

viaduc

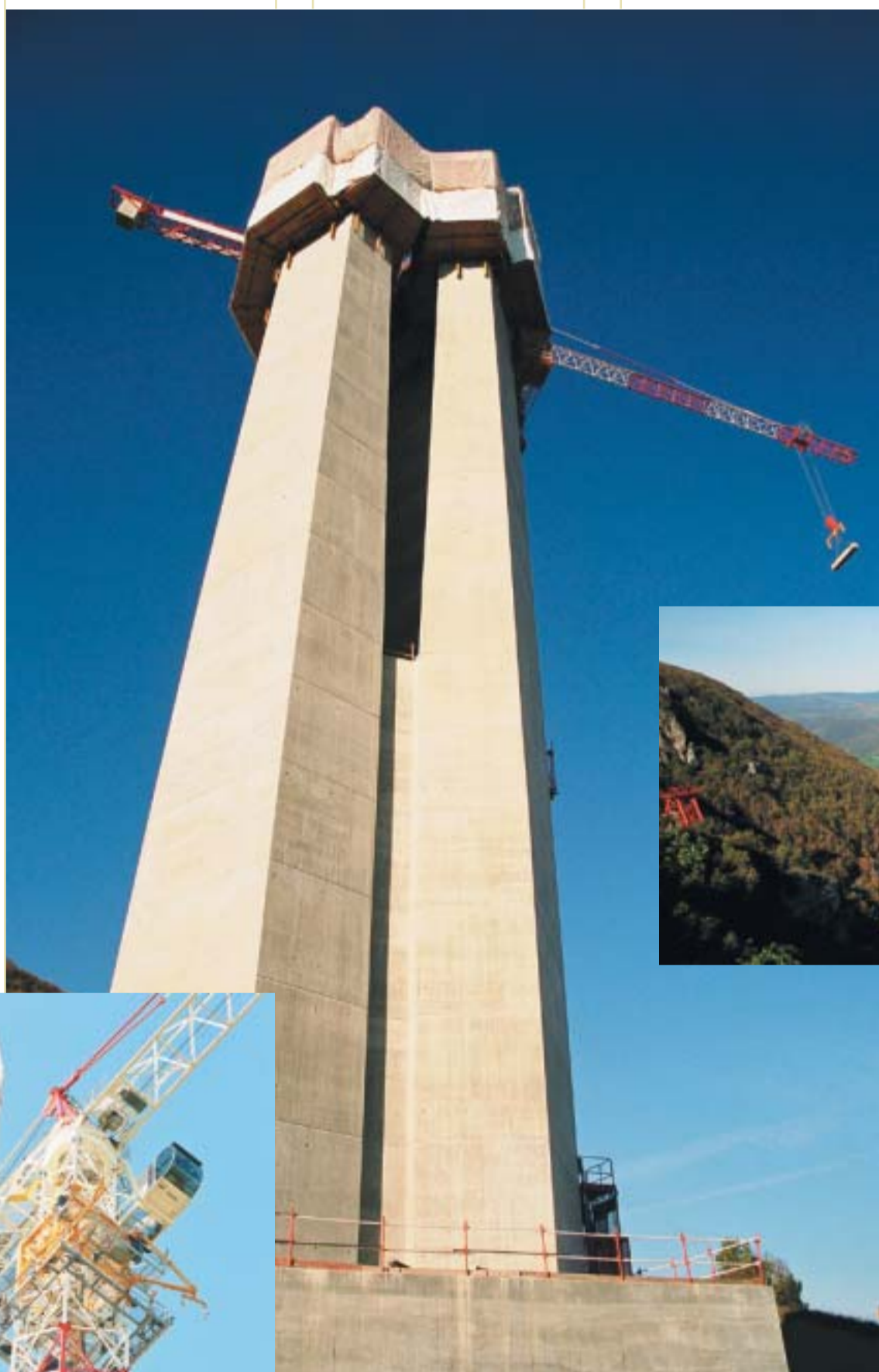
ÉDITÉ PAR LA COMPAGNIE EIFFAGE DU VIADUC DE MILLAU

One year later: more than 100 metres high!

The viaduct is rising towards the sky at the rate of four metres every three days. The twenty-fifth vertical section of pillar number 2 has been completed. The 100-metre level has been passed.

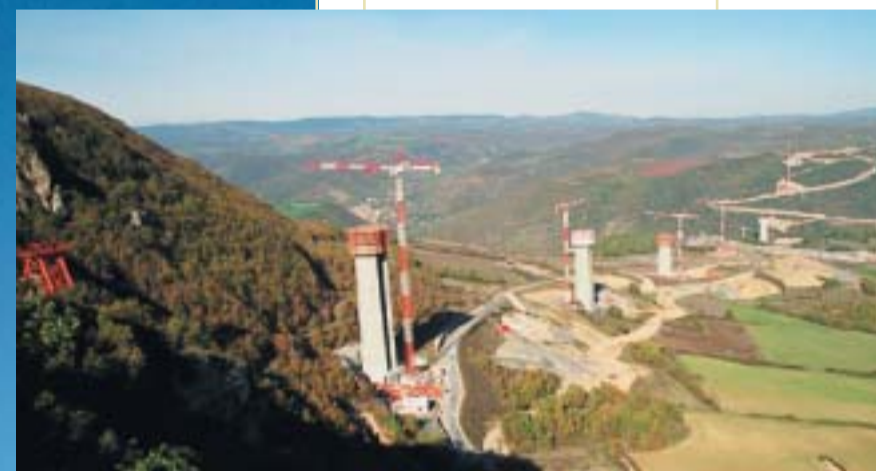
An engineering force of 250 men, joined by the Eiffel teams on the viaduct launching ramp, make the worksite look like a factory open to the sky. Everything is on schedule. The teams are united. The challenge is met, day after day. "We have reached our cruising speed", comments Jean-Pierre Martin, the worksite manager. "The initial calculations estimated a rate of ascension of four metres every three days. Today all the teams are able to sustain that. It is the proof our estimates were correct, and that a skilled workforce and appropriate machinery have been carefully selected".

The graph on the wall chart tracing the progress of the work



of metres high: a performance never before achieved. The higher the crane gets, the less stable it becomes. It is necessary to secure the body of the crane to the circumference of the pillar with temporary brackets. It is like a bridge between earth and sky, a link between the structure and the men building it. "We gave ourselves a week to raise a crane by 30 metres. We succeeded in four days", says Jean-Pierre Martin proudly.

Another challenge that the men on the viaduct have yet to face: the tops of the pillars. This concerns the last ten metres. The final concrete sections are awkward. The pillar, which is hollow to that height, is then made solid. At this level, the



The viaduct begins to take shape in the landscape.

pillars have to support the metal deck. The stress forces are going to be enormous. It will be necessary to be very precise when the steel framework, which will support the deck, is buried in the concrete heads of the pillars. The first operations are presently being carried out on pillar number 7. These will allow tests to be made to validate the calculations and methods for the whole of the structure.

One year after the start of the work, the teams are now subject to the intense rhythm that had been predicted. Forty-nine thousand cubic metres of concrete have already been poured. There is still almost as much to be done.■

shows how many operations have to be co-ordinated to obtain this result. It is impressive. The decision to set up seven worksites (one for each pillar) was the correct choice. Each workforce is stimulated by the rate of ascension of the others. Without being in competition, but proud of succeeding in the time

allotted, the men are fully concentrated on the construction.

Raising the cranes is one of the awkward operations. Always high above the tops of the pillars, they have to be raised regularly. "We are supported by a vast concrete structure. We have to follow a line hundreds

**A steel ship
See page 2**

The crane is anchored to the pillar by temporary brackets.

Craftsman: welder

"Dominique, put in the ceramic pottery!" Michel cries through the side of the viaduct deck. Inside the box-girder, his colleague has positioned the plate that



Joseph Veira, welder.

prevents the molten weld from running. The metal scar is as smooth as skin. "A good welder must be meticulous, know how to control the parameters and have a feel for his work. Here, you have to accept to set the voltage at a minimum. It makes the work harder, but the result is impeccable." Michel Josse concentrates on the line of the join. The line is unwilling to run. Nevertheless, Michel is delighted when he gets what he wants. What he wants is perfection. He has been working at Eiffel for 21 years to be able to obtain this result.

On the other side of the 32-metre wide metal road, Joseph Veira is also welding. Like Michel, he arrived this morning at 6 a.m.. It was still dark. The floodlights made the white frost shine covering the surface of the structure. The two men looked at each other, and thought

the same thing. "Until the sun rises to heat up the steel, there is no point in thinking of welding". Joseph expresses what he has done all his life: living with metal. That morning, welding would mean provoking such a thermal shock between the cold steel and the welding arc that the work would be of poor quality. "Metal is like stone", he says. "A sculptor has a gut feeling for the block of stone he is working on. Like us, he analyses in real time the right gesture to make. It is more than a job. To be a welder is an art".

With Eiffel, Michel has worked on bridges and viaducts, but never on a structure as large, as high or as prestigious as this one. Joseph, on his part, wanted more than anything to be on the team of the "Millau welders". He knew of the project, but not how to get on the Eiffel teams. So, he registered with a temporary work agency. Backed by his



experience, he easily passed the ability tests. Then he found himself where he dreamed of being: on the viaduct. It is a little like the crowning achievement of his career. He now knows that he will end his career with Eiffel. "It's a family, a spirit which suits me. I am like them. I am passionate about what I do. It's my training".

The welders have begun to work again on the viaduct. By the sound of their welding rods, they know that the weld will be good. Like the



Michel Josse, welder.

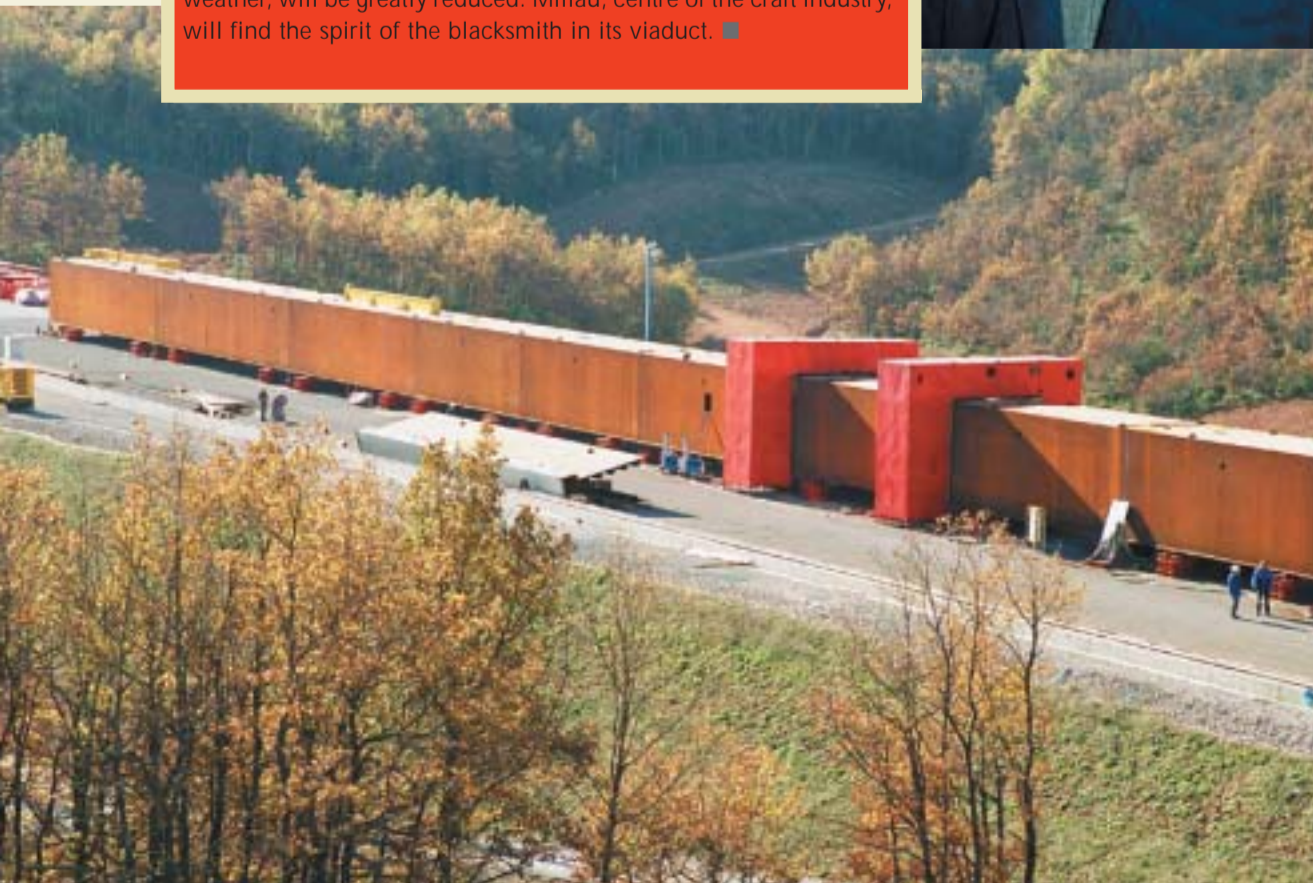
blacksmith listening to his anvil. Like the sculptor striking marble. ■

In the blacksmith's tradition

Everybody can imagine a blacksmith heating iron in his forge, beating it on the anvil and dipping it in cold water. These ancestral gestures belong to the past, but the principal remains. The 35,000 tons of steel that make up the deck of the Millau viaduct are treated in the same way. There is no alloy. We are dealing with pure metal. It is the blacksmith who gives tensile strength to the steel.

Thermomechanical steel is a speciality of Dilling-GTS, a subsidiary of the Arcelor Group, (world leader resulting from the merger of three european steel manufacturers: Arbed, Aceralia and Usinor). Situated close to the Sar region, the factory is one of the few sites in Europe capable of rolling very wide sheets of metal. Immediately it emerges from the furnace at 1,000 degrees centigrade, the sheet passes through enormous rolling mills that begin to reduce its thickness. Then the sheet is cooled with water. Stringently configured computers check the temperature. Then the process is repeated, just like a blacksmith does. By dint of repeating the process, the steel becomes thinner and thinner, while getting increasingly resistant.

It is easier to weld carbon steel that has been treated in this manner; and the quality of the welding is excellent. Thus metal fatigue, from being subjected for many years to the strains of road traffic and the weather, will be greatly reduced. Millau, centre of the craft industry, will find the spirit of the blacksmith in its viaduct. ■



The box-girder sections await their turn.

Eiffel

35,000 tons of metal structure to be assembled

Jean-Pierre Gerner, director of works for Eiffel.



They arrived at the end of summer. From now on, they are going to be part of the scene until the last day of the worksite. They are the men from Eiffel; the name of their company recalling the fact that they have always been leaders in the field of metal construction. The Garabit Bridge and the famous tower bear living witness to their heritage.

At Millau, they took possession ahead of schedule of the launching ramp built by their colleagues from Eiffage. Advantage was immediately taken of the lead established by the engineers to have the first box-girder sections delivered to the site. For the time being, these are just twenty-three gigantic metal cubes which, however, once assembled together, will form the backbone of the deck, in other words of the roadway.

A steel ship

They are almost a hundred. Half of them are welders; the others are assembly workers and fitters. As a single team, they work in shifts from 6 a.m. until 10 p.m. At night, the worksite is floodlit. The metal cutting wheels send up showers of sparks that respond to the magical flames of the welders. Gigantic hoisting gear moves the steel monsters towards each other. It is like watching a ship being built. Abutment number 8 now looks more like a great naval construction yard hiding in its entrails the ships ready to take to sea.

Here also, one day in the future, it will be necessary to release the deck towards its final destination: the air. The event is forecast for January. Hydraulic jacks will push thousands of tons into the open above the valley. To avoid the weight of the leading edge of the deck causing it to plunge towards the earth before it reaches the first pillar, a leading beak is being constructed. As the name suggests, this is a sort of flat projection like a beak which will precede the deck to allow contact to be made more quickly with the first resting point, a sort of metal tower serving as a temporary support half way between each pillar. These provisional supports will help carry the enormous weight of the structure until it is secured finally between earth and sky with steel stay-cables. "To erect the provisional supports, we are going to use a system capable of lifting the heaviest one weighing 1,000 tons with four synchronised jacks. It will be accurate to within three millimetres", explains Jean-Pierre Gerner, director of works for Eiffel.

Indeed, sensors will control the movements of the enormous framework during its launching. They are sensitive to a millimetre. A number of robots will handle this delicate phase of the launch. Everything has been foreseen. Everything is calculated. Except for the wind which, if it blows too hard, could delay everything. ■

Jean-Raymond Vernet,
head of Sévigné Industrie.



Partner

A mountain of sand

For the viaduct, the Causse Rouge has been called upon. Its entrails will deliver the best it has: its limestone. "It's a very homogeneous rock, of excellent quality", explains Jean-Raymond Vernet, in charge of Sévigné Industrie. Everybody knows Sévigné at Millau. It is an important company in the region entrusted with supplying 70,000 tons of sand and 80,000 tons of grit to the viaduct constructors. Every day the company extracts from its Rascalat quarry the stone that will be used to make the sand for the concrete.

The quarry site is impressive. A gigantic crater descending level by level to a depth of 70 metres, the thickness of the workable layer of limestone. The Sévigné Company mines a 54-acre site. "For the viaduct, the lower levels are not used because the rock is darker", explains Olivier Taquet, in charge of the mine. The specifications call for concrete of a uniform colour. There is no way Eiffage would build pillars with shades of colour dependent on the whims of the subsoil. The purity of the lines of the structure designed by the architect must be respected. It is only in this way that the viaduct will bring to nature the signature of a work of art set in the landscape.

Mountains to molehills

In the quarry, the transformation of the Causse into millimetre-sized grains of sand follows a rigorous process. Once a section of the cliff has been exploded, the jaws of hydraulic shovels gather up the blocks of stone and load them into dump trucks that drive up and down the tracks at the base of the cliffs all day long. The rocks are then emptied into the percussion crusher. The boulders fall onto a cylinder equipped with hammers that project the rocks as though hit by a baseball bat against armoured screens. The shock is such that the limestone, which enters the machine like an army of half-metre sized blocks, emerges in fragments the size of grapefruits. They follow along a series of conveyor belts that grade the rocks by size. Washed, separated from any impurities, the rocks will have become "fine-looking stones" which will have to be further reduced into grains of sand. At this stage, they are not yet suitable for the viaduct.

The men on the worksite have to be able to propel the concrete more than 100 metres high. This is achieved by using extremely powerful pumps and carefully controlled raw material. The

sand for the concrete has to correspond to criteria of specific fineness. It is not just a question of the quarry having to reduce the rocks into sand particles of a very precise size, but also having to mix together homogeneously several types of different granularity in order to obtain a mixture corresponding to a norm defined by exacting studies. "This is carried out by computers which calibrate the output of the conveyor belts", explains Jean-Charles Bourrel, in charge of this part of the operation. Indeed, each conveyor belt discharges a different quantity of different types of grains of sand. Everything is then mixed and homogenised".

Once the sand for the viaduct reaches the stockpile area, it is not yet ready to be delivered. It still has to pass a series of tests. Sévigné makes internal tests; Eiffage conducts the outside tests. The laboratories take samples every day. Until these tests have been made, a red sign on top of the pile forbids delivery. Only when the sign is changed to green can a fleet of trucks transport to the worksite this very special sand which will be used for the construction of the viaduct. This is why the pillars are so elegant and white in the Millau sky. ■



The tangle of a rigorous procedure for transforming the Causse into grains of sand a few millimetres in size.

Transport

Expert drivers

The impressive steel box-girder sections making up the structure of the viaduct arrive by road. They come from the east or from the south of France in exceptional convoys. Preceded by a guide car, each load takes three or four days to travel to its destination. On board, an expert driver directs all the manoeuvres like a ship's helmsman.

It is a profession requiring a lot of experience. Experience that they have at the Capelle transport company, which has been chosen recently moreover to transport the parts for the future Airbus A380. To be part of the team of these exceptional drivers at Capelle, about ten years of driving convoys is necessary before being entrusted with such a load. Out of fifty drivers, only two or three manage to join these elite professionals. Some of the parts of the viaduct weigh up to 90 tons. You need to have a good eye! ■

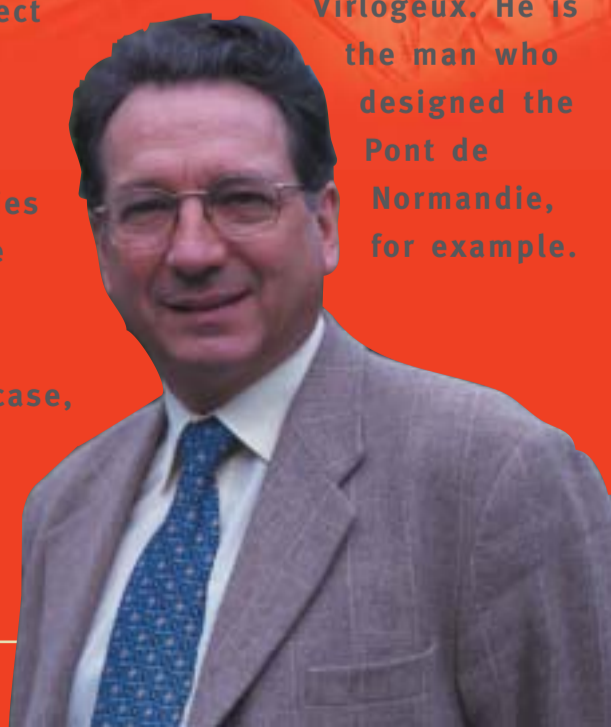
Tarn river, the natural harmony of the landscape would have been disturbed. Everybody would have been shocked".

The beauty of a structure is determined right from the start. The technical choices that allow the delicate features to be emphasised resulted from the initial design. One can talk of an artistic creation when, subsequently, a very talented architect such as Norman Foster conceives the purest forms to respond to the emotion which every traveller experiences when discovering the site. The close relationship between the designer and the architect is the reason for it. ■

Design

The designer and the architect

The histories of great structures like the Millau viaduct are not created in a day. The design begins many years before the project gets off the ground. Engineers make the initial studies for its structure and architects determine its shape. In this case, the architect is very well known. It is Lord Foster.



The concept designer is also well known, but in the field of large-scale constructions. His name is Michel Virlogeux. He is the man who designed the Pont de Normandie, for example.

As a senior civil engineer, Michel Virlogeux was working for the French central office for national roads when, for the first time, the subject was raised of building a structure at Millau to provide a fast way across the Tarn valley. This was in 1987. It was not really yet a question of a motorway.

Several routes were defined, discussed, modified, and rejected. Finally, one of them was adopted. The structure still needed to be designed. This was the role of the concept designer. What structure to choose? What techniques should be adopted, and for what specific type of structure? "We worked for several years with a large number of engineering teams, studying and proposing every possible solution", explains Michel Virlogeux. "Indeed, you cannot commit yourself to building such a large construction without first

studying all the projects submitted, even if they very quickly turn out to be not feasible or too daring to guarantee absolute safety".

Traced in the landscape

The choice of the structure of the Millau viaduct was a determining factor. "We had decided since 1990 on a series of regular spans. Our conception is not only the result of construction studies and technical imperatives. It is also, and this is very important, our wish to blend into the landscape". To explain this point, Michel Virlogeux shows us an overall view of Millau. In the foreground, the town stretches into the valley. In the background, a succession of plateaux delimits the horizon. Between the two, the model of the viaduct delicately and regularly crosses the gap. "Take careful note", says Michel Virlogeux; "You can't see the Tarn river. If we had decided to build a series of small spans and then, all of a sudden, a great wide span to cross the river, the observer would not have understood why. Without being able to see the obstacle of the

Michel Virlogeux, concept designer of the Millau viaduct.

Individual houses for some employees of the worksite.



Housing

The Millau welcome to the worksite families



Marie-Paule Solier, Cocitra Mobilité.



Able to be provided with permanent housing, often from one day to the next, relying on the property resources of Millau and the surrounding area, is how those responsible for lodging the worksite teams foresaw the arrival of 300 families, ranging from the bachelor to the couple with children. The Compagnie Eiffage du Viaduc de Millau (CEVM) turned to an organisation it knows well: Cocitra. Its subsidiary, Cocitra Mobilité, has opened a branch office at Millau with a team of female Millau residents, responsible for the CEVM staff needing somewhere to live. For more than a year, Marie-Paule Solier has been welcoming them together with her colleague Virginie. "One day I saw a man arrive with his wife and children, the car filled to the top with their personal possessions. He needed somewhere to stay. He thought it would take me 24 hours to find him something. Well, we managed to house him that very evening".

Marie-Paule readily tells us about such comical situations or about other more disconcerting stories and the impossible challenges that they have had to solve every day. For

example, the time when she asked a man for his papers in order to complete his file for the estate agencies. He just emptied a large canvas bag onto her desk containing a jumble of official documents, personal effects and pocket money. "It was up to us to sort it all out", she laughingly recalls.

No preferential treatment

At their office on Rue de la Fraternité, Marie-Paule and Virginie quickly established friendly relations with the people who had come from afar to build the viaduct. "We go to the gym with one of the clerks of works, and we are invited to the worksite barbecues", they tell us delightedly. Their knowledge of the town and their natural conviviality have opened many doors to them. "Everybody has played the game: estate agencies, public services, insurance companies, companies like the EDF electricity board... and the inhabitants of Millau

who informed us about vacant accommodation". It is true that the danger of a shortage of housing was a permanent concern at the height of the migration. It was the recurring challenge: find more accommodation. Chalets and houses were built. Thanks to the 1% employers' benefit fund administered by Cocitra, work could be undertaken, and grants obtained. For example, loans for rental deposits were provided free of interest. All the requirements concerning personal resources were met before being granted council housing. Being part of the worksite did not lead to any preferential treatment.

The worksite is going to last a long time. It is a fixed site. One of the wishes of the CEVM is to integrate the viaduct teams into the local way of life. Now, to fit in well, you first need to be comfortably housed among the inhabitants who are welcoming you. The inhabitants of Millau understood this, and responded with warmth and enthusiasm. ■

The Millau viaduct will not cost the taxpayer anything

According to the terms of the concession contract, the financing of the viaduct is entirely the responsibility of the concessionaire, with no subsidy or loan guarantee from either the State or local authorities.

The Eiffage Group brings to its subsidiary, the Compagnie Eiffage du Viaduc de Millau, the financial support required for this investment of more than 300 million euros. The collection of tolls, throughout the duration of the concession (75 years) will allow repayment of the loan, and secure a return on the capital invested by the Group.

By this method, the financial resources of the State are preserved so that they may be used to build other sections of the A75 motorway as quickly as possible. The opening of the viaduct service will indeed assume its full significance in the context of the continuity of the motorway route between Paris and the Languedoc-Roussillon region. ■



Roselyne Bachelot next to Marc Legrand, head of CEVM (left) and Jacques Godfrain, mayor of Millau (right).

During the summer and autumn, the viaduct worksite has attracted and continues to attract a large number of visitors. Among the noted personalities to have toured the worksite are Roselyne Bachelot, Minister of State for Ecology and long-term Development, as well as several former ministers. Besides Jacques Godfrain, Member of Parliament and mayor of Millau, visitors have included Jean Puech, president of the Conseil Général (departmental

council) of the Aveyron department, Jean-Claude Gayssot and Pierre Mazeaud, a member of the Constitutional Council.

Performing artists like Henri Salvador and the film director Claude Pinoteau have also visited.

The calm atmosphere prevailing on the site has particularly surprised many of the journalists and television crews who have come to tour the worksite. Every individual worker, in his place, seems to be performing his task like a cog in the works of a perfectly tuned and well-oiled machine. Moved by this image which reminded him of the serenity of working in high mountain pastures, a director of the French-speaking Swiss television station exclaimed: "But it's like a worksite in Switzerland"!

Visits to the site are continuing. Individually, one should apply to the Millau Tourist Office. Groups should apply to the public relations department of the Compagnie Eiffage du Viaduc de Millau: Tel: 05 65 59 26 52 ■

Sophie, a hostess, is conquered by Henri Salvador's good mood.



Soon: an information centre

At the beginning of 2003, on the Cazalous viewing area, opposite the worksite, the people of Millau and travellers will be able to discover the "secrets" of the viaduct. An information centre, built on the initiative of the CEVM and the "Technical Agency for Steel Use", will display all the aspects of the design and construction of the viaduct through films, scale models and information panels. Do not miss this visit! ■

Reminder

Glossary

Abutment

Anchorage points at each extremity of the viaduct.

Stay-cable

A straight, inclined metal cable contributing to the stability of the viaduct.

Temporary prop

A very high support prop placed between each pillar to facilitate the launch of the deck.

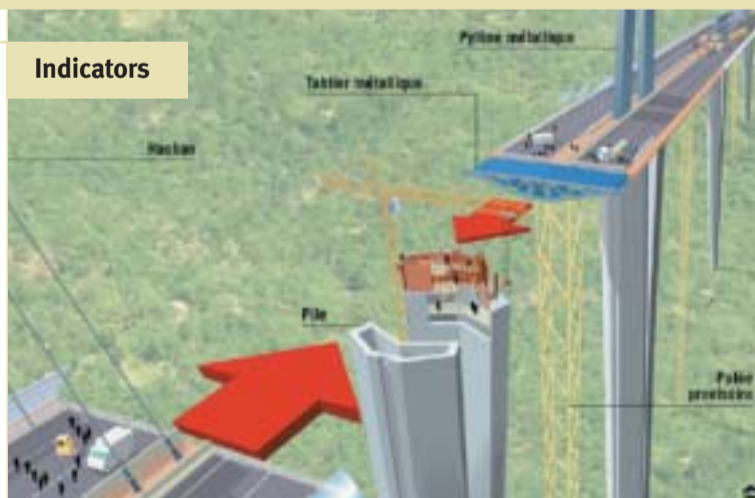
Pillar

Intermediary support for the viaduct deck. The Millau viaduct will have seven pillars.

Deck

Horizontal load-bearing structure of the viaduct, supported by the abutments and pillars, on which the traffic will drive.

Indicators



The viaduct at the heart of the media

The least one can say is that the viaduct has been talked about a lot. "Millau suspended from the viaduct" (L'Expansion), "An Eiffel Tower on the river Tarn" (La Dépêche du Midi), "The Millau viaduct is proceeding apace" (La Montagne), "Millau is watching its viaduct grow" (La Croix), "The Millau viaduct, tourists make a long weekend of it" (Centre Presse), "Millau viaduct, highest bridge in the world" (Le Monde), ten

descriptions of "the men (and women) of the bridge" published in the Midi Libre, articles published in the Le Journal du Viaduc... These are just some of the many articles published in the press during the summer and early autumn, without forgetting the television and radio reports on FR3, TF1, Europe 1... To summarise, the viaduct is talked about under all its aspects: human, technical, economic... Such is the impact of the viaduct! ■



Information newsletter published by the Compagnie Eiffage du Viaduc de Millau 4, rue de la Mégisserie 12100 Millau.

Tel. : 05 65 59 26 52

Publishing Director:

Marc Legrand.

Chief Editors:

Sandra Weigand (Eiffel), Pierre Marodon (Eiffage Construction).

Photo credits:

D.Jamme (Camara), DR

Illustration:

IDE

Printers:

Imprimerie des Chênes verts, Millau.

Concept and design:

Agence François Blanc, Asnières Annick Gillonnier, Thierry Massiet.

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