Bridges and Infrastructure

By Kyo Takenouchi and Ola Wedebrunn

AT present, it is by no means an exaggeration to say that innumerable bridges and infrastructures are able to bring us to the end of the earth, whether these are monuments, scattered in a remote area, recognized or not. situated where mankind intensively has made its effort to extend daily circles of life till the present day. Humans have always been on the move, in primitive ages they went up the hill and down the dale, over and beyond mountains, across streams and wherever obstacles had to be crossed, bridges and roads skilfully came into their hands. Emerging directly on the ground, as fruit of empirical and intuitive knowledge; as comprehensive static and dynamic engineering, state of the art science and creative use of information.

Bridges and Infrastructure

This special issue, *Bridges and Infrastructure*, deals rather briefly with the concept of infrastructure, nevertheless, most of the readers will notice that there is something common between bridges and infrastructure.

In terms of public wealth, infrastructure represents substantial services, prompt, safe and guaranteed supply of electricity, water, gas, information network, etc.; paths and roads to walk on foot, to ride bikes on, and even negotiate on horseback. As trains and motorized traffic have increased the volume of infrastructure, capacity and resources burst; at present it calls for contextual and interdependent engagement, creativity, research, and an eco-friendly network.

Both bridges and infrastructure pass essentially on roadways, pipes, cable lines and so forth. They are continuous structures generally supported by posts, pylons and towers-on abutment and foundations-substructures or sometimes by cable supported systems. When roads above ground reach a river, a valley, or any other similar obstacle it becomes a bridge; by contrast, when they go underground it is in a tunnel. This means that the level of roads merely changes when separated from ground to soar in the air, when passing in a tunnel underground, while bridges radically change tha structural system of roads. Technically speaking there is mostly no difference from road as earthwork to road on bridges. In addition most infrastructure is integrated as networks and consequences of urban growth.

History

Generally speaking, the subject Modern Movement could be considered as a project of the enlightenment. The development of bridges is in many ways parallel with the development of mobility and transportation system for goods, travellers, and commuters, etc. Increased frequency and loads of carriages and vehicles following the industrialization brought the need for robust and endurable bridges.

When it comes to bridges and infrastructure of the Modern Movement, they can neither be classified solely from a chronological angle nor as structural types and building material. At every opportunity the Modern Movement answers to diversity and transition from the enlightenment to new systems of society in accordance with local, regional and national conditions. As for bridges, it is true that the typical features as expression of Modern Movement are construction materials identified as steel and concrete and developed throughout industrialization. On the other hand bridges are also identified as bare structures, almost as the shape of a skeleton, transparent and exposed to public sights.

Briefly it could be said that while construction materials are identified as characters, such as steel and concrete, structures are rather defined as a concept of typologies. It could be noticed that in the late 1950s an increasing number of bridges with tensile stress structure appear, such as modernized pre-stressed concrete bridges (PC bridges), cable-supported bridges (suspension bridges, cable-stayed bridges), furthermore pre-stressed wooden bridges, and lately stressed ribbon bridges, the latter unfortunately not included in this issue.

Bridges and infrastructure are not to be taken for granted and automatically grasped as monument and objects. They are expression of materials, structure and system that reach beyond matter and construction typologies determined as time and scale.

Thus the methodological approaches that characterize the qualities of *Bridges and Infrastructure* in this issue of the **docomomo** Journal are diverse. The authors have been addressed to reflect on the topic of Modern Movement, which has brought answers of expectation as well as surprises, to which we will return. Meanwhile, after addressing the authors, attempts have been made to

The Kintai Bridge today. Photo by Jens Markus Lindhe.

Kintai-Hashi (Kintai Bridge) drawing by **Katsushika Hokusai**, ca. 1831. Image from the Ohta Memorial Art Museum collection.

sharpen the construction of the theme, through theoretic studies of the topic and with reference to empiric and acknowledged experiences.

An important source to Modern Movement and bridges was found in the book and exhibition *Architecture of Bridges* by Elisabeth B. Mock[1] at the Museum of Modern Art in New York, 1947. It introduces architecture of bridges with a short history and a substantial commented documentation. Mock writes:

> *Since a bridge does not define space, but cuts through it, it is free of all intricate psychological considerations that must be taken into account when space is moulded or enclosed. Thus, paradoxically, a bridge is at once the most tangible and most abstract of architectural problems [...] Since the reality of the bridge lies in its structure, the art of bridge building lies in the recognition and development of the beauty latent in those structural forms that most effectively exploit the strength and special properties of a given material [...] Man has rarely built less efficiently than he was able, and the history of bridge architecture is essentially the story of his triumph over space through increasingly skilful exploitation of the best materials available to him.*

The concern of Elisabeth B. Mock is the development of material and structure. Thus when it comes to consider context her argumentation is week, if existing at all. When arguing about bridges and space she is almost hostile. Still the book is a unique evidence about the concept of Modern bridges. In addition to the historical and analytic introduction of *Architecture of Bridges* follows the major stock of the book with a well illustrated survey of methodological approach to bridges, based on keywords of material and structural types such as material*; stone, wood, metal arch, suspension cable, metal beam, reinforced concrete, reinforced concrete arch, reinforced concrete beam and rigid frame*. Structural types*; beams, cantilever, rigid frame or portal frame, arches, fixed, two–hinged, three–hinged, suspension cables*.

Very different is the approach of Sir Ove Arup. With the article *Design of Bridges*[2] he invites with a skill and experience, that almost translocate the reader, to share the emerging concept, to learn about good design by studying it in *statu nascendi*, with presence of almost being there as mind and matter become bridges. In this Journal Jørgen Nissen introduces the text and work of Ove Arup and Arup Associates imagined and unfold in the process and context of bridge constructions.

In the centre of presence there are few limits and many possibilities for art and science, perceiving changes of social, aesthetic, and technical standards and norms. Bridges and infrastructure are evidence to analytic definitions of material and structural character, inseparable from context and processes. As technology changes, bridge and infrastructure concepts change, addressing the reality of public concern as well as private integrity. With the help of passwords and interfaces we enter paths to information complexes, sometimes shared as territories where real and virtual meet to bridge the gap.

In the article *Garden of Microchips* by Toyo Ito,[3] Ito refers to the garden of Edo. The text is an interesting reference as well as an introduction to experiences of technology, infrastructure, and reality:

It is easy to point out the violence done by technology and confusion wrought by overlapping of heterogeneous systems in Tokyo today. However, I believe it is far more meaningful to search for new ways to make today's urban space attractive than to bemoan the wretched condition of Tokyo and indulge in nostalgia for the garden city of the past [...] People and cars are not the only moving objects. The flow of diverse forms of energy and information has increased at a tremendous rate, and indeed the flow of such invisible things is coming to dominate urban space.

The ambition with this Journal is to get close to technology, to social possibilities of creative communication, and last but not least to pursue aesthetics, sensual beauty and love for craft and fellowship when sharing the interest in bridges and infrastructure. The most remarkable achievement in recent years is the exhibition *Landscape and Structures* at the Swiss Pavilion of the 12th International Architecture Exhibition in Venice, 2010. The exhibition was presented by Jürg Conzett, initiator and curator of the exhibition, and Martin Linse, photographer. Jürg Conzett highly suggests: "[...] chiefly interested in constructed or engineered work with at the same time high architectural merit–works that involve as intense engagement with issues of engineering and sufficiency on the one hand and are intended to evoke certain responses in the individuals using them on looking at them on the other [...]. The authors' response is that the most interesting solution comes about as a synthesis of engineering and architectural requirements within the conceptual design."[4]

It is reasonable to ask why and how it has been possible within this special issue of the **docomomo** Journal to find these contributions of superb articles. It is obvious that there are no boundaries when it comes to identify types of structure and material, thus introducing the challenge of structural design and conservation technology. There are few limitations to the extensive universe; in reality it is questionable if there are limitations at all, certainly when considering structural design and the Modern Movement.

The articles gathered in this Journal characterize a diversity brought together with a certain, but not demanded, relation to the mission and statement of **docomomo**. The authors have more or less explicit relations to the Modern Movement, architecture, and technology. They all represent a view of special interest and knowledge about bridges and infrastructure.

Jürg Conzett emphasizes the importance to keep up a Modern tradition of scientific engineering, an open critical process. Further, "We need more than this", J. Ruskin's work on synthetic Modernity, and the approaches into a coherent concept.

Denis Zastavni's article about concrete and Robert Maillart's innovations represents a scientific work about structural behaviour and graphic statics.

The alarming condition of the Maracaibo Bridge in Venezuela is the topic of **Hannia Gómez** and **Rino Montiel**. They ask for the need of scientific help as an urgent issue on a topic that calls for action; an important asset for infrastructure in Venezuela.

Pierre Jartoux presents Eugène Freyssinet as a natural born builder, a crack eliminator and developer of structural form under stress.

Carlos García Vázquez speaks about Eduardo Torroja's concrete shell construction, pretension and the Alloz Aqueduct.

Rinaldo Capomolla's "Theory of minimal surfaces", deals with membrane and development of infrastructure by Sergio Musmeci and the Renaissance ideal.

Annette Bögle concentrates on Fritz Leonhardt (engineer) and Friedrich Tamms (architect) and the development of cable–stayed bridges, light appearance and the efficient use of materials.

Daijiro Kitagawa presents an introduction of industrial construction in Japan after the great earthquake of 1923. The article addresses Modern structural design, technology, material and aesthetics.

Norihide Imagawa and **Shinsuke Suematsu** find in Modern Japanese bridges a survey and a heritage.

The article "Cable Supported Bridges across Straits in Denmark" by **Niels Jørgen Gimsing** is a story dealing with both bridges and infrastructure connecting the islands and the nation.

Jørgen Nissen speaks about Arup and his concept and birth of bridges, being there during construction in *statu nascendi*.

John Allan, a world within a world, concentrates on the conservation of the penguin pool in London zoo.

Pétur H. Ármannsson focuses on bridges and infrastructure while exploring Iceland and concrete technology.

Henrieta Moravčíková writes on the Piešťany spa and the promenade bridge as a social meeting spot.

Tim Samuelson speaks about the Lincoln Park Passarelle better known as the Rainbow Bridge.

Kieran Ruane deals with the Mizen Footbridge near Cork, conservation and construction authenticity.

And **Mari Hvattum** focuses on infrastructure and changing technology, reality...

Kintai–Hashi: an Example of Conservation, a Sustainable Bridge from the Edo Period

It is obviously exceptional to mention the *Kintai–hashi*, Kintai Bridge, the old wooden arch bridge built in the city of Iwakuni, Hiroshima, in 1673, assigned a national

property of scenic spot in 1922.

The restoration, with minor and major changes to the bridge, is being done with intervals of about 20 years, thus still living for nearly 340 years, time passing, before and through the Modern Movement and today.

Whenever opportunities for the restoration or retrofitting have been met, new technology was adopted with skill and precision of master-hand carpenters, not only solely keeping tradition, but also positive to make them foster. For instance, improvements were done to the islands/piers in the stream in the early 1950s, when hydrodynamic technology was introduced to be endurable to rapid current caused by repeated typhoons. Therefore concrete structure was introduced inside the supports on the islands, tiled by natural stone so the original appearance remained on the outside. The latest restoration was successfully done in 2002–2004, as an example that conservation technology has to learn from the past to live today. The bridge itself is a sort of flexible structure, still solid enough for bearing load. It is certainly an appreciated pedestrian bridge as it has been from the beginning. It is the usual footpath for the daily commuting of citizens. Furthermore, nowadays it is a scenic object for tourists, even though it has served with hunch as a footpath/deck seeming inconvenient to walk on.[5,6]

Aesthetics of Bridges

It is agreeable to know the explicit theory on the bridge design today, stated by Christian Menn:[7] "the most important design objectives, common for all bridges, are: 1. Safety, 2. Serviceability, 3. Economy, 4. Elegance."

Economy and Elegance are not defined in the design standards. These two objectives are to some extent interrelated. And optimal balance between economy and elegance requires a design effort that goes beyond the technical aspects of design and is the true art of the engineer.

The question of aesthetics has been long discussed by bridge engineers and designers. The concept of aesthetic quality is indeed difficult to define. Nonetheless, there are innumerable structures that are treasured or famed by people around the world, structures that somehow exhibit a kind of beauty/elegance, to attract general public attention. A well-designed bridge based on a consistency of conceptual design is often a mark of a successful effort. It should be holistically designed, satisfy certain basic criteria in a well-proportioned and unified structure, so to say as a unity of function (purpose, serviceability), structure (safety), material (the right factor in right place), form (configuration, finish-colour, texture), and possess a certain elegance (aesthetics, harmonization with surroundings), as a social and cultural asset. Most bridge projects nowadays are in fact influenced by political, social, and economical conditions, foremost technological and engineering knowledge and method in general, furthermore to be environmentally friendly (in other words, sustainable) is a consideration of concern especially in this global era, of course it is indispensable to manage in accordance with the diversity of site conditions as well.

Notes

1. Mock, Elisabeth, *The Architecture of Bridges*, Ayer Co Pub, 1972.
2. Arup, Ove, *The Design of Bridges*, The Arup Journal 2/2009.
3. Ito, Toyo, *Garden of Microchips*, Japan Architect, 1993.
4. Conzett, Jürg; Linsi, Martin, *Landschaft und Kunstbauten/Landscape and Structures*, Zürich, Verlag Scheidegger & Spiess, 2010, 14–15.
5. Kazuhiro, Inoue, *A Record of the Reconstruction of the Kintaikyo Bridge*, Up-frontboos, 2004.
6. City of Iwakuni, The Kintaikyo Wooden Bridge, http://kintaikyo.iwakuni-city.net/kintaikyo.pdf.
7. Menn, Christian, "The importance of the structural concept in bridge design", Proceedings of *Conceptual design of structures*, International Symposium University of Stuttgart, October 7–11, 1996, 653–662.

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Born in Tokyo, Urban Environmental Designer(JIDA), Senior Professional Civil Engineer (Infrastructure design/JSCE), from 1971 to 1993 chief designer with partnership at M+M Design Office, mid 1993-94 fellowship researcher at Royal Danish Academy of Fine arts (Inst. Structural Science), 1995 set-up and lead her own Design Studio, and now she is a freelance designer and civil-engineer. She has been involved in a number of bridge aesthetic design projects for a long time, some of those works being granted the JSCE/Tanaka Award (Excellent in Bridge Design Work), also prizes from overseas assoc., and so forth.
She is the author of several books such as *Aesthetics of Danish Bridges*, Kustakademiets Forlag Arkitektskolen Denmark, 1995; co-author of *Ped-design for footbridges networking towns*, edited by JSCE, Kajima shuppan-kai, 2006; and others.

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His work involves research and development of architecture and he has published several books and articles about Modern Movement architecture, material, technology, climate and culture. He is coordinator of Docomomo Denmark with certain concern for Nordic and Baltic cooperation. He is a member of the Docomomo Specialist Committee on Technology and ICOMOS ISC 20th century.

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