Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 55 (1987)

Artikel: Concrete structures for the year 2000

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DOI: https://doi.org/10.5169/seals-42789

Concrete Structures for the Year 2000

Structures en béton de l'an 2000

Betonbauwerke für das Jahr 2000

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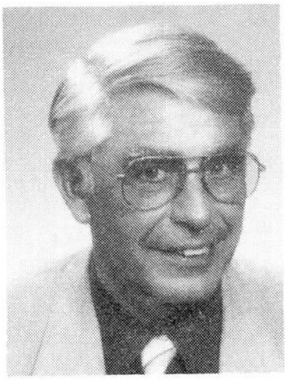

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SUMMARY
The tremendous technical development in the domain of concrete structures has too often resulted in unaesthetic constructions. Thus a compromise must be made between the economy and the integration of the structure into its environment. This report, illustrated by many examples, presents the necessity of having a good collaboration between engineers and architects, and also certain technical developments aimed directly at the economy and aesthetics. It has now become essential to satisfy the justified aspirations of the population regarding these concrete structures.

RÉSUMÉ
Le formidable essor technologique dans le domaine des structures en béton a trop souvent conduit à des réalisations inesthétiques. Il faudra donc dans l'avenir trouver des compromis entre économie et intégration des ouvrages dans leur environnement. Au travers d'exemples significatifs, cet exposé présente la nécessité d'une bonne collaboration entre ingénieurs et architectes, ainsi que certains développements techniques alliant adroitement économie et esthétique. Dès à présent, il est essentiel que les structures en béton répondent aux aspirations légitimes de la population.

ZUSAMMENFASSUNG
Der rasante technische Fortschritt mit seinen neuen Möglichkeiten besonders im Stahlbetonbau, hat oft zu aesthetisch unbefriedigenden Bauwerken geführt. Anhand von einigen Beispielen wird gezeigt wie fruchtbar die Zusammenarbeit zwischen Ingenieuren und Architekten sein kann um zu aesthetisch überzeugenden Bauwerken zu gelangen, die sich harmonisch in die Umgebung einpassen. Für die Zukunft wird es vor allem wichtig sein, der guten Gestaltung von Betonbauwerken grösste Bedeutung zuzumessen, um das Image und die Akzeptanz dieser unentbehrlichen Bauweise zu pflegen.

Fortune telling has always been a dangerous art and many a ruler had his magician beheaded when the prophesy did not please him or did not come true. In our enlightened time this risk is very small indeed, however almost everybody likes to have their fortune told, even though they do not believe in it.

Rather than to risk such a dubious prediction of what concrete structures in the year 2000 will really look like, it might be safer and more helpful to ask how we would like them to be, a task all the more imperative, where the only certainty is that concrete will remain the predominant construction material and thus decisively shape our environment.

I do not think we should close our eyes to the fact that in some highly industrialized parts of the world concrete becomes rather unpopular, and even worse it is used as a scapegoat for the malaise created in our modern society. Due to its shear bulk, the grey and raw concrete may indeed provoke uneasy feelings of soulless monotony. Many unforgivable sins committed by engineers and planners, and above all, the paranoia of some architects, have certainly contributed to the malaise sometimes associated with concrete structures.

Therefore, the aim for the future should be to cultivate as far as possible a good image and public acceptance for concrete by again creating aesthetically pleasing and technically perfect structures.

The technological and economical side of these objectives, including their promising innovations, have been extensively treated in the preceding sessions and it would be futile to plagiarize these contributions here. Therefore, the emphasis here is placed on aesthetics and the integration into the environment. These are indeed very delicate and basically subjective topics, since the "matter of taste" is very versatile.

Beautiful concrete structures have always been built, as is amply demonstrated by the two examples shown in figures 1 and 2, between which constructions there is a whole 2000 year gap: it is indeed astonishing how the ancient Romans could build such a superb concrete structure as is undoubtedly the case with the Pantheon in 27 BC, long before any theoretical tools for its design were available, and for that matter two thousand years before any symposiums on durability, serviceability, geometry control were ever held!

It is hoped that future generations will contemplate the recently completed beautiful Lotus Temple in New Delhi with the same admiration and respect, appreciating that in our technological era the sense for beauty and harmony has not been totally lost.

The same favourable appraisal of our achievement would hardly result in a comparison between the grandiose Pont du Gard (fig. 3), built in 20 BC, and an anonymously awful example of an ugly prefabricated highway bridge (fig. 4), for which aesthetics were sacrificed for mean economy.

Similar sins in engineering were and are committed almost everywhere, and unfortunately rather frequently, in spite of the fact that our enormous scientific and technological means could easily permit much better results. Certainly beauty has its price, but need not be extreme.

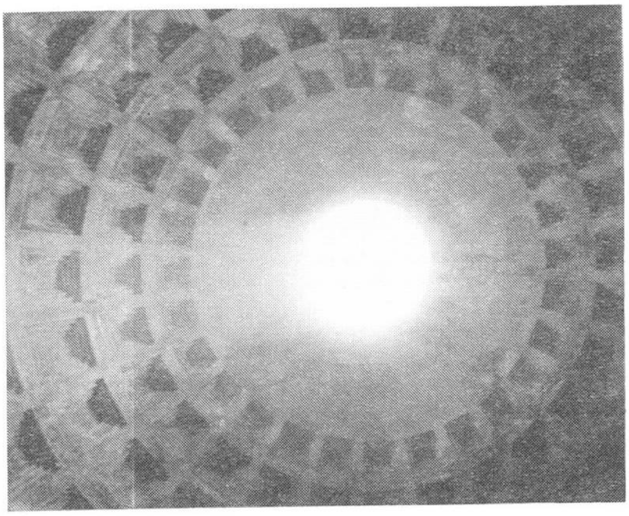

Fig. 1 - Pantheon in Rome built in 27 BC

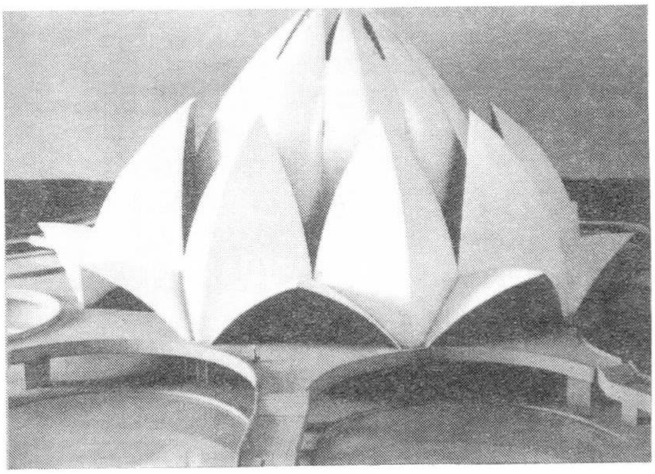

Fig. 2 - Lotus Temple, New Delhi, completed in 1986

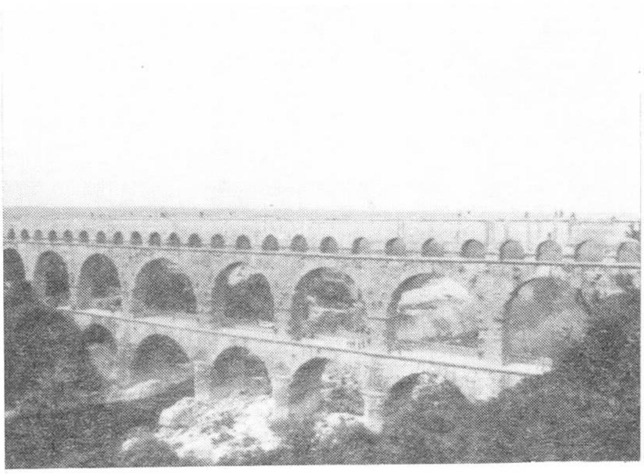

Fig. 3 - Pont du Gard (20 BC)

Fig. 4 - Monotonous prefabricated highway bridge

For future concrete structures it can only be hoped that owners will be willing to pay the little extra costs required for the aesthetic value and quality deserved. It is imperative that the bad habit of giving the work of the design and execution of the structure to the lowest bidder should be abandoned. The architectural and engineering masterpieces were certainly not carried out in this way.

One of the foremost tasks for the future will surely be the protection of our environment. The battle cry of some radical ecologists "a stop to concrete", and for that matter to all important construction projects, is absurd and can certainly not solve the pressing problems of mankind. On the other hand, it can hardly be denied that in many cases too little attention has been given to ecological desires.

Thus it could happen that such a wonderful landscape as on the shores of the Bienna lake, surrounded by picturesque fishing villages and vineyards, was all but destroyed by a modern highway (fig. 5). In the honour of our profession it may be mentioned that the highway authority engineers were vigorously opposed to this project, particularly since an ecologically and technically better solution avoiding this area was at hand. However, local politicians wanted their highway and economic benefits which would supposedly go with it.

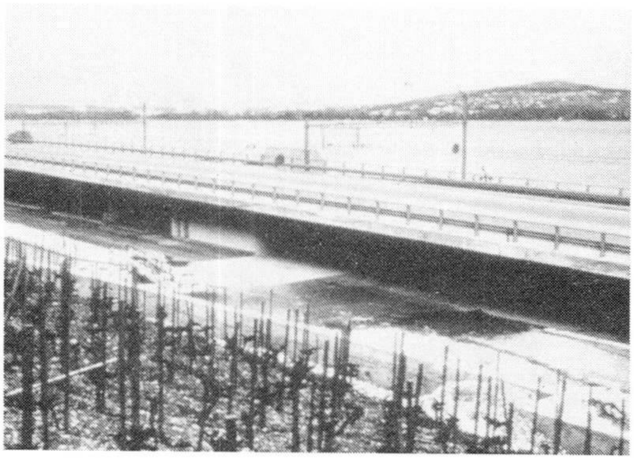

Fig. 5 - Highway on the border of the Bienna lake destroying the picturesque landscape (CH)

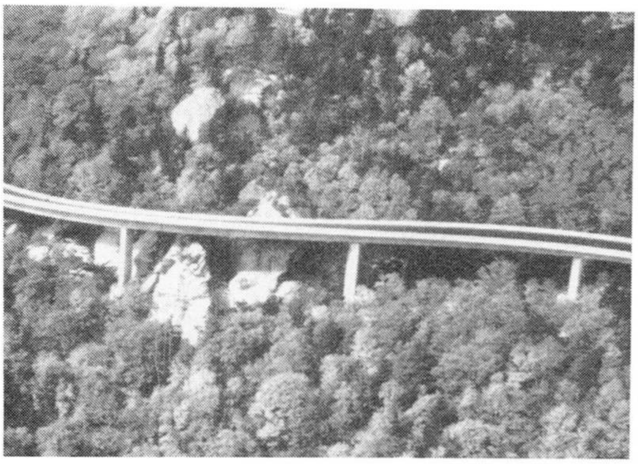

Fig. 6 - Harmonious integration of a highway in a National Park (USA)

With proper care and engineering skill, highways can be integrated harmoniously into the landscape, as was expertly demonstrated at a National Park in the USA (fig. 6). Since the steady growth of the world population inevitably requires the construction of new communications, we should at least do our best to keep the damages to nature at a minimum.

Meticulous attention has to be given to architectural aspects, even for essentially functional engineering structures. A tunnel entrance, for example, does not necessarily need to be dull (fig. 7), but may become subtly attractive (fig. 8) with help from gifted architects.

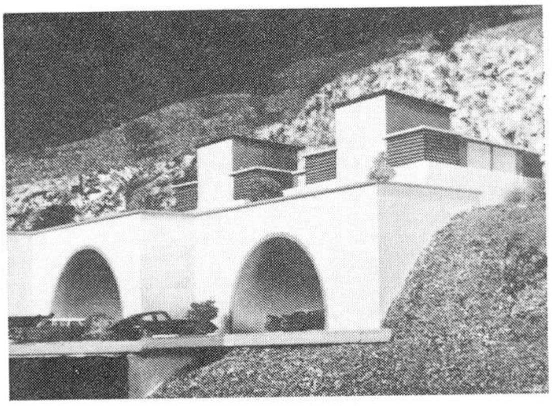

Fig. 7 - Dull tunnel entrance resulting from a purely functional design

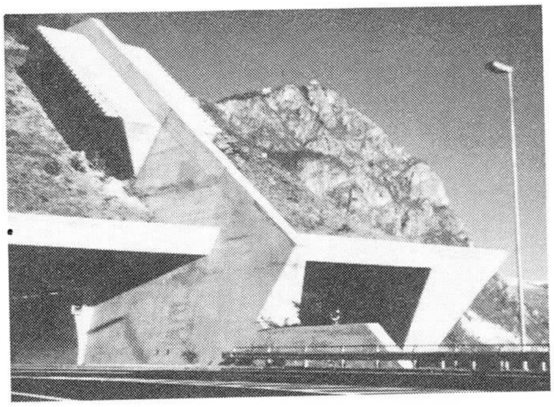

Fig. 8 - Construction of the same tunnel entrance, but attractively shaped

One lesson learned time and time again is that a lot can be gained by congenial collaboration between architects and engineers, and that the unfortunate separation of the two professions should be overcome. Admittedly this is a difficult task, since the bad habit of many architects to call upon civil engineers only to perform the analysis, dimensioning and detailing of structures, the concept of which they have already definitively determined. Conversely, many engineers shy away from consulting architects for predominantly engineering structures, since there are indeed too few of the latter, who are predisposed for a mutually helpful collaboration in this domain.

The pylon of the Hoechst Bridge (fig. 9), one of the first cable-stayed concrete bridges, is a good example of how an architect has positively helped to give this structural element an elegant shape and good proportions. The same solution for an aesthetically pleasing and interesting moulding of a pylon was observed on the Ebro Bridge in Spain (fig. 10).

In spite of the very close spacing of the cables, their collective transparency is rather astonishing, which undoubtedly makes such structures very attractive. One prediction for the future which can safely be made is that concrete cable-stayed bridges have a growing field of potential application. Due to their unquestionable elegance they can, in many cases, be harmoniously integrated into the landscape. Furthermore, recent developments and constructions have proven that they can be economically competitive, even for small and medium span ranges.

For spans up to about 250 m, the simplest and cheapest concept is to provide such bridges with slender concrete decks. The first application of this idea was carried out for the Diepoldsau Bridge over the Rhine (fig. 11 et 12).

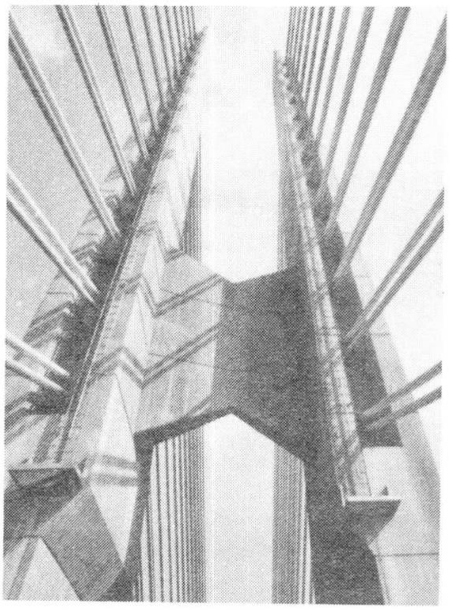

Fig. 9 - Pylon of the Hoechst Bridge over the Main

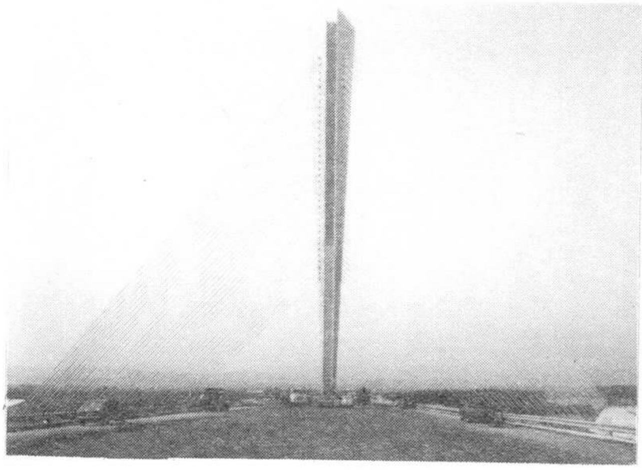

Fig. 10 - Pylon of the Ebro Bridge, Spain

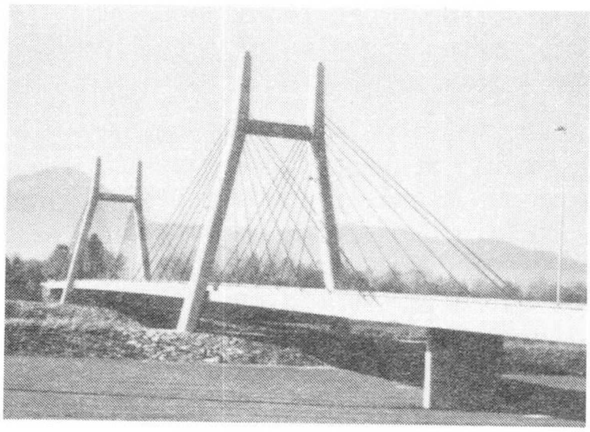

Fig. 11 - Diepoldsau Bridge over the Rhine (CH)

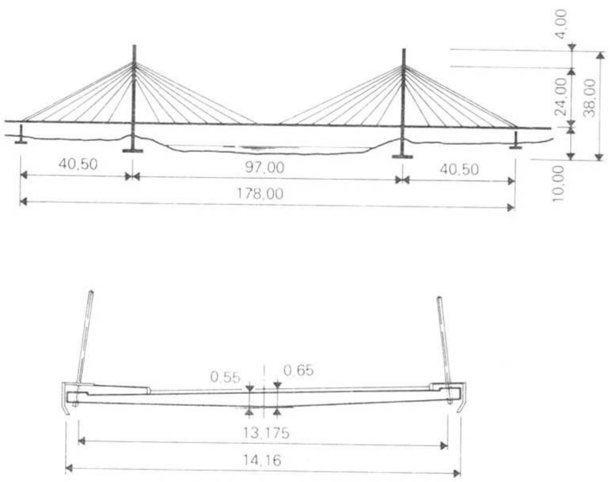

Fig. 12 - Cross-section of the Diepoldsau Bridge

In order to investigate the particular problems of this construction concept, that is mainly the static, dynamic and aerodynamic stability, tests on a large model (fig. 13) were conducted at the EPFL (Ecole Polytechnique Fédérale de Lausanne). Experimental and theoretical evidence show that static instability of the deck hardly becomes critical under normal conditions and span ranges mentioned above: buckling is prevented by the stays and by the activation of the considerable dead weight. Such bridges are also quite invulnerable with respect to the dynamic and physiological effects due to traffic loading. However, for very long or narrow bridges, the aerodynamical stability (flutter) may become a major problem, as the analysis of the La Dala Bridge in Switzerland (fig. 14) has shown. Thus it may become necessary to resort to

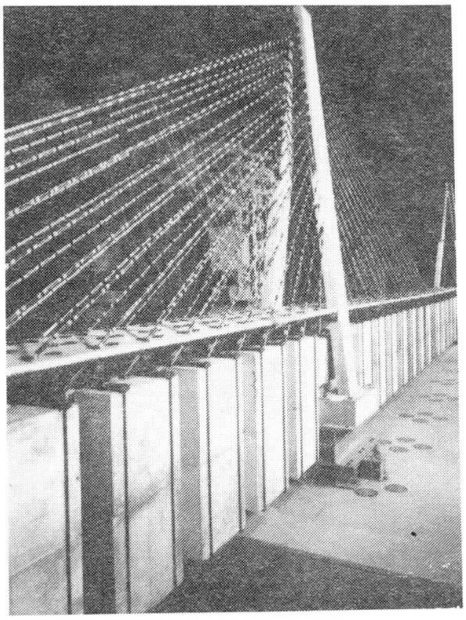

Fig. 13 - Large model test for cable-stayed bridges with slender concrete decks

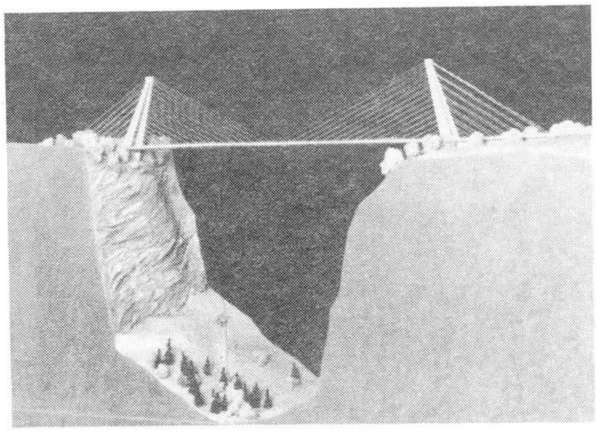

Fig. 14 - Project of the La Dala Bridge with a slender concrete deck (span 210 m)

torsionally stiff box sections, as was the case for the Barios de Luna Bridge in Spain (fig. 15 and 16) with a central span of 440 m, which is at present the world record for cable-stayed bridges with concrete decks.

Such somewhat complicated cellular decks are relatively expensive and heavy, which, especially for bridges with very long spans, constitute a serious handicap, since the cable costs become significant. On the other hand, since orthotropic steel decks cost about four times more than concrete decks, it seems evident that composite structures may be optimal for the span range of about 400 m to 800 m (fig. 17). In certain cases this type of deck can be favourable even for smaller spans, as shown by the example of the Bridge over the Rhône at St-Maurice (fig. 18).

With these examples, an emphasis was placed on the aesthetic priority, leading the way for concrete structures of the future. Many aspects of how to achieve this goal could not be elaborated here, as for example surface treatment of concrete, tinting and painting. However, there can be little doubt that only by unrelenting efforts in this direction can we meet the challenge of cultivating the image and acceptance of concrete structures for the future.

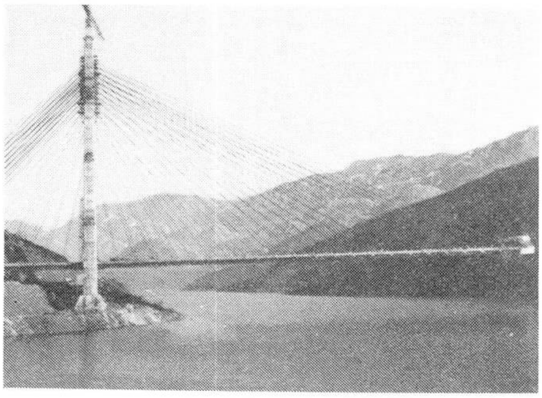

Fig. 15 - Barios de Luna Bridge in Spain

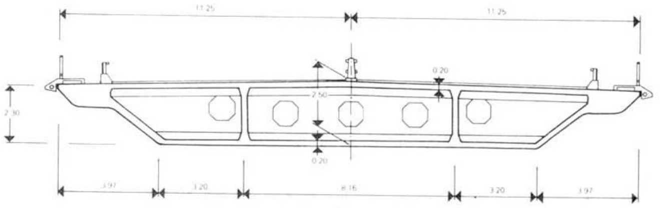

Fig. 16 - Cross-section of the Barios de Luna Bridge

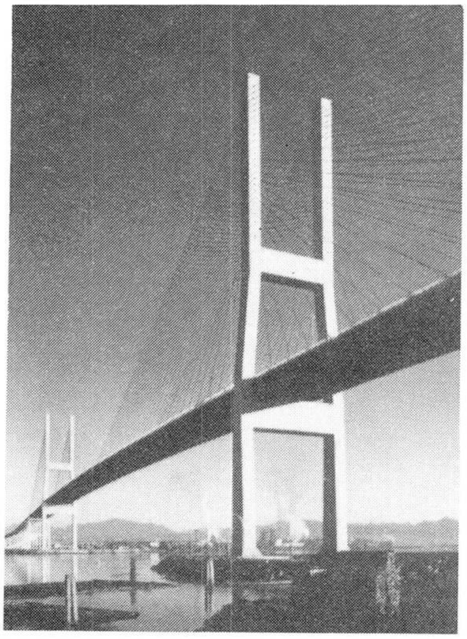

Fig. 17 - Annacis Island Bridge, Vancouver, central span 465 m, composite deck

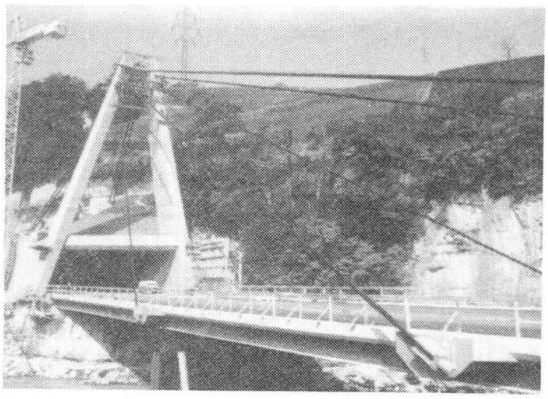

Fig. 18 - Bridge over the Rhône at St-Maurice (CH)