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# Repairs on the Givors Bridge

Réparations du pont de Givors

Instandstellungsarbeiten an der Givors Brücke

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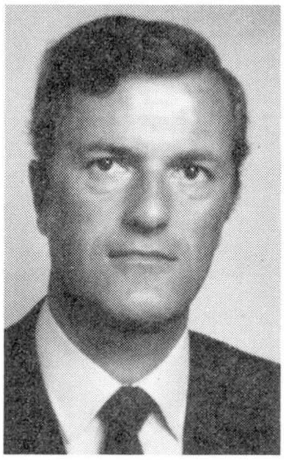

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## SUMMARY
The Givors motorway bridge exhibited certain disorders which were liable, with time, to reduce its bearing capacity and would have required it to be taken out of service in the longer term. Repairs consisted in providing additional prestressing and protecting the deck against the action of aggressive environmental agents.

## RESUME
Le pont autoroutier de Givors présentait des désordres pouvant réduire, à terme, sa capacité portante et entrainer à plus long terme sa mise hors service. Les réparations ont consisté en la mise en oeuvre d'une précontrainte additionnelle et à assurer la protection du tablier contre l'action des agents agressifs extérieurs.

## ZUSAMMENFASSUNG
Die Givors-Autobahnbrücke wies Zerrüttungserscheinungen auf, die die Reduktion der Tragfähigkeit und auf längere Sicht die Schliessung der Brücke hätten verursachen können. Die Instandstellungsarbeiten umfassten eine zusätzliche Vorspannung des Bauwerks und den Schutz der Fahrbahnplatte gegen agressive Mittel.

# 1. DESCRIPTION OF STRUCTURE

The Givors bridge, built in 1967-1969 allows the crossing of the Rhone river by the A.47 motorway providing a link between Lyons and Saint-Etienne. The bridge handles considerable traffic (25 000 vehicles/day, 30 % of which consist of lorries).

The structure is 300 m long and 18 m wide. It is made up of a traversely and longitudinally prestressed concrete deck. It has five continuous spans of 30, 110, 20, 110 and 30 m respectively.

## 1.1 Characteristics of structure

### 1.1.1 Deck

The deck includes two identical box girders of rectangular section and variable height secured by the upper slab forming a road pavement. The height of the girders varies from 5.5 m on the piers to 2 m at the key of the 110 m spans. The thickness of the webs is constant and equal to 0.3 m.

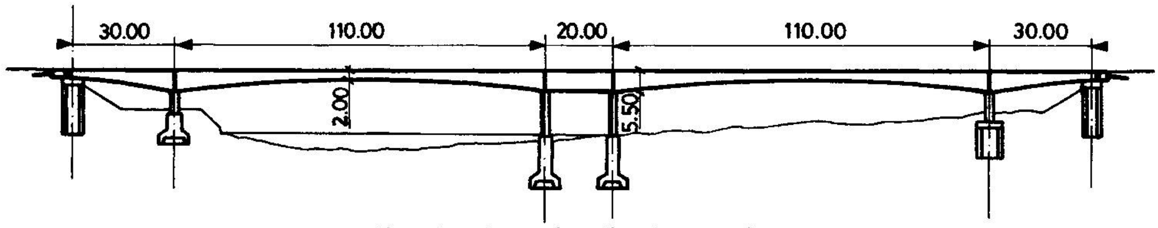


Fig. 1 _ Longitudinal section

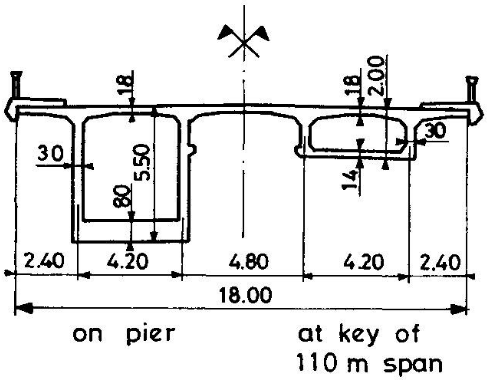


Fig. 2 _ Cross_section

### 1.1.2 Piers

The central piers and the right-bank pier are founded on steel caissons sunk by compressed air in the gravelly alluvia of the Rhone.

The left-bank pier is founded on a reinforced concrete caisson placed in the open.

The deck rests on the central piers via Freyssinet hinges and on the bank piers via plates in reinforced neoprene.

### 1.1.3 Abutments

The abutments are sunk into the access embankments and are each founded on open caissons. The deck-abutment connection has the particular feature of opposing the permanent raising of the bank span ends thanks to a tenon and mortise device, each tenon being in the projection of a web. Free expansion and rotations on the abutments are provided by bearing devices in reinforced neoprene. The abutment is transversely prestressed to withstand the forces applied to it, a lean concrete ballasting being used to prevent lifting.

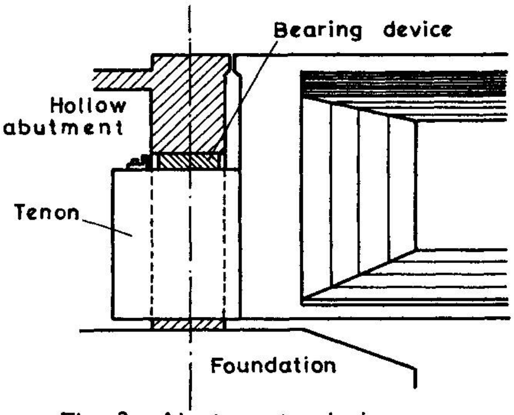


Fig. 3 _ Abutment device (longitudinal section)

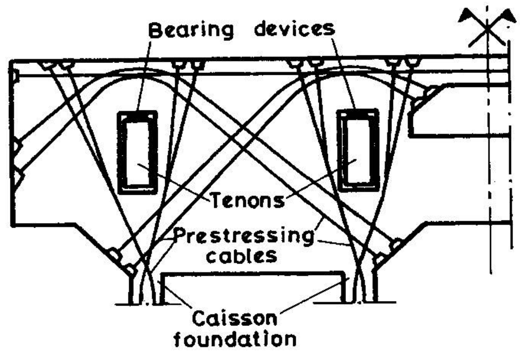


Fig. 4 _ Abutment device (cross-section for a caisson)

1.2 Construction of bridge

After completing the piers, the deck was constructed by contilevering from the piers with voussoirs 3,4 m long concreted in place by means of travelling formwork. The voussoirs on piers are 8 m long. Longitudinal prestressing was applied according to the STUP process using cables consisting of 12 strands of 31 mm diameter (12 T 13) and 8 mm diameter (12 Ø 8). In the transvere direction, prestressing is provided by 12 Ø 8 cables with an average spacing of 1,12 m. The waterproofing of the structure consisted of a "Colpont" type blanket, the road pavement being of the "Gussasphalt" type.

## II DESCRIPTION OF DISORDERS

As part of the periodic inspection of bridges, the management department had a detailed inspection carried out on the bridge during the months of May and June 1977. This showed the existence of apparently serious disorders capable of jeopardizing the operating safety of the bridge and justifying in-depth investigations.

The damages affected :
- The road pavement : the pavement exhibited cracking and crazing of a widespread nature and of such a depth locally that the underlying concrete was visible.
- The inside of the caissons : the following were observed :
  . numerous leaks,
  . cracks in the lower slab and in the webs ; the affected zones in the lower slab being located in the central part of the large spans and were broken down into three distinct categories :
    .. bending cracks on the voussoir joints,
    .. cracks at the back of the anchorage bosses,
    .. prestressing diffusion cracks along the bosses.

The disorders in the web were of a more generalized nature, showing :
- voussoir joint openings,
- cracks following the path of the cables,
- many zones of segregated concrete (bad facings, rock pockets),
- distortions and splitting in bearing devices and excessive or abnormal migration on the abutments.

## III. ANALYSIS OF CAUSES

A priori, after the detailed inspection, two major causes offered an explanation for the disorders :
. inadequate construction,
. Insufficient prestressing.

In order to better assess the situation and to determine the required repairs, an additional series of investigations was carried out on the bridge itself and on its construction documents.

### 3.1 Additional investigations

The following investigations were conducted :
- Crack measurements under traffic and under the influence of tempereature and humidity.
- Measurement of bearing pressures on pier.
- Gammagraphy, along with the placement of inspection openings on certain cables.

At the same time, the different construction documents were examined, namely :
- design drawings and calculations,
- the results of inspections carried out during construction (results on concrete, tensioning records, etc...).

### 3.2 Results of investigations

These additional investigations yielded the following findings :
. Under traffic, crack movements reach 0,3 mm.
. 60 % of the X-rayed cables exhibited grouting defects sufficiently serious so that their protection was jeopardized.
. The damages observed do not come from the materials (steel and concrete) themselves.
. There is every indication that the specified prestressing was applied.
. Design calculations do not show any procedure not in accordance with regulations.

### 3.3 Diagnostics and assessment

After the examination of several elements, the obvious lack of prestressing was found to come from a series of events summarized briefly below.
At the time of construction, adaptation phenomena were only exceptionally taken into account in the design calculations ; this was however covered by a special note of the contracting firm and was taken into account to the amount of 50 % in the dimensioning of prestressing.
Moreover, jobsite difficulties led to a repair intended to "make up" the longitudinal profile. However, in the design calculations for verifying this new load, no account was taken of the results of the adaptation calculations. Hence, if the validity and the procedures used for the adaptation calculations are accepted, the structure as it was constructed exhibits tensions in the lower slab reaching 3,1 Mpa. Furthermore, since the time of construction, the influence of temperature gradients has been established.
All these accumulated factors bring about tensile stresses of 4,7 Mpa in the lower slab, largely sufficient to explain the cracking especially as the joints between voussoirs are not reinforced.

Let us finally points out that the results of bearing pressure measurements confirm those of the adaptation calculations of the contracting firm.

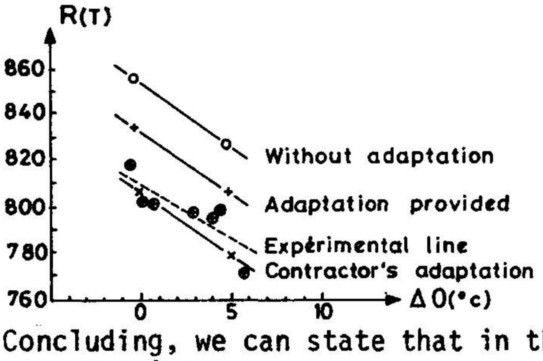


Fig.5 - Variation of bearing pressure on abutment with temperature gradient

Concluding, we can state that in the case of this bridge there was insufficient prestressing.
The problems are aggravated by the insufficient grouting accentuated by waterproofing defects. Proper waterproofing must consequently be provided on this structure at the level of the road pavement as well as to prevent the penetration of moisture at the level of the cables.

## IV. DEFINITION OF REPAIRS

### 4.1 Waterproofing

The aim was to protect prestressing cables against corrosion. Two solutions were examined :
- Protecting the structure against any infiltration of water capable of reaching the cables.
- Protecting the cables themselves, i.e. regrouting 60 % of the ducts (10 litres of slurry to be used).

The second solution was found to be risky because :
- Regrouting had to be carried out under vacuum, hence practically requiring the waterproofing of all the cracked zones.
- The location of the ducts for feed borings was regarded as difficult if not dangerous, in view of the number involved.
- Gammagraphy showed that grouting defects were in most cases "dotted" along the path of the cables.

The first solution was consequently adopted with the following conditions :
- Removal of wearing course and of waterproofing layer.
- Demolition and reconstruction of cracked or ruined repair zones (and reconditioning of sidewalks).
- Treatment of joints between repaired blocks.
- Placement of new wearing course waterproofing system.
- Reinforced bridging outside of fine cracks (thickness $\leq$ 0,5 mm).
- Grouting of largest cracks (thickness $>$ 0,5 mm).
- Smoothening and blinding of degraded concrete zones.
- Application of a waterproofing layer under the cantilevers and on the external flanks of the caissons.

### 4.2 Prestressing

The additional prestressing was dimensioned according to the following criteria :
- Adaptation according to the initial calculations of the contracting firm.
- Temperature gradient equal to 5°C cumulated at the load locations.
- Dead weight of structure + repairs + new superstructures.
- Loads in accordance with 1971 regulation.

Under these conditions, the tensile stresses to be compensated were T,8 Mpa.

For the entire structure, the additional cabling includes :

| | |
|---|---|
| - eight 12 T 15 cables<br>- four 6 T 15 cables<br>- four 12 T 13 calbes | running from abutment to abutment in each span of 110 m |

These cables are deviated in order to improve the efficiency. The anchorage of the 12 T 13 cables is accomplished by means of bosses bearing on the spacers on the piers.

The anchorage of the 6 T 15 and 12 T 15 cables is accomplished, for each caisson, by means of a still (in prestressed concrete) bearing on the end tenons via Freyssinet type hinges.

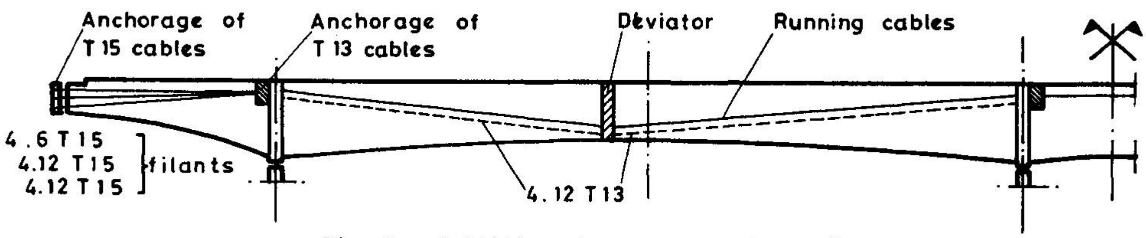


Fig. 6 – Additional prestressing diagram

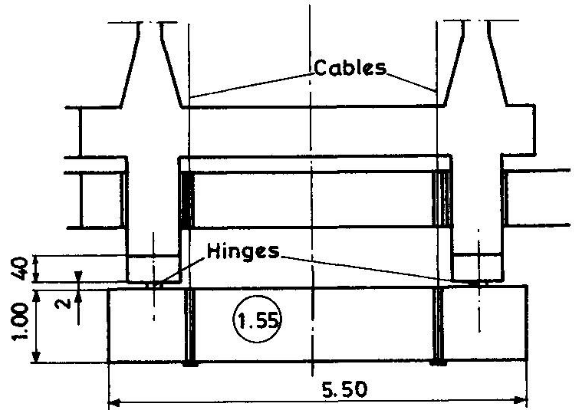


Fig.7 - Anchoring device on abutment

## V . WORK PHASES

The different operations were carried out between May 1979 and September 1980. They required constant follow-up and inspection in view of the difficulties encountered :

- lack of room for the changing of bearing devices,
- necessity of surfacing the bearing zones,
- complexity of setting anchorage structures in zones of difficult access,
- coordination of crack grouting with prestressing,
- treatment of all cracks and general waterproofing.

### 5.1 Conclusions on work carried out

- Additional prestressing : Prestressing operations were followed by extensometry ; the analysis of the tests shows that prestressing transited into the sections according to the calculation model.
- Waterproofing : The adopted arrangements appear to have achieved what was expected ; in fact, the structure is now perfectly dry.

On the whole, it can consequently be considered that the repairs have allowed the bridge to go back into normal service. However, it is a bridge which must be kept under constant supervision owing to the lack of knowledge regarding the longterm behaviour of certain materials and notably of resins.