In fact, two rows of cables branch off from a central pier to support and balance the bridge's two separate lanes, the bicycle lane which is 4 metres wide and the pedestrian lane which is 3 metres wide, that near the two ends merge into a single 5 metres wide lane. In this way, the bridge recreates a sort of empty space in the air, rich in meaning, that enclosed between the two curvilinear lanes gives the work the symbolic value of a monument to peace and gateway to new cultural exchanges, like those recently developed by the countries that border the Adriatic Sea.

Client: Comune di Pescara / **Designers:** Walter Pichler – Mario De Miranda

Italy

Footbridge over the Adige River
(Ponte pedonale sul fiume Adige)

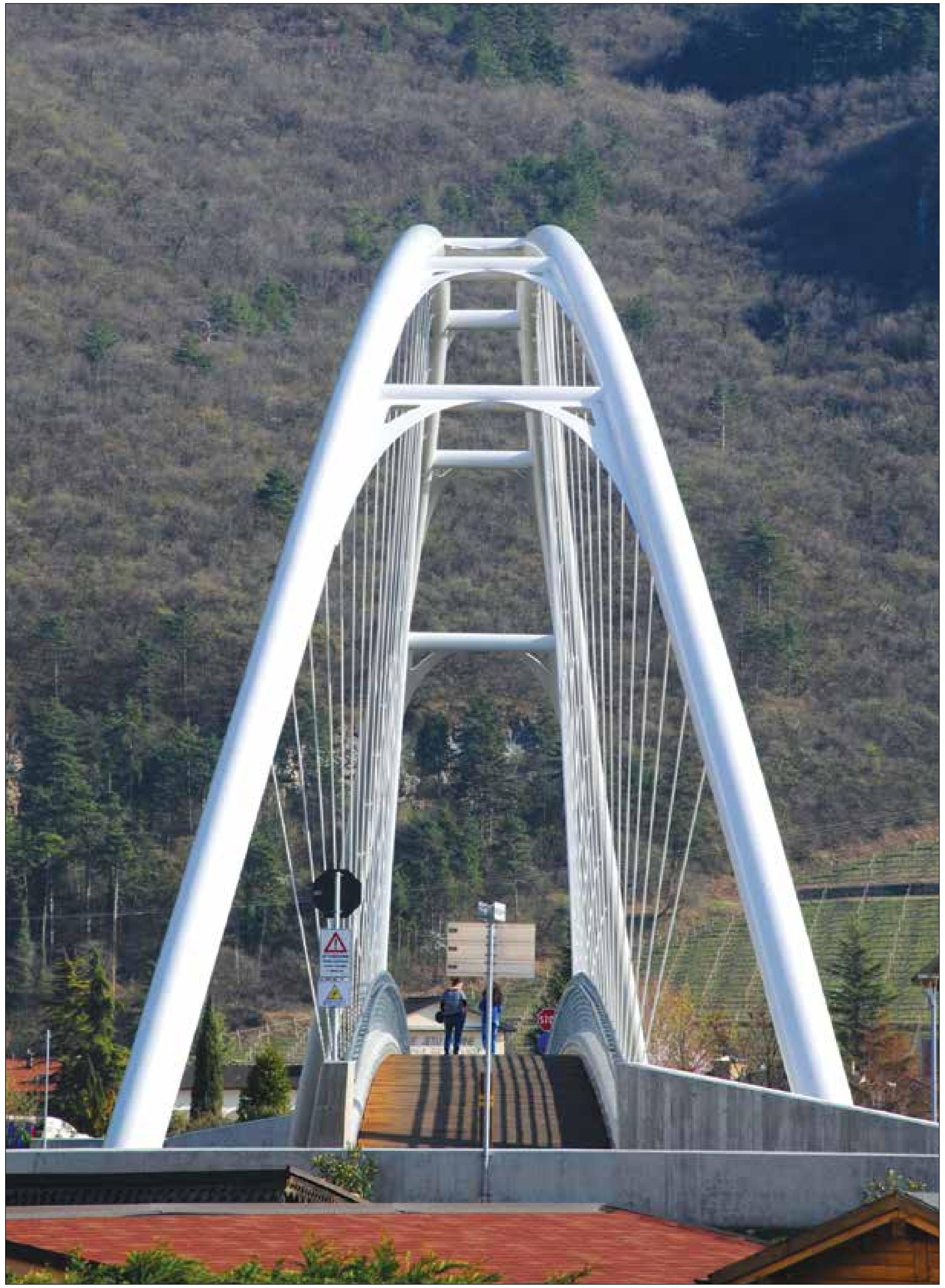
- **San Michele all'Adige**
- 2006 - 2011
- Steel arch bridge
- Span of the bridge 107 metres
- Double arched tubular structure

All photos: courtesy of Alfonso Dalla Torre

This elegant and rather dainty footbridge was inaugurated in September 2011 and connects the town of San Michele all'Adige with the suburb of Grumo, thus paving the way for two communities to become even more united and continue their cooperation both in creating areas suitable for cycling and in promoting tourism in Trentino which is such a rich, vibrant territory. This work is situated along a provincial cycle route that was initially built for recreational purposes but is now becoming increasingly important both for tourism and the economy of the area and also for the issue of sustainable mobility.

This crossing over the Adige was therefore built using a double arched tubular structure which is 20 metres high and crosses the river with a total span of over 107 metres. Two rows of 31 hangers each span out radially from the two arches converging towards the middle of the structure. The structure itself is 3.2 metres wide and has a floor made with wooden slats with led illumination built into the lower part of the parapet.

Client: Provincia Autonoma di Trento / **Design:** Alfonso Dalla Torre /
Team: Studio IGT, Marco Piccolroaz, Cesare Micheletti, Claudio Micheletti



FOOTBRIDGES - SMALL IS BEAUTIFUL

Footbridge over the Adige River

Italy

All photos: courtesy of Chiara Meucci

Science Bridge
(Ponte della Scienza)

- **Roma**
- 2007 - 2011
- Span of the bridge 142 metres
- Width of the bridge 10 metres
- Creating a terrace on the river

Created by the ApsT firm, the Science Bridge is a "fleshless" 142 metres structure that attempts to link two areas of the city of Rome that today are part of a large urban renewal project. The purpose of this project is to revitalise the ex industrial area of the Ostiense district. Large industrial plants lie in disuse and this place appears a real "gap" in the consolidated building fabric of the city. Designing a bridge in this place, therefore, meant repairing ties this area had with the rest of the surrounding district, sewing up, as it were, the tear created by the fact that time has seemed to have ground to a halt here.

This is why the designers chose to use the materials of the place as the materials of the project, because in these materials we can find proof of the past and this almost short-circuits our perception of the present directing it back towards the past. Reinforced concrete and COR-TEN steel was used to give shape to a minimal supporting structure that, as if it were hanging by a thread, bears witness to the rough treatment it was put through. Whilst the thread, a suspended cable, is also part of the structure along with the two supporting crutches on the banks of the river Tiber that materially face each other.

As a kind of terrace on the river, the bridge is open not only to pedestrians and cyclists but also to shared activities and events, ends that justify its greater width of 10 metres and the presence of benches. In order to fill the needs of both, the paving of the cycle lane is treated differently to that of the pedestrian part. For the first, cement paving was used, for the second Tek wood. In this way the bridge has gained the added worth of becoming a place to share with and meet new people, that is a place that can bring about a renaissance of the Gassmann Riviera.

Client: Comune di Roma / **Design:** ApsT Architettura / **Project Manager:** Gianluca Androletti / **Team:** Maximiliano Pintore, Stefano Tonucci, Giorgo Monti, Mauro Minciotti

Italy

All photos: courtesy of Chiara Meucci

Music Bridge
(Ponte della Musica)

- **Roma**
- 2008 - 2011
- Span 190 metres, 22 metres wide
- Arch steel structure supports the bridge
- A piazza on the river

The international project competition tendered by the city of Rome was won by the English firm Buro Happold Engineering with Powell-Williams Architects, who went on to design this bridge. The building of this infrastructure is an important step forward when it comes to the mobility of the city of Rome in the Flaminio area, connecting Renzo Piano's Auditorium and the Maxxi designed by Zaha Hadid with the sports complex of the Foro Italico.

The bridge is 190 metres long and 22 metres wide, with a structure which is divided into a central paved lane, for the use of ecological public transport, and two side lanes with wooden flooring. A depressed arch steel structure supports the bridge. These arches lean outwards and rest on reinforced cement piers that contain the stairs that give access to the two banks of the river. Furthermore, from an urban point of view, the bridge has become almost a 'piazza' over the river, a place to walk and linger in along the way between the Lungotevere Flaminio and the Lungotevere Maresciallo Cadorna. It has thus become an important intersection within the new 'Parco della Musica e delle Arti' (Park of Music and the Arts) that will be built along the route that leads form the Maxxi to the Foro Italico.

Client: Comune di Roma / **Design:** Buro Happold, Powell-Williams Architects

Italy

Footbridge at Mirabello Harbour
(Passerella Pedonale al Porto di Mirabello)

- **Pescara**
- 2010 - 2013
- Mobile cable-stayed footbridge
- Total length 156 metres
- Part of the new city waterfront
- The pylons resemble the masts of sailing boats

All photos: courtesy of Exa Engineering Srl

This new mobile footbridge, inaugurated in July 2013, was part of the restoration of Mirabella Harbour and had been left out of the urban, social development of La Spezia for too long. It was the first step in building the new waterfront of the Ligurian city. This work represents a great opportunity to bring life and fun back to this place that overlooks the sea, encouraging the locals reclaim one of the most beautiful corners of La Spezia's gulf. The bridge has a length of 156 metres. As you walk across it, you can get a view of the city that was previously only visible on board boats and ferries. Its two pylons, that resemble the masts of sailing boats, on the other hand, give a strong reminder of the sea culture present here. Anchored to the pylons are the cables that support on both sides the parts of the structure that connect the masts to their respective docks. Instead, at the centre of the bridge is the lock that can be opened with a total span of 8 metres.

Client: Autorità Portuale di La Spezia / **Design:** Exa Engineering Srl

FOOTBRIDGES - SMALL IS BEAUTIFUL

Footbridge at Mirabello Harbour, Pescara

Latvia

Footbridge over city canal

- **Riga**
- 1892
- Brick arch
- Main span 26 metres

This bridge is located in the most romantic part of Riga, close to the artificial hill made from the remains of the city's medieval walls. The bridge was erected in 1892 for pedestrian traffic. A single-span brick arch bridge, it was designed by the engineer Ā. Agate. The arch is 26 metres long and 2.6 metres high. The width of the walkway is 3.66 metres. The bridge has steel railings and 4 lamp posts. Its masonry supports are 1.2 metres thick and rest on 35 wooden piles.

Designer: Ā. Agate

Footbridge over the canal next to the Latvian National Opera

- **Riga**
- 1900
- Steel truss arch bridge

The bridge is located in the centre of Riga. Its construction was proposed by Professor Timma in 1900 and a competition was held to select a design. It was originally planned to place the bridge in such a way as to connect the National Opera and the University of Latvia by the shortest route. During the course of the project, however, this plan was changed in order to conserve the existing green area. The steel truss arch bridge is 20.52 metres long and 2.03 metres high. It is 3.60 metres wide and originally had a wooden deck structure supported by transverse I-beams.

Designer: Ivans Kropivjanskis

Latvia

Footbridge over the river Ogre

- **Ogre**
- 1966
- Reinforced concrete arch bridge
- Main span 83 metres

This reinforced concrete footbridge over the scenic river Ogre connects two parts of the city of the same name. The bridge was built in 1966 in order to connect the centre of the city to the Pārogre district, with its open-air events venue, summer cottages and new residential neighbourhood. The bridge 96.2 metres long and 3.5 metres wide. The reinforced concrete arch has a span of 83 metres and is 7.8 metres high, giving it a span-to-rise ratio of 10.63:1. The bridge deck structure is made of precast concrete slabs. The two parallel arch ribs are connected together by reinforced cross-beams. The bridge has become an important river crossing for both local residents and tourists.

Designer: V. Salcēvičs

Footbridge over the river Ogre

Latvia

Footbridge over the river Gauja near the Devil's Cave

- **Gauja National Park**
- 1979
- Cable-stayed bridge

This bridge is situated in the Gauja National Park and forms part of a tourist route in the ancient Gauja Valley. It was opened in 1979 and provides a scenic view of the Devil's Rock and the river. The bridge is a cable-stayed structure with steel deck girders and a wooden deck. Renovation was carried out in 2008 and the wooden deck was replaced with a new one.

Designers: J. Zavickis and A. Ādmine

Latvia

Pedestrian overpass over Karlis Ulmanis Avenue
(Kārļa Ulmaņa gatve)

- **Riga**
- 2006
- Total length 175 metres
- Main span 38 metres

Designers: SIA Inženierbūve, Raitis Lācis

This cable-stayed footbridge with a glued laminated timber deck is situated in Riga's business district. The location is characterised by a high traffic intensity. Before construction, the area was divided by a six-lane avenue and virtually no means were provided for pedestrians and cyclists to cross it.

The bridge was built in 2006. With its seven spans and approach ramps, the pedestrian overpass has a total length of 175 metres and a main span of 38 metres. The continuous glued laminated wooden deck is 3 metres wide and has a depth 0.4 metres. The overpass is designed as a cable-stayed structure with "A"-shaped tubular steel pylons. The wooden deck is attached to the steel pylons by four pairs of stays providing a proper configuration of anchorages and joints.

Cesis Castle Park Bridge

- **Cesis**
- 2012
- Wooden bridge

Length: 9 metres
Width: 1.80 metres
Height of rails: 1.02 metres
Material: wood (larch)
Project: Artūrs Lapiņš,
Designer: Guntars Jansons

The Cesis Castle Park Bridge was built in 2012 following the discovery of the original plans drawn up in 1862 by the famous eclectic architect Otto Dietze (Latvian: Oto Dīce, 1833–1890). The plans were stored in the Rare Books and Manuscripts department of Latvia's National Library.

The bridge is a wooden arch structure with metal fastenings.

The original bridge was built in the mid-nineteenth century, when the castle belonged to the noble Sievers family. It was built according to the tenets of the Romantic era as a crossing over the stream running past Karlis Hill. During alterations to the castle park in the 1960s, a broad ditch was dug across the peninsula in the lake and filled with water to create an island. The new Castle Park Bridge, built in 2012, stands very close to the original nineteenth-century location and serves as a crossing over the ditch to the island, where a romantic bower has been created.

Latvia

Footbridge over Cesis Castle moat

- **Cesis**
- 2006
- Wooden bridge structure

Built in 2006 as a part of the renovation of the Cesis Castle complex. Total length 38.5 metres. The bridge structure consists of wooden beams fastened together with steel bolts and secured by wooden cross-beams. The deck is 3 metres wide and consists of longitudinally placed planks. The railings are also of wood. The wooden piers stand on concrete foundations.

Designers: SIA Arhitektoniskās izpētes grupa, Artūrs Lapiņš

Latvia

Mitava footbridge over the river Driksa

- **Jelgava**
- 2012
- Winner of 2012 Best Engineering Structure award

Contractor: SIA Tilts
Project manager: Artjoms Gridnevs
Designer: Project 3, Girts Skupelis
Architect: Ivars Slivke

In July 2011 Jelgava city council contracted SIA Tilts to build a footbridge over the River Driksa River and create a whole new area of the city, including two pedestrian promenades, renovation of nearby streets, alterations to the landscape, etc.

A cable-stayed footbridge with a length of 150 metres and a main span of 75 metres was built over the river Driksa. The bridge has two 28-metre pylons and 28 cables and was constructed from pre-fabricated steel sections finished with a timber deck and stainless steel railings forming aesthetically pleasing parapets and seats along the bridge.

The project also included an arched road bridge over the canal connecting the river Lielupe to the Driksa, a two-storey boat station with concrete pontoons for boats, and a steel pontoon bridge located further along the Driksa.

The project included many architectural features such as specially designed lamp posts, bicycle racks, illuminated fountains and steel benches that together complement the overall design concept of this new city district.

The streets were paved with concrete blocks in various colours – yellow, blue, red, white, grey, etc. All the nearby streets underwent renovation and communications were revised and updated.

Alterations to the landscape included moving the canal connecting the Driksa and the Lielupe to allow the expansion of Post Island (Pasta sala). The ground level of the island was raised by approximately two metres and the riverbed was lowered so as to allow boats to navigate freely around the site.

Site engineering and temporary works were designed and managed by SIA Tilts. The project was completed in November 2012 and a beautiful opening ceremony was held on the eve of Latvian Independence Day.

The bridge, which has already become a Jegava landmark in its own right, stands next to a historic palace designed by Francesco Bartolomeo Rastrelli and built in 1738. The present-day development of the city may be seen as a continuation of a process that began with Rastrelli.

Urban regenaration is now in full swing and is expected to bring new life to the area in the form of public events, cafés, restaurants and so on. All this will increase the number of tourists and benefit the local population.

The unique and complex design of this project afforded the contractor, SIA Tilts, plentiful opportunities to demonstrate its engineering and project management expertise. The bridge won the 2010 Best Engineering Structure award.

Technical characteristics:

Length – 200 metres (152-metre steel superstructure, 50-metre concrete superstructure)
Width – 3.5 metres
Pylon height – 24 metres
Number of stays – 28

FOOTBRIDGES - SMALL IS BEAUTIFUL

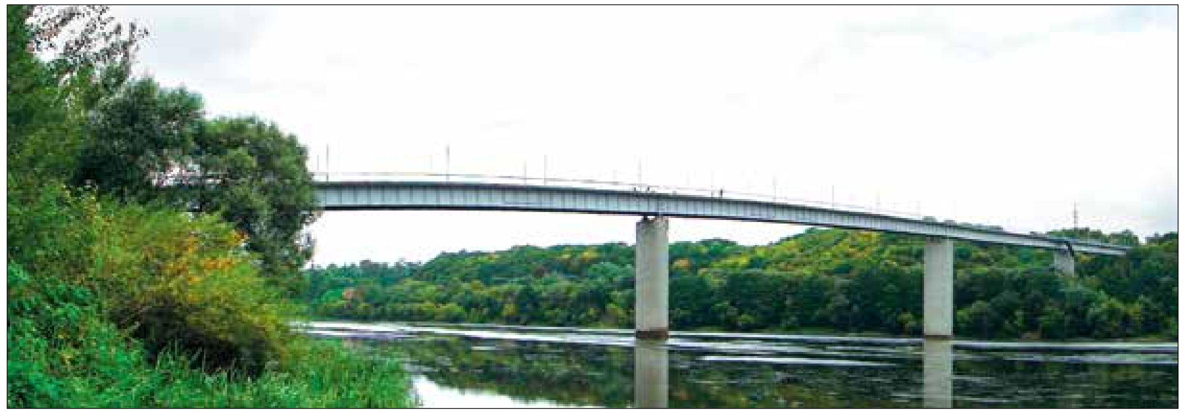

Mitava footbridge over the river Driksa, Jelgava

Lithuania

Three Maidens Bridge

- **Kaunas**
- 1976
- Total length 388.5 metres
- Steel box girder
- Leading to Kaunas's recreation areas

This footbridge was built over the river Nemunas and the Vilnius–Kaunas railway in 1976 so that local residents could enjoy the pleasures offered by Panemunė forest and the riverside area. The bridge is 388.5 metres long and 5 metres wide.



Lithuania

Trakai Castle Footbridge

- **Trakai**
- 1977
- Two bridges linked by an island – 180 metres
- Linking the castle and the shores of Lake Galvė
- Two wooden footbridges supported by reinforced concrete
- Beautiful picturesque landscape

Construction of Trakai Island Castle, which stands on an island in Lake Galvė, began in the second half of the fourteenth century. Contemporary sources also mention the bridge leading to the castle. The castle was the residence of Vytautas the Great, Grand Duke of Lithuania, until his death in 1430. Trakai Island Castle is now a museum and the venue for a variety of cultural events. The current bridge was built in 1977 by the Vilnius Road Construction Board. The first part of the bridge, leading to the intermediate island, is 72.1 metres long, while the second part, leading to the castle island, is 107.9 metres long. The width of the bridge is 2.85 metres. The piles and beams of the bridge are of reinforced concrete; the deck and railings are of wood. All the wooden elements were replaced with new ones in 1999.

Trakai Castle Footbridge

Lithuania

Lake Širvėna Bridge

- **Biržai**
- 1987
- Total length 525 metres
- Longest footbridge in Lithuania

Lake Širvėna Bridge – this wooden pedestrian bridge is the longest footbridge in Lithuania and stands on an artificial lake. The bridge is in a regional park and connects the city of Biržai with Astravas Manor, located on the northern shore of the lake. The famous wooden bridge is 525 metres long and 2.45 metres wide. The bridge was officially opened in 1987 and was renovated in 2003.

Lithuania

Daukantas Bridge

- **Kaunas**
- 1988
- Total length of the bridge 151 metres
- The pilot Jurgis Kairys has twice flown under the bridge

Simonas Daukantas bridge – a footbridge over the river Nemunas to Nemunas Island in the centre of Kaunas.

The architect of the bridge was Algimantas Sprindys, with Darius Žickis acting as structural engineer. The construction manager was the civil engineer Alfonsas Meškinis. The bridge was built in 1988 and is 151 metres long with a width of 5.5 metres.

On 4 July 1996, to celebrate Lithuania's national day, the well-known pilot Jurgis Kairys performed an aerobatic manoeuvre by flying under the bridge (the height of the bridge structure above the surface of the river is just 7 metres). On 2 September 2000 he flew under the bridge again, this time upside-down in an SU-26 aircraft.

Lithuania

Footbridge to Kleboniškis Forest

- **Kaunas**
- 2006
- Leads to the forest in Kleboniškis Park
- Total length 76.7 metres

This arched footbridge with a suspended deck was built in Kaunas in 2006. The project manager was Gintaras Bajoras and the structural engineer was Arvydas Čibirka. The structure has a light, modern, graceful feel and allows residents to reach Kleboniškis Park without having to cross busy roads. The bridge is 76.7 metres long and 3 metres wide and has a height of 52 metres.

Zarasas Bridge

- **Zarasai**
- 2011
- Panoramic footbridge
- Unusual circular design

Zarasas Bridge is a popular panoramic footbridge in the centre of Zarasai.

The bridge was designed by the architect Šarūnas Kiaunė and built in 2011. The structure is 17 metres high and 34 metres wide. Thanks to its unusual shape, the bridge offers stunning views of Lake Zarasas and the city of Zarasai.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Malta

Fortifications and Stone Footbridges of Valletta

- **Valletta**
- 16th–18th century
- Access bridges to the walls of Valletta
- Part of the system of fortifications

Text: Ruben Paul Borg & George Cassar

The Maltese archipelago, with the main inhabited islands of Malta and Gozo, is strategically located in the centre of the Mediterranean Sea. Malta's position and role as a military stronghold can be traced back to prehistoric times. However, it was in more recent centuries that this value became considerably enhanced. When, in 1530, the Order of St John took up the responsibility of protecting and administering the islands on behalf of the Kingdom of Spain, to which Malta belonged, the archipelago became at one and the same time a fortress and a monastery. Between 1530 and 1798 Malta was gradually transformed into an island fortress, and practically all of the largest island of Malta and parts of the second island of Gozo were fortified. The main enemies at this time were the Ottoman Turks and the Barbary corsairs. The former were feared for their declared mission to oust the Hospitallers and take over the archipelago as Sultan Suleiman had already done in Rhodes in 1522. The latter were dreaded for their

frequent raids on the islands, which had devastating effects on both the islanders and their property. It was therefore imperative that the islands became as impregnable as possible, and this is exactly what the Order set out to do. By 1798, the year in which the Hospitallers lost Malta to the Republican forces under the command of the future Emperor of France, Napoleon Bonaparte, Malta and Gozo had accumulated a variety of defensive structures which comprised forts, coastal batteries and redoubts, coastal watchtowers, entrenchments, fortified towns and citadels, as well as the capital city of Valletta embraced within its fortified enceinte.

On their arrival the Knights of the Order of St John first settled at the Borgo, the small seaside town which thrived under the protection of a small and run-down castrum maris. This defensive structure would soon be turned into a strong fort called St Angelo – a name it has kept to this day. The Borgo (now Birgu) was on a peninsula in the majestic natural port of Malta, called the Grand Harbour, and thus was very close to the Order's fleet which was anchored there. With time the Knights realised that Malta was not going to be a temporary abode – many of them had for many years dreamt that one day the Order would return to its former island home of Rhodes, but this had been lost to the armies of the Turkish

Fortifications and Stone Footbridges of Valletta

sultan some years previously. This realisation was also a result of the Ottoman siege of 1565, which the Maltese call the Great Siege of Malta. With the Turkish armies defeated and the Knights emerging as the heroes of Europe, the victorious Grand Master Jean de Valette decided that this was the time to make a statement to both the Order's brethren and to Europe in general. The Order was going to remain in Malta and to seal this connection a new city – their city and their "Convent" – was now going to be built. The Pope's architect, Francesco Laperelli da Cortona, was engaged to draw up plans for a new fortified city to be sited on a tongue of land – the Sciberras peninsula – jutting out between two natural ports. Its streets were designed on a grid pattern, which allowed the breeze to circulate in a country where hot weather was typical and acute.

Priority was, however, given to the fortifications, as this city needed to be impregnable. The artillery fortifications with angled bastions joined together by curtain walls that were designed for this city were intended to ensure that it could withstand any attack both either land or sea. The first stone was laid in 1566 and by 1571 the construction had advanced enough for the Order to officially move into the Humilissima Civitas, as the new city was also known. The land front was elaborate, comprising a series of defensive structures which included two bastions with orillions and two demi-bastions, linked by strong curtain walls and pierced by a single gateway – Porta San Giorgio – which was accessed by means of a bridge. It also presented to an attacking force two cavaliers, counterguards, a ravelin, tenailles, a place d'armes, a ditch and other features. A truly robust front which was further protected and reinforced by the Floriana Lines in front of the city.

Globigerina limestone and the more durable coralline limestone were both exploited in the construction of the fortification structures.

One feature which is evident in the Valletta fortification ensemble consists of a number of masonry arched footbridges linking the main enceinte to some of the outworks. The purpose of such structures was to facilitate the movement of troops from the bastion onto the counterguard in the fortification system. At one point these bridges were criticised by the Order's Commissioner for Fortifications, Bali de Tigné, who felt that they were too high up. The bridges still stand today and to a large extent retain their original appearance.

Malta

Victoria Lines Masonry Bridges

- **Malta**
- 19th century
- Footbridges acted also as dams
- Pierced by musketry loopholes

Text: Ruben Paul Borg & George Cassar

In 1800, while much of Europe was engaged in a war against France, Malta ended up in the hands of the British, who gradually took it over while helping the insurgent Maltese population to drive the French occupying forces out of the island. In 1815 the islands were officially and unequivocally integrated into the British Empire. The new masters, knowing full well how essential this new colony was for their military cause, at once saw to it that its defences would be strong and secure Such military preoccupations continued throughout the British domination and for some years beyond Malta's political independence in 1964.

The British considered the islands to be one of the most important naval bases in the Empire. Their strategic importance increased with the opening of the Suez Canal, since Malta now became a port of call for ships on their way to India. Moreover, as the Mediterranean was a politically active and agitated

FOOTBRIDGES - SMALL IS BEAUTIFUL

Malta

region, the Maltese naval and military post acted as a strategic sentinel, monitoring the countries on its shores and those that showed interest in slipping into this maritime basin. To protect their property and ensure its impenetrability, the colonial administration first took over and strengthened all the fortifications built by the Knights of St John and then embarked on the construction of new defences. These included many strong forts lining the coast of the main island of Malta. The primary aim of these forts was to keep invading enemies out by deterring them from approaching the island. The defensive system adopted by the British followed similar lines to that established by the many experienced military engineers who had served the Order of St John. The British military authorities recognised that a significant outlay was necessary in order to continue with the programme of fortification building that would further strengthen their prized Mediterranean colony. They succeeded in this aim by adding new fortifications according to the military needs and political circumstances that evolved during the 164 years of British rule.

Just as had occurred during the domination of the Hospitallers, the defensive eye of the British occupiers fell on the natural geological fault that divides Malta in two and runs from Madliena in the east of the island to Binġemma in the west, passing through the town of Mosta, situated in the middle of the 12-kilometre Great Fault. The end result was a series of fortified positions linked together by a continuous infantry line. These fortifications were originally known as the North-West Front but were given the name the Victoria Lines on the occasion of the Diamond Jubilee of Queen Victoria in 1897. The purpose of the Victoria Lines was to provide an advanced line of defence to protect the southern part of Malta, including the harbour area. In this way any eventual landward invasion of Malta, which was expected to come from the northern, more desolate part of the island, could be blocked halfway by means of the defences constituting the Victoria Lines. This project began with a fort at Binġemma in 1874. Two other forts, those of Mosta and Madliena, soon followed. Other batteries and posts were later constructed, along with additional fortifications, until the whole system was officially abandoned in 1907, when it was decided to revert back to conducting the defence of Malta from its shores. The Victoria Lines are a fine example of Victorian military structures comprising a wealth of architectural

Victoria Lines Masonry Bridges

features and concepts, all intended to provide an efficient defence system. The lines were never tested, since the dreaded invasion never materialised.

Because the Victoria Lines span Malta from coast to coast, from east to west, they had to follow the contours of the island and thus ran over hills, across plains and down into valleys. The stonemasons who built the infantry line had to deal with drops in levels which at times were very steep and deep. This was especially the case with the so-called stop walls, which were constructed in the dry river valleys that cut through the geological fault and are known locally as Wied il-Faham, Wied Anġlu, Wied il-Ghasel and the Binġemma Gap. These walls also served as footbridges, linking one side of the valley to the other and following the defensive structure to the next gap. They would also act as dams in the valleys, especially after heavy rainfall. In order to relieve this obstruction to the flow of run-off water, arches or culverts were constructed within the stop walls. In terms of defence, however, such openings created a weakness in the defensive line, since they facilitated penetration by the enemy in the event of attacking forces reaching that point of the valley, with predictable consequences for the defenders. To thwart this danger a substantial number of soldiers would need to be posted in such spots in order to reinforce the defensive deterrent. To make the footbridges defensible, musketry loopholes were created on the side of the bridge facing the direction from which the enemy was expected to approach.

Today one can still walk along the Wied il-Faham, Wied Anġlu and Binġemma Gap footbridges, just as the Victorian soldiers used to do. One of the footbridges, that of Wied il-Ghasel, did not pass the test of time as it was swept away during a severe storm in 1979, which only left the three lower arches standing as a reminder of its hundred-year presence.

Malta

St Elmo Footbridge

- **Valletta**
- 2012
- 70-metre span classic arched truss
- The new bridge respects the historical context
- Designed to withstand sea storms

Text: Ruben Paul Borg & George Cassar

Malta provided a secure base for the British fleet in the Mediterranean during the nineteenth and twentieth centuries. Grand Harbour, a natural port, incorporates a number of inlets which provide adequate shelter to naval vessels. However, it had one particular drawback: it was not an all-weather port due to its exposure to north and north-easterly winds. With the increasing strategic importance of Malta as a British naval base during the 1800s – as a port of call for ships en route to India – the need was recognised to transform Grand Harbour into a year-round port. Studies were undertaken in as early as 1872 with a view to constructing a breakwater at its entrance. In February 1990, the British Admiralty then commissioned civil engineers Messrs Coode, Son and Matthews to draw up plans to protect Grand Harbour.

Since Grand Harbour was exposed to the north-easterly Gregale wind, the engineer's brief was to render the entire harbour usable when the strong and stormy Gregale wind blew at its most furious, without impeding the circulation of water. The distance between the breakwater arms had to allow the largest warships to enter safely but at the same time protect the harbour against the north-easterly wind – and torpedo attacks. The proposal included a 378-metre arm at Fort St Elmo, following a slightly curved line along Monarch's Shoal, a 122-metre arm at Fort Ricasoli, a spur pier at the base of Il-Ponta ta' l-Imgerbeb (not constructed) and the levelling down of the rocky shore along the bastions to form a wave trap. The Grand Harbour breakwater was constructed between 1902 and 1909, not only as a means of protection against bad weather but also to provide a defensive barrier against a potential naval attack on Grand Harbour. The completed breakwater thus incorporated a wall offering protection against north-easterly storms, a dog-leg steaming course and a boom defence against naval attack, with an enlarged anchorage for vessels within the harbour.

The breakwater arms consist of precast concrete blocks bonded together to form an almost vertical gravity barrier wall 11.4 metres thick and up to 14 metres deep, designed to resist the powerful wave action caused by the Gregale. The layout of the arms was also intended to allow for a system of floating steel boom defences with anchorage chambers hidden in the St Elmo breakwater arm and the tip of the Ricasoli arm.

A precast concrete block production yard was set up at Mistra, supplemented by coralline limestone aggregate from quarries in Gozo. The coralline limestone was also used for the cladding of the breakwater above the level of the sea, the creation of an access stairway at St Elmo and the construction of the lighthouses. The blocks cast at Mistra were transported by barges to Grand Harbour and lowered into place using cranes. Vertical precast concrete dowels were used to join the blocks, with horizontal dowels used to resist horizontal movements, resulting in a homogeneous barrier.

The longer arm of the breakwater is detached from the shore at St Elmo, with a 70-metre gap. The gap allows for the circulation of seawater. In 1906, a two-span iron footbridge was constructed to provide access from the shore to the breakwater and the lighthouse. The footbridge consisted of two spans each measuring 34.4 metres, supported on central supporting structures consisting of cylindrical iron columns with concrete infill. The bridge structures had a width of 6.4 metres and a height of 4.8 metres, with the main elements of the bridges consisting of two trusses with arched top chords and timber decking. In 1941, during the Second World War, the footbridge was partially destroyed in an Italian naval attack and eventually the bridge structures were removed. The central cylindrical supports were retained but one of them was carried away during a storm in December 1991. The breakwater and its lighthouse remained isolated until a new steel footbridge was constructed in 2012.

The construction of a new footbridge was put out to tender by Transport Malta in 2009 and awarded to a joint venture composed of Vassallo Builders, Spanish bridge designers Arenas Asociados and Bezzina & Cole. The new bridge consists of a new design that takes the historical context into consideration. The main structural element of the bridge consists of a single arched truss with a span of 70 metres, designed with similar proportions to the original bridge structure in terms of height-to-span ratio. The bridge deck with an internal width of 5.4 metres and an external width of 6.45 metres, cantilevers out from the bottom chord of the single truss.

The single Pratt truss, which controls the main structural longitudinal behaviour of the bridge, is made up of an L-shaped box girder with high stiffness acting as a bottom chord; a top chord with an asymmetrical triangular hollow section whose top flange extends seawards to give formal continuity to the walls of the abutments; and diagonal and vertical members with a triangular symmetrical section based on the seaward side of the truss. The transverse behaviour of the bridge is governed by cantilever ribs of variable height and an inverted triangular cross-section, joined to the truss. A secondary box girder with a trapezium cross-section is located on the harbour side. Timber decking is fixed to glue-laminated timber beams and the ribs. The new vertical truss rests on the existing masonry abutments and is aligned along the external face of the breakwater. The resulting L-shape transverse cross-section of the footbridge forms an unobstructed viewing platform towards Grand Harbour, while the arch provides a sense of protection from the sea. The bridge is accessed via the original coralline limestone stairway. The single-span structure stands above the remains of the historical central supports. The bridge was designed to withstand the harsh environmental conditions of the site, with protective coatings and suitable access for inspection and maintenance. The new structure is a contemporary design that acknowledges the historical context, the original bridge structure and the ruins. The contem-

FOOTBRIDGES - SMALL IS BEAUTIFUL

Malta

porary expression of the St Elmo Footbridge provides a landmark at the entrance to Grand Harbour.

Bibliography

Beade H., Capellan G., Arenas J.J., Bezzina A., (2011). *Reconstruction of a Steel Footbridge at Valletta Grand Harbour Breakwater*, Malta. In Sustainable Development Civil Engineering and the Built Environment, Borg R.P. et.al. Ed. Malta: KTP & ECCE.

Bonnici J., Cassar M., (1994). *The Malta Grand Harbour and its Dockyard,* Malta: Malta Maritime Authority.

Borg P.P. (1996). *Selmun. A Story of Love.* Malta: Union Print.

Cachia Zammit, R. (1996). *Malta's Heritage: The Victoria Lines.* Malta: Progress Press.

Giorgio, R. De (1985). *A City by an Order.* Malta: The Author.

Hoppen, A. (1979). *The Fortification of Malta by the Order of St John.* Edinburgh: Scottish Academic Press.

Hughes. Q. (1993). *Malta: A guide to the fortifications.* Malta: Said International.

Spiteri, S.C. (1994). *Fortresses of the Cross.* Malta: The Author.

Spiteri, S.C. (1996). *British Military Architecture in Malta.* Malta: The Author.

Spiteri, S.C. (2001). *Fortresses of the Knights.* Malta: Book Distributors Limited.

Spiteri, S.C. (2008). *The Art of Fortress Building in Hospitaller Malta.* Malta: Book Distributors Limited.

Montenegro

Bridge over the Sutorina stream
(Most preko riječice Sutorina)

- **Herceg Novi**
- from the Roman period
- Destroyed and rebuilt several times
- Bridges a torrential stream

The bridge is an example of ancient Roman bridge building expertise in Montenegro. It is believed to have been built between the second and third centuries AD.
It has been destroyed and rebuilt several times over the course of its history, and has frequently been damaged by flooding of the torrential stream that flows beneath it.
In the Roman period the bridge was an important link on the road between the ancient town of Epidaurum (formerly the Greek colony of Epidauros) and the Bay of Kotor.
The bridge is no longer in use.

The Old Bridge at Moštanica
(Stari most u Moštanici)

- **Nikšić, Moštanica**
- Third century AD, Roman period
- Also known as the Roman Bridge
- The oldest bridge in Montenegro
- Protected status as an engineering monument

The bridge was built in the third century AD, in the ancient Roman period. At the time it was the largest bridge in the region. It has been destroyed and rebuilt several times over the course of the centuries. The last time the bridge was destroyed was during the Second World War.
Today, despite being protected as an engineering monument, the bridge is not in the best shape. Nevertheless it remains a valuable part of Montenegro's historical and cultural heritage.

Montenegro

Ribnica Bridge
(Most na Ribnici)

- **Podgorica**
- First built in Roman times
- One of the oldest bridges in Montenegro
- Also known as the Nemanja Bridge

The origins of the bridge date back to Roman times. It was rebuilt in the Middle Ages when the city was under Ottoman rule. The stone parapet was added after the Second World War.

The bridge is also a popular meeting place for young people, thanks to its romantic setting.

It is perfectly integrated into its surroundings and gives the impression that it has always stood here.

Montenegro

Rijeka Crnojevića Bridge
(also known as Danilo's Bridge)

- **Rijeka Crnojevića**
- 1853
- Very picturesque bridge
- Built by Prince Danilo
- Total length 43 metres

All photos: Robert Cortright

This two-arch limestone bridge over the river Crnojević stands on the site of a former wooden bridge built by Prince-Bishop Peter II (Petar Petrović Njegoš). The new stone bridge was built in 1853 by Prince Danilo, who dedicated the bridge to the memory of his father Stanko Petrović. The bridge was later destroyed by the Turks and rebuilt by Prince Nikola.

Today the bridge is a popular tourist attraction, particularly because of the unique landscape and surrounding mountains. A further attraction is its proximity to beautiful Lake Skadar.

Many famous Montenegrin painters have painted the bridge, giving it additional glamour.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Robert Cortright

Rijeka Crnojevića Bridge, Montenegro

Montenegro

The Tsar's Bridge
(Carev most)

- **Nikšić, over the river Slivlje**
- 20 October 1894
- Total length 269 metres, 18 arches
- The biggest construction project in nineteenth-century Montenegro

The setting in which the Tsar's Bridge stands is a very unusual one. For most of time it does not function as a true bridge. Only when the rising water level transforms the Nikšić karst polje into a great lake, does it become clear why such a long and imposing bridge was built. Without this bridge it would not be possible to cross the polje for much of the year.

The bridge was built on the old road linking the cities of Nikšić and Podgorica. This connection was very important and a bridge of this nature was needed to ensure that it remained passable.

It was built with financial assistance from Tsar Alexander III of Russia, after whom the bridge is named. The 269-metre bridge was designed by Josip Slade. The Tsar's Bridge was built on the orders of Prince Nikola.

At the time of its construction it was the biggest construction project in Montenegro.

The bridge has 18 stone arches, giving it a unique appearance.

Montenegro

The Moscow Bridge
(Ruski most)

- **Podgorica, over the river Morača**
- 2008
- Donated to Podgorica by Moscow
- Tubular steel structure

All photos: Robert Cortright

This footbridge over the river Morača in the very centre of the Montenegrin capital was donated to the city of Podgorica by the city of Moscow.

It is a tubular steel arch structure with a single span. It stands just downstream of the cable-stayed Millennium Bridge, a well-known Podgorica landmark.

A monument to the Soviet singer-songwriter Vladimir Vysotsky stands next to the footbridge on the right bank of the Morača.

Poland

FOOTBRIDGES IN POLAND, PAST AND PRESENT

Text by Janusz Rymsza

Introduction

Footbridges were the first man-made structures used to cross obstacles such as rivers. Other kinds of bridges appeared later with the development of wheeled transport. We may thus assume that the history of footbridges in Poland is as long as the history of the country itself.

There are around 5,000 footbridges in Poland. These footbridges have been built:
– over roads and railways;
– over rivers and lakes;
– in recreational areas, such as parks, where footbridges form part of landscape architecture;
– in mountain areas, where settlement is concentrated in valleys. Roads often follow rivers along the bottom of valleys. Development on the two banks of a river requires connections to the road, which leads to the construction of numerous footbridges;
– in industrial areas where footbridges and walkways provide access to plants and installations.

Various materials have been used in the erection of footbridges, including timber, stone, brick, reinforced concrete, prestressed concrete, iron, steel and plastics. Footbridges have recently become the subject of diverse architectural experiments, a phenomenon which may also be observed in Poland.

A few remarks on the history of footbridges in Poland

The field of footbridges has received only marginal coverage in literature. The history of the development of footbridges in Poland has yet to be formulated and extensive research is required.

The earliest bridges in Poland were made of wood. The availability of materials such as stone was limited to certain areas of the country. Access to timber and the ease of working with it were the reasons why bridges in Poland were constructed of timber until the mid-nineteenth century, when railways started to be built.

Mieszko I, the first ruler of Poland, built a fortified settlement on the island of Ostrów Lednicki, located on Lake Lednickie, 50 kilometres south-west of Biskupin. Two wooden bridges, respectively 438 metres and 187 metres long, were used to link the eastern and western parts of the island to the shores of the lake. These bridges were between 4.10 and 4.50 metres wide and had spans of between 4.00 and 4.50 metres. The oak structures consisted of beams resting on groups of piles. Since the lake was up to 10 metres deep in places, some of these piles were up to 14 metres long. All the elements of the structure were joined together by means of carpentry, without the use of any metal elements. On the basis of dendrochronological examination of the excavated piles and other historical records, it has been established that the bridges stood here from 993 to 1038.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Poland

Footbridge over the river Odra

- **Krosno Odrzańskie**
- Built before the First World War

The picture above is from an old postcard from 1917.

Footbridges of this kind were used in Poland for centuries and some can still be seen today in mountain villages.

Stone footbridge over a walled footpath

- **Puławy**
- 1791
- Believed to be the oldest stone bridge in Poland

This footbridge dates from the period of the Polish–Lithuanian Commonwealth and was built by Princess Izabela Czartoryska in the grounds of Czartoryski Palace in Puławy. It is believed to be the oldest stone footbridge in Poland.

Poland

Cast-iron arch bridge over the river Strzegomka

- **Łażany (Laasan)**
- 1796
- The first cast-iron bridge in Europe outside Great Britain
- Destroyed during the Second World War

The first use of iron in bridge building in Poland dates from 1796, when an arch bridge was built over the river Strzegomka in Łażany. This bridge, which was destroyed during the Second World War, was the first iron bridge in Europe outside Great Britain. Three iron footbridges built in the 1820s are still standing today: in Opatówek near Kalisz (1824), in Ozimek (1827), and in Krzeszowice near Kraków.

Opatówek cast-iron footbridge

- **Opatówek**
- 1824
- The oldest cast-iron footbridge in Poland still in use
- Span 10.30 metres
- Recently renovated

The footbridge in Opatówek was built in 1824 in the grounds of the country house belonging to General Józef Zajączek. It is a single-span structure consisting of four main girders cast in iron. Each of the girders is made up of three segments joined by bolts. The deck probably originally consisted of timber planks, although these were later replaced by reinforced concrete slabs. The bridge rests on solid stone abutments and has a span of 10.30 metres and a total length of 13.80 metres. The total width of the deck is 3.50 metres. The main girders are adorned with ornaments which were cast whole.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Poland

Courtyard footbridge at Lviv Polytechnic

- **Lviv**
- 1894
- The first reinforced concrete footbridge in Poland
- Thickness of the arch 10 cm

The first reinforced concrete footbridge in Poland, located in the courtyard of Lviv Polytechnic (today in Ukraine), was built in 1894 by Maximilian Thullie. Remarkably, the arch has a minimum thickness of just 10 centimetres. At the time of its construction it was one of the most slender reinforced concrete footbridges in the world.

Cable-stayed footbridge in Tylmanowa

- **Tylmanowa**
- 1959
- The first cable-stayed footbridge in Poland

A number of footbridges were erected during the Second Polish Republic (1918–1945), most of them near railway stations. The period from the end of the Second World War to the end of the 1960s saw sporadic construction of footbridges, mainly in small towns and villages, in order to facilitate the development of areas that were cut off from the rest of the world. A notable example of such an area is the village of Tylmanowa on the river Dunajec, where the first cable-stayed footbridge in Poland, designed by J. Szulc and W. Główczak was built in 1959. This bridge has a span of 78 metres. Three other significant structures were later built in this area, including a footbridge with a span of 100 metres (1961).

Poland

Footbridge over Trasa Łazienkowska

- **Warsaw**
- 1973

Poland's economic revival in the 1970s saw an increase in road building and the construction of urban infrastructure. The arch footbridge over Trasa Łazienkowska, an urban expressway in Warsaw, was designed by W. Witkowski and built in 1973.

Turn of the millennium

Footbridge over the river Kłodnica

- **Sławięcice**
- 1993

The last two decades have seen intensive growth in private car use in Poland. This has resulted in the construction of motorways and city ring roads and the activation of recreation areas. One consequence of this has been the construction of numerous bridges, including footbridges.

Bridge building in this period has been characterised by the use of a variety of structural solutions, architectural forms and materials. Recent developments include the increasingly common use of steel tubes as structural elements of bridge superstructures and supports (spatial trusses, arches, pylons, etc.). The main girder of the footbridge over the river Kłodnica in Sławięcice consists of steel tubes.

Cable-stayed footbridge over the river Bystrzyca

- **Wrocław**
- 1999
- Pylon and main girder made from steel tubes

This footbridge over the river Bystrzyca in Wrocław-Leśnica was built to replace an earlier timber structure that was destroyed during the great flood of 1997. The present bridge is a steel cable-stayed structure.

Designed by: Mosty-Wrocław s.c., chief designer Jan Biliszczuk

Poland

Crooked Stick (Krzywy Kij) footbridge over the A4 motorway

- **Mlyński Staw, near Opole**
- 2000
- Main span 62.4 metres

Two cable-stayed footbridges were built over the A4 motorway in 2000. The two footbridges are identical in terms of structure and only differ in colour and the arrangement of the supports, as a result of the different configurations of the two sites. In both cases a prestressed concrete deck is supported by stays anchored to a steel pylon. The pylon is A-shaped. The span is supported only by the abutments (not directly by the pylon). The footbridge pictured is one of two identical structures.

Design: Mosty-Wrocław s.c., chief designer Jan Biliszczuk

Eros Arch footbridge over the A4 motorway

- **Olešnica Mala, near Opole**
- 2000

The deck of this footbridge, known as the Eros Arch, was designed using the same assumptions that are used for cable-stayed structures. The plane of the single steel arch is diagonal to the axis of the deck.
Design: Mosty-Wrocław s.c., chief designer Jan Biliszczuk

Poland

Malt Island Footbridge over the river Odra

- **Wrocław**
- 2002
- Footbridge to Malt Island

The Malt Island Footbridge crosses one of the arms of the river Odra in the centre of the city of Wrocław. The footbridge connects the riverside promenade to Malt Island (Wyspa Słodowa). The structure consists of two reinforced concrete spans and a main span in the form of a braced steel arch.

Design: Mosty-Wrocław s.c., chief designer Jan Biliszczuk

Poland

Footbridge over the river Dunajec

- **Sromowce Niżne**
- 2006
- Span 90 metres
- Was the longest glued laminated timber bridge in the world when completed

Spanning the river Dunajec, this cable-stayed footbridge links the village of Sromowce Niżne in Poland to the village of Červený Kláštor in Slovakia. The deck of the footbridge is suspended from a pylon consisting of steel tubes. The deck itself is a glued laminated timber structure. On completion in 2006, the bridge became the longest glued laminated timber bridge in the world, with a span of 90 metres.

Design: Mosty-Wrocław s.c., chief designer Jan Biliszczuk

FOOTBRIDGES - SMALL IS BEAUTIFUL

Footbridge over the river Dunajec, Sromowce Niżne

Poland

Footbridge over the S11 expressway

- **Kurnik**
- 2009
- Deck made of plastic materials

This footbridge was built in 2002 on the site of a sewage treatment plant in Łódź. Spanning the S11 expressway in Kurnik, it is a steel arch structure with a deck made of plastic materials.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Poland

Malta footbridge

- **Poznań**
- 2009
- Attractive illumination at night

The Malta Footbridge in Poznań was designed to allow pedestrians and cyclists to cross Ulica Baraniaka (Archbishop Baraniak Street) and provide a connection between the Malta Park recreation area and the shopping and entertainment complex on the other side of the road. The vision and aim of the architect was to create a spatial arrangement reminiscent of a marina on the shores of Lake Malta, an artificial lake with an Olympic rowing course, since the Malta area is the largest recreation and sports area in the city. The area of Malta Park is visited by around 40,000 people daily – more at weekends. The footbridge is a cable-stayed structure with a single pylon at the southern end and a curvilinear plan. The pylon consists of two vertical elements bent into an arc and joined by horizontal steel bracing. The vertical elements are of different heights in order to highlight the asymmetry of the structure. The footbridge is attractively illuminated at night.

Poland

Arch footbridge over the river Vistula

- **Kraków**
- Computer visualisation

This planned new footbridge will connect the historic Kazimierz district to the Ludwinów area on the right bank of the river. It will be located in the city centre, in the vicinity of the Wawel Royal Castle. The main part of the structure is a span consisting of two steel girders anchored to massive concrete abutments of complex shape, with a central deck located between them. The side decks are intended for pedestrian and cyclists, while the central deck, equipped with a stairway, is intended exclusively for pedestrians. The connection of the central girder to the lateral girders supporting the side decks is provided by an irregular radial arrangement of slender steel columns and cross-beams.

Design: Mosty-Wrocław s.c., chief designer Jan Biliszczuk

FOOTBRIDGES - SMALL IS BEAUTIFUL

Poland

Arch footbridge over the river Vistula

- **Kraków**
- 2010
- Main span 148 metres
- Assembled on shore and launched into final position

This footbridge connects the Kazimierz and Podgórze districts of Kraków. In structural terms it is a fixed braced arch with a span of 148 metres and a rise of 15.34 metres. The deck structure consists of steel pipe transverse beams. They are supported by the arch by means of skewed cable hangers in an X-shaped arrangement, creating equilateral triangles with the transverse beams in the cross-section. The bridge was assembled on the riverbank (parallel to the river) and launched by means of rotation onto the supports.

FOOTBRIDGES - SMALL IS BEAUTIFUL


Arch footbridge over the Vistula, Kraków

Portugal

Pedro and Inês Footbridge

- **Coimbra, over the river Mondego**
- 26 November 2006
- Main span 110 metres, deck width 4 metres
- Total length 274.5 metres (30.5+64+110+64+6) metres
- Steel arches with mixed steel-concrete decks and timber pavement

This bridge connects the green parks located along both banks of the river Mondego, very close to the centre of Coimbra. The central span allows rowing competitions and small sailing boats to pass underneath. A central "piazza" is created by the two straight but longitudinally non-aligned half-bridges extending from each riverbank. Half-arches in those half-bridges are shifted upstream on the left bank side and downstream on the right bank side, which ensures improved lateral stability. Structurally, the bridge combines the central arch with two cantilevers extending from the strong triangular cells defined by the half-arches and the deck.

The rowing channel on the left bank required an extra span to provide continuity over a pier located on the peninsula. The small "false" span over the abutment on the right bank reproduces the structural continuity by clamping and ensures lower positive bending moment and lower deflections in the adjacent span.

Designers: CECIL BALMOND (Architecture) and
ANTÓNIO ADÃO DA FONSECA (Structural Engineering)
Structural Engineers at AFAconsult: António Adão da Fonseca, Renato Bastos,
António Pimentel Adão da Fonseca and Nuno Neves

Pedro and Inês Footbridge, Coimbra

Portugal

Carpinteira Footbridge

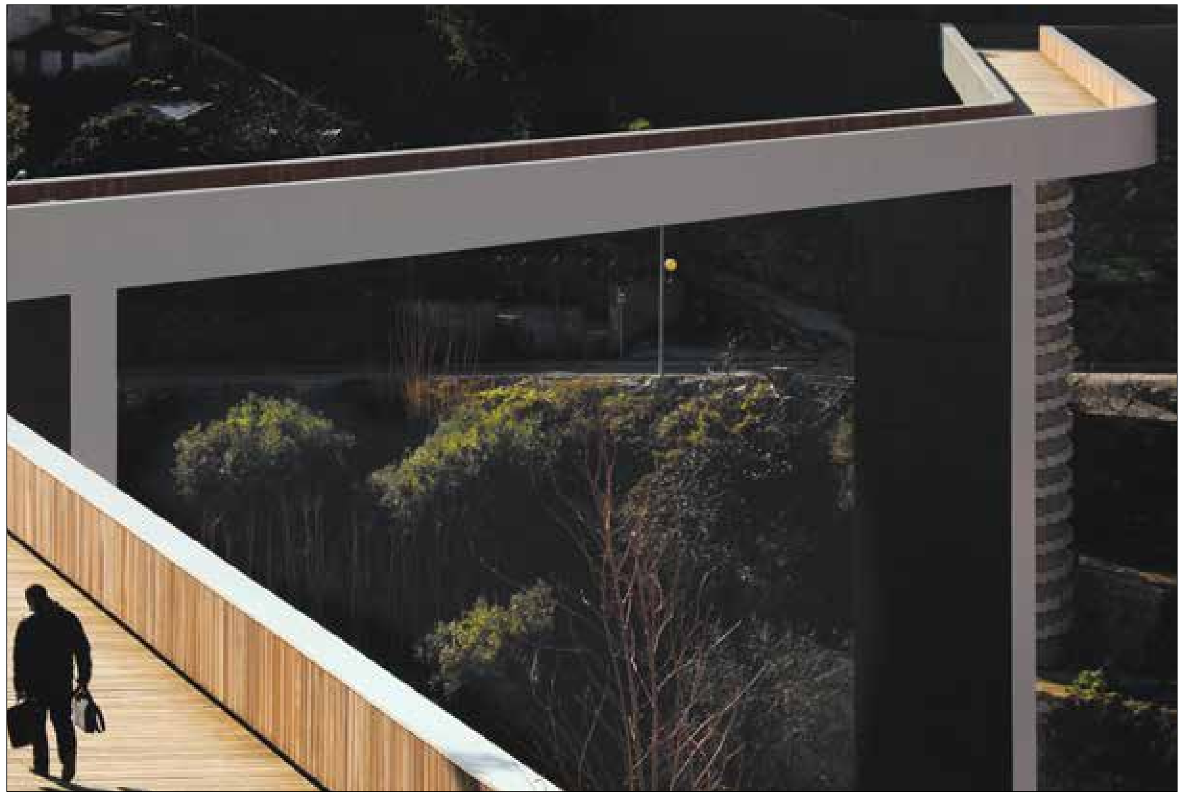
- **Covilhã**
- 6 September 2009
- Main span 49.00 metres, deck width 3.50 metres
- Total length 220,74 metres (42.27+48.41+49.00+49.30+31.77 metres)
- Steel deck with timber pavement

This bridge is located in the small city of Covilhã, at the foot of the Serra da Estrela mountain range. Covilhã is built on hillsides and this footbridge allows pedestrians to cross from one hill to the other without having to walk all the way around the valley of the Carpinteira stream. The architectonic concept is a clear-cut planar "π" over the stream, with non-aligned straight segments connecting to the hillsides. The result is a meandering deck with improved lateral stability, although the piers are not positioned at the corners of the intersecting deck segments.

Structurally, the deck is composed of two lateral "C"-shaped steel beams of a depth of 1.75 metres.

The two central piers, 40 metres high, have a rectangular steel-concrete composite section, while the two lateral piers, 20 metres high, are reinforced concrete circular sections.

Designers: JOÃO LUÍS CARRILHO DA GRAÇA (Architecture) and ANTÓNIO ADÃO DA FONSECA (Structural Engineering)
Structural Engineers in AFAconsult: Antonio Adão da Fonseca, Carlos Quinaz, Renato Bastos and Miguel Pereira



FOOTBRIDGES - SMALL IS BEAUTIFUL

Carpinteira Footbridge, Covilhã

Slovenia

The Lanthieri Mansion Bridge

- **Vipava, over the river Vipava**
- 1669
- Gives access to the baroque Lanthieri mansion
- Unique monolithic cut-stone piers
- Crossed by many notabilities

Text by: Gorazd Humar
All photos: Gorazd Humar

One of the most interesting bridges in Slovenia – a veritable pearl of its rich stonecutting tradition and culture – is without a doubt the footbridge by the Lanthieri mansion in Vipava. Hidden away on the inner courtyard side of the baroque mansion built by the noble Lanthieri family in Vipava, the bridge spans one of the many springs of the river Vipava and connects the house to the estate's farm buildings. It is interesting not only for its architecture, enriched by a stone balustrade of a clearly Mediterranean type, but also for its picturesque surroundings. The bridge is unique in terms of its construction, since it is entirely made of cut stone. This would not be anything unusual if the bridge were an arch bridge, but the main supporting structure of this bridge consists of solid flat stone slabs resting on specially shaped monolithic cut-stone piers standing in the bed of the Vipava.

This is a very unusual design for a bridge, since stone slabs are known to have a very low tensile stress tolerance. For this reason stone is almost never used for the supporting elements of completely

flat bridges such as the Lanthieri mansion bridge. Such a design is only possible if the spans of the stone bridge structure are relatively small. In the case of the Lanthieri bridge, which has seven spans of different lengths, the span of the longest stone slab (which is a full 12 centimetres thick) is 2.63 metres.

The total length of the bridge, which has seven spans, is 14.18 metres. The width of the bridge is 2.65 metres, widening to 4.32 metres at the centre (the widest part).

The beauty and harmonious appearance of the bridge are complemented by two loggias, one on either side, that have the effect of widening the central part of the bridge.

In the structural sense the Lanthieri bridge is unique in Slovenia – and probably the world. While short stone slabs are a frequently used structural element of many bridges, I know of no other bridge that also has individual monolithic stone piers in the middle of a river.

The cut-stone piers are wedge-shaped on the upstream side in order to reduce the pressure of the water on them. Despite the bridge having been reconstructed, the piers are all original and have never been replaced.

Thanks to its rare and remarkable combination of structural and supporting elements, the Lanthieri bridge in Vipava takes its place among the unique bridges of the world.

The bridge is believed to have been built in around 1669 (although the exact date is not known), when the noble Lanthieri family built their new mansion in Vipava. This was the period of greatest prosperity of the Lanthieri family, and just a few years later (in 1683) they also built a summer residence called Belvedere, today better known as Zemono Manor, not far from Vipava. The Lanthieri family hosted many important guests in their Vipava mansion, among them emperors, popes and artists. Carlo Goldoni, Italy's greatest comic playwright, who was famed as the renovator of the commedia dell'arte tradition, stayed with the Lanthieris for several months in 1727. The famous adventurer Giacomo Casanova was also a regular guest of Count Lanthieri and his family.

The Lanthieri bridge underwent a thorough renovation in 2001. This generous action, an initiative of the Municipality of Vipava supported by funds from the European Union's PHARE programme and with the technical assistance of the Restoration Centre in Ljubljana, included extensive and thorough repairs and reconstruction of the bridge, in this way saving one of the most interesting and beautiful bridges in Slovenia from falling into ruin.

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Gorazd Humar

The Lanthieri Mansion Bridge, Vipava

Slovenia

The Hradecky Bridge

- **Ljubljana, over the river Ljubljanica**
- 1867, moved to new location in 1931 and 2011
- Cast-iron tubular arch bridge with a hinge in the centre
- The world's first hinged pedestrian bridge

Text by: Gorazd Humar
All photos: Gorazd Humar

This cast-iron arch bridge has an extremely interesting history. It is named after a long-serving mayor of Ljubljana, who held office from 1820 to 1846. The bridge itself is the most notable product of the famous Auersperg iron foundry in Dvor, near the town of Žužemberk. The plans for the bridge were drawn up by chief engineer Johann Hermann of Vienna. He designed what was for the time an extremely avant-garde bridge structure consisting of two separate sections joined in the centre of the bridge by means of a hinge. From the static point of view the bridge can thus be seen as a single-hinged arch bridge.

The first bridges to use hinged structures began to appear in Europe after 1858. For the most part these were railway bridges. Almost none of these early hinged bridges survive today.

The Hradecky Bridge was not only remarkable for its structure of hollow cast-iron tubes, it was the first footbridge in the world to use a hinged structure. In 1867 hinges still represented a revolutionary technical solution. In view of these facts, the Hradecky Bridge is at least from this point of view unique in the world and an early representative of an important stage in the development of engineering expertise in bridge-building.

Given that the majority of iron bridges (for the most part railway bridges) in which hinges were first used have been demolished or removed, we may claim with considerable certainty that the Hradecky Bridge is today the oldest surviving hinged bridge in the world.

The bridge's cast-iron arch structure has a span of 30.3 metres and comprises three parallel arches consisting of bolted together prefabricated sections. The supporting cast-iron tubes are hollow and reinforced by longitudinal ribs. The two halves of the arch meet at the centre of the bridge in a hinge, which enables each half of the arch to rotate independently of the other.

The interesting thing about this bridge, which originally stood in Ljubljana's old town centre, is that it has changed location twice since it was first built in 1867. The first move took place in 1931, when work began on its replacement – the new Cobblers' Bridge designed by the famous architect Jože Plečnik. The bridge stood – somewhat neglected – in its new location for 80 years, until 2010, when it was once again dismantled and re-erected in a new location in Ljubljana. In 2011 the bridge was carefully restored and today it once again serves as a pedestrian bridge over the Ljubljanica. A cycle path has also been added.

Almost 150 years after it was first built, with the entire bridge structure having twice undergone a move to a new location, the Hradecky Bridge is still in solid good health. Thanks to its unique and original construction, it remains an important technical monument from the pioneering age of the first hinged bridges

FOOTBRIDGES - SMALL IS BEAUTIFUL

Photo: Gorazd Humar

The Hradecky Bridge, Ljubljana

Slovenia

The Cobblers' Bridge
(Čevljarski most)

- **Ljubljana, over the river Ljubljanica**
- 1931–1932
- Functions as a town square above the water
- Designed by the famous architect Jože Plečnik (1872–1957)
- Interestingly designed lights

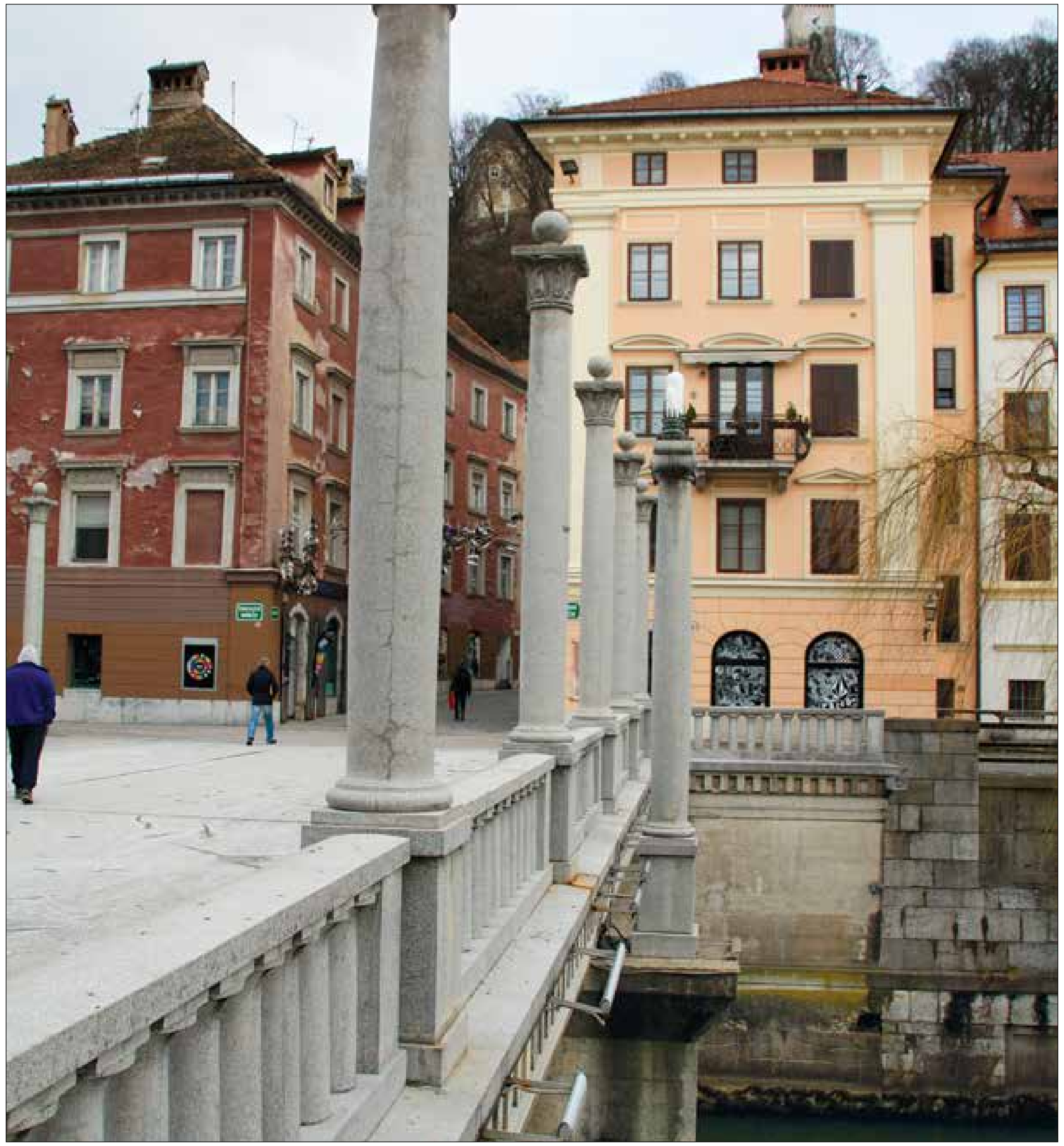
Text by: Gorazd Humar
All photos: Gorazd Humar

The Cobblers' Bridge is another of the most distinctive bridges in Ljubljana. It stands on the site of a former (probably wooden) bridge that dated from Roman times. Medieval Ljubljana gained a brand-new wooden bridge in the twelfth century. For reasons of defence, only two bridges provided access to the old centre of Ljubljana in the Middle Ages.

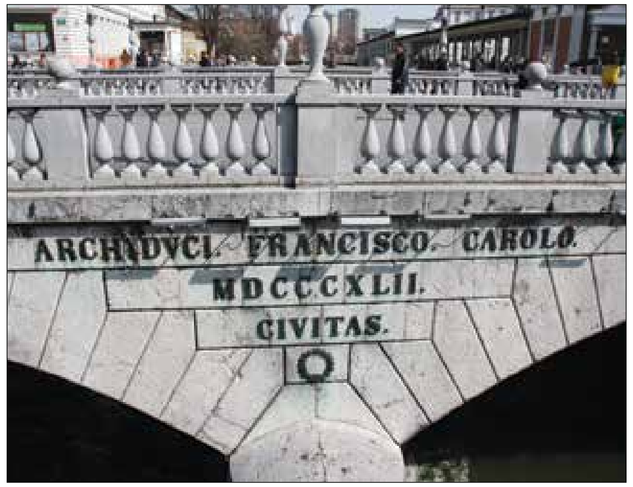
Today's Cobblers' Bridge was known in the Middle Ages as the Butchers' Bridge, since numerous butchers had their stalls on it. After the Butchers' Bridge burnt down in the nineteenth century, a new cast-iron arch bridge called the Hradecky Bridge was built in 1867. This bridge is still standing today, in a new location not far from the Cobblers' Bridge. The cast-iron bridge stood here until 1931, when

the architect Jože Plečnik began to build the present-day Cobbler's Bridge in the same location. He wanted to give the new bridge a more monumental appearance. Above all, he wanted to make it wider and create a new town square lying over the water. The many decorative elements of the bridge include the stone balustrades and, most notably, the rows of columns with Corinthian and Ionic capitals. The lights on the columns at the bridge's centre point are positioned outside the bridge parapets. In this way Plečnik emphasised the fact of the water flowing between his new "town square".

Plečnik's Cobblers' Bridge is just one more link in the chain of interesting and uniquely designed bridges that the great architect created for Ljubljana. Once again Plečnik showed how to insert a new bridge into the context of Ljubljana's old town centre, and how to give a bridge structure a distinctive and individual physiognomy. In the case of Cobblers' Bridge, he was entirely successful in this aim.



Slovenia



The Triple Bridge
(Tromostovje)

- **Ljubljana**
- 1842 – central stone bridge, 1932 – lateral bridges
- The most famous pedestrian bridge in Slovenia
- A unique creation of the famous Slovene architect Jože Plečnik
- Trams once ran over the bridge

Text by: Gorazd Humar
All photos: Gorazd Humar

Tromostovje (literally "Triple Bridge") is a group of three bridges, one next to the other, that represent the most important connection between Ljubljana's Old Town and the newer districts on the opposite bank of the Ljubljanica. Since the introduction of a new traffic regime in the city centre, Tromostovje has been a pedestrian-only bridge, but this was not always the case. From 1901 onwards trams ran across the central bridge, along with other motorised traffic.

Although the three bridges that make up Tromostovje date from different periods, together they form a single harmonious and highly functional whole, thanks above all to the intervention of the famous architect Jože Plečnik in 1931 and 1932.

Plečnik used the experience he had gained while working in Prague to create a group of bridges with a curious funnel-like shape that unobtrusively channels traffic from different directions towards the bridges.

Walking across the three bridges, one gets the impression of a broad city square, since the water beneath them can hardly be seen. The poplars that grow on the river bank between the individual bridges are artfully positioned in such a way as to remind us of the depth beneath the bridges.

The central bridge of today's Tromostovje is a stone bridge with two arches. Built in 1842, it was dedicated to Archduke Franz Karl of Austria, the father of Emperor Franz Joseph I. The dedicatory inscription still adorns the bridge today.

In 1931 it was decided to widen the bridge to cope with the growing amount of traffic, and the architect Jože Plečnik was commissioned to draw up the plans. The remodelling of the older central bridge, the construction of two lateral reinforced-concrete arch bridges to the right and left of the central bridge and the addition of balustrades and lights of original design gave rise to a new bridge complex that has become an icon of Ljubljana. The lateral bridges are somewhat reminiscent, in their form and their balustrades, of the bridges of Venice. In this way Plečnik aimed to give Ljubljana a little of the Mediterranean inspiration that numerous baroque architects, most of them Italian, had given the city before him.

Today Tromostovje is without question crossed by more pedestrians than any other bridge (or group of bridges) not just in Ljubljana but in the whole of Slovenia.

Slovenia

The Škocjan Caves

The Škocjan Caves are an extraordinary piece of the subterranean world of the Karst, in south-western Slovenia. This enormous system of caves and passages has a total length of 5.8 kilometres. The height difference between the highest and lowest points of the cave system is 209 metres. The underground river Reka flows through a large part of the caves.

The Škocjan Caves are among the most important and most beautiful caves in the world. Their importance as part of world natural heritage is reflected in the fact that in 1986 they were added to the UNESCO World Heritage List. The caves are the only natural heritage sight in Slovenia to be under the aegis of UNESCO.

The Škocjan Caves contain one of the largest subterranean chambers in Europe. The Martel Hall is 146 metres high, 120 metres wide and 300 metres long: almost large enough to contain the Great Pyramid of Cheops. A path runs almost the entire length of the Škocjan Caves, allowing visitors to admire most of its beauties. The path crosses several bridges, the most notable of which are the Cerkvenik Bridge and the Marinič Bridge.

The Cerkvenik Bridge

- **Škocjan**
- 1937, rebuilt in 2004
- One of the largest bridges ever built underground
- Lies 47 metres above the surface of the river

Text by: Gorazd Humar

The Cerkvenik Bridge spans the river Reka at the point where it passes through the Hanke Channel, which is essentially a deep natural hollow. The visitors' path crosses the river at this point, via the bridge. The bridge is named after a local man, Miklov France Cerkvenik, the head of a group of guides from the local area who worked in the caves shortly after the First World War.

The bridge, which has a span of 15.65 metres and passes 47 metres above the river Reka, is located in a 90-metre-high cavity. The two ends of the bridge are cut into the living rock. The Reka is a true underground river with an extremely changeable water level. Its average annual rate of flow is 9 m^3/s, but it has been known to reach a maximum rate of flow of 380 m^3/s. In 1965 the Cerkvenik Bridge was submerged when a flood in the caves saw the water level rise to a height of 10 metres above the level of the bridge. In 1828, before the bridge was built, the water level reached 30 metres above the level of the current bridge.

The Cerkvenik Bridge was rebuilt in 2004. With a more durable steel supporting structure, it will enable the safe crossing of the Hanke Channel far below for many years to come.

The construction of the new Cerkvenik Bridge was an operation of considerable complexity, but one that was necessary because of the poor state of the old bridge, corrosion damage to the old steel supports and the growing numbers of visitors to the Škocjan Caves. Construction of the new bridge represented a unique logistical challenge for the builders, since the bridge site is 900 metres from the cave entrance and can only be reached via a steep, narrow path among stalactites and stalagmites. The main steel supporting elements were therefore made in five smaller pieces weighing no more than 250 kilograms. These were then fitted together using prestressed bolts to form a girder 17.55 metres long.

FOOTBRIDGES - SMALL IS BEAUTIFUL

The Cerkvenik Bridge

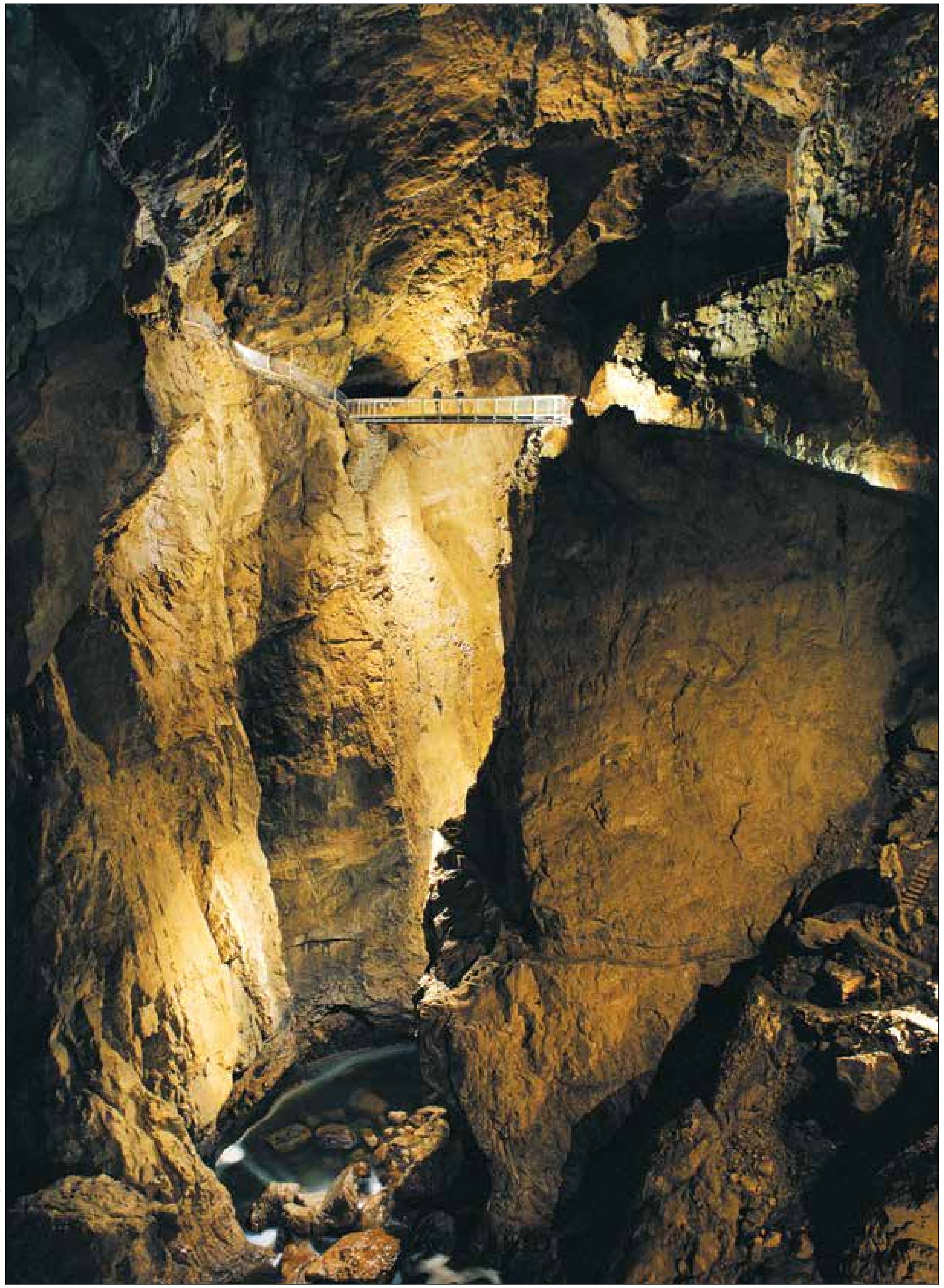


Photo: Borut Lozej, arhiv PŠJ

Slovenia

The concrete for the deck of the bridge – five cubic metres of it – was mixed over a period of eight hours in a small cement mixer set up next to the bridge. The concrete had to be transported using wheelbarrows. The old bridge served as a supporting structure for the new bridge. After completion of the new bridge it was removed and taken out of the cave by the same route.

Client: Škocjan Caves Park
Design: Gregor Gruden, IMK Ljubljana, Slovenia
Contractor: IMKO Ljubljana d.d., Slovenia

The Marinič Bridge

- **Škocjan**
- 1891 - first construction, 2010 - reconstruction
- Footbridge Award 2011, Wroclaw (High commendation)
- Steel tube girder with two bends gives original shape
- Highly complex assembly using high-mountain construction techniques

Text by: Rok Mlakar, Viktor Markelj

The Marinič Bridge is the second bridge in the Škocjan Caves complex to have been reconstructed in recent years. Actually, it is not really accurate to talk about the reconstruction of the old bridge, since the bridge erected in 2010 (2008-preveri) is a brand-new and highly original structure. The first bridge in this location was built in 1891 and was known as the Concordia Bridge. Following renovation between the wars, it was renamed the Bertarelli Bridge.

The Marinič Bridge, which also crosses the river Reka, is located at the entrance to the eastern section of the Škocjan Caves. Above it rises a vertical cliff more than 100 metres high – down which the bridge structure had to be lowered during construction. The new Marinič Bridge replaced an older bridge of simple design that had reached the end of its useful life. The new bridge can hardly be compared to its predecessor, either in terms of size or position, since although it stands in practically the same location it follows an entirely different route.

The essence of the new Marinič Bridge is a supporting structure consisting of a single steel tube with a diameter of 457.20 millimetres and a thickness of 20 millimetres. This 28-metre tube is divided along its length into 12 sections, with crosspieces welded directly to the main tube. These represent the system that supports the steps and landings that comprise the bridge deck. The entire bridge structure was made in three separate sections and bolted together, using prestressed bolts, via flanges on the tubular elements. At two points the bridge is suspended from steel cables fixed to an anchorage in the rock wall. The anchorage is held in place by two geotechnical anchors. Assembly of the bridge's main structure was a particularly attractive operation, since owing to the inaccessibility of the bridge location, it was lowered into position down a 100-metre cliff. A mobile crane was used to lower the bridge substructure to a precisely determined spot.

The new Marinič Bridge undoubtedly represents an additional attraction in the wonderful Škocjan Caves park that serves to make the route through the caves even more interesting. The new bridge rep-

Photo documentation Ponting d.o.o.

Slovenia

The Marinič Bridge

resents an exciting new experience for visitors by offering them new and unique views of the caves. The original, imaginative and attractive design of the bridge is breathtaking, just like the structural concept itself. The impression is completed by the vertical cliff that rises for more than 100 metres above the bridge and, together with the noise of the river far below, sets the adrenaline pumping. Thanks to its well-thought-out design and details, the bridge provides all visitors to the caves with a reassuringly safe way to cross the Reka.

For its planners and builders, the new Marinič Bridge represented a unique challenge. The design and structure of the bridge had to ensure that it would fit unobtrusively into the sensitive and distinctive natural environment of the cave. This called for a considerable degree of expertise, particularly on the part of the planners, when it came to considering structural and architectonic details. The inaccessibility of the bridge's location represented an additional problem for the builders, since assembly of the bridge structure required techniques normally used for construction in mountain areas.

The result of the effective and highly professional cooperation of all parties involved in the construction of the new Marinič Bridge in the Škocjan Caves is a new part-suspended steel bridge that, in terms of its location, is unique in Europe and perhaps even the world.

Client: Škocjan Caves Park, Škocjan, Slovenia
Design: Rok Mlakar and Viktor Markelj, Inženirski Biro Ponting d.o.o. Maribor
Contractor: Joint Venture Primorje d.d. and Kraški Zidar d.d.

Photo documentation Ponting d.o.o.

Slovenia

New footbridge

- **Ptuj, over the Drava**
- 1997
- Tubular steel structure, length 154 metres
- ECCS European Award for Steel Structures, 1999

Text by: Tanja Peteršič

The ancient town of Ptuj stands on the river Drava, at the point where the Panonnian region extends most deeply into the sub-Alpine region of central Europe, and has been the site of important bridges since Roman times. In the Middle Ages the ancient monumental stone bridges located near the Roman castrum of Poetovio were replaced by wooden structures. These survived until relatively recently, before eventually being swept away by floods. After the Second World War they were replaced by concrete and steel bridges that carried new roads and railways across the river. The organic connections between the two banks of the river represented by the historical pedestrian crossings were thus interrupted. In order to stimulate the revitalisation of the old town centre, the local authorities decided to build a new footbridge in order to reestablish the former connection.

This bridge connects the left bank of the Drava with a square on the right bank. Despite the fact that the new bridge is a modern steel and concrete structure, numerous elements drawn from history are reminiscent of the wood and iron structures of the past.

The 154-metre steel superstructure of the bridge, with a geometry which resembles that of the former wooden bridge, rests on four piers and two abutments. The deck consists of a thin concrete slab with, on either side, a coping supporting a polished steel railing. The railing is topped by a wooden handrail which invites strollers to lean on it and admire the river. Lights housed discreetly in the underside of the handrail illuminate the deck without spoiling the view of the night sky.

Owner: Municipality of Ptuj
Design: Marjan Pipenbaher, Ponting d.o.o., Maribor
Contractors: SCT d.d., Ljubljana and Meteorit d.o.o., Hoče

Slovenia

Studenci Footbridge

- **Maribor, over the Drava**
- 2007
- Footbridge Award 2008, Porto (Winner)
- Original steel truss structure
- Very economical solution

Text by: Viktor Markelj

The Studenci Footbridge over the Drava in Maribor is an example of the successful reconstruction of an old bridge through the design of a new, technically innovative structure with a thoughtful steel truss design. This footbridge is characterised by an extraordinary transparency and lightness of appearance, achieved through a relatively simple structural solution which, thanks to clever design, has created an extremely elegant footbridge that is visually more reminiscent of a shallow arch structure than a monotonous load-bearing lattice structure. This successful optical illusion was achieved through the almost playful geometrical relationship between the bridge's main load-bearing structure (a steel truss) and the wooden deck. While the main steel truss structure has a straight geometry and a constant depth for the whole length of the bridge, the wooden deck, mounted on a secondary steel structure (crossbeams), follows a radial curve. With this layout, the steel truss penetrates the wooden deck towards the abutments, dividing the footpath in two. Towards the middle of the bridge the truss sinks completely beneath the bridge deck, creating a wider, uniform and elevated public space directly above the river. The combination of a steel load-bearing structure with a wooden deck has become something of a design trend for long-span footbridges in urban settings. The Studenci Footbridge, which is also designed to be used by cyclists, is lit by energy-saving LED lights housed in the railings that illuminate the bridge along its entire length and emphasise its contours at night. The total power consumption of these lights is just 350 Watts. This was also an optimal solution for the developer in terms of cost.

The main load-bearing structure of the bridge is a triangular steel space truss girder with a depth of 2.05 metres. The space truss consists entirely of welded steel tube sections. The three equal spans of the bridge derive from the position of the existing riverbed supports and are 42 metres long. The total length of the bridge is 126 metres and the structural weight of the entire steel structure is just 93 tonnes. The clear width between the handrails increases from 3.20 metres in the middle of the bridge to 5.80 metres at the abutments. The deck planking, the individual planks of which have a thickness of 44 millimetres and a width of 140 millimetres, is made from the tropical hardwood bangkirai.

The Studenci Footbridge won the prestigious Footbridge Award in the technical medium span category at the Footbridge Conference in Porto (Portugal, 2008). The jury highlighted the bridge's unique design, the imaginative approach to construction and implementation, and the remarkable cost/performance ratio. The total cost was less than €1,200,000, which has since been recognised as a record low price for a landmark footbridge.

Design: Viktor Markelj, Ponting d.o.o., Maribor
Cooperating architect: Reichenberg arhitektura d.o.o., Maribor
Owner: Municipality of Maribor
Contractors: The POMGRAD group, Konstruktor NGR d.d., Hoče
Steel structure: Meteorit d.o.o., Hoče
Time of construction: Jan. 2007 – Dec. 2007

Slovenia

Footbridge over the Sava

- **Radovljica**
- 2007
- For pedestrians and cyclists
- Slender arch structure
- Set in a beautiful landscape

The new bridge over the river Sava near the town of Radovljica forms part of the Lesce–Bled cycling route, which crosses an area of Slovenia that is particularly popular with tourists. The cycling route links two beautiful lakes: the man-made Šobčev Bajer and the larger and more famous Lake Bled.

The bridge is a slender reinforced concrete structure that is 55 metres long and crosses the Sava in a single span.

It is located in an environment that is extremely sensitive to all forms of construction and development. The task of the designers was therefore particularly difficult. The solution they proposed – an elegant and slender arch structure – was deemed acceptable. The bridge is used also by cyclists. The illumination concealed in the railings creates a special effect at night.

Design: Peter Koren, Ko-biro Maribor, for the structure / Peter Gabrijelčič, for the architecture
Contractors: CP Kranj and CP Maribor
Engineer: ZIL Inženiring d.d., Ljubljana
Consultant: DDC svetovanje inženiring d.o.o., Ljubljana

Slovenia

The "Beruna Bridge" – a film star

- **Bovec, over the river Soča**
- 2007
- Temporary bridge built for the film Prince Caspian
- Modelled on the ancient Roman "Caesar's Bridge" on the Rhine
- Built in 3 weeks

Text by Gorazd Humar and Viktor Markelj

In 2007 the final scenes of a film called Prince Caspian were filmed on the banks of the river Soča near Bovec. This was the second film based on the bestselling Chronicles of Narnia series of books by C. S. Lewis to be made by Walt Disney Pictures and Walden Media. The making of this film was rated in 2007 as the biggest film project in the world that year.

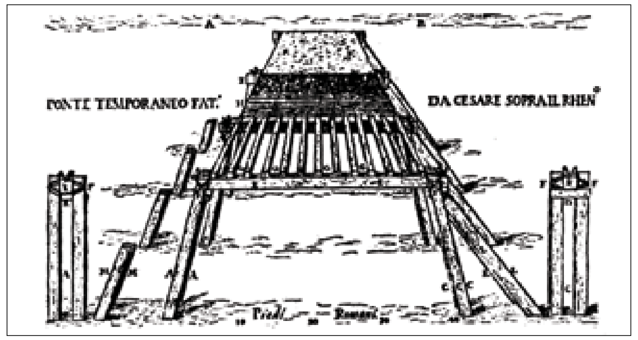
The action of the final part of the film takes place on a bridge that was built specially for this film project and which had to be crossed by 300 foot soldiers and 60 horsemen. The climax of the film sees a river god destroy an army of evil spirits at the precise moment that the army is crossing the bridge. The bridge is destroyed along with the army.

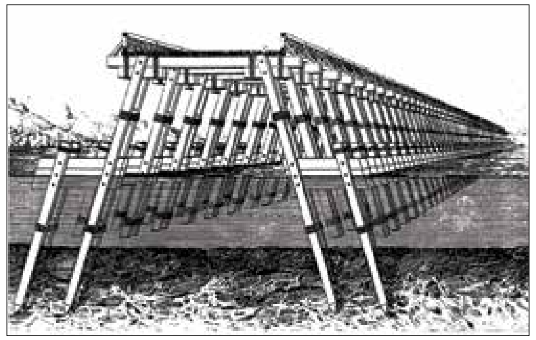
The bridge used in the film was built over the river Soča near Bovec. A detailed plan containing static calculations and all the necessary drawings was prepared for the actual construction of the bridge. The famous wooden Caesar's Bridge over the Rhine in Germany, built two thousand years ago, was used as a model for the bridge in the film.

The bridge rested solidly on specially prepared prefabricated concrete foundations hidden in the bed of the Soča. The supporting piers were made of pine logs with a diameter of 50–60 cm, fastened together by concealed steel bolts and – purely for visual effect – bound by thick ropes. Despite the practical difficulties involved in its construction, with the builders having to work in the water, the bridge – 55 metres long and 6 metres wide – was built in just three weeks. The requirements of the screenplay also meant that it had to be removed in a mere two days. During the filming of Prince Caspian, the level of the Soča rose and almost entirely covered the bridge, but it survived undamaged.

When filming was complete, the remains of the bridge were removed and the entire area of the film set was returned to its original state, so that it looked just as it did before filming began.

Commissioned by: Walt Disney Pictures and Walden Media.
Design: Viktor Markelj, Ponting d.o.o., Maribor, Slovenia.
Contractor: Primorje d.d., Ajdovščina, Slovenia; project manager Gorazd Humar.





FOOTBRIDGES - SMALL IS BEAUTIFUL

The "Beruna Bridge" over the Soča near Bovec, Slovenia

Spain

Walkway connecting the Trasmediterránea terminal and new passenger halls

- **Barcelona**
- 1998
- 430-metre elevated pedestrian walkway
- Very little maintenance required

As a functional element providing direct access to the new passenger halls of the Port of Barcelona, together with a connection between terminals, an elevated pedestrian walkway was proposed so that passengers could have direct and comfortable access from ships to the terminal buildings. The main idea driving the design was an attempt to harmonise the functional, contemplative, aesthetic and structural aspects of the walkway, which enjoys a privileged position with views of the harbour area. Thus, the functional aspects determined the following prerequisites:

- Maximum protection against wind, rain and sun along the walkway, which could be as long as 430 metres, providing both a comfortable and visually pleasing walk.
- Maintaining a sense of open space while providing a direct and unobstructed view of the sea.
- Simplicity in the operation of passenger access at all points, including movable gangways between ships and the walkway.

No less important, the walkway must be aesthetically pleasing, although this must derive mainly from technical and structural aspects rather than showy or merely decorative design.

Finally, another important aspect was the absence of any sort of joints along the walkway, since no matter how good the maintenance, the deterioration of joints is inevitable in both the medium and long term.

In order to satisfy all the above requirements, the form chosen was that of the colonnade, an element deriving from classical architecture, in order to create a light and slender system of white concrete, incorporating the following elements:

- A 3.20-metre wide deck consisting of a thin slab and two lateral ribs; these hold the prestressing cables that are necessary in order to keep all sections permanently under compression, due to the marine environment of the site.
- Full slab areas resembling capitals which, while creating a certain coffered effect, hold the prestressing anchors and connect monolithically to the piers/columns.
- A series of cylindrical columns, with smooth curved surfaces and a gem-like cross-section, of great longitudinal slenderness in order to allow the displacements imposed by rheological phenomena such as creep and shrinkage, and those due to thermal states, without the need for joints or bearings.

From the functional point of view, the following aspects were defined:

- Full openness towards the quays, with a single handrail of removable sliding modules.
- Complete closure of the opposite longitudinal side, by means of tinted glass panels which, while allowing a view of the surroundings of the port and the city, reduce glare and create a certain sense of shelter within the domain of the walkway.
- A roof of translucent white cellular polycarbonate, which protects from sunlight but retains an appropriate luminosity and a sense of openness above.

This design made it possible to reduce to a minimum the maintenance of the walkway, which will fully retain all its qualities over time despite being located in an aggressive environment.

Owner: Barcelona Port Authority
Designer: Julio Martínez Calzón, MC2 Estudio de Ingeniería
Contractor: NECSO

Spain

GFRP Footbridge

- **Lleida**
- 2001
- Glass-fibre reinforced polymer (GFRP) structure
- Span 38 metres, total weight 19 tonnes
- Believed to be the longest GFRP span in the world
- Winner of the 2005 Footbridge Award

This footbridge, built in 2001, is located in the city of Lleida and spans the high-speed railway between Madrid and Barcelona. It is an entirely glass-fibre reinforced polymer structure using standard pultruded profiles. Finding an appropriate structural form to bridge the required span using standard GFRP profiles was a significant challenge.

The final structure is a bowstring truss with a span of 38.0 metres, a rise of 6.2 metres and a width of 3.0 metres. The total weight of the bridge is approximately 19 tonnes. It is believed to be the longest span in the world using this type of structure, i.e. an arch with standard GFRP profiles. The bridge won the 2005 Footbridge Award 2005 (category: innovation) in Venice.

The range of applications of advanced fibre-composite materials is very wide, particularly when minimum maintenance, lightweight structures, ease of handling, short construction times and no magnetic interaction are required. Material supply and design costs mean that the initial expense is higher when compared with traditional steel-based solutions, but considerable savings are made in construction and maintenance over the complete life cycle.

The GFRP profiles were made in Denmark. The profiles were so light that they could be easily handled in the assembly area, which was located in the footbridge access. Here they were assembled into a complete single unit and lifted into position in a single lifting operation which lasted less than three hours.

Owner: ADIF
Designer: Juan A. Sobrino & F. Javier Jordán Pedelta
Constructor: Rubau-Copasa JV

Spain

Pedro Arrupe Footbridge

- **Abandoibarra (Bilbao)**
- 2003
- Main structure in stainless steel
- Total length 142 metres, width 7.6 metres
- Perfect symbiosis of structure and functionality

The design of the new Abandoibarra footbridge, which spans the river Nervión in Bilbao (Spain), next to the Guggenheim Museum and the University of Deusto, had to be striking enough to fit in with its surroundings. This was the main reason that stainless steel was chosen as the main structural material. A duplex stainless steel of grade 1.4362 with high mechanical properties was chosen, providing a yield strength of 400 MPa, an ultimate tensile strength of 630 MPa, a Young's modulus of 200 GPa and an expansion coefficient of 13x10-6 ºC-1 . With a total length of 142 metres, the footbridge has a central deck 7.6 metres wide and eight side ramps each 4.1 metres wide spanning from the main supports, adjacent to the river banks, onto the central deck, allowing pedestrian access from all levels. The U-shaped folded plate cross-section, 20 millimetres thick and 1.95 metres deep, is transversally stiffened by U-shaped frames, which provide the necessary stiffness against distortion, act as load-carrying members and support the wooden deck, which is fixed to a concrete slab spanning the transverse frames. A perfect symbiosis of structure and functionality is achieved, since the stainless steel webs act not only as load-carrying elements but also as the parapets of the footbridge.

Stainless steel is therefore the main structural material, allowing the design to take full advantage of its aesthetic qualities.

Owner: Bilbao Ría 2000
Designer: José Antonio Fernández Ordóñez, Francisco Millanes Mato, Lorenzo Fernández Ordóñez
Contractor: Ferrovial-Agroman & URSSA Joint Venture

FOOTBRIDGES - SMALL IS BEAUTIFUL


Pedro Arrupe Footbridge, Abandoibarra (Bilbao)

Spain

Pedestrian/Bicycle Overpasses on Madrid's Green Cycling Ring

- **Madrid**
- 2006
- Part of a 60 km bike path
- Very transparent structures

The Green Cycling Ring (Anillo Verde Ciclista) is a kind of linear park that joins the existing or planned major green areas that will encircle the city of Madrid.

The Ring crosses several high-density arterial roads, making at-grade crossings unfeasible. It was therefore decided to build overpasses to allow cyclists to "jump over" these roads without affecting traffic.

The works were divided in three phases: The design of the first two phases was developed by PROES. The first phase (17.7 km) was opened in May 2003 with three new overpasses: one over the A3 Highway, another over the A5 Highway and the third over the Avenida de Arcentales. The second-phase works (15.3 km) were completed in April 2006 and included two overpasses: one over the A2 Highway and the other over the Avenida de los Andes.

The structural type that best complied with requirements was the spatial tubular steel lattice. Based on this structural type, very light, almost "transparent" structures were designed which are nevertheless designed to resist high loads, since in many parts of the Ring, the track itself is the natural road for park maintenance vehicles.

Another significant determinant of the project was the width of the overpasses. The cycling lanes that make up the Ring are 6 metres wide (4 metres for cyclists and 2 metres for pedestrians). However, the overpasses, as crossing points, are just 5 metres wide (3.5 metres for cyclists and 1.5 metres for pedestrians). This still allows easy access to firefighting vehicles.

Owner: Department of Works and Infrastructures, Madrid City Council
Designer: PROES Consultores S.A.
Contractor: Elsan Pacsa S.A.
Technical Assistance: Euroconsult

Spain

Bowstring Arch Overpasses on the Madrid Cycling Ring

- **Madrid**
- 2007
- Unique conceptual design and aesthetic appeal
- Long spans with stringent clearance conditions
- Quick analysis and erection
- Minimum traffic interference during the erection process

The design of three bowstring arch overpasses on the Madrid Cycling Ring, with spans of 52 metres (M-500), 60 metres (A-6) and 82 metres (N-II), paid special attention to the above conceptual parameters.

The most noticeable aspect of the design is the aesthetic and structural effectiveness, obtained by using oblique hangers in either a Nielsen arrangement or a network configuration (80-metre span). This allows for homogeneous hanger proportioning (Ø 42 mm bars, S460N steel) and minimal bending moments in the arch and tie beams. Both in-plane and out-of-plane buckling response is also improved. The arch and tie beams virtually take purely axial loads, thereby achieving great slenderness (span/thickness = 131) and material economy (Ø 508 mm to Ø 610 mm steel tubes no thicker than 25 mm). Tie beams are 8.5 m apart and the arches converge at the crown, with a span-to-rise ratio of about 7 to 1.

A Nielsen hanger arrangement was ruled out for the longer arch, since steeper hangers meant unacceptable compression forces under non-symmetric loading.

The deck is made up of a concrete slab 5 or 6 metres wide connected to transverse belly-shaped beams pinned to the tie beams.

• Prefabrication kept land occupation and on-site works to a minimum. The light weight of the structure made it possible to hoist the complete steel structure together with the deck's precast slabs and rebar by means of one crane only in less than 5 hours at night, barely disrupting traffic.

Client: Madrid City Council
Structural design: IDEAM S.A. Francisco Millanes, Luis Matute, Jorge Nebreda
Contractor: Acciona

Spain

La Cava Footbridge

- **Logroño**
- 2006
- A variable-width footbridge
- An iconic gateway to the city of Logroño

The La Cava footbridge is a perfect example of the lattice bridge structural type, with its curved web and variable width. It is the result of a natural evolution of the Arenas-Moneo team's design for the Expo 2008 Bridge Pavilion Competition.

With a span of 61 metres and a fixed-hinged main element, it allows pedestrians to cross the city's ring road. The lattice, with transverse "Gothic" arches linking the top and bottom longitudinal chords, has a slightly variable web, growing wider as it approaches the anchored side, where an initial triangular cell rests on the inclined concrete frame of the pier, which decomposes the forces and guide them to the foundations. The other end acts as threshold to a more open space.

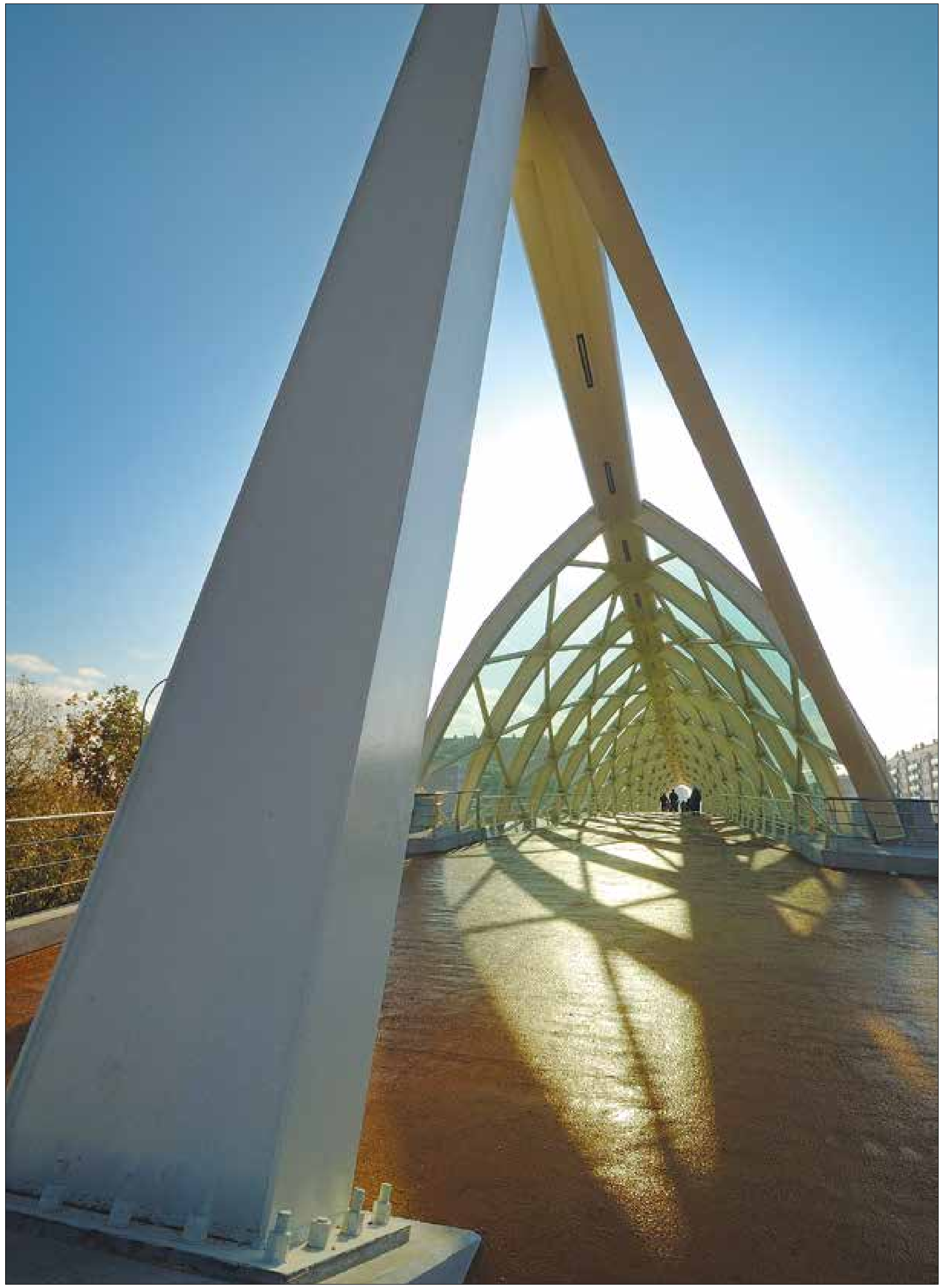
The combination of the glazed skin and the curved lattice not only generates interesting sensations along the bridge crossing, but also protects from adverse weather and traffic noise.

The access elements are designed with different solutions. On the north side access is through two meandering ramps with inclines of between 6% and 9%, consisting of a concrete slab over asymmetrical steel piers associated to lighting elements. The curved outline creates a fluent and organic access which respects the existing trees in the park.

The south side is resolved by a different approach. A new artificial hill with ramps and stairs was created as a noise protection barrier for the new buildings. Its elliptical form is sliced and contained by a retaining wall.

In conclusion, this footbridge creates a new urban space which fits in with its surroundings and fulfils its mission of connecting the two sides of the ring road, becoming in the process an iconic gateway to the city of Logroño.

Client: Logroño Council / **Designer:** Arenas&Asociados, Bridge Designers / **Contractor:** Ferrovial



FOOTBRIDGES - SMALL IS BEAUTIFUL

La Cava Footbridge, Logroño

Spain

Polvorines Footbridge

- **Toledo**
- 2007
- Tender requirement: no pier in the river
- Main span 105 metres, suspension bridge
- A modern structure respecting the traditional architecture of the surroundings

The aim of the project was to provide a connection between the two banks of the river Tajo in Toledo (Spain), close to the former Firearms Factory. Toledo is a world heritage city. For this reason it was a principal requirement to design a modern structure respecting the traditional architecture around it. On the other hand, in order to respect the environment, it was stipulated that the bridge should span the river without an intermediate pier.

The final design was for a suspension bridge with a main span of 105 metres. The bridge was designed by Estudio AIA, and built by FCC Construcción. The owner of the bridge is Toledo City Council.

The deck is 6 metres wide and the main cables are 9 metres apart. The four steel pylons are 22 metres high. The deck is connected to the main cables by hangers spaced at three-metre intervals and connected to transverse beams. The main cables are of the locked-coil type and have a diameter of 84 metres; the hangers are seven-wire strands with a diameter of 16 millimetres.

The deck is a composite box section with a depth of 950 millimetres, consisting of a steel box section with 800-millimetre webs, a two-metre bottom plate and 300-millimetre top flanges. This is covered by a brown concrete slab 6 metres wide and 150 millimetres thick. The connection between the concrete slab and steel box is by means of studs.

The four steel pylons were built from rigid box section, two on each riverbank. The box section has an additional transverse stiffener, since there is no bracing between the towers.

Each pylon is tied back to the anchor block by two steel pipes to minimise axial deformation. The anchor for the tie-back rods consists of prestressed steel bars 20 metres long which are anchored into the ground.

The steel type selected for the structure is S-355, while the concrete grade for the composite deck slab is C-35/40.

The bridge foundations consist of concrete piles with a diameter of 850 millimetres: 14 on the north bank and 13 on the south bank. The piles are more than 15 metres long.

All construction took place without encroaching on the river. Once the concrete foundations were finished, the steel structure was installed. First the four pylons were lifted in as single elements using a crane. Next, the tie-backs were installed, to allow the main cable to be erected. The hangers were connected to the main cable before it was installed, to avoid any work having to be carried out in the river. The deck was built in five segments; once all the steel box segments were in place, they were connected to the main cable. After that, the concrete slab was constructed in situ over the steel section.

Finally, a load test was carried out to check structural behaviour. The maximum vertical deflection (130 mm) was reached with only half the main span loaded, according to the bridge computer model.

Owner: Toledo City Council
Design engineer: Ramón Sánchez de León.
Structural engineering: Estudio AIA.
Contractor: FCC Construcción

Spain

Expo 2008 Tubular Footbridge

- **Madrid**
- 2008
- Composite steel-and-concrete footbridge
- Total length 103 metres

The structure consists of a composite steel-and-concrete tubular footbridge, designed and built for Expo 2008 in Zaragoza.

The footbridge is 103 metres long and 8.5 metres wide, with two lateral cantilevers of 10.64 and 9.06 metres and five spans of 15.42, 18.51, 18.51, 18.51 and 12.34 metres. On the west side the footbridge connects to the Water Tower Footbridge, while on the east side it ends at the Support Building. In both cases, the junction is skewed, the footbridge's slab adapting its shape to the geometry of the two structures.

The cross-section consists of a steel-and-concrete composite three-dimensional lattice of constant depth with hollow circular S355 grade steel tubes, on top of which a reinforced concrete slab is placed.

The lattice has the shape of an inverted triangle, with two upper chords 177.8 mm in diameter and 6 mm thick, and a single lower chord 273.0 mm in diameter and 8–16 mm thick. The upper chords are 3.0 metres apart, while the vertical distance between the upper and lower chords is 1.25 metres.

The chords are linked by two inclined planes of trusses, made up of hollow steel tubes 139.7 mm in diameter and 6–10 mm thick, with a horizontal separation between the ends of 1.543 metres.

With this arrangement, four diagonal elements meet at the lower chord every 3.086 metres. All elements are united directly, by means of welding, without any overlap between diagonals.

At the upper chords, and every 3.086 metres, two diagonals meet at each chord, and at the same point the latter is connected to the concrete upper slab. This union is materialised by means of a plate located on each inclined plane which, cutting the upper chords along one diameter, meets a horizontal plate on which the studs are located.

The concrete upper slab is cast onto precast slabs which span the deck's whole width.

The piers are made of reinforced concrete with a Y shape, consisting of a full-section rectangular shaft of variable thickness, with two branches springing from its top to the upper chords.

Owner: Expo Zaragoza 2008 / **Design:** IDEAM S.A. Francisco Millanes, Antonio Carnerero, Juan José Laso / **Contractor:** Obenasa-Obearagón Joint Venture

Spain

Las Delicias Footbridge

- **Zaragoza**
- 2008
- Four main suspension cables
- Also acts as an observation point
- Wooden deck

This footbridge, over 240 metres long and with a 90-metre curved suspended main span, is located in Zaragoza and crosses the major road junction in front of Zaragoza-Delicias railway station and provides access to the La Almozara district.

The composite access ramps, with asymmetrical piers of graceful structural form, resolve the problem of the connection to the station without competing with the architecture of the station building itself. The main span requires a much more "visible" structure, not only because of its length but also because of its location, a Y-shaped area between Las Delicias and La Almozara.

The central span is structured around an eccentric inclined steel mast from which the four main cables supporting the footbridge deck are suspended. At 28 metres high, the mast does not exceed the height of the station arches. The mast backstays are needed for stability, while its strut allows the transmission of vertical loads to the deep foundations. The main cables describe non-planar spatial curves due to the curved plan of the footbridge, so an iterative form-finding analysis was necessary to define the hangers, which were cut to measure. The interplay between the mast, the cables and the slender curved deck results in a light, transparent structure that is integrated into its surroundings in terms of scale and height, thus minimising the visual impact, while at the same time employing advanced technological and design solutions.

The finished footbridge includes a wooden deck which, in combination with the curved plan, the rhythmically spaced hangers and the concordance of colours, turns the footbridge into an observation point from which pedestrians can contemplate and interact with the surrounding landscape.

Client: Zaragoza Alta Velocidad / **Designer:** Arenas&Asociados, Bridge Designers / **Contractor:** Ferrovial

Spain

Cable-stayed footbridge over the river Ebro

- **Zaragoza**
- 2008
- Curved steel closed box beam
- Length 235 metres
- Inclined pylon, height 70 metres

This footbridge was built for the 2008 International Expo in Zaragoza, the theme of which was Water and Sustainable Development. The bridge crosses the river Ebro upstream of the Almozara Bridge. It consists of a steel closed box beam which is curved in plan view and which is supported by cable stays along its external edge. The cable stays are of the locked coil type and are anchored to an inclined steel pylon which is 90 metres long and 70 metres high.

The footbridge is 235 metres long and 4.5 metres wide and its shape in plan view is a circular arch with a radius of 250 metres. The cables are anchored at a distance of 5.8 metres along most of the bridge except near the left river bank abutment, where this distance is reduced to 2.90 metres. The total number of cables is 38.

The inclined pylon is located on the river bank at a distance of 94 metres with respect to the right river bank abutment and at a distance of 141 metres from the left river bank abutment. Its shape is a cone trunk with a diameter of 2.20 metres at the base and 0.30 metres at the top. All the cables (38 for the footbridge and 10 backstays) are anchored to the upper part of the pylon by means of steel sockets. The pylon foundation consists of 8 piles with a diameter of 1.5 metres. The abutment foundations consist of micropiles.

Owner: Ebro River Basin Authority / **Design:** Carlos Fernández Casado S.L. (Spain) / **Contractor:** FCC (Spain) / **Steelwork:** Horta Coslada (Spain) / **Cables:** Redaelli (Italy)

Spain

Footbridge over the river Segre

- **Balaguer, Lleida**
- 2008
- Steel bowstring arch, span 62.80 metres
- Stainless steel hangers
- Arch follows a parabolic line
- Very economical solution

The project consists of two different but perfectly integrated parts: two access spans, which constitute a link between the two pedestrian paths running along the banks of the river, and a central span over the channel of the river Segre.

The access spans are 0.40-metre-thick reinforced concrete slabs resting on slender concrete piers. The access span on the right bank is wider, forming a square and serving to support a stairway giving access to the lower level of the river bank.

The central structure is a steel bowstring arch with a span of 62.80 metres. The deck is a steel triangular box girder with the width of 6.00 metres and a depth of 0.53 metres. The deck is supported along its axis by a set of hangers at intervals of 6 metres. The hangers are stainless steel bars with eyed anchors at the connections with deck and arch.

In the abutment area, the deck section varies slightly, becoming almost rectangular.

The arch follows a parabolic line and has a quadrilateral (almost triangular) cross-section with a span-to-rise ratio of 8.1:1. The cross-section has a constant area but its dimensions vary from the base to the crown. The cross-section is wider at the crown than at the base in order to stabilise the arch against lateral buckling. Conversely, the cross-section is narrower at the base in order to reduce interference with the footway.

This geometry, based on the resistance needs of the structure, gives the footbridge a visual dynamism.

The combination of concrete access spans with a bowstring arch has resulted in an interesting footbridge and an economically affordable piece of infrastructure for a small town such as Balaguer.

Owner: Municipality of Balaguer / **Design:** J. Romo, J. Sanchez, J. De Cabo FHECOR Ingenieros
Contractor: EXCOVER Grup HERACLES

Spain

Footbridge over the river Fuengirola

- **Fuengirola, Málaga**
- 2008
- Length 90 metres
- Asymmetric cable-stayed structure
- Prefabricated pier and deck

In order to provide continuity to the maritime promenade in Fuengirola, the Coasts Authority (a body within Spain's environment ministry) decided to build a footbridge on the estuary of the river Fuengirola, with supports located in such a way that it would not interfere with the river's discharge. To comply with this restriction and in order to maintain the level of the existing stretches of promenade, the footbridge has a length of almost 90 metres and a maximum depth of 0.60 metres, with a minimum number of supports in the riverbed.

A built-up area consisting of ten-storey buildings is located very close to the footbridge on the right bank of the river. For this reason it was decided to build an asymmetric cable-stayed structure, with the abutment located opposite the buildings. The structure was thus designed with a main span of 68.20 metres and a side span of 14.8 metres.

Due to the uncompensated spans, whose lengths are in a ratio of approximately 5:1, the balance of the vertical loads from the main cable-stayed span is obtained by means of a counterweight connected to the compensation span in such a way that horizontal loads transmitted by the retaining cables are counteracted by the compression transmitted by the deck.

The cable-stayed system was achieved using cables of the locked coil type with a typical diameter of between 40 and 55 mm.

The reinforced concrete deck is typically 5.10 metres wide and comprises two side beams of a thickness of 0.60 metres, which are connected to the deck via a slab with a thickness of 0.20 metres.

The deck is embedded into the counterweight and supported by a pier and the abutment, where the only expansion joint of the structures is located. The side span, which contributes to the effect of the counterweight, is solid in section and has a variable width ranging from 11.50 metres to 5.10 metres with the same thickness as the rest of the deck (0.60 metres), in order to maintain the continuity of the bridge's line.

The A-shaped pier is situated 31 metres above the foundation, and has a longitudinal thickness of 1 metre, with shafts 0.90 metres wide up to the point where they join at the cap. Beneath the level of the deck is a reinforced concrete lintel which connects the two shafts and provides support for the deck. Both the pier and the deck are prefabricated.

Owner: Coasts Authority, Ministry of the Environment
Design: J. Romo, J. Sanchez, F. Prieto FHECOR Ingenieros
Contractor: ACS-Dragados

FOOTBRIDGES - SMALL IS BEAUTIFUL

Spain

Cable-stayed footbridge over the river Manzanares

- **Madrid**
- 2009
- Footbridge crossing two carriageways
- Two curved and connected U-shaped footbridges
- Single pylon
- Main span 120 metres

The purpose of the footbridge is to connect the two banks of the Manzanares river. Although the river is not very wide, the footbridge has to cross the two carriageways of the M30 peripheral motorway, which run parallel to the river, one on each side (Fig. 1) and the landing space is reduced since two streets run parallel to the river on both sides. The conceptual design consists of two curved U-shaped bridges connected in the centre and supported by a single pylon located on one of the river banks by means of cable stays. The shape of the bridge is the result of all the mentioned constraints as well as of the need to respect the maximum grade permissible for disabled users. The design was produced with the help of a scale model. The main span measures 120 metres and the height of the pylon is 42 metres.

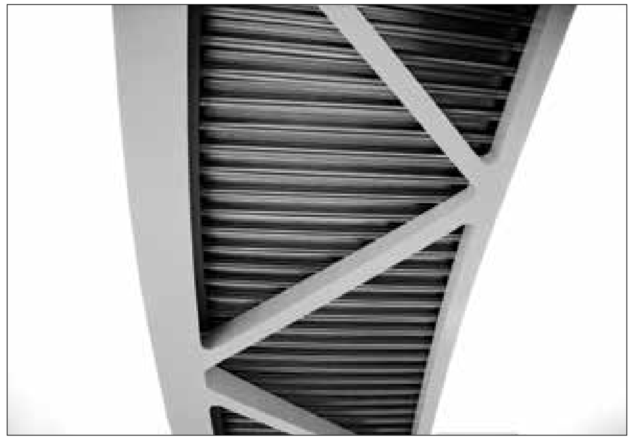
The deck is a 2.44-metre-wide steel trapezoidal closed box which is complemented by transverse beams and a tube to increase the structural width and, consequently, the horizontal moment of inertia. The cables are of the locked coil type with a maximum diameter of 40 mm which were prefabricated to their exact length before installation. The steel pylon has a circular cross-section with a diameter ranging from 1.5 metres at the base to 0.3 metres at the top.

The deck was built in segments in a steel workshop. It was erected on site and welded to provisional supports limiting the spans to approximately 25 metres. These operations had to be performed during the night to allow interruption of traffic along the M30 motorway.

Owner: Municipality of Madrid / **Design:** Carlos Fernández Casado S.L. (Spain)
Contractor: FCC (Spain) / **Steelwork:** Megusa (Spain) / **Cables:** Tensoteci (Italy)

Cable-stayed footbridge over the river Manzanares

Spain



La Paloma Footbridge

- **Madrid**
- 2010
- Designed to meet stringent standards and requirements
- Four-span system, total length 190 metres

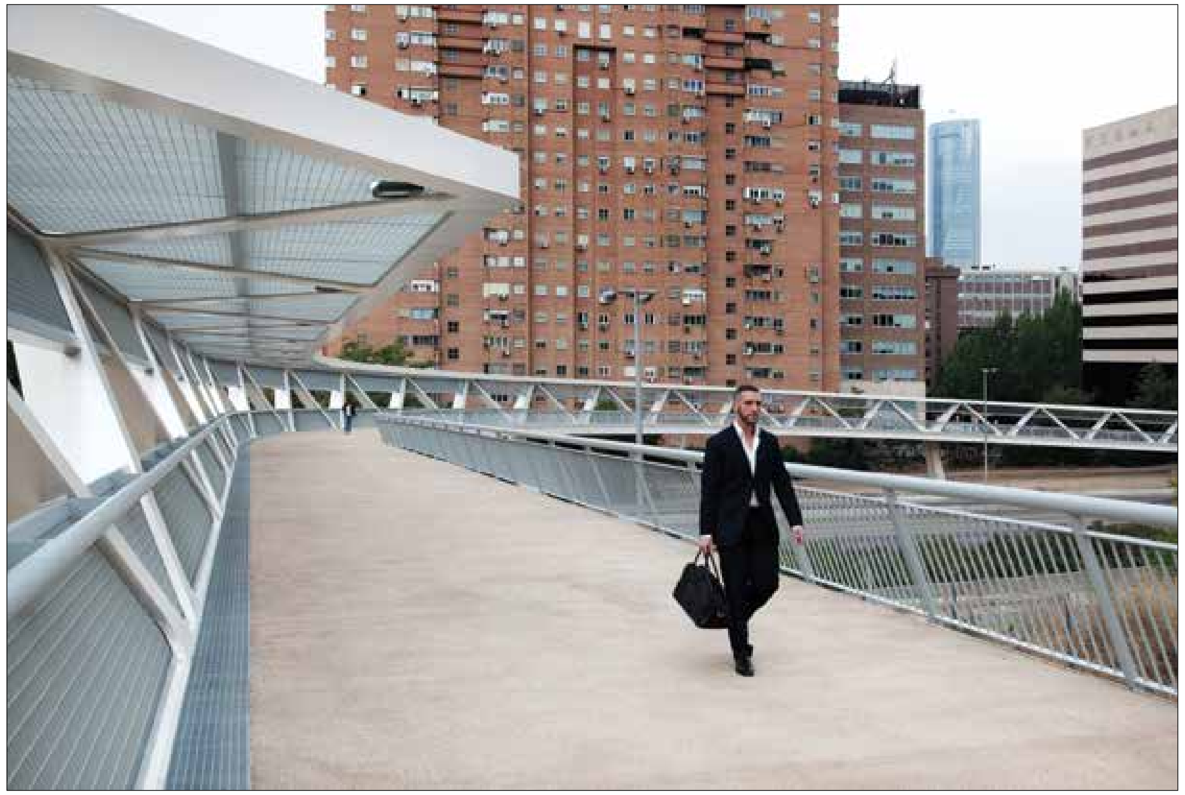
The shape adopted for the La Paloma footbridge, one of a series of footbridges built to improve the lateral permeability of an urban motorway in Madrid, was the result of site constraints and the functional requirements defined in the specifications for the design contest organised by the municipal government.

A continuous four-span system with a total length of 190 (43+52+52+43) metres was devised for the bridge deck. In plan view, the two outer spans are straight for most of their length, while the two central spans form a curve with a radius of 68 metres. In elevation view, the bridge has a slope of 4%. The path for pedestrians and cyclists is over 4.5 metres wide.

The top and bottom flanges and inclined lattice on the open C-shaped bridge girder consist of three structural steel trusses. The top and bottom flanges are 4 and 5.5 metres wide respectively, while the cross-sectional height is 3.9 metres. Both the longitudinal chords and the diagonals are steel members with welded box sections whose dimensions vary in the bottom flange and lattice diagonals. This, together with the incline of the lattice, determined the use of trapezoidal steel boxes for the top and bottom chords of this truss. The centres of the diagonals are at 8.7-metre intervals along the chords of all three trusses. The composite slab (depth: 0.23 metres) is supported by the bottom truss chords and diagonals.

The piers are Y-shaped, with the upper branches formed by two adjacent slanted truss diagonals made of welded steel box sections with variable dimensions. Their cross-sectional height and width increase from top to bottom and are larger than the standard truss diagonal dimensions. Consequently, they project beyond the outer surface of the slanted truss. The pier shaft, a steel box with variable cross-sectional dimensions inclined at the same angle as the lattice of the bridge girder, abuts with its branches on the bottom chord of the truss.

Owner: City of Madrid / **Structural engineers:** P. Tanner J.L. Bellod and D. Sanz; Cesma Ingenieros, Madrid, Spain / **Main contractor:** Intersa, Murcia, Spain / **Steel structure subcontractors:** Iturmo S.A., Asturias, Spain; Montajes Camargo S.L., Cantabria, Spain / **Specialist subcontractor:** ALE Heavylift, Spain



FOOTBRIDGES - SMALL IS BEAUTIFUL

La Paloma Footbridge, Madrid

Spain

Matadero and Invernadero Footbridges

- **Madrid – Madrid Río park**
- 2010
- Internal surfaces of the concrete shell decorated by mosaics
- Unique joint achievement of architects, engineers, constructors and an artist
- Total length of concrete shell 49.10 metres

The twin Matadero and Invernadero shell footbridges are two fundamental elements in the new system of footbridges designed to link the two banks of the river Manzanares in Madrid.

The structures consist of a composite deck with a span of 43.50 metres hung from a reinforced concrete shell by means of two series of Ø 8.1 mm cables at 0.6-metre intervals on both sides of the deck. The concrete shell has a total length of 49.10 metres and a camber of 7.7 metres.

It was decided to place a mosaic on the internal surface of the concrete shells, a different one for each bridge. These mosaics, created by Daniel Canogar, are designed to reflect the day-to-day activities of a broad spectrum of Madrid's inhabitants.

The design of the shell had to meet several goals: structural efficiency, the construction process, appreciation of the artwork placed inside the shell, and aesthetic criteria.

Temporary shoring was needed in the river during construction of the composite deck. A temporary rock peninsula was therefore placed on the riverbed to support the shoring.

The concrete shell was built in situ using double-sided wooden shuttering resting on a scaffolding unit placed on the deck, which in turn rested on shoring on the temporary rock bed.

The uniqueness of the shape of the shell meant that the construction and the assembly of the formwork, as well as arrangement of the reinforcement and the casting of the concrete, were approached in an artisanal manner.

It is a project that brought together many great minds – something that in the past might have been the work of a single genius. It required the cooperation of architects, engineers, constructors and an artist to make it come true.

Owner: City of Madrid
Design: Burgos&Garrido Arquitectos: Francisco Burgos y Ginés Garrido (team director) + Porras & La Casta Arquitectos: Fernando Porras y Arantxa La Casta + Rubio&Alvarez-Sala Arquitectos: Carlos Rubio y Enrique Álvarez Sala + West 8 Landscape Architects: Adriaan Geuze y Edzo Bindels
Structural engineering: Flecor Ingenieros Consultores:
Hugo Corres, Jose Romo, Julio Sánchez, Cristina Sanz
Contractor: ACCIONA

Spain

Vilafant hybrid footbridges

- **Figueres**
- 2011
- Made from stainless steel and GFRP
- Main span 45.2 metres
- Maintenance-free structure

The high-speed railway line connecting Barcelona and the French border crosses the municipality of Vilafant six metres below ground level. It was decided to build two footbridges to cross the sunken railway lines. The structure, with a single span of 46 metres, is monolithically connected to the abutments. The use of unusual geometric shapes fabricated using stainless steel and GFRP and combined in an innovative fashion gives rise to an austere and elegant solution. Both materials are structural, so the structure becomes an example of hybrid footbridge.

The two bridges have a main span of 45.2 metres and a deck width of 4.0 metres. The structures are built-in on both abutments. The cross-section consists of two supported Vierendeel trusses combined with double sheets of GFRP as structural webs. The height of the trusses varies from 3.4 metres at the ends to 1.2 metres at mid-span.

The design concept is based on three basic ideas: the use of lightweight materials, the use of maintenance-free materials such as stainless steel and GFRP, and a minimalist approach (sober and elegant forms and clean lines, creating a bridge with a clear identity that nevertheless does not dominate the landscape).

Owner: ADIF
Designer: Juan A. Sobrino
Contractor: SACYR

Switzerland

The Chapel Bridge
(Kapellbrücke)

- **Lucerne**
- 1333
- World's oldest covered wooden truss bridge
- Features painted triangular panels dating from the seventeenth century
- Current total length 170 metres

Text by: Gorazd Humar

The covered wooden Chapel Bridge over the river Reuss is one of the most recognisable symbols of the city of Lucerne and stands at the point where the waters of Lake Lucerne flow into the Reuss. Lucerne boasted three covered wooden bridges in the Middle Ages, of which only two survive today.

Built in 1333, the bridge (at that time 202.90 metres long) connected the old part of the city in a diagonal line with the new district on the opposite bank of the Reuss.

The bridge stands on wooden piles driven into the riverbed. Its deck is covered by a wooden roof running the entire length of the bridge. The roof thus protected the supporting truss structure of the bridge and the (relatively small) individual spans.

The Chapel Bridge is the oldest surviving wooden truss bridge in the world.

The bridge is best known for the numerous religious paintings situated on triangular wooden panels in its interior. A devastating fire in 1993 destroyed almost two-thirds of the bridge, and with it the majority of the famous seventeenth-century paintings that adorned it. Of the 147 paintings on the bridge at the time of the fire, only around a third survived. Most of these have since been restored. In 1994, shortly after the fire, the bridge was renovated and new concrete piles were driven into the riverbed to support the renovated section.

The bridge crosses the Reuss next to the 33-metre-high octagonal Water Tower (Wasserturm), which stands in the river and is believed to have been built in around 1300, just a few years before the bridge was built. At the time of their construction, both the Water Tower and the bridge formed part of the defences of the city of Lucerne.

FOOTBRIDGES - SMALL IS BEAUTIFUL


Photo: Gorazd Humar

The Chapel Bridge (Kapellbrücke), Lucerne

Switzerland

The Chaff Bridge
(Spreuerbrücke)

- **Lucerne**
- 1408
- Covered wooden bridge with arched supports
- Famous for its interior paintings
- One of the two oldest wooden bridges

Text by: Gorazd Humar

This covered wooden bridge was built in 1408, 75 years after its larger and more famous neighbour, the Chapel Bridge. Like its neighbour, this bridge does not cross the Reuss in a straight line but instead follows a dog-leg route. It is the second-largest wooden bridge in Lucerne.

At the time of its construction it connected Mill Square (Mühlenplatz) to the bakers' quarter (Pfistergasse). Like the Chapel Bridge, it served for a time as part of the city's fortifications. The original supporting structure of the right-hand section of the bridge is interesting in that it consists of two parallel wooden arched supports fastened together by treenails. The arched supports are partially hidden in the interior of the bridge and are only partly visible from the outside. Like the neighbouring Chapel Bridge, this bridge is decorated with fascinating images from Swiss history that remind us of the period in the Middle Ages when the Black Death swept Europe. Images of the Totentanz (Dance of Death) by the baroque painter Kaspar Meglinger appear on a series of panels in the roof section. The theme of the paintings is the age-old story of the fleetingness of human life, in which Death chooses his victims regardless of the wealth or prestige of the individual.

The bridge was known as the Chaff Bridge because it was the only point from which millers were permitted to throw wheat chaff into the river. This was because in the Middle Ages it was the furthest downstream of all Lucerne's bridges.

Photo: Robert Cortright, USA

Turkey

Photo supplied by Freyssinet

Three footbridges in Izmit (UG 1, UG 2, UG 3)

- **Izmit**
- 2009
- Cable-stayed footbridges
- Constantly changing light effects during the night
- Total length: UG 1 = 99 metres, UG 2 = 107 metres, UG 3 = 110 metres

Text: Freyssinet

Three very similar yet different footbridges were built as pedestrian overpasses over the D-100 national road in the city of Izmit. All of them are cable-stayed footbridges and each has a single pylon. The decks are made of steel girders covered by concrete slabs. The stays were supplied by the French company Freyssinet (Freyssinet Ht1000, with outer HDPE pipe). The heights of the 3 pylons range from 38 metres (UG 3) to 43 metres (UG 2). The width of the deck of all three footbridges is 3.9 metres.

During the night the footbridges are illuminated, with lights producing special and constantly changing effects in different colours. One of the three footbridges (UG 2) is also known as the Mimar Sinan Footbridge after the famous Turkish architect and bridge builder Mimar Sinan (1490–1588), who built several famous mosques and bridges during the Ottoman period.

Photo supplied by Freyssinet

UG 2 - Mimar Sinan Footbridge

Photo: Robert Cortright

Owner: Kocaeli Metropolitan Municipality / **Design:** Yüksel Proje / **Contractor:** Ilke Construction Company / **Cable stays supplied and assembled by:** Freyssinet, Freysaş Turkey

FOOTBRIDGES - SMALL IS BEAUTIFUL

Contributions of Japan Society of Civil Engineers

The contributions of the Japan Society of Civil Engineers (JSCE) to this book are the fruit of cooperation between the European Council of Civil Engineers (ECCE) and the JSCE. A cooperation agreement between the two organisations was signed by ECCE President Fernando Branco, ECCE President Elect Wlodzimierz Szymczak and JSCE President Takehito Ono in Lisbon, Portugal on 30 May 2013.

Japan

All photos: M. Matsui and Hirano

Kintai Bridge
(Kintai-kyo)

- **Iwakuni, Yamaguchi Prefecture Spans the river Nishiki**
- 1673
- Length 193.3 metres, main spans 35.1 metres, width 5 metres
- 15th reconstruction completed in 2004

Text by M. Matsui

The Kintai Bridge is a unique bridge consisting of five wooden arches spanning the river Nishiki.

The bridge was built in 1673 to link the town where Kikkawa Hiroie, the feudal lord, and upper-level samurai lived, and the town where mid-level and low-level samurai and merchants lived. The river Nishiki served as an outer moat for the lord's castle. Later, in the Edo period (from the early seventeenth century to the mid-nineteenth century), the common people came to enjoy peaceful everyday lives, and a bridge was built to be sturdy enough to withstand floods and provide a crossing between the two towns.

To date the existing bridge has been repaired and reconstructed 15 times. Rebuilding the bridge has always been done locally. For this reason, the necessary skills and techniques have been passed down from generation to generation.

Original designer: Kikkawa Hiroie, first lord of the Iwakuni Domain (17th century)

FOOTBRIDGES - SMALL IS BEAUTIFUL

Kintai Bridge, Iwakuni

Photo: M. Matsui and Hirano

Japan

All photos: M. Matsui

Monkey Bridge
(Saruhashi)

- **Saruhashi-cho, Otsuki, Yamanashi Prefecture. Spans the river Karturagawa**
- 17th century
- Length 31 metres, main span 31 metres, width 3.3 metres
- Oldest bridge still in use in Japan

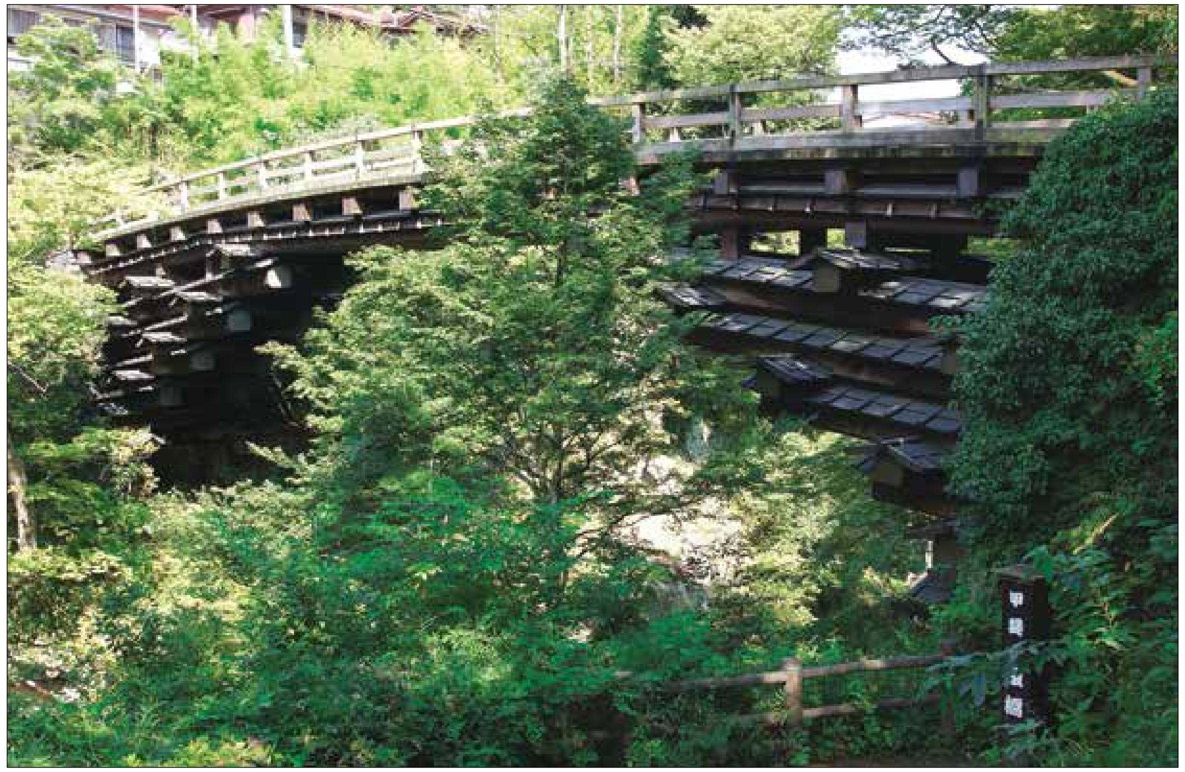
Text by M. Matsui

The original Monkey Bridge is believed to have been built some time in the seventeenth century, although the exact date is not known.

The present bridge, incorporating a timber-covered steel frame, was completed in 1984 as a restoration of the original structure.

The bridge spans a 30-metre valley. Because the valley has steep sides, the bridge is supported by four layers of poles protruding from either bank, taking the place of piers. Many bridges were built using this method. The Monkey Bridge is the oldest bridge in Japan that is still in use today.

Owner: Yamanashi Prefecture



FOOTBRIDGES - SMALL IS BEAUTIFUL

Japan

Ipponbashi

- **Shirakawa, Higashiyama-ku, Kyoto**
- 18th century, rebuilt in 1907
- Length 11.7 metres, width 0.6 metres
- Stone beam bridge, 4 spans

Text by M. Matsui

All photos: M. Matsui

This is a simple yet elegant bridge. It fits well into the historic setting of Kyoto and is used by residents daily. The bridge is also used as a symbolic bridge for shrine rituals and festivals. It is the first bridge crossed by practitioners of the sennichi kaihōgyō (Thousand-Day Mountain Walk) on Mount Hiei when they enter the town.

Owner: City of Kyoto

Japan

All photos: M. Matsui

Kozuya Bridge

- **Kyoto Prefecture. The bridge spans the river Kizu**
- 1953
- Wooden beam bridge
- Length 356 metres, width 3.3 metres
- Needs to be repaired every year because of floods

Text by M. Matsui

The bridge is designed to allow its deck planks to float away with the current when the river floods, so as to reduce the damage that would otherwise be caused by the force of the water. The planks are then retrieved by hauling on the cables to which they are attached and reassembled into place once the flood has subsided. The bridge has experienced many floods since it was built and is rebuilt every time it is hit by a flood. In recent times, as a result of frequent heavy and torrential rains, which cause the river's level to rise, the bridge has had to be repaired almost every year.

Owner: Kyoto Prefecture

FOOTBRIDGES - SMALL IS BEAUTIFUL

Japan

Inachus Bridge

- **Beppu, Oita Prefecture**
- 1994
- Suspended arch footbridge
- Total length 35.7 metres, single span
- Width 2.0–2.9 metres
- 1997 JSCE Tanaka Award

Text by F. Masubuchi

Photo: M. Matsui

- Lenticular shape
- The stone deck constitutes the upper chord member, which is prestressed by the steel lower chord
- The form corresponds to the flow of forces

Owner: Civil Engineering Dept., Beppu
Designers: Mamoru Kawaguchi & Katsumi Nagase (Kawaguchi & Engineers)
Structural designer: Masayuki Ihara (Kawaguchi & Engineers)

Kujira (Whale) Bridge

- **Inagi, Tokyo**
- July 1997
- Prestressed concrete rigid frame bridge
- Length 107 metres, single span
- Width: 8.9–16.5 metres
- 1997 JSCE Tanaka Award

Text by F. Masubuchi

Photo: M. Matsui

- The bottom surface of the bridge features a double curve
- The bridge looks like the belly of a whale, hence the name
- Has become a local landmark

Owner: Urban Redevelopment Authority
Designer: Japan Transportation Consultants Inc.
Structural designer: Japan Transportation Consultants Inc.

Japan

Photo: © Koji Horiuchi

TFP-Model

Photo: © Nakaca & Partners

The circular walkway supported by a 25-metre column.

Photo: © Hidetsugu HORIKOSHI

Detail of a walkway: a lattice truss tube

Tottori Flower Corridor/ Tottori Flower Park

- **Aimi, Tottori Prefecture**
- 1999
- All-weather observation walkways
- Design based on geometric rationality in nature

Text by K. Takenouchi
Credit line (each photo): q.v.its@individually

- Designed to provide an opportunity for people to enjoy a variety of garden plants throughout the year (even in winter), Tottori Flower Park, surrounded by hills, is a unique and striking complex entirely composed of geometric forms, with all-weather observation walkways and barrier-free access.
- The main concept behind the project is "geo-natural." This is the idea that any design must be based on geometric rationality in nature, explains chief design supervisor Hidetsugu Horikoshi of the Architect 5 partnership.
- The observation walkways consist of two types of structure. The main part, the covered circular walkway known as the "Flower Corridor", has an approximately 1 km circumference and is constructed using an innovative eccentric truss system with seamless joints and supported on slender columns. Attached to it at right angles are straight walkways comprising a half-glazed tubular structure with a single-layer latticed shell. These meet at the centre of the circle under a colossal glass dome.

Owner: Tottori Prefecture
Designers: Hidetsugu Horikoshi / Architect 5
Structural Designers: Ryozo Umezawa / Umezawa Structural Engineers
Constructors: ***Circular observation walkway:*** JDC Co. + Taniguchi Co. JV, ***Straight walkways:*** Zenitaka Co. + Takeda Co. + Matsumoto Co. JV

A bird's-eye view of Tottori Flower Park

Photo: © Nakaca & Partners

A straight walkway and the glass dome, illuminated.

Photo: © Nakaca & Partners

Japan

Shibuya 21 Bridge

- **Tokyo**
- 2001
- Superstructure – single-span Vierendeel bridge
- Length 49.5 metres, simple beam span 47.5 metres, total width 4.5 metres, deck width 3.2 metres

Text by K. Takenouchi
Photos: © Hidetsugu Horikoshi

- This urban footbridge over two roads running parallel to each other was required to have a single clear span and sufficient clearance for traffic. The optimum structure proved to be a unique Vierendeel bridge with slightly diagonal members.
- The design concept for this bridge project was "parallel lines fly across the air" explains Hidetsugu Horikoshi of the Architect 5 partnership.
- Both upper and lower chords are made of H-steel, with the diagonal members inserted without the use of gusset plates, thus creating a unique and innovative footbridge with a clear-cut form that gives an impression of lightness.

Owner: Ministry of Land, Infrastructure and Transport, Japan
Designers: Hidetsugu Horikoshi / Architect 5 + Tokyu Construction Co. Ltd.
Structural Designer: Ryozo Umezawa / Umezawa Structural Engineers
Constructor: Tokyu Construction Co. Ltd.

F O O T B R I D G E S - S M A L L I S B E A U T I F U L

Japan

Karato Market Approach

- **Shimonoseki, Yamaguchi Prefecture**
- 2001
- Length 44 metres, span 36 metres
- Very innovative form of footbridge
- Designed based on the appearance of sea foam

Text by M. Iso

Photo: M. Matsui

This footbridge links the fish market facing the Kanmon Strait, a popular tourist attraction, with a car park. Based on the truss bridge concept, the structure consists of connected elements forming a cuboctahedron combined with triangular units. It is a very unique and innovative form of footbridge.

Owner: City of Shimonoseki / **Designers:** Masao Saito, Laboratory M. Saito and Kotofumi Kato, Arch, KOT Architect & Associates / **Structural designer:** Masao Saito, Laboratory M. Saito and Kotofumi Kato, Arch, KOT Architect & Associates

Sakae-cho Greenwalk

- **Yokohama, Kanagawa Prefecture**
- 2001
- Steel tube bridge
- Spans 34.3 + 26.6 + 19.9 metres
- Width 3.0 metres

Photo: M. Matsui and Ono

Text by M. Iso

This walkway is a horizontally-braced, Y-shaped structure.

Due to the expressway running below, the structure is of the through girder type.

Owner: City of Yokohama
Designer: M+M Design Office
Structural Designer: Pacific Consultants Co. Ltd.

Japan


Photo: Sumitomo Mitstui Construction Co., Ltd.

Ganmon Bridge

- **Togi, Hakui District, Ishikawa Prefecture**
- 2001
- Prestressed concrete curved-chord truss bridge
- Length 39.0 metres, deck width 1.5 metres
- 2001 JSCE Tanaka Prize

Text by F. Masubuchi

• The world's first prestressed concrete curved-chord truss bridge
• Self-anchored bridge stiffened by stressed ribbons that make up the lower chord members.

Owner: Environment Division, Ishikawa Prefecture / **Structural designer:** Nihonkai Consultant Co., Sumitomo Mitsui Construction Co. Ltd. / **Constructor:** Sumitomo Mitsui Construction Co. Ltd.


Photo: M. Matsui

Kikiki Pedestrian Suspension Bridge
(Kikiki no Tsuribashi)

- **Ichinohe, Iwate Prefecture**
- 2002
- Wooden cable-stayed two-span bridge
- Length 86.5 metres, width 1.8 metres

Text by N. Kuroshima

The Kikiki pedestrian suspension bridge is a horizontally curved suspension bridge with pylons inclined at an angle of 45 degrees supporting a roofed wooden truss structure. The bridge has high torsional rigidity thanks to the curved deck and inclined pylons.

This roofed timber bridge gives users the impression of being transported back in time.

Owner: Town of Ichinohe, Ninohe District, Iwate Prefecture (as of 2002) / **Designers:** Mitsuru Senda + Environment Design Institute / **Structural designer:** Yoshiharu Kanebako, Kanebako Structural Egnineers

Japan

Kawasaki Muza Deck

- **Kawasaki Station West Exit, Kawasaki, Kanagawa Prefecture**
- 2003
- 4-span, continuous steel deck, box girder (rigid frame) bridge
- Length 120 metre, 4 spans of 30 metres, width 7.5 metres
- 2010 JSCE Civil Engineering Design Prize

Text by N. Kuroshima


Photo: N. Kuroshima

The Kawasaki Muza Deck was built as part of the JR Kawasaki Station West Redevelopment Project. This deck is a pedestrian walkway facilitating access between Kawasaki Station and the new Muza Kawasaki complex.

The project took into account the need to preserve green spaces in the area, so the curving walkway is designed in such a way as to allow people to enjoy the trees planted around the station.

The uniquely and elegantly designed walkway cantilevers out from the buildings on either side and provides a roof over the bus stops and pavements below.

Owner: Kawasaki City / **Designers:** Urban Development Planning, M&M Design Office, Nippon Engineering Consultants Co. Ltd. / **Structural designer:** Nippon Engineering Consultants Co. Ltd. / **Constructor:** Taisei Corp., Iwakura Construction Co. Ltd., and Steel Pipe Construction JV

Photo: N. Kuroshima

Japan

All photos: N. Kuroshima

Ohizumi Station Pedestrian Walkway

- **Ohizumi Station, South Exit, Nerima, Tokyo**
- 2003
- Steel deck box girder (rigid frame) bridge
- Deck 1,500 metres^2, spans 10–36 metres, width 6.0 metres

Text by N. Kuroshima

This walkway was constructed as part of the Ohizumi-Gakuen North District Development Project. It connects the station concourse, surrounding buildings, bus stops and taxi stands in a gently sloping arc. The curved shaped allows light to reach the ground, while trees provide shade over the benches along the walkway, helping to make it more user-friendly.

Owner: Nerima Ward, Tokyo
Designer: Hideaki Tomooka, Nippon Engineering Consultants Co. Ltd.
Structural Designer: Nippon Engineering Consultants Co. Ltd.
Constructor: Konoike Corp, Nittoc Construction and Kawada Construction Co. Ltd. JV

Japan

Photo: Sumitomo Mitsui Construction Co. Ltd.

Seishun Bridge

- **Tsumagoi, Agatzuma District, Gunma Prefecture**
- 2006
- Single-span prestressed concrete bridge with double suspension structure
- Length 60.1 metres, main span 57.5 metres, width 2.0 metres

Text by M. Iso and M. Matsui
Photos: ©Sumitomo Mitsui Construction

A double suspension structure with two cables was adopted. The primary cable was used to support the deck load, while the secondary cable served to adjust the sag of the deck during construction. When the bridge was completed, both cables were transferred to the deck to convert the structure into a self-anchoring one. The U-shaped deck increases bending stiffness and reduces pedestrian-induced vibrations.

Owner: Tsumagoi Village
Designer: Sumitomo Mitsui Construction Co. Ltd.
Structural Designer: Sumitomo Mitsui Construction Co. Ltd.
Constructor: Sumitomo Mitsui Construction Co. Ltd.

Japan

All photos: M. Iso

Kokonoe "Dream" Suspension Bridge
(Kokonoe "Yume" Otsurihashi)

- **Tano, Kokonoe, Kusu District, Oita Prefecture**
- October 2006
- Single span unstiffened suspension bridge
- Main span 390 metres, width 1.5 metres
- The longest pedestrian suspension bridge in Japan

Text by M. Iso
Photos: © Kawada Industries Inc.

With a main span of 390 metres, the Kokonoe "Dream" Suspension Bridge is the longest pedestrian suspension bridge in Japan, spanning the Naruko Gorge at a height of 173 metres.

Owner: Town of Kokonoe
Structural Designer: Kyodo Engineering Co. Ltd.
Constructor: Kawada Industries Inc.

Japan

Hama Mirai Walk Footbridge

- **Nishi, Yokohama, Kanagawa Prefecture**
- 2008
- two-span, continuous steel deck, box girder (rigid frame) bridge
- two spans of 47.9 and 40.7 metres, deck width 10.4 metres
- 2011 JSCE Civil Engineering Design Prize

Text by N. Kuroshima

All photos: N. Kuroshima

The Hama Mirai Walk Footbridge spans the river Katabira and links the Yokohama East Exit and Minato-Mirai 21 areas. The footbridge is a tube-shaped deck which allows breezes to flow through it while providing shelter from wind, rain, snow, etc. The bridge is the integration of functional and aesthetic values achieved through modern technology.

Owner: City of Yokohama / **Designers:** Nippon Engineering Consultants Co. Ltd., M+M Design Office, and Nakajima Tatsuoki Lighting Design Laboratory Inc. / **Structural designers:** Nippon Engineering Consultants Co. Ltd. and Kanebako Structural Engineers / **Constructors:** ***Substructure:*** Kajima Corp. and Iwaki Kogyo Co. Ltd. JV, ***Superstructure:*** Yokogawa Bridge Corp., ***Shelter:*** Tsuboi Corp., ***Lighting:*** Kouyo Electric Equipment Co. Ltd., ***Deck:*** Techno-Japan Co. Ltd.

Photo: N. Kuroshima

Hama Mirai Walk Footbridge, Yokohama

Content

FOOTBRIDGES - SMALL IS BEAUTIFUL

European Council of Civil Engineers

ECCE member organisations

(Situation as per August 2014)

BULGARIA (BG)
СЪЮЗ НА СТРОИТЕЛНИТЕ ИНЖЕНЕРИ В БЪЛГАРИЯ
Union of Civil Engineers in Bulgaria
www.uceb.eu

CROATIA (HR)
Hrvatska komora inženjera građevinarstva
Croatian Chamber of Civil Engineers
www.hkig.hr

CYPRUS (CY)
Cyprus Council of Civil Engineers
(representing three organizations: Cyprus Civil Engineers & Architects Association, Cyprus Association of Civil Engineers, Union of the Chambers of Cyprus Turkish Engineers and Architects / Chamber of Civil Engineers)

CZECH REPUBLIC (CZ)
Český svaz stavebních inženýrů / Česká komora autorizovaných inženýrů a techniků činných ve výstavbě
Czech Institution of Structural and Civil Engineers / Chamber of Certified Engineers and Technicians
www.cssi-cr.cz / www.ckait.cz

ESTONIA (EE)
Eesti Ehitusinseneride Liit
Estonian Association of Civil Engineers
www.ehitusinsener.ee

FINLAND (FI)
Suomen Rakennusinsinöörien Liitto
Finnish Association of Civil Engineers
www.ril.fi

FRANCE (FR)
Ingenieurs et Scientifiques de France
Engineers and Scientists of France
www.iesf.fr (Associate Member)

GEORGIA (GE)
Georgian Society of Civil Engineers
www.gsce.ge

GERMANY (DE)
Zentralverband Deutscher Ingenieure
The Institute of German Engineers e.V. – ZDI
www.zdi-ingenieure.de (Associate Member)

GREECE (GR)
Σύλλογος Πολιτικών Μηχανικών Ελλάδος
Association of Civil Engineers of Greece
www.spme.gr

HUNGARY (HU)
Magyar Mérnöki Kamara
The Hungarian Chamber of Engineers
www.mmk.hu

FOOTBRIDGES - SMALL IS BEAUTIFUL

IRELAND (IE)
Engineers Ireland
www.engineersireland.ie

ITALY (IT)
Consiglio Nazionale Degli Ingegneri
National Council of Engineers
www.tuttoingegnere.it

LATVIA (LV)
Latvijas Būvinženieru savieniba
Latvian Association of Civil Engineers
www.buvinzenierusavieniba.lv

LITHUANIA (LT)
Lietuvos statybos inžinierių sąjunga
Lithuanian Association of Civil Engineers
www.lsis.lt

MALTA (MT)
Kamra tal Periti
Chamber of Architects and Civil Engineers
www.ktpmalta.com

MONTENEGRO (ME)
Inženjerska komora Crne Gore
Engineers Chamber of Montenegro - Civil Engineers Chamber
www.ingkomora.me

POLAND (PL)
Polska Izba Inżynierów Budownictwa
Polish Chamber of Civil Engineers
www.piib.org.pl

PORTUGAL (PT)
Ordem dos Engenheiros
Order of Engineers
www.ordemengenheiros.pt

RUSIA (RU)
Российское общество инженеров строительства (РОИС)
Russian Society of Civil Engineers
www.rois.ru

ROMANIA (RO)
Romanian Union of Civil Engineers Associations
www.utcb.ro

SERBIA (RS)
Inženjerska komora Srbije
Serbian Chamber of Engineers
www.ingkomora.org.rs

SLOVAK REPUBLIC (SK)
Slovenská komora stavebných inžinierov
Slovak Chamber of Civil Engineers
www.sksi.sk

SLOVENIA (SI)
Inženirska zbornica Slovenije
The Slovenian Chamber of Engineers
www.izs.si

SPAIN (ES)
Colegio de Ingenieros de Caminos, Canales y Puertos
College of Civil Engineering, Channels and Ports
www.ciccp.es

TURKEY (TR)
İnşaat Mühendisleri Odası
Turkish Chamber of Civil Engineers
www.imo.org.tr

UNITED KINGDOM (UK)
Institution of Civil Engineers (ICE)
www.ice.org.uk

European Council of Civil Engineers

European Council of Civil Engineers

was created in 1985 out of the common concern of the professional bodies for Civil Engineers in Europe that the Civil Engineers working together across Europe could offer much more to assist modern European society with sustainable designs, practical use of research & development, and economic and well funding structures.

OBJECTIVES

European Union

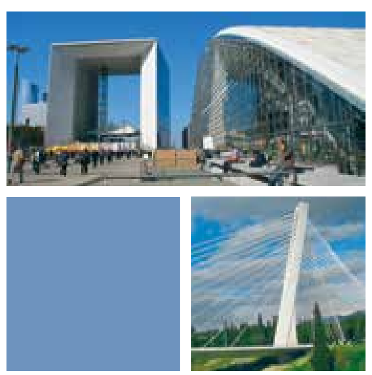
- Promote the highest technical and ethical standards;
- Provide a source of impartial advice;
- Promote co-operation with other pan-European organisations in the Construction Industry;
- Contribute towards professional recognition of qualifications and mobility in the framework of existing EU directives.

National Governments and Institutions

- Advice and influence individual governments and professional Institutions;
- Formulate standards and achieve a mutual compatibility of different regulations controlling the profession;
- Formulate standards for a European Code of Conduct of the Civil Engineering Profession and disciplinary procedures applicable throughout the Union.

Profession, Related Organisations and Industry

- Formulate guidelines to maintain and raise standards of civil engineering education; training and professionals' competence;
- Assist in achieving mutual compatibility of Eurocodes, standards and regulations in the related industry;
- Encourage and improve levels of safety and quality in the industry



CURRENT STANDING COMMITTEES & TASK FORCES:

Education & Training
Environment & Sustainability
Development & Business Environment
Knowledge & Technology
Associate Membership
Task Force Civil Engineering Heritage

ECCE MEMBERSHIP

The current membership is made up of member organizations from BULGARIA, CROATIA, CYPRUS, CZECH REPUBLIC, ESTONIA, FINLAND, FRANCE, GEORGIA, GERMANY, GREECE, HUNGARY, IRELAND, ITALY, LATVIA, LITHUANIA, MALTA, MONTENEGRO, POLAND, PORTUGAL, RUSSIA, ROMANIA, SERBIA, SLOVAK REPUBLIK, SLOVENIA, SPAIN, TURKEY, and UNITED KINGDOM.

MEMBERSHIP IN EUROPEAN AND INTERNATIONAL ORGANIZATIONS

ECCE is a member of World Council of Civil Engineers. (WCCE), European Council for Construction Research, Development and Innovation (ECCREDI), European Construction Forum (ECF) and also a member of the European Civil Engineering Education and Training (EUCEET) Association.
ECCE also maintains continuous and close cooperation with European Council of Engineers Chambers (ECEC), European Federation of Engineering Consultancy Associations (EFCA), World Federation of Engineering Organisations (WFEO) and European Federation of National Engineering Associations (FEANI).
ECCE has formal agreements with counterparts across the globe - American Society of Civil Engineers (ASCE), Japan Society of Civil Engineers (JSCE) and Korean Society of Civil Engineers (KSCE).

www.ecceengineers.eu

FOR MORE INFORMATION CONTACT

ECCE Secretariat: Maria Karanasiou, ECCE Secretary General

Thiras 49, 112 52, Athens, Greece

Tel./ Fax: +30 210 8623992 • E-mail: ecce_sps@otenet.gr

Registered Office: 1 Great George Street • Westminster • London SW1P 3AA • United Kingdom

Some details about the book

- the book contains 416 pages
- a total of 196 footbridges (179 in Europe and 17 in Japan) are presented in words and pictures
- the book contains a total of 613 photographs, including 43 two-page spreads
- important events in the history of bridge building are covered in a 34-page section
- more than 70 different authors from Europe and Japan have contributed to the book
- the book presents a rich and diverse selection of footbridges of various kinds, many of them world record holders
- both historic and modern bridges are included
- the key criteria for the selection of individual bridges were their technical and architectural features and characteristics, while some are simply attractive