High above the clouds: The Millau Viaduct

By Rachel James and David Arscott
• World’s tallest road bridge. 275 metres high, measured from base to bridge deck.
• Almost the world’s highest suspension bridge! 343 metres high, measured from base to highest point.

High above the clounds: The Millau Viaduct
The Humber Bridge, Hull

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Humber Bridge, Hull. October 2015
• The highest bridge in Europe.
• Taller than the Eiffel tower which used to be the tallest structure in France.
• More than twice the height of the Garabit Viaduct.

High above the clouds: The Millau Viaduct
• Spans the Tarn River.
• Conceived to relieve traffic congestion through the town of Millau on the main Paris to Barcelona route.

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• Department of Transport and Public Works France decided to forge a partnership of civil engineers and architects in order to marry function with beauty.
• Architectural competition saw several entrants propose crossing the river at its narrowest point.
• Foster & Partners proposed bridging the entire valley with a cable stayed viaduct slung between the high plateaux on either side.
• Foster & Partners worked with the French structural engineer Michel Virlogeux.
• Construction process commenced in October 2001.
• Virlogeux had previously designed cable stayed bridges and used the Millau bridge to refine the concept.
• Construction of the bridge took just over three years – quite remarkable for such a feat of engineering.
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• New construction technique developed to ‘launch’ the bridge from either side of the valley.
• The two sides of the bridge deck met in the middle.

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Tacoma Narrows Bridge, Washington. November 1940
- Flexibility of deck causes a deformed shape as the deck oscillates during launch.
- Wind protection and monitoring equipment incorporated into bridge design.
Constructing the piers

The bridge is supported by 7 piers, the tallest of which is 245 metres.

The ground conditions, anticipated weight of the bridge and loads placed upon it determine the size and depth of foundation for the piers to sit on.

The local soil is principally Limestone and full of caves and fissures containing bacteria used in the making of the region’s main export – Roquefort Cheese.
Each pier sits on a concrete base plate supported by 4 pile foundations, each of which is 5 metres in diameter and up to 14 metres deep.

The piers are pairs of tapered columns, octagonal in section.

In general, each pier is identical from the road deck down.

For a distance of 90 metres from the deck, a twin pier is used.

90m below deck is a transition point where the twin pier becomes a single pier.

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Each constructed independently – like separate building sites.

The piers were ‘slip formed’ on a self-climbing shutter system (mould).

The piers were formed from reinforced concrete

This is a common way of constructing tall structures
Andromeda Tower, Vienna

Sharq Building, Kuwait

North Danube Bridge, Hungary

SLIP FORMING AROUND THE WORLD

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Mega Bridge, Bankok
The geometry of the piers varies from one pouring step to the next and is tapering entire way up.

The shape of the mould was changed at every 4m step to fit the profile.

GPS checking systems ensured a precision of the order of 5mm in any direction.
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The deck of the bridge was made from steel rather than concrete in order to reduce the overall weight both in operation and construction.

The steel deck was fabricated in a factory and delivered to site in approx. 2200 sections.

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Installing the Deck

The deck sections were assembled on-site at each end of the bridge to form two complete decks and launched into place on computerised hydraulic launchers.

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The launchers push the decks towards each other over the piers, moving 600mm every 4 minutes

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The deck sags during each span crossing and a ‘nose recovery’ system is attached to raise the deck to the level of the next pier.

The nose recovery system uses hydraulics to lift the deck as it begins to sag and uses GPS navigation to achieve an accuracy of up to 4mm.

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After about 5000 cycles the decks meet and are joined

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Constructing the pylons

Each deck was positioned with one pylon in place to provide stiffening when joining the structures.

Each pier is topped by a steel pylon which takes the form of an inverted ‘Y’ to match the ends of the concrete piers to achieve maximum rigidity.

Following the deck construction the pylons were erected to attach the cables and support the bridge.

Although the temporary piers were supporting the deck it was very warped so the pylons and cables needed to be installed as soon as possible to straighten the undulating deck.

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The technique used to place the pylons can be traced back to ancient Egypt.
The pylons were slowly lifted using hydraulics and at the same time were made to pivot into place.

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Attaching the cables

The cable stays stiffen the road deck, prevent sagging or collapse and provide the strength to endure constant traffic loading.

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Each cable stay consists of 91 strands of steel and can take a tensile load equivalent to 25 jumbo jets at full thrust.
Wind Screens

As the wind speed at the bridge deck level could reach 100 miles per hour (significantly higher than the valley below) a solution was sought to reduce the effect on the traffic.

Wind screens were designed along each edge of the bridge deck

These stand at 3 metres high and use ‘blades’ to reduce the wind speed by around 50% whilst retaining views across of the valley.

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General Technology

Other technical advancements that are less obvious to the eye include an array of movement and motion sensors including:

- anemometers
- Accelerometers
- Extensometers

Data collected from these devices will help engineers pinpoint potential trouble spots and unwanted wear and tear that could shorten the life span of the many bridge components.

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Form Follows Function

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"Whether it be the sweeping eagle in his flight, or the open apple-blossom, the toiling work-horse, the blithe swan, the branching oak, the winding stream at its base, the drifting clouds, over all the coursing sun, form ever follows function, and this is the law. Where function does not change, form does not change. The granite rocks, the ever-brooding hills, remain for ages; the lightning lives, comes into shape, and dies, in a twinkling."
“It is the pervading law of all things organic and inorganic, of all things physical and metaphysical, of all things human and all things superhuman, of all true manifestations of the head, of the heart, of the soul, that the life is recognizable in its expression, that form ever follows function. This is the law”

Louis Sullivan (1896)
High above the clouds: The Millau Viaduct
Visit after sunrise in autumn when the bridge appears to float above the mist.
Piers act as lightning rods during storms

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• The bridge traces a shallow curve of 20km radius to prevent travel sickness.
• Movement joints on the deck allow for expansion of one metre.
• The total cost of the viaduct construction was €340 million.

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