



The Millau Viaduct – Ten years ago

Lord Foster & Michel Virlogeux

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Introduction: 25 Years of *SEI*

This year *Structural Engineering International*, *SEI*, is celebrating its 25th year of publication. To mark this anniversary, a poll held at the end of 2014 included a selection of 25 structures that have been highlighted in the journal and/or have received the prestigious IABSE Outstanding Structure Award. The poll produced three clear winners, with the most votes going to the Millau Viaduct in France. Second and third place went to the Burj Khalifa in the United Arab Emirates and the Sunniberg Bridge in Switzerland, respectively.

While the poll gave a snapshot of some of the most exceptional structures that have been constructed over the past 25 years, it also gave rise to reflection and questions: how have these great structures fared since their completion, what was learned from their conception, design and construction, what effect have they had on the profession or on society as a whole?

In the following papers, the three winning structures from the *SEI* poll are revisited and some of the questions regarding their performance and impact are explored. First, we are pleased to have received a foreword to the Millau Viaduct

from its primary designers, Norman Foster and Michel Virlogeux, followed by an overview from a team of authors of the extensive structural monitoring that has been carried out during the construction and subsequent 10 year service life of the structure. Bill Baker and James Pawlikowski continue in the second paper with a description of the Burj Khalifa, including the development of the structural system used for this super-tall building and its influence on future buildings of this kind. Finally, Thomas Vogel and Kristian Schellenberg detail the many considerations and refinements made over the years leading to the construction of the Sunniberg Bridge, and the result, which has had a tangible influence on the profession both in Switzerland and internationally.

We hope you enjoy this special series of papers and invite you to join *SEI* in its next 25 years as the journal continues to publish papers that bridge the gap between theory and practice.

Ann Schumacher, Chair Editorial Board, *Structural Engineering International*

The Millau Viaduct — Ten years ago

It was a pleasure for us—all those involved in the design and construction of this monument and especially the engineer and the architect who created and developed the design—to have learned that the Millau Viaduct was voted *SEI*'s favourite structure from the past 25 years.

The success of this structure can be analysed through the three famous design goals of Vitruvius Pollio, written some 2000 years ago.

- **Utilitas**, utility, meaning public utility, but with a special attention to preserve public money which is more rare today than it could have been.
- **Firmitas**, solidity, meaning of course structural strength but also durability which is the most important goal for true environmental preservation, to avoid spoiling resources.
- And finally **Venustas**, beauty, which refers to both the elegance of the structure itself and the quality of its integration in the site.

Utilitas was clear when considering the congestion of the Rhône Valley motorway and the traffic requirement to connect South France and Spain, and to avoid the well-known traffic jams in Millau. Before the Viaduct was opened to traffic, two to three hours were needed to cross the city with two-way flow of users, North–South and South–North, crossed end of July and beginning of August.

More than 50 million cars and trucks have since then passed on the Viaduct.

As regards the cost, another solution with two towers—one on each side of the deeper part of the valley—could have been slightly less expensive and its erection would have been easier.

But from start, and despite oppositions and disputes, the engineer preferred giving more unity to the bridge with the now famous seven towers, and the architect convinced the jury in charge of the final decision, stating that the bridge was not to cross the River Tarn, but only the River Tarn valley.

Structural design and architectural elegance, *firmitas* and *venustas*, have been fully integrated by the architect and the engineer who were convinced that extreme elegance can come only from the structural shapes themselves.

The final goal was to produce a light structure, leaving to the site its transparency.

- Long spans, to reduce the number of piers to a minimum
- A cable-stayed bridge to limit the structural depth to about 4 m
- A sensible design of piers and towers to meet at the same time both structural needs and elegance, with shapes that are far from being as simple as they appear, while letting light and shadow play in the varying day light
- A slightly curved alignment—suggested by Roger Lacroix—to enhance the view of the bridge for users passing by the motorway
- Piers emerging from the ground, and the deck penetrating the hills at each end, for a perfect integration in the landscape as requested by the architect, calling for unusual technical details
- And finally a structure reduced to its essence, a thin line crossing the valley, supported by seven identical towers, the design giving the desired impression of simplicity and tranquillity by the repetition of identical spans.

But the success could not have been attained without the creativity and the involvement of the concessionaire and the contractor.

Workers in charge of pier erection had all been trained on a trial wall with the type of self-climbing forms that they will use on the piers.

Eiffage Group developed a new technology to launch the deck from both sides without introducing any longitudinal action on the piers, the necessary launching force being produced on each support, and by using a central computer and sensors to control the uniformity of the deck displacements.

The deck has been launched with the corresponding equipment in steps of 171 m, one every five or six weeks, under careful meteorological control.

Finally, the bridge had been completed one month sooner than anticipated, in 38 months.

The success of this project comes from the creativity of the design, which has not been developed for display but to serve the structure; from the constant support of the local authorities and population; from the devotion of the successive design teams; and also from the involvement of the Eiffage Group, from their executive officers to the workers on site, some of them being so excited at the construction end, saying that they will never live such a fascinating and rewarding adventure.

We have been part of some fascinating projects, but this one has been a special experience with many obstacles and oppositions to cross, but above all with the exceptional human experience created by the common goal of the design and construction teams.

Lord Foster of Thames Bank, Michel Virlogeux



SEI 25 Years Online Poll Results January 2015

Rank	Structure	Country
1	Millau Viaduct <i>- SEI paper by C. Servant and M. Virlogeux</i>	France
2	Burj Khalifa <i>- SEI paper by J. Pawlowski and W. Baker</i>	Dubai
3	Sunniberg Bridge <i>- SEI paper by Th. Vogel and K. Schellenberg</i>	Switzerland
4	Rion Antirion Bridge	Greece
5	Great Belt Fixed Link	Denmark
6	Gateshead Millennium Bridge	UK
7	Olympic Velodrome	UK
8	Hongshu-Shikoku Bridge	Japan
9	Normandie Bridge	France
10	Guggenheim Museum Bilbao	Spain