Le journal du viaduc

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ÉDITÉ PAR LA COMPAGNIE EIFFAGE DU VIADUC DE MILLAU

North - South the meeting draws closer...

After the piers are completed in early November, the deck should span by Christmas more than 1,100 metres out of the total 2,460 metres.

In October 2003, on the south side, the deck reached a new objective: pier P6. Stage by stage, it is creeping towards the northern section of the deck that has already taken its first leap over the void. The countdown to the momentous meeting in July 2004 has begun.

At a hundred metres above the void this October morning the atmosphere is one of confidence. The swiftly falling temperature and the low clouds brought by a chill wind have no effect on the good mood of the workers busy on top of temporary tower Pi6. Just above their heads, within arm's reach, the 15,000 tons of the steel deck are advancing steadily in sixty-centimetre steps. The L5 launch is proceeding without a hitch at seven metres an hour. In perfect synchronisation, the transfer jacks for lifting and pushing the gigantic steel hull placed along its entire length are functioning without any problem: in barely a day, two-thirds of the distance separating Pi6 from the next pier have been spanned. The leading beak is already within reach of P6: the objective is in sight.

"L5 has enabled us to test and validate all the steps for the launching of the deck", stresses Marc Buonomo, Eiffel project manager. "Reception on the temporary towers and piers is now running smoothly. We are keeping to the planned schedule of a launch every five weeks. Between now and Christmas, the deck should have reached pier P5 on the south side and P1 on the north side." This will therefore represent more than 1,100 metres spanned of the 2,460 metres that the deck will measure. Just a few more months of patience and the welding of the two halves of the deck will take place, as planned, directly above the river Tarn.

Raising a temporary pylon to relieve the strain on the deck's leading edge.

Towers fit for oilrigs

The temporary towers, very high intermediary supports, are also exceptional. These steel structures, the tallest of which reaches a height of 172 metres, are constructed with the same steel as that used to build offshore oilrigs.

Marc Buonomo, Eiffel project manager: "L5 has allowed us to test all the launching stages."

Under the watchful eye of the laser

At the top of temporary tower Pi6, one's attention is drawn to a little red spot in the centre of a translucent plate in the floor. Imperceptibly it turns around its point of equilibrium symbolised by a cross. "At the end of the launch, the temporary tower will by itself support 7,000 tons, equivalent to the weight of the Eiffel Tower", Marc Buonomo explains. "Its slightest movements are detected by this laser beam projected from its base. It strikes the centre of the plate when the structure is exactly vertical. If the tower moves just a few millimetres, it is immediately detected. Should the movement exceed four or five centimetres, hydraulic jacks enable us to

.../... continued on page 2

Exhibition

A meeting with the forerunners of the viaduct

As you know, the Millau Viaduct is a chef-d'œuvre and a work of art at the forefront of technology, but it is not the first structure to have defied nature and the void. Jacques Godfrain, Member of the French National Assembly and mayor of Millau, was given, while at a convention, scale models of four other bridges which all have a specific technological feature: the Pont d'Iéna in Paris, the Pont Vieux in Toulouse, the Pont de Montanges and the Pont de Valentré in Cahors.

If civil engineering structures interest you, come and visit the exhibition organised by the town of Millau on the theme "The art of building devoted to bridges", situated in the centre of Millau at the Beffroi School (opposite Les Halles, next to the Tourist Office). ■

Information and visits:

Millau museum,
place Foch:
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modify the distribution of the load created by the weight of the deck on the transfer jacks… and so restore perfect alignment."

On the road which visitors take to the Cazalous viewing area, drivers who raise their eyes are far from imagining the close surveillance to which the steel deck is subjected. What is most striking are the graceful, undulating lines of this steel ribbon stretching out across the valley. This distortion is quite normal and, just as in the design of aircraft wings, enables the structure to tolerate the different stresses to which it is subjected. "Since the deck is constructed on abutments, it must for example on the south side "dive" down from its own height (more than 4 metres) to reach the level of the future motorway", explains Jean-Pierre Gerner, director of works for Eiffel. "This adjustment in the level occurs at each end of the viaduct between the abutment and the first pier to be reached. During the launching phase, this first "wave" is followed by a second, due to the 700 tons of the pylon placed on the deck. The maximum cantilever of the deck between the two supports is a dip of between one and two metres." It is certainly impressive, but strictly in conformity with the calculations carried out during the technical studies!

Load factors calculated by computer

Erecting the first pylon was essential to prevent the leading edge of the deck from sagging too much under the effect of its own weight. Twelve cable-stays were placed under tension on both sides of this steel mast, enabling the deck to be kept at the exact level of its next resting point, whether pier or support tower. Six cable-stays were equipped with sensors to measure the load factors to which each of them was subjected. "Their exact tension is calculated by computer", explains Jean-Pierre Gerner. "An initial adjustment was made during the launch, when we positioned the deck on the first pier (P7) on the south side of the construction site. A second will be carried out when it is "in place" above pier P6." There will be no further intervention until the construction is completed. The viaduct will then be held up by veritable arms of Hercules subject, for the largest, to a load factor of 900 tons. ■

Secured to the temporary pylon, each cable-stay is subjected to constant controls.

A magnificent memory

They have been there since the concrete worksite began. They will soon be working on other worksites. Comments from Michel Pyot, clerk of works, and Dominique Laporte, site manager.

"The preparatory phase for the work required a lot of care. The first six months were devoted to defining the operating procedures for the different levels of the piers, to designing task check lists, to tests, and to validating the selected materials, etc. Every detail had to be perfected before the any concrete was poured! Since the beginning of the worksite, everything has gone very well. We have really had the means to be able to do the work, on both the material and human levels. The planning was clear. We had time to anticipate each new phase as the work progressed, which enabled us to save an enormous amount of time."

Michel Pyot, clerk of works.

"I am happy to have participated in the construction of a magnificent structure, and to have done so in a very good atmosphere. The only pressure we experienced was having to keep up the pace in order to respect the deadlines, while at the same time maintaining an irreproachable quality of our work. The fact of having separated the construction of the abutments and piers into nine "sub-sites" was a source of motivation. It was impossible to allow another team to do better than one's own! But the grandiose nature of the structure is just one aspect of our work which, above all, represented a human adventure that we lived from day to day."

Dominique Laporte, site manager.

Instrumentation

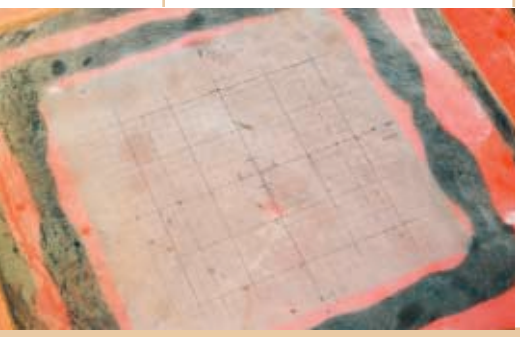
In shape to the tops of the piers

All leading athletes have to undergo stringent medical check-ups on a regular basis: respiratory capacity, endurance, and cardiac rhythm… During these examinations, each parameter is evaluated by the use of very highly technical instruments. This preventive medicine is designed to detect any physical problem and to optimise the length of the athlete's career. "At the request of Eiffage, we have applied this same preventive principle to the Millau viaduct", explains Hervé Lançon, technical director of the SITES company, specialised in instrumentation for civil engineering structures. "It has been equipped with a multitude of sensors capable of detecting its slightest movements and of measuring its resistance to erosion and the weather."

There are all types of instruments: anemometers for recording wind speed, accelerometers, inclinometers, and temperature sensors. Besides, twelve fibre-optic extensometers have been buried in the concrete of the P2 platform, the highest of the piers subjected to the greatest stresses. These sensors can record movements of the order of a thousandth of a millimetre. More than fifty extensometers, electrical on the other hand and placed up the full height of piers P2 and P7, will be activated as soon as the viaduct goes into operation. "These instruments are capable of taking up to 100 readings a second which, in the case of storms, enables vibration phenomena, which could affect the viaduct under extreme conditions, to be monitored continuously", Hervé Lançon continues.

All the readings are transmitted on a network similar to Internet to the technical centre located beside the toll barrier. Provided with its own genuine analytical laboratory, never has a civil engineering structure been so thoroughly examined. Security calls for it. ■

A laser beam detects the slightest movements of the temporary tower during the launch.



Interview

A75: towards coherent economic development

Bernard Seillier, senator for the Aveyron department and mayor of Sévérac-le-Château, is president of the joint association for economic development in the Aveyron linked to the A75 motorway.

What are the goals of this association?
Created in 1990, the group aims above all to harmonise the standpoints of the territorial communities situated along the length of the motorway, particularly concerning economic questions and tourism. In conjunction with the municipalities and district communities, we have created coherent industrial developments, centred on two clearly defined areas, Sévérac-le-Château and La Cavalerie on the Larzac plateau. The creation of these two development centres has prevented the spread of industries along the route of the A75.

Doesn't this risk favouring certain communities at the expense of their neighbours?
Yes, without a doubt! Therefore, to avoid what could have been considered an injustice, we have created a system whereby the professional taxes generated by the two sites will be redistributed. In this way, 80% of the tax proceeds will be reinvested in the other communities, as soon as the development grants accorded by the department have been repaid. This is an exemplary model of self-discipline and solidarity between communities, which deserves to be underlined.

Have you initiated any projects regarding the motorway itself?
The association is the concessionaire for two service areas on either side of the Tarn valley, namely the Aveyron and the Larzac service areas. We have entrusted their operation to different companies, such as Total, Roquefort, Restair or Relais Espace, while at the same time requiring strong harmony between the two areas. We are ready, if the need arises, to apply this same policy to the service area that will be created close to the viaduct.

You are an ardent advocate for this civil engineering structure. It connects two parts of a motorway that in several stretches exceeds 1,000 metres in altitude. How can one ensure optimal service, even during the winter period?
It is true that in the past certain departmental authorities have ordered the closure of the A75 in the north of the Aveyron department for fear of exceptionally heavy snowfalls. However, in reality, dealing with winter conditions here is no more difficult than in the Alps where the question is not even raised! It is up to the State to assume responsibility for clearing the snow on this trunk road… and every effort will be made to provide the necessary equipment for ensuring the flow of traffic 365 days a year.

A comment on the viaduct itself...
It heralds the permanent end to the isolation of the Aveyron department. The inhabitants of Millau must not expect everything to come to them. They should look up, towards the viaduct, and think of the opportunities it offers. The development of the Millau basin must also be made by looking towards other horizons, with enthusiasm. ■

Concrete

The piers are (up)right on time!

The construction of the piers is almost finished. The first mission given to Eiffage TP has been achieved. Every attention is now being given to the construction of the canopy over the toll barrier, stopwatch in hand.

The "concrete" teams can be satisfied with their work: the final formwork lift on the highest pier in the world (P2) was poured several weeks ahead of the original schedule. Between now and the end of November 2003, P3 will be completed… All that will then need to be done will be to dismantle the equipment used to raise these seven concrete needles, and to clear up… a task that will take several weeks. Already, however, the construction of the seven piers is acclaimed as a success, both as a technical and human achievement. "Whatever the level of responsibility of the staff employed on the site, I have only had a positive comments", stresses the project director, Jean-Pierre Martin, with satisfaction. "They are all extremely proud of the work they have achieved, and have already decided to keep in touch with each other by creating an "association" of former workers on the Millau viaduct!"

Now for the toll barrier!

If the chapter on the construction of the piers is now closing, a new challenge already awaits Jean-Pierre Martin and his teams: the construction of the canopy for the viaduct toll barrier, an enormous "leaf" of twisted concrete, 100 metres long and weighing close to 2,500 tons. "It is a real technical challenge", he confirms. "The concrete that will be used, BSI Ceracem® (ultra high-performance concrete), contains metal fibres which are several centimetres long, giving it enormous capacity for mechanical resistance. It has never yet been used for a construction of this scale."

Construction of the canopy for the toll barrier: a twisted "leaf" of concrete, 100 metres long and weighing close to 2,500 tons.

It is impossible to construct such a volume in one piece. The canopy will therefore be made up of about fifty prefabricated elements, called voussoirs, each two metres long and which will be poured one after the other. The main difficulty is to achieve the exact geometric shape to allow them to be assembled together. To succeed, there is only one solution: the formwork must be perfectly adjusted before any concrete is poured, so that each voussoir is in perfect alignment with the one that precedes it, exactly to the millimetre! ■

Seven concrete needles, erected on time

Self-climbing scaffolding: higher and higher!

How to work at a height of more than 200 metres in all safety? By using self-climbing scaffolding… to which the metal formwork is attached! This was an ingenious idea put forward by the German company **Peri**, world leader in this field. Based on the use of hydraulic jacks and steel clamps bolted to anchorage cones set in the concrete, the system allows metal rails to be gradually hoisted up the length of the pier. Once the rails have been secured to the clamps, the entire scaffolding can then be raised by sliding up them. A key-bolt on each clamp ensures the security of the whole assembly by freeing the rails from all the weight of the structure. This then rests exclusively on the key-bolt system that is subsequently secured against the pier by two enormous locking screws.

"These scaffolding assemblies have several levels: a gangway to reach the lifts, a floor for recovering the clamps and the anchorage cones which are released when the structure is raised, and to check the correct functioning of the jacks, a floor for the formwork, and finally a floor used during the pouring of the concrete", explains Marc André, head clerk of works, responsible for the construction of the piers. It only takes twenty minutes to hoist the sixteen metres of scaffolding the height of a concrete lift, representing about four metres. What more can you ask for?

Millau inhabitants

Jean-Claude Flavier, vice-president of the CCI (chamber of commerce and industry) and member of the retailers' association "Vivre Millau".

An opportunity to be seized

"Millau must seize the opportunity which it is offered for a real boost to the tourist industry provided by the viaduct." Jean-Claude Flavier, vice-president of the CCI for the town in the Aveyron department and board member of the retailers' association "Vivre Millau" is categorical: the opening of the viaduct should enable his town to become the centre for promoting tourism in the region.

Up until now, there were the Tarn gorges, Roquefort, Micropolis and the vultures of the Jonte area. From now on, the Millau viaduct must be added to the list. "It is absolutely necessary to get ready for the event now, so that tourism generated by the construction doesn't just fall flat like a soufflé", he asserts. "Even if it is still difficult to predict the knock-on effects for the local trade, the existing resources (at the hotel level for example) must be developed to a maximum while already preparing for the introduction, at a second stage, of new infrastructures for accommodation."

In Jean-Claude Flavier's view, the ideal solution would be to propose a genuine tourist route, centred on the viaduct, to the users of the A75 who stop at the rest area that will be created near the construction. A promotion that would be like an invitation to go on a voyage of discovery… a good way of encouraging holiday makers to stop over at the town.

Michel Galandrin, professor and deputy mayor.

A mathematical approach to the viaduct

The students of Michel Galandrin, professor of mathematics at the Marcel Aymard College in Millau, have a decidedly unusual way of looking at the structure that will link the Causse Rouge to the Larzac plateau. Between the sixth and the third grade, the viaduct is an almost inexhaustible source of exercises! An original way to adopt it on an everyday basis.

"One student out of four, he notes, has been to the viewing area of the Cazalous. I would like every class to be able to spend if only two hours on the site. This construction site presents a triple interest for young people. First, the viaduct is a monument that is now part of our tourist heritage. It is a magnificent example as well of the applied principles

of technology, physics and mathematics that feature on the school syllabus. Finally, it gives young people the opportunity to appreciate for the first time the range of professions in the BTP building and public works sector, which suffer from not being well enough known." Michel Galandrin is strongly preoccupied with career guidance for his students. He strives to convince his third grade students to spend their work experience course with the Compagnie Eiffage du Viaduc de Millau… so that they can experience for themselves that today BTP is very often inseparable from high technology.

Are you good at maths?

1 An object falls off the deck into the river Tarn, 270 metres below. How many seconds does it take before it makes a splash?

2 A cable is stretched from the top of the 87-metre high pylon to the middle of a 342-long span of the deck. What is the length of the cable that is visible?

3 The architect, Lord Foster, designed a viaduct based on the arc of a circle with a 20 kilometre radius, 2,460 metres in length. If the viaduct had been straight, how many centimetres shorter would it have been?

Answers
1 – About 7.5 seconds
2 – 192 metres
3 – About 155 centimetres

Forecasts

The viaduct in all weathers

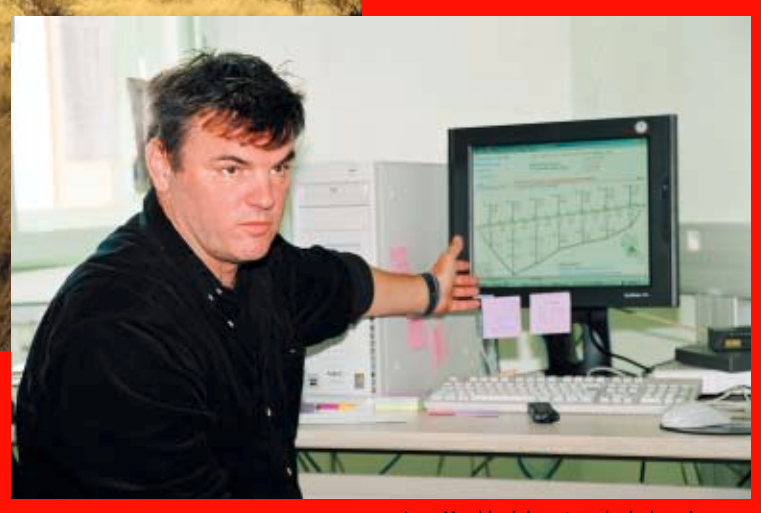
At the Soulobres weather station, the whole team gives precious advice that affects progress on the construction site, and will continue to do so throughout the operation of the viaduct.

Since life on the construction site depends, among other things, on meteorological conditions, it is essential to have reliable weather forecasts. The services of the Météo France team at Soulobres are therefore called upon every day.

Perched on top of a hill, a few hundred metres north of the viaduct, lies a small white building in the middle of sparse vegetation. It is there at Soulobres that since 1964 the Météo France team has been predicting the weather for the Aveyron department. It occupies a strategic position affording a panoramic view over the whole area. Even if nowadays weather forecasting is heavily dependent on satellites and computers, according to Jean Marchionini, meteorological engineer and departmental delegate for Météo France "there is still a real need for visual observation".

Multiple tests at Météo France in Toulouse

The analysis and study of the weather are of paramount importance for the construction of the viaduct. Since its conception, Météo France was called upon to establish precise records of the weather characteristics in the Millau region. Temperature, rainfall, wind... everything was exhaustively examined. "Our work was not restricted to this statistical study employing innovative methods", points out Jean Marchionini. "We called upon our laboratories in Toulouse to create a 1/3,000th scale model of the Causses and the Tarn valley. This was then immersed in a hydraulic seam, a sort of vast channel 30 metres long, 3 metres wide and 1.6 metres deep, which enabled us to study the flows of the current and their impact on the viaduct." The first case for a civil engineering structure!



Jean Marchionini, meteorological engineer and departmental delegate for Météo France.

These experiments made it possible to calculate wind speeds at all points of the viaduct based on the data measured at the Soulobres weather station. Moreover, the examination of the airflow over the piers helped to determine with precision the optimal positioning of the cranes. "Customised computer programmes were designed by the Aveyron departmental weather centre to provide weather forecasting for the viaduct", continues Jean Marchionini. "A specifically designed Internet site enables us to provide, among other things, our wind forecasts for a five-day period as well as an atmogramme (forecasts of weather conditions for the region) for a 36-hour period, updated every three hours." A wealth of information that gives those responsible for the construction site the possibility of stopping the work if there is any risk of winds which would be too violent. Just such a case occurred during the night of last October 7–8. Winds were forecasted of 50 kilometres/hour with gusts exceeding 90 kilometres/hour, conditions that caused the launch of the southern deck to be temporarily halted. ■

The records set by the wind god Aeolus

A north-westerly wind of 176 kilometres/hour and a south-easterly wind of 173 kilometres/hour are the maximum wind speeds, measured respectively in December 1976 and February 1966 at the Soulobres weather station.

The Venturi effect, what on earth is that?

When the diameter of a pipe through which a fluid is flowing is reduced, the speed of the flow increases. This physical phenomenon, known as the Venturi effect, exists in the case of the Millau viaduct, notably in an east to west direction. It is caused by the narrowing of the Tarn valley at this point. Winds can reach speeds greater by 25% than those forecasted by the weather station close by, but on the Causse. This parameter is taken into account by Météo France in their calculations.

People

Still attracting crowds!

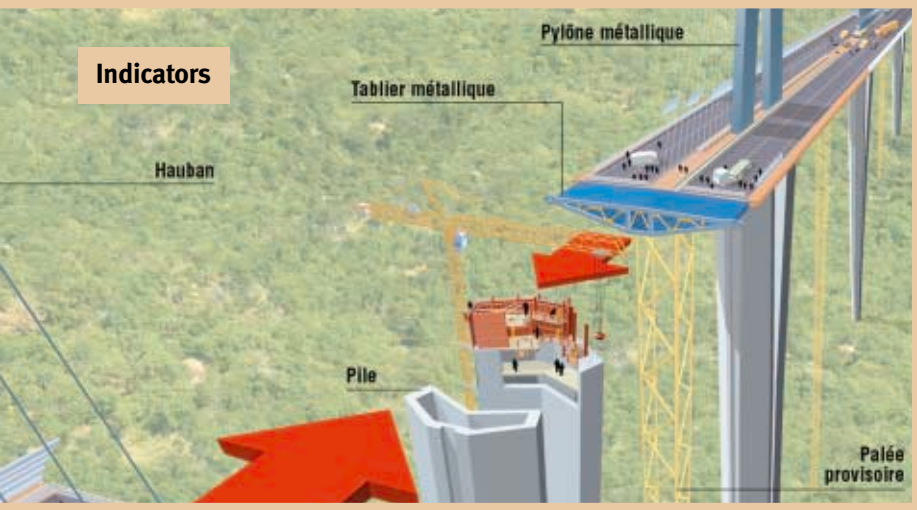
Lord Foster, the architect of the viaduct (fourth from the right), on a visit last October 17.

At the end of October, close to 200,000 people have visited the viaduct construction site. Among these feature Dominique Busserau, Secretary of State for Transport, Jean-Claude Gayssot, former Minister of Equipment, the final year engineering students from the Ecole des Ponts et Chaussées, the governor of the Chinese province of Guizhou, the participants from the congress of the technical association for roads...

Prize-winner!

At Fimbacte 2003 (festival for leaders of the construction industry and the environment), the Compagnie Eiffage du Viaduc de Millau was awarded the first prize for communication in the category "Exemplary communication projects". A prize presented by Gilles de Robien, Minister of Equipment, which rewards "the featuring of the viaduct in a comprehensive campaign to promote tourism for Millau and the south of the Aveyron department in collaboration with institutional and economic partners, as well as promoting the prestige of the range of techniques employed to build such an exceptional structure, making it a symbol of French and European know-how". With all due modesty, it is a prize of which the CEVM is very proud!

Indicators



Eiffage at a glance

- Awarded six civil engineering and earthwork contracts, Eiffage is one of the main operators on the future TGV Est high-speed railway line that will link Paris to Strasbourg. In Germany, its subsidiary Wittfeld has just completed renovation of the Berlin-Hamburg railway line.
- One of the largest shopping centres in Europe has just been inaugurated at Gondomar in Portugal. This complex, on the outskirts of Porto, was designed by the Eiffage and Auchan groups.
- The former premises of the American Center at Paris Bercy will soon house the Cinémathèque Française, after having been entirely reconstructed by the building and electrical subsidiaries of Eiffage. ■

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