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fib CEB-FIP

Bulletin 87



2018 *fib* Awards for Outstanding Concrete Structures

Presented at the 2018 *fib* Congress in Melbourne

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fib CEB-FIP Bulletin 87

2018 *fib* Awards for Outstanding Concrete Structures

October 2018

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COVER PICTURES Winners, Special Mention recipients and Exceptional Recognition recipient of the 2018 fib Awards for Outstanding Structures, from left to right:

- Replacement of the roof structure and main dome over La Laguna Cathedral, Spain
- R·Torso·C, Japan
- Takubogawa Bridge, Japan
- Yavuz Sultan Selim Bridge, Turkey
- Viaduct over River Almonte, Spain
- Footbridge over the Labe River in Čelákovice, Czech Republic
- Manta, Austria
- Utsikten View Point, Norway

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POSTAL ADDRESS
Case Postale 88,
CH-1015 Lausanne,
Switzerland

STREET ADDRESS
Swiss Federal Institute of Technology,
Lausanne
EPFL, Section Génie Civile, Office GC A2 424

TEL +41 21 693 2747
FAX +41 21 693 6245
EMAIL info@fib-international.org
WEBSITE www.fib-international.org

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2018 *fib* Awards for Outstanding Concrete Structures

Contents

3 President's Foreword
4 About the Awards
5 Chairman of the Jury's Foreword
6 Previous Awards: Category Buildings
7 Category Buildings
8 Winners
13 Special Mention
14 Nominees
18 Previous Awards: Category Civil Engineering Structures
19 Category Civil Engineering Structures
20 Winner
24 Special Mentions
27 Exceptional Recognition
28 Nominees
33 Index of Projects
34 *fib* Bulletins
37 *fib* Commissions
38 *fib* membership benefits
39 *fib* Model Code 2020

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President's Foreword



Concrete has been profusely used throughout History in order to satisfy the real needs of humankind: housing, shelter, industry and infrastructure. Since its early applications, concrete has been undergoing a continuous evolution due, firstly, to the inventiveness of builders and, more recently, to persistent researchers. In fact, within the last two decades, progress in concrete technology has allowed numerous and innovative improvements for a classical material whose cost-effectiveness and versatility remain unrivalled. Nevertheless, new challenges continuously arise, thus requiring new answers.

Concrete is the second most-used material in the world (second only to water) – up to more than one cubic meter for every person on Earth, according to some statistics published shortly before the global crisis of 2008. The quantity of concrete produced is so large that, although it is, in fact, a relatively low-carbon product compared to other construction materials, it nevertheless accounts for about 5% of CO_2 emissions of the world. Not surprisingly, therefore, there are colossal research efforts being made across the globe by cement and concrete producers to reduce the carbon impact, with considerable success. It is clear that we will not significantly reduce the amount of concrete used on Earth in the near future. However, we can carefully examine the way we use it.

The current efforts towards sustainability take existing structures into account. Indeed, many concrete structures or facilities are nearing the end of their service life. Therefore, in order to keep their performance above acceptable threshold values, they must be assessed, refurbished or, in some cases, demolished. In this last case, many of the old materials – including concrete – may be recycled, as recent experiences have proved.

The management of the life cycle of existing structures– erected when sustainability concepts were not yet considered – provides new opportunities in different fields of activities. These include conceptual attitudes and the basis of decision (maintenance engineering), new materials and techniques for repair and strengthening, as well as more interaction with other matters of concern, such as energy efficiency, reuse of materials or, among others, issues related to our cultural and historical heritage, considered from an updated perspective.

In this regard, a fundamental part of the mission of the *fib* is to synthesise the latest research in design and construction to facilitate innovation and the smart use of concrete. Our federation has produced outstanding contributions in the last years and is currently devoted to a new edition of the Model Code, expected to be completed in 2020. This huge task, based on the sound tradition of the past *fib*'s Model Codes, provides to worldwide users a consolidated synthesis of recent knowledge. The Model Code 2020 addresses both the design of new structures and the assessment and refurbishment of existing constructions, whose service life can be extended – perhaps for different purposes. There is no doubt that the enormous challenge of preparing such a document will contribute to the increased and improved use of concrete in the near future, inspiring updated supra-national and regional codes.

Considered from the above-described perspective, our Awards seek to recognise the outstanding, whether the concrete is visible or not, whether it is a new or an existing structure, making true once again the Vitruvian virtues: *Firmitas* (bearing capacity and durability), *Utilitas* (functionality) and *Venustas* (beauty, aesthetical adequacy) in mutual equilibrium.

I encourage you to leaf through this book, which contains some of the outstanding achievements of the worldwide Structural Concrete community during the past four years. I hope you will enjoy reading about the best new Concrete Structures as we present the Outstanding Concrete Structures Awards at the 5th *fib*'s Congress in Melbourne in October 2018.



fib President

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About the Awards

The *fib* Awards for Outstanding Concrete Structures are attributed every four years at the *fib* Congress, with the goal of enhancing the international recognition of concrete structures that demonstrate the versatility of concrete as a structural medium. The award consists of a bronze plaque to be displayed on the structure, and certificates presented to the main parties responsible for the work.

Applications are invited by the *fib* secretariat via the National Member Groups. Information on the competition is also made available on the *fib*'s website, and in the newsletter *fib*-news published in *Structural Concrete*.

The submitted structures must have been completed during the four years prior to the year of the Congress at which the awards are attributed. The jury may accept an older structure, completed one or two years before, provided that it was not already submitted for the previous award attribution (Mumbai, 2014).

The submitted structures must also have the support of an *fib* Head of Delegation or National Member Group Secretary in order to confirm the authenticity of the indicated authors.

Entries consist of the completed entry form, three to five representative photos of the whole structure and/or any important details or plans, and short summary texts explaining:

- the history of the project;
- description of the structure;
- particularities of its realisation (difficulties encountered, special solutions found, etc.).

A jury designated by the Presidium selects the winners. The awards are attributed in two categories, Civil Engineering Structures (including bridges) and Buildings. Two or three 'Winners' and two to four 'Special Mention' recipients are selected in each category, depending on the number of entries received.

The jury takes into account criteria such as:

- design aspects, including aesthetics and design detailing;
- construction practice and quality of work;
- environmental aspects of the design and its construction;
- durability and sustainability aspects;
- significance of the contribution made by the entry to the development and improvement of concrete construction.

The decisions of the jury are definitive and cannot be challenged. They are unveiled at a special ceremony during the *fib* Congress in Melbourne.



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Chairman of the Jury's Foreword



Since its inauguration in 1990 by the FIP, the Award for Outstanding Concrete Structures (AOS) has gained worldwide recognition as a prestigious award for structural engineers and designers responsible for the design and construction of buildings and civil engineering structures, respectively, which constitute the two categories of the competition. The Award is bestowed every 4 years on the basis of project submissions, which are evaluated by a jury of experts.

Following the rules of the Award, the *fib* National Member groups were invited to submit applications for the award by 31 December 2017. The submissions from non-*fib* countries were also welcome. A total of 25 entries were received from 14 different *fib* National Member Groups: 10 in the Buildings category and 15 in the Civil Engineering Structures category.

The AOS Jury is composed of the *fib* Presidium members and its Past Presidents. Its work follows the principles established by the Swiss Standard SIA 142. The following Jury members have been actively involved in the 2018 edition of the award (in alphabetical order): György L. Balázs (Hungary), Gordon Clark (England), Hugo Corres (Spain), Michael Fardis (Greece), Hans R. Ganz (Switzerland), Akio Kasuga (Japan; Buildings category only), Harald S. Müller (Germany), Aurelio Muttoni (Switzerland), Tor Ole Olsen (Norway), Larbi Sennour (United States), Joost Walraven (The Netherlands). The Jury members Iria L. Doniak (Brazil), Jim Forbes (Australia) and Giuseppe Mancini (Italy) contributed by sending their reviews to the Jury chair prior to the Jury meeting.

The Jury members received well-prepared copies of all entries on Feb. 2, 2018, for their personal review in order to prepare the Jury meeting, which took place in Madrid on Feb. 17, 2018, after the meeting of the *fib* Presidium. In order to make the full-day Jury meeting as effective as possible, the Jury members have been asked to identify their candidates for the Award Winners and the Special Mentions from the list of all entries. This was intended to facilitate the creation of a short list of award candidates in the first round of discussion at the meeting, to be followed by the second round of discussion which should be concluded by final voting.

During the Jury meeting each entry was first introduced by the chairman, and afterwards examined and discussed in detail by all Jury members. The Jury was particularly impressed by the excellent quality of the submitted entries. Most submissions proved to be outstanding in view of conceptual design, use of innovative materials and/or design procedures, taking into consideration environmental and sustainability aspects. These criteria played an important role in the Jury's evaluations of the submitted entries, as well as aesthetics and design detailing, construction practice, quality of work and durability aspects. Moreover, the significance of the entry's contribution to the development and improvement of concrete construction has been taken into consideration.

After the long and careful deliberations that followed the stepwise process mentioned above, the Jury selected unanimously a total of three structures as Award Winners, four structures as Special Mention recipients and one structure for an Exceptional Recognition. All nominees, Award Winners, Special Mentions and the Exceptional Recognition are presented in this brochure.

The Jury takes this opportunity to thank all the *fib* National Member Groups and applicants for their entries and sincerely congratulates all the Winners, the Special Mentions and the Exceptional Recognition recipients. In conclusion, all entries demonstrate excellence in concrete construction and contribute to fulfilling the mission of the *fib* through the advancement of the technical, economic, aesthetic and environmental performance of concrete construction.



Prof Harald S. Müller
Chairman of the Jury

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Previous Awards

Buildings

2014 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Centro Ovale Concrete Shell, Chiasso, Switzerland
- Park City Musahi Kosugi, Kawasaki, Japan
- Bella Sky Hotel, Copenhagen, Denmark

SPECIAL MENTIONS

- Shenzhen Vanke Center, Shenzhen, China
- Trollstigen View Point, Trollstigplataaet, Norway

2010 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- National Portrait Gallery, Parkes ACT, Australia
- Island Tower Sky Club, Fukuoka, Japan

SPECIAL MENTIONS

- Gyldendalhuset, Oslo, Norway
- Grand Rapids Art Museum, Michigan, USA
- Doha High Rise Office Building, Doha, Qatar

2006 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Turning Torso, Malmo, Sweden
- Shawnessy Light Rail Transit Station, Calgary, Canada

SPECIAL MENTIONS

- Forsterstrasse Apartment House, Zurich, Switzerland
- Tomorrow Square, Shanghai, China

2002 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Tower at La Défense, Paris, France
- The Scientia, University of New South Wales, Australia

SPECIAL MENTIONS

- City Library, Roermond, The Netherlands
- Engineering Design and Research Centre, Chennai, India

The *fib* awards continue the tradition of the former FIP Awards for Outstanding Concrete Structures, attributed from 1990 to 1998.

1998 FIP Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Waterfront Hall, Belfast, Northern Ireland
- Municipal Central Gymnasium, Osaka, Japan

SPECIAL MENTIONS

- Indoor swimming arena, Osaka, Japan
- Indoor stadium, Bangalore, India
- Laakhaven Hollands Spoor parking garage, The Hague, The Netherlands

1994 FIP Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Administrative building, Chennai, Tamil Nadu , India
- Tennis center, Yale University, USA

SPECIAL MENTIONS

- Auditorium, Hyderabad, India
- ANA Hotel, Sydney, Australia
- Hassan II mosque, Casablanca, Morocco
- Ministry of Social Affairs Building, The Hague, The Netherlands

1990 FIP Awards for Outstanding Concrete Structures

WINNING STRUCTURE

- La Grande Arche, Paris, France

SPECIAL MENTIONS

- New Parliament House, Canberra, Australia
- Thorp Receipt and Storage Facility, UK
- Sludge fermentation installation, Bottrop, Germany

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Buildings Category

From a total of ten entries, only eight entries could be considered for the AOS 2018 competition, as two buildings were completed too late (after June 30, 2017). The Jury strongly encouraged the authors to submit their excellent entries for AOS 2022.

The remaining buildings in the category cover a remarkably wide range of different structures. They include small family residence, a tall apartment building, a football stadium, a roof structure over a historical cathedral, a multi-level car parking building and a shell structure used as a canopy for events. The Jury was deeply impressed with the high quality of the entries, some of which have already received other awards.

All these buildings demonstrate one or more of the following special characteristics: extraordinary form, innovative design, innovative use of materials, special construction technology, excellent integration with the environment, successful use of exposed concrete, lightness and elegance, high-quality surface finishing, careful analysis of various loads and environmental effects, and meeting high sustainability requirements.

Subsequently, the two winning buildings and the special mention building are presented first, followed by the other entries in the order of their submission date.

The Jury is convinced that these structures – which demonstrate the versatility of concrete application – will contribute to the wide acceptance and appreciation of the use of concrete for buildings of any kind and nature.

Prof Harald S. Müller
Chairman of the Jury







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La Laguna Cathedral roof & dome replacement

Replacement of the roof structure and main dome over La Laguna cathedral Tenerife, Spain

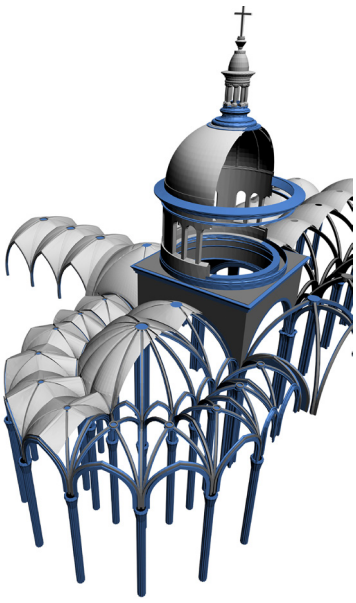


The historic centre of San Cristóbal de La Laguna, one of the most significant examples of Spanish colonial urban design, has maintained its grid layout intact since the late 16th century. In 1999, it was declared a UNESCO World Heritage Site. The Cathedral is the most prominent of the 400 buildings in this complex. Built over an early 16th-century structure, the former Nuestra Señora de los Remedios Church attained Cathedral status in 1818 with the establishment of the Tenerife bishopric under a papal bull issued by Pope Pious VII. As a result of extensive damage induced by differential settlements, the building was declared in ruins in 1897 and completely demolished, except for the neo-classical façade. It was rebuilt between 1905 and 1913 to plans drawn by engineer José Rodrigo Vallabriga. He left the main façade unaltered and, to hasten construction and consequently lower costs, he used a then novel technology, partially reinforced concrete, to build the present domed neo-gothic cathedral.

The trade-off for these benefits was the risk associated with the use of a scantily understood technology. Indeed, less than 100 years after its reconstruction, due to many types of deterioration observed, including extensive corrosion and spalling, the roof was propped and the cathedral closed for fear that it could not be safely visited. Although a reliability based assessment of the damaged load bearing system showed that structural safety requirements were fulfilled for the future service life, the temple was so profoundly deteriorated that the roof had to be replaced entirely, in spite of the strict construction constraints to protect the heritage quarter's integrity.

Reconstruction began on the sound part of the existing columns, underneath the capitals, and included the domes of the nave and two side aisles, the chapels, the transept with the main dome, the chevet and the ambulatory. The new roof was to respect the 1913 geometry of the cathedral while improving its appearance by designing all proportions to or near the golden ratio. Natural lighting and ventilation were also to be improved by introducing openings at the top of each dome.

The structural solution included building short columns between the established demolition level and the top of the former capitals, which supported the arches and shells of the adjacent domes. New mouldings would then emulate the finish on the capitals and ribs in keeping with the Gothic style of the cathedral. In addition to honouring the original geometry (barring the golden ratio criterion), a second architectural requirement had to be met: the new mouldings had to be continuous and aligned with the existing ornaments on the non-demolished part of the columns.



In situ concrete domes were the best solution to comply with the difficult geometric and economic limit conditions. No expansion joints were provided between the different parts of the roof. Moreover, the new domes were connected to the existing columns and walls in a manner that ensured the overall system would work monolithically. The

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new members and the connections to the existing structure were designed not only to withstand all foreseeable events and effects but also to absorb sufficient energy, in order to meet basic robustness requirements.

In light of the limited durability exhibited by the former roof, the use of steel reinforcement was avoided. Since the most significant actions would primarily induce membrane compression forces, no mesh or bar reinforcement was envisaged for the very thin shells: rather, these elements were built with polypropylene fibre-reinforced self-compacting concrete (PFR-SCC). For the same reason, the short columns and the arches were reinforced with glass fibre-reinforced plastic (GFRP) rebars. Post-installed starter bars of the same material were placed in the connections between the existing and new structural members.

Given the geometry of the new roof, as conditioned by the aforementioned requirements, the overall load-bearing system was designed around the need to ensure a monolithic structure. In the typical domes, a quadratic cross-section was envisaged for the bottom of the short columns, identical to the core of the existing columns to which they were to be connected. In contrast, the side dimension was gradually increased toward the top of the capital for connection to the respective mouldings with no need for intermediate elements. Each arch, associated with the shell, constitutes a T-shaped cross-section. Given the 0.08 m depth of the shells, the cross-sections of the downstanding arches were designed as rectangles, 0.2 m wide, whereas the diagonal arches were 0.28 m and the side arches 0.2 m high. The diagonal arches were connected at the key of the dome to a compression ring with a rectangular cross-section and an internal diameter of 0.6 m to accommodate the natural lighting and ventilation device.

The main dome was designed conceptually to the same principles as the typical domes to ensure that the entire structure





– including 'cimborio', drum and sphere with its tensile ring – would be monolithic. The 'cimborio' was connected to the four existing columns on which it rests. It was likewise connected to the side arches of the adjacent typical domes in the lower roof. Voids were built into the upper 'cimborio' to reduce the volume of concrete and consequently its selfweight by placing polystyrene cylinders between the reinforcement bars. That procedure obviated the need for costly formwork.

The new roof construction, characterised by complex geometry and small dimensions, called for high-performance concrete, particularly in terms of compaction, durability and surface quality. The performance of PFR-SCC was assessed to technical, economic and constructability criteria to determine the optimal mix design. Since the addition of fibres lowers concrete self-compaction capacity, different mix designs were extensively tested to determine compressive and flexural strength, modulus of elasticity, toughness and water permeability. Additionally, in order to reduce to acceptable levels the uncertainties associated with innovative technologies, as well as for optimisation of materials, processes and ancillary facilities, a full scale prototype of a typical dome was built and tested prior to the construction of the new roof.



OWNER Nivariense Diocese
MAIN AUTHORS José Miguel Márquez (Architect), Peter Tanner, David Sanz and Juan Luis Bellod (Structural Engineers)
OTHER PARTICIPANTS Roberto Molinos (building information modelling), Antonia Pacios and David Revuelta (Concrete mix design)
CONTRACTOR Víctor Rodríguez e Hijos, S.L.U.
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Private micro-house made of 100 % recyclable concrete
Tokyo, Japan

"We want to see exposed concrete finish inside and outside. We want a distinctive piece of architecture that is at the same time environmentally conscious." These were the initial requests of the clients. With those words as a starting point, an interdisciplinary project team was formed to develop a new environmentally-friendly concrete.



The depletion of natural concrete aggregate has long been a serious problem in Japan. River sand is getting scarce and it has been replaced by the gravel scraped from the bottom of the ocean. However, most local governments have banned the use of sea gravel for environmental reasons. One alternative is to use crushed recycled concrete; however, this requires a lot of energy for its production, thus resulting in a problematic mass emission of CO_2.

Ancient Roman concrete is known for its strength and longevity. Modern concrete is designed to last roughly 50 to 120 years, while Roman concrete structures have survived nearly two thousand years. Studies have established that the durability of Roman concrete comes from its use of volcanic ash. Many volcanoes are still active in the Japanese archipelago. As a result of a pyroclastic flow that occurred around 25 thousand years ago, SHIRASU was deposited abundantly in Kagoshima. SHIRASU was used before in civil engineering, but not in architecture.

SHIRASU is used as fine aggregate in the concrete developed to build R·Torso·C. The strength and durability of the resulting concrete are expected to increase because of its pozzolanic reaction. Portland blast furnace slag cement type B was used to achieve low-carbon emissions. Limestone macadam and limestone sand were chosen as aggregate and, together with SHIRASU, made the concrete 100 % recyclable as well as to control the drying shrinkage cracking.

SHIRASU Concrete has five main benefits: it contributes to the preservation of natural resources, it is strong and durable, it is environmentally friendly and it has a smooth surface as well as humidity-controlling qualities.

The columns and walls are the same thickness in the rigid-frame structure; 220 mm is the minimum thickness that satisfies the anchorage length and the bending of the reinforcement bars. Since the structure is essentially a "frame-structure", it does not have to meet the specification of the "box frame construction". Therefore, it is more flexible as far as the location of the openings is concerned. The challenge was to arrange all the structural members and components within the 220 mm thickness limit while maintaining a polyhedron form. Tests on a full-scale mock-up of a part of the structure with the actual





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amount of reinforcement bars showed that SHIRASU Concrete demonstrates high potential.

In high-density residential districts in Tokyo, such as this site, one seldom has the luxury of large open spaces, let alone visual or physical connection with vast nature. The only direction one can turn to for this factor is the sky. The architect has studied this theme and has established a number of ways to approach the sky as an element of nature. In this house, it was achieved by "pruning" the corner of a rectangular volume at an angle. Large openings facing the sky become an effective means to incorporate the feeling of vastness into the compact internal space.

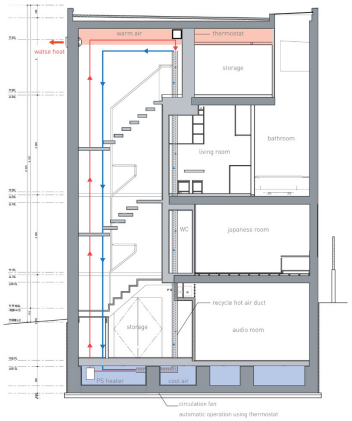
To secure a comfortable indoor climate, a "thermal circulation system" was incorporated. This system makes use of the stacking effect in the four-story stairwell, which is opened to the spaces on each floor. In the winter, the warm air that accumulates in the upper part of the house is automatically transferred to the pit below the basement floor through a ventilation duct and reversible fan connected to a thermostat. An electric radiator is added in the pit for the extra heat needed in the coldest season. In the summer, the chilled air from the pit is sent up to the third floor and flows down into the pit again, cooling the entire house.

The three essential methods for micro-house design are "NU-KE", the simultaneous contemplation of plan and section, and colour and texture. Using visual and psychological connections between interior and exterior, "NU-KE" "enlarges" space and adds depth by multi-layering of walls and spatial volumes. Some corners were pruned





from the rectangular building to create "NU-KE" towards the sky, which is the last vast piece of nature left in Tokyo. The materials used inside the house are exposed concrete, charcoal-stainedwooden-boards, persimmon-tanned wooden boards, hammered steel, black stainless steel, oxidized black silver plate, etc. The colours of these luxurious materials are unified by grey and black undertones. Moreover, the surface of these mateirals are all matt. This attention to colour and texture creates unity and makes spaces rich and interesting, giving a sense of blurred boundaries adding to the spacious feeling.



OWNER Koshiro & Junko Katayama
MAIN AUTHORS Yasuhiro Yamashita (Architect), Jun Sato & Takafumi Noguchi
OTHER PARTICIPANT Hiroyuki Yamada (Mechanical Engineer)
CONTRACTOR Shigeki Matsuoka
SUBCONTRACTORS Tsukasa Ito (Concrete manufacturer) and Kazuro Higashi (SHIRASU supplier)
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Development of New Construction Methods





1. Lafnitz Bridge (ASFINAG Bau Management GmbH)
   First application of balanced lift method 2018

2. Egg-Graben Bridge (Land Salzburg)
   Bridge deck without reinforcement
   fib AOS Award 2014

3. Manta Shell (ÖBB Infrastruktur AG)
   Pneumatic forming of hardened concrete
   fib AOS Special mention 2018

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Vienna | Austria

INSTITUTE OF STRUCTURAL ENGINEERING
PROF. JOHANN KOLLEGGER
www.betonbau.tuwien.ac.at



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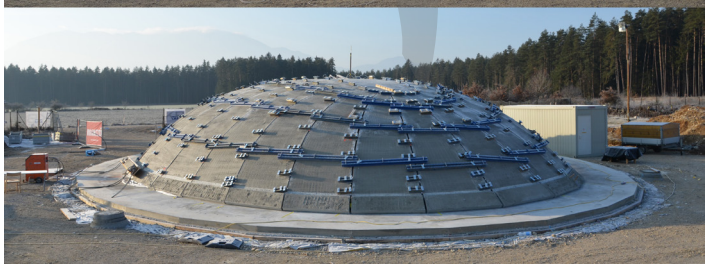
Manta, constructed with Pneumatic Forming of Hardened Concrete Bleiburg, Carinthia, Austria

Concrete shells are aesthetic and economic supporting structures if properly designed. They can absorb high loads and can span large areas with little material. Unfortunately, high costs caused by the complicated formwork prevent a wider use in practice.

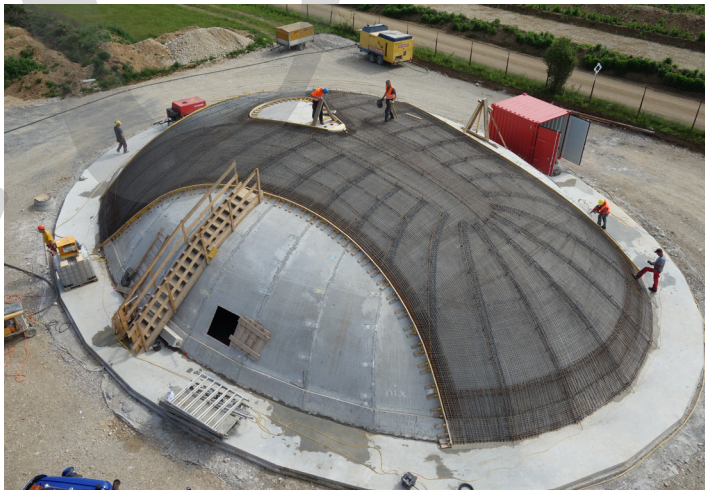


The designers developed a new shell construction method – called Pneumatic Forming of Hardened Concrete (PFHC) – in the past years within the research project "Free formed surfaces out of concrete" at TU Wien. The idea is to simplify the production of concrete shell structures by bending a thin flat hardened concrete plate to a double curved shell structure. The flat hardened concrete plate is lifted by inflating an air cushion placed underneath the concrete plate and by tensioning post-tensioning tendons mounted around the circumference. Thus, the complicated spatially curved formwork and falsework are not required anymore. The method allows constructing complex concrete geometries with a positive Gaussian curvature without any formwork or falsework.





The next development step was to use the construction method for a first practical application. On behalf of the Austrian Railways (ÖBB-Infrastruktur AG), two concrete shells – an event canopy and a concrete shell bridge serving as a passageway for animals over the two rail tracks of the new Koralmbahn – were built in Carinthia in Austria. "Manta" is a lightweight concrete shell structure constructed with this newly-invented construction technique. The project is the first large-scale application of the construction method and proves its practical applicability. In the first work step, the flat 80 t heavy and 50 mm thick concrete plate with the plan measurements of 28.3 m by 21.4 m was transformed into a double curved shell with the plan measurements of 26.5 m times 19.1 m and a height of 4.2 m by the use of PFHC. After the erection process was finished, additional reinforcement was placed and an in-situ concrete layer was cast in the required areas. In the following work steps, openings were cut out according to the design and the edges were sealed. The building is now used as an event canopy.



After the completion of the event canopy, the second structure, the shell bridge, was built (plan dimensions 36.2 × 38.7 m^2, height 8.1 m). The shell bridge was successfully completed in the spring of the year 2018. It shows that the new shell construction method can also be applied for large-dimension projects.

OWNER ÖBB-Infrastruktur AG
MAIN AUTHORS Johann Kollegger, Benjamin Kromoser, Martin Ritt, Thomas Pachner & Hinko Jusufagic
OTHER PARTICIPANTS Hannes Kari, Gerhard Oberlerchner, Karin Gradenegger
CONTRACTOR Kostmann GmbH
COMPLETION June 2017

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Nominees

Buildings

Knapphullet
Sandefjord, Norway



Knapphullet is a small annexe to a family holiday home situated in Sandefjord, a coastal town 120 km south of Oslo. The house nestles between large rocks surrounded by low vegetation, a typical example of a Norwegian coastal landscape.

Knapphullet is only 30 square meters but contains an open living space with a small bathroom and a mezzanine bed that sleeps two people. Although the building occupies such a small footprint, the space expands vertically over four levels including a roof terrace.

The project started with an idea of how to utilize this naturally sheltered area surrounded by large rocks and dense vegetation. The idea developed to create a way to climb up from this shelter to see the panoramic view over the sea, which led to the characteristic shape of the roof: a stepped ramp leading up from the terrain to the top of the roof, connecting to the landscape beyond.

The roof is executed in 270 mm thick reinforced concrete with 20 mm VIP insulation underneath. The concrete itself is watertight, thus no additional roofing materials are required. As a result, the roof is a smooth white surface creating a dialogue with the rocky landscape, and giving the cabin its distinctive character.



OWNER Svein Lund
MAIN AUTHORS Svein Lund & Solveig Sandness
CONTRACTOR Slaks as
COMPLETION June 2014

Villa Holtet-Larsen
Stange, Norway



Villa Holtet-Larsen is a unique single-family residence, all in cast-in-place concrete, situated along the Eastern shores of Mjösa, Norway's largest lake, located in a quiet, ordinary neighborhood of mostly traditional Norwegian timber houses.

All the surfaces in the house are in concrete outside and inside. The only exceptions are the wooden floors in the large living room and bedrooms, and in the entrance area.

The budget, which was quite generous in the beginning, allowed for onerous solutions and principles: stairs need not be placed above each other, rooms could span two floors, and openings for daylight and views could be tailored to the different specific uses within the house.

The load bearing cast in place concrete also allowed for compelling constructions both in the exterior and the interior, enabling cantilevering of stairways, roofing, terraces, galleries, etc.

The outer walls are sandwich construction with foam insulation, simultaneously cast both inside and outside with the insulation held firmly in position. The concrete work is very high quality.



OWNER Urda Larsen & Tom Olav Holter
MAIN AUTHORS Carl-Viggo Hölmebakk, Terje Maelum & Finn Erik Nilsen
CONTRACTOR M Grönvold as
COMPLETION September 2013

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Trobe Tower
Melbourne, Australia



The 133 m high, 44-level La Trobe Tower used an innovative construction method. It is the first Australian high-rise project to use design for manufacture and assembly construction methods, and its successful installation has led to interest from overseas builders keen to adopt this method.

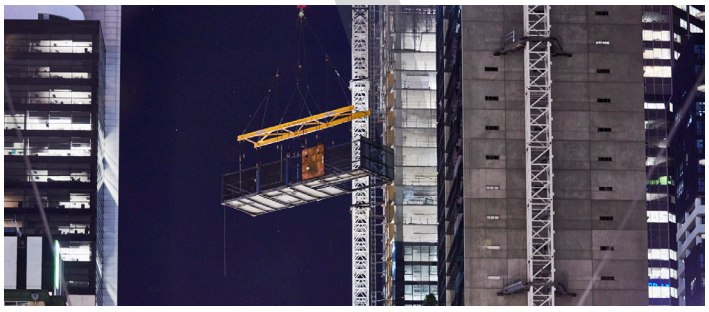
It uses a structural system that integrates the concrete core, shear walls, GRC bath pods and façade of a building into individual structural units ("modules") which are built ex-situ and in parallel with on-site works.

Flexibility is a key differentiator of this system, setting it apart from modular systems that are restricted to low and medium-rise building projects.

This application is one of the first examples of integrated, prefabricated construction for a high-rise project, which performs equally in capability to conventional cast in-situ construction systems.

Key innovative concrete structural elements introduced into the building method include shear wall/core construction system, a hybrid system using precast wall and shotcreting, precast sliding load-bearing walls assembled between modules, and lightweight composite concrete floor system to enable ease of transportation and erection.

The key benefits of this type of construction include: a reduction in building time and labour required as compared with a conventional on-site approach, an increase in safety by reducing the need to work at heights and removing the live edge from site by preinstalling the façade and pouring the building slabs off site, and delivering materials to the point of fabrication eases onsite construction logistics.



OWNER Longriver Group
MAIN AUTHORS Shan Kumar
OTHER PARTICIPANTS Rothelowman architect & Rocco Carinci
CONTRACTOR Hickory Building System
SUBCONTRACTOR Mitchcon
COMPLETION November 2016

Infosys Multi Level Car parking - 2
Pune, India



This structure was a truly challenging project. It is entirely made of concrete, without any other materials or finishes. It is a combination of concrete prefabricated elements and in-situ concrete. All aspects of design, viz architectural, structural, façade landscape and MEP services were tested to perfection and accuracy to achieve sustainability.

The execution of this project was a challenge with the use of a 50-ton rail mounted tower crane inside the footprint and complex transportation requirements. There was a total of 3,500 elements in the building, consisting of 16 m span precast TT slabs and 15 m PC columns. The structure was built with 1,300 concrete façade elements, each around 7 m long and weighing 2.5 tons, triangular in profile, set up in around 160 days on site. The challenges involved complex structural design in seismic zone 3, combining the structural and façade elements, methodical connections between column and column, beam and column, column and spandrel, spandrel and façade element, façade element to element.

This project has a unique self-designed and electronically-managed factory and site construction site coordination, culminating in the installation of all 3,500 elements within an erection tolerance limit of more or less 10 mm. This was made possible as a result of constant coordination and exchanges between all the stakeholders including design, planning, production, transportation and installation of all the elements. It was ultimately featured on the cover page of the *fib* Bulletin 78.



OWNER Infosys Limited
MAIN AUTHORS Ajit Bhate
OTHER PARTICIPANTS Spyridon Tsoukantas & Tryfon Topintzis
CONTRACTOR Precast India Infrastructures Private Limited
SUBCONTRACTOR Bhate & Raje Construction Company Pvt. Ltd
COMPLETION November 2015

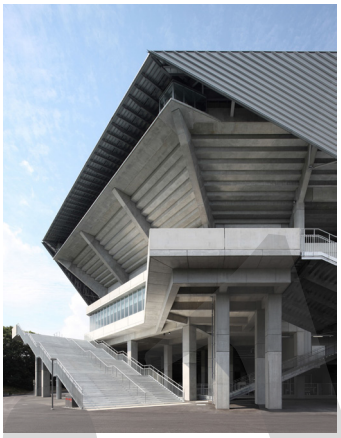
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Nominees

Buildings

Suita City Football Stadium

Suita, Japan



The Suita City Football Stadium is the first stadium built in Japan to be funded by donations. It can accommodate 40,000 spectators, making it the largest stadium in the western part of Japan. The stadium was built as the home stadium for Gamba Osaka, a member of Japan Professional Football League J1.

In order to reduce the construction period of the stadium, the adoption of a new construction system for the concrete structure of the stands was essential. As the number of construction workers has declined due to Japan's ageing population, reducing work tasks in the field during the construction of the stadium was necessary by adopting precast concrete elements manufactured in a factory and on site.

Although a cast-in-situ method was used for columns, precast concrete elements were adopted for beams and beam-column connections which were all manufactured in a factory. When a precast beam with integrated beam-column connections was placed on columns, columns' rebars were passed through holes in the precast beam-column connections. Subsequently, a rigid frame was completed by grouting the gaps around rebars.

Precast prestressed concrete beams were adopted to reduce beam-sections and to suppress cracks. In addition, by limiting the types of beams, precast elements which were constructed on-site were used. Precast concrete elements were employed not only in the superstructure but also in the foundation structure where 206 precast pile caps and 460 precast grade beams were used.



OWNER Longriver Group
MAIN AUTHORS Hisato Okude, Ohno Masahito & Takashi Kihara
OTHER PARTICIPANTS Hirokazu Nozawa, Shigehiko Ohira & Tomoyuki Hamaya
CONTRACTOR Takenaka Corporation
COMPLETION September 2015

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Previous Awards

Civil Engineering Structures

2014 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Egg-Graben Bridge, Valley of Grossarl, Austria
- Térénez Bridge, Rosnoën (Brittany), France

SPECIAL MENTIONS

- Hoover Dam Bypass, Clark Count Nevada, USA
- Kalisindh Thermal Power Project, Jhalawar, Rajastan, India
- Pedestrian Bridge Albstadt Lautlingen, Albstadt Lautlingen, Germany
- Sustainable Modular UHPFRC Bridge, Rotterdam, The Netherlands

2010 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Svratka River Pedestrian Bridge, Brno, Czech Republic
- Third Millennium Bridge over the Ebro River, Zaragoza, Spain
- Wadi Abdoun Bridge, Amman, Jordan

SPECIAL MENTIONS

- Ferney Tunnel, Geneva, Switzerland
- Navia Viaduct, Asturias, Spain
- Adriatic LNG Terminal GBS, near Rovigo, Italy

2006 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Rion-Antirion Bridge, Gulf of Corinth, Greece
- Floating Breakwater, Monaco
- Seiun Bridge, Tokusima, Japan

SPECIAL MENTIONS

- New Svinesund Bridge, Norway-Sweden
- Flaz River Bridges, Samedan (Grisons), Switzerland
- Infante Dom Henrique Bridge, Porto, Portugal

2002 *fib* Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Bras de la Plaine Bridge, La Réunion, France
- Vltava River Metro Tunnel, Prague, Czech Republic
- Sart Canal Bridge, La Louvière, Belgium

SPECIAL MENTIONS

- Tensho Bridge, Miyazaki, Japan
- TGV Viaducts, Avignon, France
- Ticino Bridge, Villa Bedretto, Switzerland

The *fib* Awards for Outstanding Structures continue the tradition of the former FIP Awards for Outstanding Concrete Structures, attributed from 1990 to 1998.

1998 FIP Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Normandy Bridge, France
- Great Belt East Bridge, Denmark

SPECIAL MENTIONS

- Lerez River Bridge, Spain
- Heidrun tension leg platform, Norway
- Odawara Blueway Bridge, Japan

1994 FIP Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Skarnsundet Bridge, Norway
- Vranov reservoir footbridge, Czech Republic
- Breakwater jetty, Sakai, Japan

SPECIAL MENTIONS

- Bray Viaduct, North Devon, UK
- Helgeland Bridge, Leir Fjord, Norway
- Bridge over the Isère, France
- Kikki Pedestrian Bridge, Japan

1990 FIP Awards for Outstanding Concrete Structures

WINNING STRUCTURES

- Pedestrian Bridge across the Altmühl River, Germany
- Oosterschelde storm surge barrier, The Netherlands
- Gullfaks C oil platform, Norway

SPECIAL MENTIONS

- Parana River Bridge, Argentina/Paraguay
- Beppo Myoban Bridge, Japan
- Ekofisk Oil Drilling Platform protecting wall, Norway
- Elbe River Bridge at Podebrady, Czech Republic

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Civil Engineering Structures Category



From a total of 15 entries, only 13 entries could be considered for the AOS 2018 competition. One bridge structure was completed too late to be included. The Jury strongly encouraged the authors to submit their excellent entry for AOS 2022. The second entry was an 18km-long expressway that included 17 bridges and other structures. It could not be considered as a single engineering structure as specified in the call for entries. The remaining thirteen civil engineering structures constitute a diverse group of structures that includes different kind of bridges (prestressed concrete, suspended, cable-stayed, extradosed) for cars, trains, bikes and pedestrians, avalanche galleries, a viewpoint and a covering structure of a railway in a city centre.

The Jury was impressed by the careful selection of structural systems and construction technologies, use of innovative concrete materials, integration of the structure into its surroundings, the elegance, originality and beauty in form and appearance, the high-quality surface finishing, serious consideration for earthquake loads, reasonable use of resources for supporting sustainability, as well as the effectiveness and the short period of the construction work. Some of the civil engineering structures break records for concrete structures and have already received other awards. The Jury decided that one civil engineering structure – a combination of a steel and a concrete bridge and thus not meeting completely the AOS entry criteria – had to be awarded by an Exceptional Recognition, due to its outstanding design, dimensions and elegance, breaking several records.

Subsequently, the winning civil engineering structure, the three special mentions and the exceptional recognition structure are presented first, followed by the other entries in the order of their submission date. All these projects emphasise that the selection of structural concrete as a building material may provide optimal solutions regarding technical, aesthetic, economic as well as sustainability aspects.

Prof Harald S. Müller
Chairman of the Jury









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Takubogawa Bridge

10-SPAN CONTINUOUS BUTTERFLY WEB BOX GIRDER HIGHWAY BRIDGE
MIYAZAKI, JAPAN



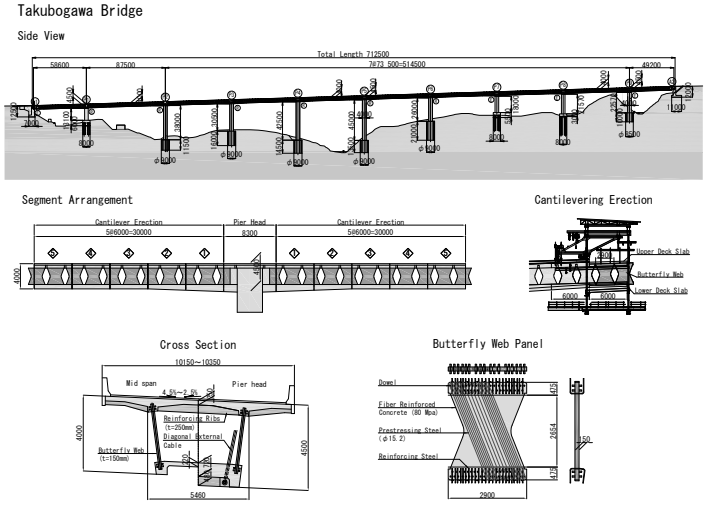


The Tokugawa Bridge is a 10-span continuous butterfly web box girder highway bridge, whose longest span is 87.5 m. "Butterfly Web Bridge" is a new type of bridge structure and this bridge is the world first application of this structure. The "Butterfly" name comes from factory-fabricated web panels shaped like butterfly wings. This bridge project was started in August 2010 and was completed in August 2013.

This characteristically shaped web forms a structure that exhibits a behavior similar to that of a double Warren truss. Due to the butterfly shape of the panels, the shear forces acting on the web are primarily transferred to the panels as compressive and tensile strength. In this structure, the concrete resists the compressive forces transferred to the panels, whereas the tensile forces are counterbalanced by the compressive stress due to prestressing steel. The panels used as webs are placed in the direction of the bridge axis independently of one another, barely affecting the prestressing in the bridge axis direction. Moreover, this is a simple structure in which the panels are connected to the upper and lower deck slabs linearly using dowels with no need to connect adjacent panels, thus facilitating a rapid construction.

In order to confirm the behavior of the butterfly web panel – a member made into an unprecedented shape – a 3-D elastic FEM analysis was conducted to examine the stress distribution under loading. Based on these analysis results, loading tests were also conducted on 1/2-size specimens to confirm the consistency between the actual and the analyzed behaviors. The analysis results agreed with the test results, demonstrating that the behavior of the butterfly web panel can be simulated by analysis. In addition, a nonlinear 3-D FEM analysis was conducted to confirm the behavior of the entire bridge after panels damage under increased loads. The analysis results revealed that, after yielding of prestressing steel in the panel under the largest shear force, damage does not progress concentrically in the panel. Instead, prestressing steel in adjacent panels yields in a progressive manner, demonstrating the ductile behavior of this structure.

The concrete for butterfly web panel was developed based on the concept that it should be composed of commonly used materials instead of special materials so that it can be produced at as many plants as possible. Since the only reinforcing bars to be embedded in the panels were prestressing steel, the thickness of the panels was also restricted by the bar layout. For this reason, the design strength of concrete was set at 80 MPa so that the design-related requirements would be met with that thickness. The target strength was decided to be 100 MPa in consideration of the material variability. Moreover, steel fibers were used to prevent shear failure at the narrowed centers and



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cracking in the anchorages of prestressing bars. Based on testing of various types of reinforcing fibers, steel fibers of diameter 0.2 mm and length 22 mm were selected from among the cases that attained the target strength as those requiring the smallest fiber content and easily available.

As described above, butterfly web panels use an innovative material with steel fiber mixed into 80 MPa high-strength concrete. The panels are 150 mm thick and the prestressing steel components are 15.2 mm diameter strands with etched surfaces to enhance the adhesion of concrete. There is no reinforcing steel, which makes the panels easy to work with and facilitate their maintenance. In addition, this material is extremely durable and represents a powerful technique for reducing the weight of concrete bridges. The butterfly web weight used for Takubogawa Bridge is 3 tons. This bridge is constructed according to the free cantilevering method and because of its lightness, the girder enables an erection segment length 1.5 times longer than that of ordinary cast-in-situ box girder. Consequently, a construction segment length of 6.0 m could be used, equivalent to the length of two butterfly web panels on each side of the bridge. Moreover, since the butterfly web panels are not continuous in the longitudinal direction, there is no need to join adjacent web elements, which also enhances execution efficiency. As a result, the construction speed of cantilevering can be increased about 50 % compared to conventional cast-in-situ box girder method.





It is important to reduce the superstructure weight in an earthquake-prone country like Japan. Therefore, corrugated steel web bridges have been used in many projects. However, high maintenance cost will be required to keep the durability of the structure during their designed lifetime. This new type of bridge meets the requirement of lightness and low maintenance. In addition, the use of butterfly web reduces the weight of the superstructure by 10 % compared to the conventional cast-in-situ box girder, enabling a size reduction of the substructure as well. As described above, this structure is effective for rapid construction. For these reasons, this structure can help reduce construction costs as well as the environmental impact compared to a conventional structure. This makes Takubogawa Bridge a sustainable structure.

OWNER West Nippon Expressway Co., Ltd
MAIN AUTHORS Akio Kasuga, Kenichi Nakatsumi & Kenichi Kata
OTHER PARTICIPANTS Kenichiro Ashizuka & Kenji Miyamoto
CONTRACTOR Sumitomo Mitsui Construction Co., Ltd
SUBCONTRACTOR Sumitomo Steel Wire Corporation
COMPLETION August 2013

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VIADUCT OVER RIVER ALMONTE

HIGH SPEED RAIL LINE MADRID-LISBON

HS RAIL CONCRETE ARCH WORLD RECORD, WITH A MAIN SPAN OF 384 m

CONCEPTUAL DESIGN

DETAILED DESIGN

TECHNICAL ASSISTANCE, SITE CONTROL AND CONSTRUCTION SUPERVISION

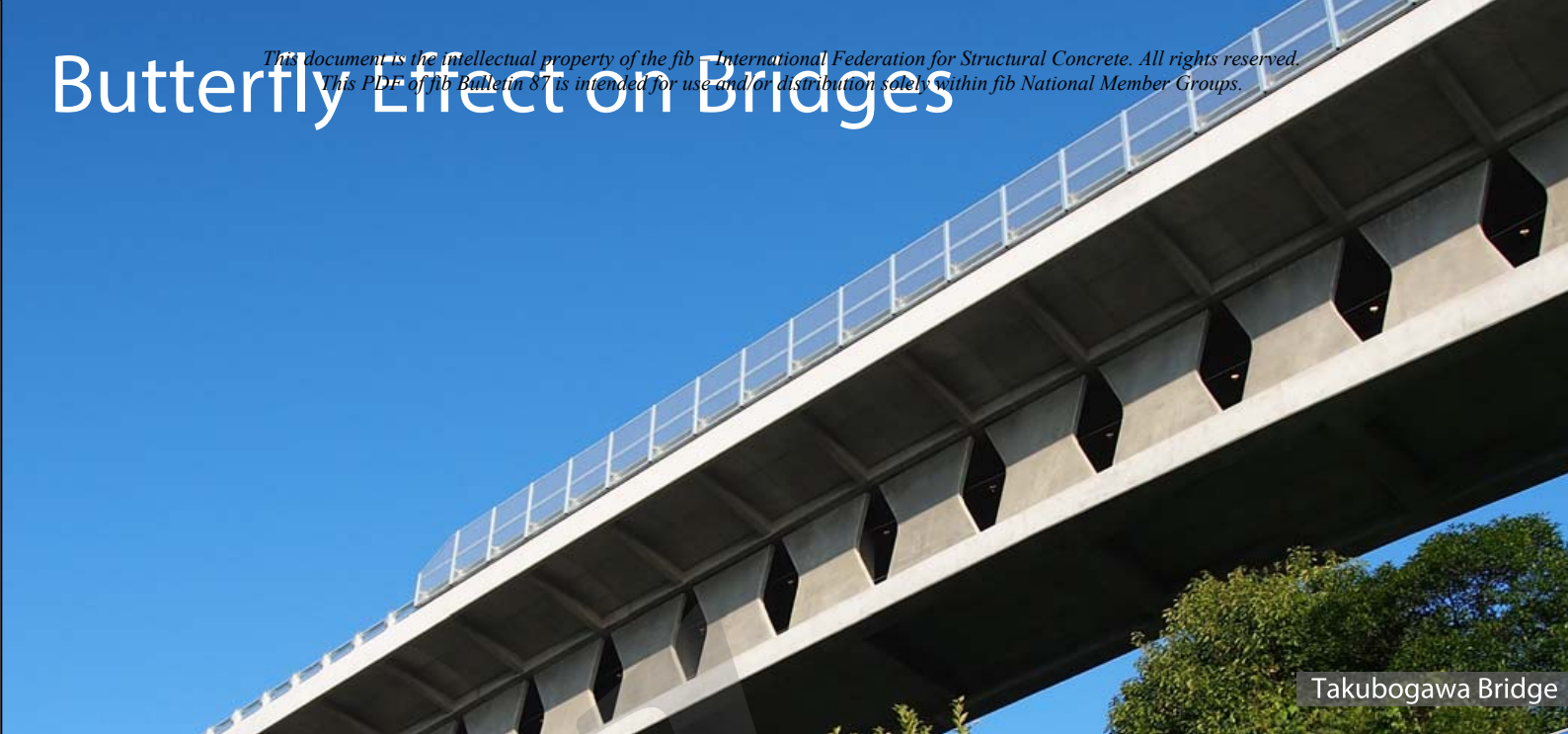


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Butterfly Effect on Bridges



Takubogawa Bridge



Mukogawa Bridge



Akutagawa Bridge



Okegawa Viaduct

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https://www.smcon.co.jp/en/

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Utsikten Viewpoint in Gaularfjell, Norway



Eighteen carefully selected roads in Norway have been designated National Tourist Routes. National Tourist Routes are roads that take you through the most beautiful scenery Norway has to offer. Half of the routes are in Fjord Norway. Picnic areas with exciting architecture have been built along the routes to enable road users to enjoy the views and the weather, take photos, have a bite to eat and explore the unique Norwegian scenery. Several of these picnic areas have been built in concrete, and several have been awarded both national and international prizes. Utsikten ("The Viewpoint") is such a picnic area and a viewing platform along the National Tourist Route Gaularfjellet.

The concrete structure is a large, triangular concrete platform with sides stretching up to 49 meters (160 ft) situated right next to the road. The platform is 80 cm (32 inches) thick but appears to rest lightly atop the terrain with raised, wing-like corners that protrude upwards into the air.

The corners all fulfil special functions. One wing stretches towards the East over the steep mountainsides and the deep valley and provides an excellent viewpoint over the majestic scenery. Another wing is shaped like a steep amphitheater, lending itself for special gatherings or cultural arrangements. The third corner contains service functions like toilets, technical rooms and even solar panels for required functions.



To ensure the optimal location of the finished project and to exploit the site's various qualities, the architects sketched the concept at full scale directly on site with the aid of a crane and ropes, the structure was made as a wire model over several rounds before finally being made as a 3D model, drawings, and the finished product. The steep terrain proved to be a special challenge – particularly for the formwork – while the cantilevering corners demanded extraordinary large amounts of reinforcement.

The concrete platform has a clear sculptural shape with its straight lines and light-colored concrete. It creates a special contrast to the surrounding rugged and varied landscape. The viewpoint at Gaular Mountain has become a unique tourist attraction and a new landmark for the area. The platform is a cast-in-place structure. It has been quite the engineering, design and construction challenge with its very special geometry. The concrete work is of very high quality and shows excellent craftsmanship.



The high-quality concrete surfaces have a range of finishes varying from timber shuttered surfaces, ground surfaces, polished and sandblasted surfaces. Due to the unique properties of concrete, no other building material could have been selected. Over time the concrete will acquire natural vegetation and its color will approximate that of the surrounding mountains.

In 2016, Utsikten Gaularfjell was awarded the "Betongtavlen", the Norwegian Concrete Society's award for "Outstanding Concrete Structures".

OWNER National Tourist Routes, Norway
MAIN AUTHORS Eivind Nygaard, Bjarne Ringstad & Steinar Bjercke
OTHER PARTICIPANTS Sunnfjord Betong
CONTRACTOR Veidekke Sandane
COMPLETION June 2016

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Viaduct over River Almonte in Cáceres, Spain

The high-speed railway between Madrid and Extremadura crosses River Almonte at the Reservoir of Alcántara through a 996 m long viaduct. It overhangs the reservoir with a great concrete arch bridge whose main span is 384 m long. This makes it the largest high-speed railway arch bridge built to date.

Both the design and the definition of the erection procedure (which conditions the design itself) have sought, from the start of the project, to combine the technical feasibility and the optimization of resources and costs. This led to a very advanced and efficient structure. The infrastructure is composed of twenty-three deck spans executed by a movable scaffolding system, with spans of 45 m between approaching piers and 42 m between spandrel columns over the arch.

The total width of the deck is 14.0 m. The deck's cross-section is divided in a central space of 10.1 m to host the platform ballast, two 0.20 m wide ballast-retaining walls and side spaces to accommodate parapets, drainage gutters, service paths, barriers and birds' protections.



It is a continuous-deck structure, with prestressed-concrete box-girder section executed in situ. The construction was planned in successive stages, using a movable scaffolding system. Its configuration is an entirely standard box-girder deck for a high-speed multi-span bridge, with typical 45 m spans in the arch accesses. This helps reduce the costs and improve the construction output. The same erection procedure was used throughout the deck – even on the arch over the river – only reducing the type-span to 42 m so as to adapt to the span length and the different support conditions.

The arch was built using 80 MPa self-compacting concrete, specifically made for the high setting temperatures of this project: Ultraval SR concrete reaches 40 MPa in 12 hours and 90 MPa in 28 days. Moreover, it was mixed with fly ash and river sand as well as admixture Glenium TC1425. The arch has a hollow octagonal section in its central 210 m, separating afterwards into two inclined parts with an irregular hollow hexagonal section down to their foundation, providing greater transversal stability. Both parts are braced in the embedment between the second spandrel column (from springers)



and the arch. The octagonal shape has an adequate aerodynamic behavior, very favorable in large spans like the one considered. The section varies between the 6 m central width and the 4.80 m depth, and a total 19 m width among both parts and 6.90 m depth, resulting in a span/depth ratio varying from 1/80 to 1/56.

Other crucial analyses made to evaluate the performance of this structure include material and geometric nonlinearity influence. These studies cover the assessment of shrinkage and creep, the control of the concrete's cracking during construction stages and once the bridge is in service, and the nonlinearity of the constitutive equations of steel and concrete. Furthermore, the analyses include the examination of geometric nonlinearity and 2nd order effects counting on assembly imperfections as well as dynamic calculations and deformability control of the structure, to accomplish the functionality criteria in terms of users' security and comfort.

The bridge construction began in July 2011 and was completed end of 2016. The erection procedure for the arch is a cantilever method with temporary stay-cables from two temporary steel towers, following the same construction project sequence.



OWNER Adif Alta Velocidad
MAIN AUTHORS Arenas & Asociados and Idom
OTHER PARTICIPANTS Oritia & Boreas and University of Western Ontario
CONTRACTOR FCC Construcción - Conduril
SUBCONTRACTOR FCC Technical Services, Cementos Portland Valderrivas, Rubrica Ingeniería and Bridge Construction System-Bcs (Deck Mss)
COMPLETION November 2016

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Footbridge in Čelákovice, The Czech Republic



The footbridge in Celakovice connects the town on the left bank of the Labe River with a popular recreational area on the right bank. It allows pedestrians, cyclists and emergency vehicles (up to 3.5 tons) to cross the river comfortably. In the tender documents, a cable-stayed footbridge with a composite superstructure consisting of two longitudinal side beams of welded steel profiles, steel cross beams and a concrete slab was designed. The composite slab was originally designed from precast concrete elements of C110/130 with steel fibre reinforcement. The elements were supported on the bottom flange of the side beams and cross beams. After assembling, all gaps between the slabs and steel beams should be filled with in-situ cast concrete. The contractor proposed an alternative solution to a segmental bridge deck entirely made of concrete C130/150 with steel fibres and the arrangement of spans 43+156+43 m.

Steel pylons with a total height of 37 m are shaped like the letter A. They are fixed on the foundation blocks on in-situ cast piles. Stays are arranged in two planes. The lower adjustable anchorages are located on the side of the deck. The deck is supported by fully locked cable-stays with galvanisation corrosion protection. The abutments on both river banks are massive reinforced concrete blocks on piles that act as a counterweight to uplift reactions of the superstructure. The walkable surface of the deck is covered by sprayed waterproofing that is 5 mm thick. The 1.3-m high steel railings have integrated lighting. A detailed numerical model for structural analysis was prepared including the launching gantry movements, stressing and removal of temporary cables, adjustment of forces in final tendons etc., resulting in approx. 120 stages. The analysis included the effects of nonlinear behaviour of the structure caused by varying stiffness of stays due to their sag.



The UHPC was developed by the team of Metrostav and TBG Metrostav since 2010 in precast as well as cast in-situ structures. Local materials are used. The size of aggregate is limited to 5 mm and short high strength steel fibres are applied. The mixing process and the type of the mixer have a substantial influence on the properties of the UHPC in the fresh as well as in hardened state. The tests executed on laboratory specimens proved that the compression strength measured on cylinders exceeded 150 MPa. The design required a tensile strength higher than 15 MPa; therefore 160 kg of steel fibres per 1m^3 were used. The developed concrete mix kept its workability for about 90 minutes which allowed for using it for applications of ready-mixed concrete.

The footbridge is prestressed and the anchors of the prestressing



bars are coupled in the match cast joints. The small space for the anchors required verification of the concrete area under the anchors, which is loaded by concentrated load, also resulting in transversal tensile stresses.

A steel mould was used for the production of segments. The mould has a fixed bottom part, longitudinal tiltable sideboards and a top cover. The mould has only one front face, since a match casting is assumed, and the second face is created by the segment which was cast earlier. The segments were cast by halves with a reinforced working joint. The complete standard segment 11.3 m long was then transported to the site. Only one match cast glued joint is designed between the two stays.

OWNER Josef Pátek, Mayor of the city
MAIN AUTHORS Milan Kalný, Václav Kvasnička & Jan Komanec
OTHER PARTICIPANTS Jan L. Vítek (Expert of the contractor) & Petr Keil (Architect)
CONTRACTOR Metrostav a.s., Robert Broz & Petr Koukolik
SUBCONTRACTOR TBG Metrostav s.r.o. & Robert Coufal
COMPLETION April 2014

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Yavuz Sultan Selim Bridge in Istanbul, Turkey

The "Yavuz Sultan Selim Bridge" (Third Bosphorus bridge) is a so-called "High rigidity suspension bridge" breaking the world record for combined road/railway bridges and for railway bridges with its 1'408 m of central span. It is the first modern application of a combination between a classical suspension bridge and a cable-stayed bridge.

In addition to the natural elegance given by the conceptual design, special attention has been given to developing a dynamic and elegant shape for the towers avoiding any intermediate crossbeam on their height. The triangular-shaped and inclined legs procure a stable and strong feeling despite their slenderness. They give a dynamic and elegant impulse towards the crossing.



The inclinations of the legs have been fixed to accommodate the vertical plan of the main cables between the roadway and the railway, placing the hangers in the central zone. This allows for a completely free lateral view for the car users on all the central suspended part, which turns the crossing of the bridge into a dramatic experience.

By anchoring the stiffening cable laterally in the main span and between the railway and the roadway on the back span, it highlights the crossing of the main span and gives the users an unobstructed view of the great scenery provided by the steep-sided Bosphorus and the business city of Istanbul in the background. The extraordinary morning or evening natural light on site plays with the effect brought by the progressive stiffening cable line geometries along the bridge like fingers on a harp.

As a result of this conceptual design, the bridge offers an elegant and top class crossing to the straight, which perfectly symbolises the link between the two continents and could become one of the major landmarks of the extraordinary city of Istanbul. All the constitutive materials have been chosen for their best use, taking into account the local practices and procurement possibilities and the special geographical situation of the bridge in a sensible seismic area and in a maritime environment.



The foundations, piers, towers and side span up to 24 m apart from the tower axis in the main span are made of concrete, mainly C60. The main span is a full orthotropic deck with a steel box girder. Most of the structural steel quality is grade S460. Main cables are PPWS with 5.4 mm wires in grade 1'860 Mpa. They are protected by a dehumidification system. Hangers are PWS with dia 7 mm zinc coated wires in grade 1'770 Mpa, protected by a polyethylene sheathing.

Due to their exceptional length (more than 600 m for the longest), stiffening cables are standard PSS with dia 15.7 mm strands in grade 1'960 Mpa to limit the self-weight of the stays and their consecutive sag.



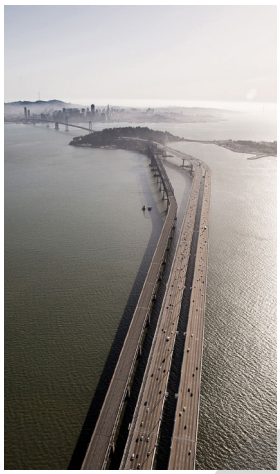
OWNER KGM – Republic of Turkey, General Directorate of Highways
MAIN AUTHORS Jean-Francois Klein, Michel Virlogeux & Thierry Delémont
OTHER PARTICIPANTS V. de Ville, Cécile Cremer, Olivier Flamand, Gerard Grillaud, Giorgio Diana, Alberto Zasso, Antonio Reis & Alp Yagcioglu
CONTRACTOR ICA – JV IC Içtaş Insaat, Turkey / Astaldi Spa, Italy
SUBCONTRACTOR JV Hyundai construction, S.Korea / SK construction, S.Korea, with Freyssinet intl – Freyssas – cable stays and prestressing & Endem – Turkey - Concrete side spans, anchor boxes and towers
COMPLETION August 2013

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Nominees

Civil Engineering Structures

Skyway Bridge
Oakland, USA



The seismically resilient San Francisco-Oakland Bay Bridge New East Span includes the 1,900-meter-long Skyway that sweeps up from the Oakland shoreline to connect with the self-anchored suspension span portion of the bridge. The Skyway is the bridge's longest component, with parallel viaducts carrying 10 lanes of traffic (five eastbound, five westbound).

The Skyway comprises precast segmental bridges erected in balanced cantilever, with a typical span of 160 m. The twin viaducts consist of four frames connected by expansion joints, which resist seismic motion by allowing frames to move and slide while maintaining overall structural rigidity. Hinge pipe beams were also placed between deck sections to absorb seismic energy and minimize damage to the main structures.

The 425 precast segments for the superstructure were precast in a specialized casting yard and floated on barges 112 km to the site. Each segment was lifted into position using self-launching winch lifters and post-tensioned. Weighing up to 680 metric tons each, the Skyway segments are the largest of their kind ever cast.

Skyway foundations had to reach up to 91 m below the water's surface, at a batter of 1:10, to anchor in stable soils. While this method has been used to secure foundations for offshore oil rigs, this is the first time the technology was used for bridge construction on this scale. The Skyway represents one of the most complex feats of bridge design and concrete construction and will play a key role in regional recovery after a major earthquake.





OWNER California Department of Transportation
MAIN AUTHORS Sajid Abbas & Ade Akinsanya
OTHER PARTICIPANTS Donald MacDonald
CONTRACTOR Kiewit/FCI/Manson, A Joint Venture
SUBCONTRACTOR Pacific Cement, San Francisco, CA, USA & RMC Lone Star, Davenport, CA, USA
COMPLETION September 2013

Avalanche Galleries Akkarvika
Lofoten, Norway



The road to the most western point of Lofoten islands in Northern Norway has always been popular, but very troublesome at times during winter. Passing Akkarvika used to be a great challenge. Avalanches, or fear of avalanches, have caused the road to be regularly closed. The situation was intolerable and in December 2014 a 1461 m long tunnel and four avalanche galleries with a total length of 955 m (0.6 miles) were completed.

The galleries, with their soft and organic concrete form, give a new and unique character to Akkarvika. They have become a new attraction along the beautiful road through Lofoten. The new concrete structure improves the view and the scenery between the ocean and the mountain in a natural way.

The structure has a clear structural cross-section principle as it grips into the rock wall and leaning against it, showing clearly that the road is cut into the mountainside. The concrete wall has an incline of 5 degrees towards the rock, while the concrete roof has a small incline upwards towards the ocean. This gives a feeling that this structure is solid enough to withstand loads from falling rocks and snow.

The project has a clear idea of integrating the structure into the landscape. The concrete surfaces and detailing are excellent. They bear the signature of excellent craftsmanship taking into the account the severe challenges.



OWNER National Tourist Routes, Norway
MAIN AUTHORS Knut Hjeltnes, Rolf Maere & Jostein Björbekk
CONTRACTOR Ronny Robertson
COMPLETION November 2014

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Innovation Bridge

Miami, USA



Located on the University of Miami campus in Coral Gables (FL), the Innovation Bridge is a 20-meter-long single span prestressed concrete bridge. Although the bridge serves as a pedestrian passageway, it comprises a number of striking features intended to ensure a 100-year service life with minor maintenance cost. The structure comprises a variety of non-corrosive reinforcement solutions, including carbon fiber reinforced polymer (CFRP) prestress strands, basalt fiber reinforced polymer (BFRP) pile cages, and glass fiber reinforced polymer (GFRP) rebars. Stainless steel (SS) is employed for bearing plates, hooks, and handrails. The result is a structure enclosing not a pound of carbon steel.

The Innovation Bridge is designed for resilience in aggressive subtropical exposure and features composite reinforcement in accelerated bridge construction (ABC). This unique example of a completely steel-free prestressed concrete bridge served as a baseline and demonstrator for the development of ad-hoc design and construction guidelines. The Innovation Bridge contributes to a comprehensive effort to leverage non-corrosive technologies in infrastructural applications.

Construction of the Innovation Bridge was a challenge undertaken with passion by all the involved actors. The opportunities offered by composites proved not limited to improved durability: innovative shapes, preassembling, and reduced labor on site resulted in improved quality, constructability, and performance of this unique concrete bridge.



OWNER University of Miami
MAIN AUTHORS Brill Rodriguez Salas, Antonio Nanni & Richard Jones
OTHER PARTICIPANTS Marco Rossini, Saverio Spadea & Guillermo Claure
CONTRACTOR OHL Arellano Construction Co.
SUBCONTRACTOR Anzac Contractors & Coreslab Structures
COMPLETION June 2016

Railway covering structure

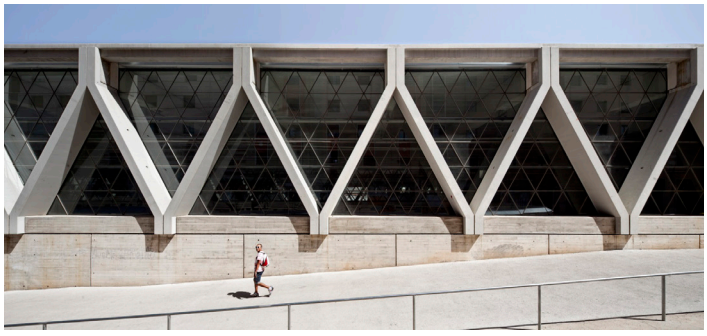
Barcelona, Spain



The structure uniqueness lies in the need to ensure the compatibility of its design and construction with the existing railway structures and installations, in order to span significant clearances and avoid loading structures which were not designed for this purpose, while keeping, as much as possible, the six railway lines in service.

The solution also needs to take into account that the structure must not collapse in the unlikely event of an impact due to a train derailment. Regarding the covering structure, its design copes with the requirement of possible vehicle traffic, along with up to 1-meter soil overload, and always complying with firefighter's truck access specifications.

The project establishes the construction of a double height covering structure, which is about 760 m long and 22.500 m^2 areal, separating the area of underground Line 1 from the local, regional and long-distance lines from RENFE. The lateral enclosures of the covering structure generate a façade of more than 11,300 m^2 and are mostly formed by a diagonalized wall of precast concrete which generates a predominant triangular structure in a large part of the façade, using transparent or translucent glass to close the clear spaces between the inclined concrete pieces, or opaque enclosures where a vegetal/green wall cladding is foreseen.



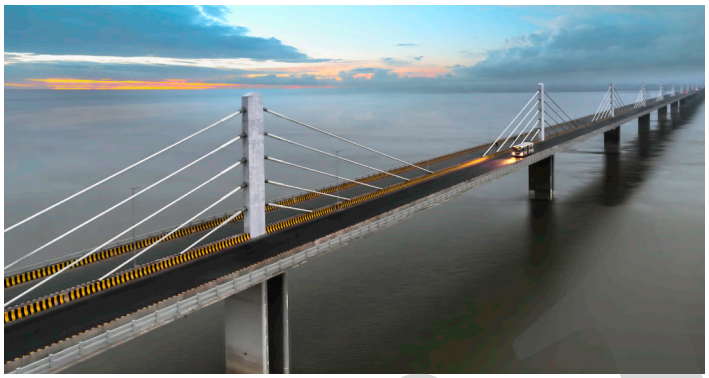
OWNER BIMSA, Barcelona d'Infraestructures Municipals, S.A. (Barcelona City Council)
MAIN AUTHORS Javier Rui-Wamba Martija, Carlos García Acón & Sergi Godia Fran
OTHER PARTICIPANTS Andreu Estany Serra & Ana Molino Roca
CONTRACTOR SACYR-SCRINSER, VIAS & COMSA EMTE
SUBCONTRACTOR Bombardier Transportation & Cobra
COMPLETION August 2016

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Nominees

Civil Engineering Structures

Veer Kunwar Singh Setu
Bihar, India



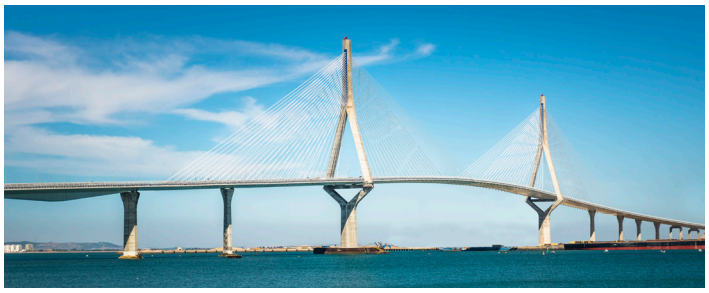
The Veer Kunwar Singh Setu, the world's longest extradosed bridge, has shortened the travel time between the two cities of Arrah and Chhapra by up to three hours and, more importantly, has helped fuel economic development of one of the most impoverished states of India.

This world record concrete bridge was engineered to address the challenging site conditions including extreme water fluctuations, seismic activity, and the existing framework. The team developed an extradosed concept using a constant-depth precast girder erected in free-cantilevering, which allowed the contractor to deliver the project ahead of time without a significant increase in construction cost compared to the traditional variable depth cast-in-place concrete girder system. Through precasting constant depth segments in the casting yard, the erection cycle time was significantly reduced compared to a typical cast-in-place construction, and the more efficient extradosed system reduced significant concrete volume, as well as steel reinforcement. This innovative approach is expected to be the future state of the art trend for similar multi-span crossings with spans between 120 m and 180 m in India.



OWNER Bihar Rajya Pul Nirman Nigam Limited
MAIN AUTHORS Dave Jeakle, Morgan Trowland & Brook Robazza
OTHER PARTICIPANTS Raj Singh
CONTRACTOR S. P. Singla Constructions Pvt. Ltd.
COMPLETION June 2017

Constitución de 1812
Cádiz, Spain



The Constitución de 1812 bridge is a singular, 3092 m-long structure that provides the peninsular city of Cádiz with a new link to the mainland. It is the longest Spanish bridge and features the third longest cable-stayed span in Europe (540 m). It is also the second tallest bridge in the world in terms of vertical clearance over a seaway (69 m).

As it is located on the bay, highly visible from the city, the span distribution was particularly sensitive, especially as regards the design features ensuring uniformity between the approach and main spans. This conceptual uniformity was not, however, incompatible with the use of cross-section typologies and materials adapted to the structural requirements of spans and construction procedures.

Different construction techniques were used to complete the four structurally different sections comprising the bridge. The 580 m-long approach viaduct from Cádiz was incrementally launched over the sea. The 1182 m-long approach viaduct from the mainland was built by means of shoring, falsework and form travellers. The simply-supported 150 m-long removable span was heavy-lifted from a barge. Finally, the 1180 m-long cable-stayed bridge was constructed by free cantilevering from its two pylons.

Although it comprises four structures with different structural typologies and materials, formally speaking they have been harmoniously combined into a single unit, with constant width and depth practically throughout.



OWNER Ministry Of Public Works And Transport. Spain Government
MAIN AUTHORS Javier Manterola, Antonio Martínez, J. Antonio Navarro & Silvia Fuente
OTHER PARTICIPANTS Luis Muñoz Campos & Juan Tardón Díaz
CONTRACTOR DRAGADOS S.A.
COMPLETION SEPTEMBER 2015

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Cantilever Construction of a Bridge

Bhutan, India



A three-span continuous structure in prestressed concrete was proposed to connect the power plant to the other side of the Punatsangchhu River & National Highway. The central span was integral to the piers. The construction of the central span was carried out according to the free cantilevering method on both sides. The central span was 114 m long to facilitate the construction of foundations and short end spans of 29.825 m due to the mountainous topography.

Bridge aesthetics and minimum disturbance to the environment were important design aspects to preserve the elegance of the surroundings. The construction of such a bridge in a remote area with limited resources that could be mobilized was a difficult task and required several design innovations and improvisation during the execution for its successful completion.

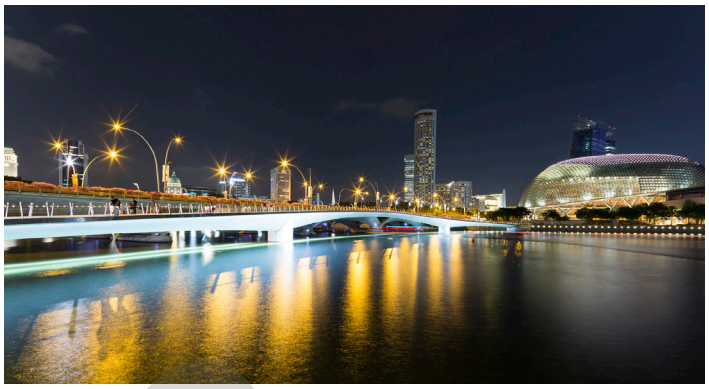
The peculiar span configuration, narrow width, lack of stacking space and high seismicity posed several design challenges: the foundations for the bridge were designed for peak maximum probable flood and scour in the river corresponding to the 1000 year return period; the project was located in zone liable to shaking intensity of IX or more on Modified Mercalli Scale; the deck width for end spans had to be increased to enable the turning of long trailors to be used to transport equipment for the power project; wing walls were required of large heights and complex design to protect the end abutment piers from hill slopes on both sides; and due to the short end spans, there was excessive uplift demand on the end piers.



OWNER Punatsangchhu Hydroelectric Project Authority
MAIN AUTHOR Ashish Srivastava
OTHER PARTICIPANTS Vikrant Chaudhary
CONTRACTOR M/s. Hindustan Construction Co. Ltd
COMPLETION December 2014

Jubilee Bridge

Singapore



Set in a busy maritime environment in the heart of Singapore, the design team was challenged to achieve the aspiration of a slender bridge form, while minimising disruptions to the surrounding landmarks.

A 95 m span was bridged to achieve the pedestrian crossing between the Merlion and the Esplanade Theatres across the mouth of the Singapore River. The three-span bridge does not require any vertical support from above, allowing for unhindered views of the surroundings and events in Marina Bay.

The designers pushed boundaries on the structural design to achieve a high span-to-depth ratio of 63 – resulting in a shallow deck depth of 1.5 m at mid-span and 3.5 m at the two columns. The culmination of these engineering solutions is presented as a beautiful, curved geometry achieved at the apex of the bridge. More importantly, this approach allowed for a wider unobstructed access for watercraft navigation in and out of the Singapore River.

Taking inspiration from tall building design, a high-strength 80M Pa concrete was specified for the post-tensioned box-girder. The superstructure was precast in 3 m long segments and lifted into place in stages to minimise obstruction to the busy Marina Bay precinct.



OWNER Urban Redevelopment Authority (URA), Singapore
MAIN AUTHORS Eoin O'Donovan, Wong Ling Chye & Peter Burnton
OTHER PARTICIPANTS See Lin Ming, Jesper Jensen & Colm McKenna
CONTRACTOR Marina Technology & Construction Pte Ltd
SUBCONTRACTOR VSL Pte Ltd
COMPLETION March 2015

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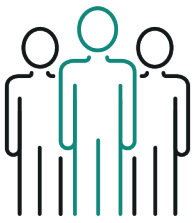
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Index of Projects

Buildings

WINNERS

Replacement of the roof structure and main dome over La Laguna cathedral, Spain 8

R·Torso·C, Japan 10

SPECIAL MENTION

Manta, Austria 13

NOMINEES

Knapphullet, Norway 14

Villa Holtet-Larsen, Norway 14

Latrobe Tower, Australia 15

Infosys Multi Level Car parking – 2, India 15

Suita City Football Stadium, Japan 16

Civil Engineering Structures

WINNER

Takubogawa Bridge, Japan 20

SPECIAL MENTIONS

Utsikten Viewpoint, Norway 24

Viaduct over River Almonte, Spain 25

Footbridge over the Labe River in Čelákovice, Czech Republic 26

EXCEPTIONAL RECOGNITION

Yavuz Sultan Selim Bridge (Third Bosphorus Bridge), Turkey 27

NOMINEES

San Francisco-Oakland Bay Bridge New East Span: Skyway, USA 28

Avalanche Galleries Akkarvika, Norway 28

Innovation Bridge, USA 29

Covering structure of the railway access to Sants Station in Barcelona, Spain 29

Veer Kunwar Singh Setu, India 30

Constitución de 1812, Bridge over the Cádiz Bay, Spain 30

Cantilever Construction of Bridge Over River Punatsangchhu, India 31

Jubilee Bridge, UK/Singapore 31

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1 *Structural Concrete – Textbook on Behaviour, Design and Performance*; Vol. 1: Introduction, Design Process, Materials
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Guide to good practice (July 2000)

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State-of-art report (August 2000)

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State-of-art report (January 2001)

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Technical report (August 2001)

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State-of-art report (September 2001)

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Technical report (October 2001)

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Technical report (November 2001)

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Technical report (January 2002)

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Technical report (April 2002)

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State-of-art report (April 2002)

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State-of-art report (April 2002)

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Guide to good practice (July 2002)

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State-of-art report (March 2003)

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State-of-art report (May 2003)

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State-of-art report (June 2003)

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State-of-art report (August 2003)

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State-of-art report (October 2003)

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State-of-art report (February 2004)

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State-of-art report (November 2004)

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Recommendation (January 2005)

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Technical report (February 2005)

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Guide to good practice (November 2005)

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Recommendation (December 2005)

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Model Code (February 2006)

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State-of-art report (May 2007)

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Technical report (September 2007)

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State-of-art report (November 2007)

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State-of-art report (January 2008)

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Guide to good practice (February 2008)

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Guide to good practice (February 2008)

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State-of-art report (June 2008)

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State-of-art report (July 2008)

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Guide to good practice (January 2009)

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Technical report (February 2009)

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State-of-art report (May 2011)

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State-of-art report (August 2011)

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Technical report (September 2011)

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Guide to good practice (January 2012)

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Technical report (February 2012)

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72 *Bond and anchorage of embedded reinforcement: Background to the fib Model Code for Concrete Structures 2010*
Technical report (May 2014)

73 *Tall buildings: Structural design of concrete buildings up to 300 m tall*
State-of-the-art report (August 2014)

74 *Planning and design handbook on precast building structures*
Manual – textbook (September 2014)

75 *Polymer-duct systems for internal bonded post-tensioning*
Recommendation (December 2014)

76 *Benchmarking of deemed-to-satisfy provisions in standards: Durability of Reinforced Concrete Structures Exposed to Chlorides*
State-of-the-art-report (May 2015)

77 *Corrugated-steel-web bridges*
State-of-the-art-report (December 2015)

78 *Precast-concrete buildings in seismic areas*
State-of-the-art-report (March 2016)

79 *Fibre-reinforced concrete - From design to structural applications*
ACI-*fib* workshop proceedings (May 2016)

80 *Partial factor methods for existing concrete structures*
Recommendation (December 2016)

81 *Punching of structural concrete slabs: Honoring Neil M. Hawkins*
ACI SP-315, ACI-*fib* symposium proceedings (April 2017)

82 *Precast segmental bridges*
Guide to good practice (August 2017)

83 *Precast Tunnel Segments in Fibre-Reinforced Concrete*
State-of-the-art report (November 2017)

84 *Precast insulated sandwich panels*
State-of-the-art report (December 2017)

85 *Towards a rational understanding of shears and beams in slabs*
Technical report (May 2018)

86 *Safety and performance concepts*
Guide to good practice (August 2018)

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The *fib* has ten commissions, each with corresponding task groups and working parties, grouped into four principle areas of activity: planning and execution, materials and production, sustainability and durability, and education and publications.

fib Commission 1 "Concrete Structures": It seeks to encourage and develop good practices in the design of concrete structures, with a special emphasis on innovation and imagination. Its work should complement national, regional (e.g. Eurocodes), as well as international codes (e.g. the *fib* Model Code for Concrete Structures 2010), which in principle give only design specifications.

fib Commission 2 "Analysis and Design": Analysis and design are understood as core tasks of structural engineering. Today, the analysis – i.e. the detailed investigation of the stress and strain state – has gained in importance. Refined and physically-based models and calculation procedures are therefore required. On the other hand, the design of new structures (comprising conception, dimensioning and detailing) still is fundamental for practicing engineers. In general, the respective approaches should be one and the same for the two levels of detail, but more practical and easier to apply for the latter case. Commission 2 supports and follows this line of development of structural engineering.

fib Commission 3 "Exisitng Concrete Structures": The goal of Commission 3 is to define appropriate and reliable procedures to establish the safety of existing structures and any associated requirements for interventions to extend the safe operation or working life of such structures.

fib Commission 4 "Concrete and Conrete Technology": The overall motivation of Commission 4 is to make theoretical and practical developments in the field of concrete and concrete technology, and to present these developments in an understandable and code-type formulated manner. COM4 positions itself at the forefront of new technologies and techniques by considering both fundamental research and practical issues.

fib Commission 5 "Reinforcements": It gathers a balanced mix of experts coming from various fields (academics, owners, suppliers, government agencies and testing laboratories) who are volunteering their work into several task groups aiming to provide knowledge and information to students and the professional workforce for the best use of concrete.

fib Commission 6 "Prefabrication": Prefabrication plays an important role in the construction of concrete structures worldwide and is evolving continuously to cope with current society's habits and needs related to housing, commercial buildings and civil engineering works. In fact, industrialised construction may result in cost efficiency, good quality and environmentally friendly solutions, as well as the ability to adapt to market demands.

fib Commission 7 "Sustainability": Concrete is the most used material for the construction of buildings and civil structures. Concrete and concrete structures should contribute to the development of a sustainably built environment in a socially, environmentally and economically responsible manner. There is no general methodology for sustainability design and assessment of concrete structures covering all important sustainability aspects and all life cycle phases from acquisition of materials, through production of concrete and concrete components, construction, operation of structure, up to demolition and recycling.

fib Commission 8 "Durability": It aims to identify concrete-related durability issues, consider and review current information available on the topic, and provide guidance on materials and methods that will assist in optimal durability design of new structures and restoration design of existing structures.

fib Commission 9 "Dissemination of Knowledge": Up-to-date technical information is needed to construct the best concrete structures. The newest information is necessary when it comes to material properties, design methods as well as construction methods. By recognising its importance, the *fib* decided to create a separate commission on the dissemination of knowledge.

fib Commission 10 "Model Codes": A central aspect within the mission of the *fib* is the release of model codes on concrete structures and related subjects. These codes should serve worldwide as the guiding science-based documents offering in a code-type version the state of the art knowledge on the planning, design, construction, execution, operation or in service performance, maintenance, rehabilitation and dismantlement of new and existing concrete structures, respectively. The model codes should meet the latest requirements and technologies in view of aspects related to safety, serviceability, durability, resilience and to fulfil the resilience and sustainability of structures, recognising economic and aesthetic needs of different societies.

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fib Membership Benefits

The *fib* offers its members excellent networking opportunities and access to high quality, peer-reviewed publications. Individual members may be student members, young engineer members, e-ordinary members, ordinary members, e-subscribing members, or subscribing members. The level of subscription determines the number of publications and benefits members receive.

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A central aspect within the mission of the *fib* is the release of model codes on concrete structures and related subjects. These codes should serve worldwide as the guiding science-based documents offering in a code-type version the state of the art knowledge on the planning, design, construction, execution, operation or in service performance, maintenance, rehabilitation and dismantlement of new and existing concrete structures, respectively. The model codes should meet the latest requirements and technologies in view of aspects related to safety, serviceability, durability, resilience and to fulfil the resilience and sustainability of structures, recognising economic and aesthetic needs of different societies.

On this background COM10's mission consists of initiating and surveying the work on new model codes within its task groups and in coordinating the ongoing work, both based on existing experience and new developments in the field of concrete structures and structural materials. This mission necessitates the organisation of meetings and workshops at different places of the world in order to gather the latest scientific knowledge, new ideas and visions and to actively involve the worldwide technical society.

Commission 10 started its work in 2016. Its first task group is TG10.1 "Model Code 2020 (MC2020)", which began its work also in 2016. MC2020 is considered as the overarching model code for concrete structures.

The vision for *fib* MC2020 as a single general structural code goes beyond the point reached by *fib* MC2010, recent ISO codes (such as ISO 16311) and the current activities to extend application of Eurocodes and other (inter)national standards to existing structures. The envisaged development is intended to result in an internationally recognised and comprehensive *fib* Model Code 2020 for new and existing concrete structures.

The MC2020 shall be:

- an operational model code that is oriented towards practical needs, provides guidelines to the practitioners when provisions in regular standards are deficient or lacking, and can serve as a reference for engineering standards worldwide,

- a model code that includes worldwide knowledge with respect to materials and structural behaviour and recognises the needs of engineering communities in different regions of the world,

- a model code that reflects the importance of sustainability and provides guidelines for the consistent treatment of sustainability when dealing with new and existing concrete structures,

- a model code that will take sustainability as a fundamental requirement, based upon a holistic treatment of societal needs and impacts, life-cycle cost and environmental impacts. These overarching requirements will have defining implications for subsidiary performance requirements critical to structural design and assessment procedures. These are matters such as human and environmental safety, serviceability and durability, and other specific performances such as the robustness of the structure and the resilience of its functionality,

- a model code with fundamental principles and a safety philosophy based on reliability concepts, and that takes advantage of the understanding of uncertainties and of the risk acceptance and risk differentiation concept to set target verification criteria for both new and existing structures for different levels of approximation,

- a model code that consequently makes use of the performance based concept to close the gap between material engineers and structural engineers and to remove specific constraints for novel types of concrete and reinforcing materials,

- a model code with fully integrated provisions based on generalised models and implementation of the level of approximation approach applicable for both the design of new structures and all the activities associated with the assessment, interventions and the through-life management of existing concrete structures,

- a model code that allows full advantage to be taken of information that can be acquired by testing and monitoring of existing structures, both with regard to the assessment and to the through-life management of existing concrete structures, which includes prediction and updating of reliability and durability for deteriorating structures and use of information from in-situ testing and monitoring.

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2018 *fib* Awards for Outstanding Concrete Structure

Contents

3 President's Foreword
4 About the Awards
5 Chairman of the Jury's Foreword
6 Previous Awardees: Category Buildings
7 Category Buildings
8 Winners
13 Special Mention
14 Nominees
18 Previous Awards: Category Civil Engineering Structures
19 Category Civil Engineering Structures
20 Winner
24 Special Mentions
27 Exceptional Recognition
28 Nominees
33 Index of Projects
34 *fib* Bulletins
37 *fib* Commissions
38 *fib* membership benefits
39 *fib* Model Code 2020

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