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Rebuilding of the Bridge Over the River Damuji in Cuba

Reconstruction du pont sur la rivière Damuji à Cuba

Wiederaufbau der Brücke über den Fluss Damuji in Kuba

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SUMMARY

This paper deals with the reconstruction of a prestressed concrete Gerber bridge, partially collapsed due to the collision of a bus and a truck-mounted crane and the corrosion of the vertical anchoring cables of the deck in one of its abutments. Different studied alterna-tives are described here and a technical-economical comparison between them is also made, enumerating the difficulties of the most economical one, showing the adopted solutions in each case.

RÉSUMÉ

L'article présente la reconstruction d'un pont Gerber en béton précontraint qui a été partiellement détruit lors de la collision d'un autocar et d'une grue mobile et résultant de la corrosion des câbles d'ancrage verticaux du tablier dans l'une des culées. Différentes études sont décrites et une comparaison technique, économique est présentée énumérant les difficultés de la solution la plus économique et indiquant la solution retenue.

ZUSAMMENFASSUNG

Der Beitrag behandelt den Wiederaufbau einer vorgespannten Gerber-Brücke, die nach Anprall eines Busses und eines Kranwagens teilweise einstürzte, mitverursacht durch die Korrosion vertikaler Verankerungskabel in einem der Auflagen. Unterschiedliche Konstruktionsmöglichkeiten werden in technischer und wirtschaftlicher Hinsicht miteinander verglichen, die Schwierigkeiten der Bestvariante erläutert und die jeweils gewählten Lösungen dargestellt.

1. DESCRIPTIONS.

1.1. Schematic description.

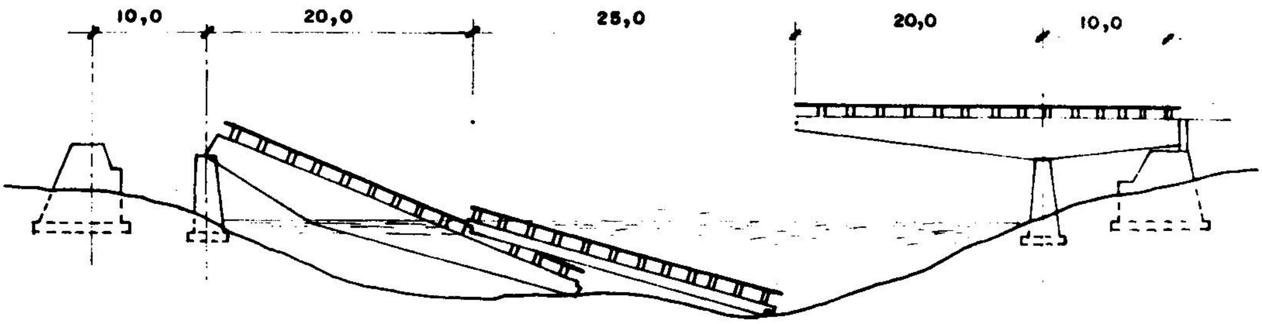
This prestressed concrete bridge (12 ϕ 7mm.Freyssinet cables) with a (10.00 m. +65.00 m. + 10.00 m.) sketch has a principal structure or deck composed by two extreme Gerber 30.00 m. longs and a simply supported 25.00 m. beam. The 30.00 m. Gerber beams are distributed in 10.00 m. extreme spans and 20.00 m. cantilevers close to the central bay. Deck cross section (1.50 m.+ 6.00 m.+ 1.50 m.) has been achieved with box girders for the extreme 10.00 m. spans and for the first 5.00 m. cantilevers; for the 15.00 m. extreme cantilevers and the central simply supported beam, "T" sections have been used. Longitudinally, the height of the deck section varies between 1.25 and 3.00 m.

1.2. Functional description.

As can be appreciated, extreme 10.00 m. spans are not able, by themselves, to compensate or balance the central bay; consequently, these spans are anchored, in their extremes, to their respective massive abutments, by vertical cables pressing the deck against the top of the above mentioned abutments and guaranteeing the deck stability under dead and live loads. These anchoring cables were designed with a working force of 6 400 kN and a breaking force of 10 000 kN.

1.3. Collapse description.

Due to a defficiency in design, vertical cables to anchor the deck to the abutments had not enough anticorrosive protection; due to this fact, those cables were submitted to corrosion in the contact zone between the abutment and the deck in the side next to Abreus town, since there was penetration of moisture, in that zone, through the cavities due to the non coincidence of the different contact surfaces and due to the separation between those surfaces provoked by the crossing of great loads; this corrosion was weakening the cables´ cross sections until the appearance of live loads (a truck-mounted crane and a bus) making these corroded cables reach to breaking stresses. When the cables were broken, occurred excessive surcharge to the adjacent cables, making them break as a chain action and reaction.



ELEVATION

FIG. 1

After collapsing, only one Gerber beam remained in place while the other sank in

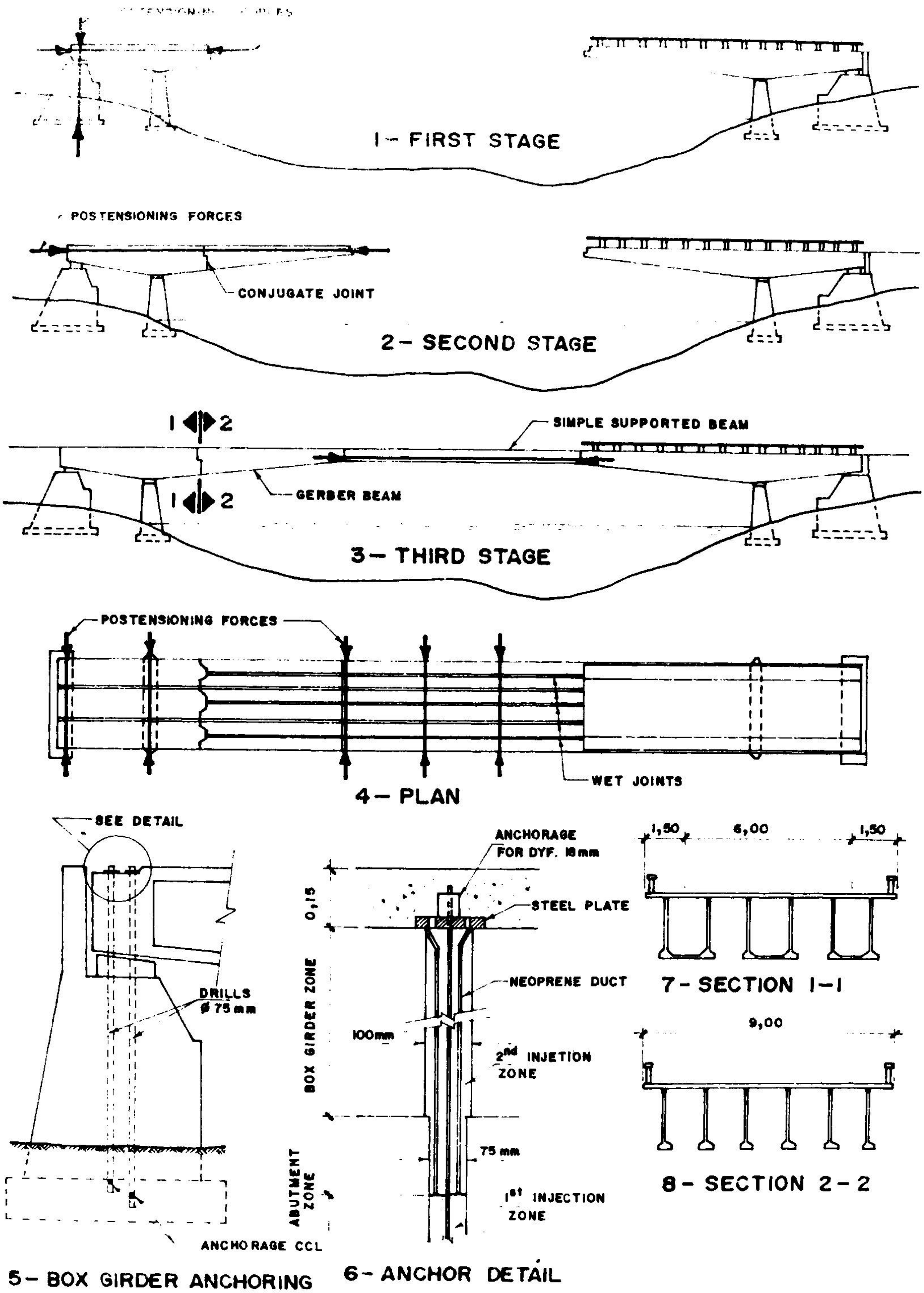

POSTENSIONING FORCES
1 – FIRST STAGE
POSTENSIONING FORCES
CONJUGATE JOINT
2 – SECOND STAGE
SIMPLE SUPPORTED BEAM
GERBER BEAM
3 – THIRD STAGE
POSTENSIONING FORCES
WET JOINTS
4 – PLAN
SEE DETAIL
DRILLS
Ø 75 mm
ANCHORAGE CCL
5 – BOX GIRDER ANCHORING
ANCHORAGE
FOR DYF. 16 mm
STEEL PLATE
0,15
BOX GIRDER ZONE
NEOPRENE DUCT
100mm
2nd INJETION
ZONE
ABUTMENT ZONE
75 mm
1st INJECTION
ZONE
6 – ANCHOR DETAIL
1,50
6,00
1,50
7 – SECTION 1–1
9,00
8 – SECTION 2–2

FIG. 2

an inclined position with its main part inside the river water.The single central simply supported 25.00 m. beam remained totally submerged in bent position too (see fig. 1).

2. STUDIED ALTERNATIVES.

2.1.Counting of the alternatives.

2.1.1. Bridge of single spans, utilizing the existing supports and creating new piers.
2.1.2. Bridge of single spans, changing its location.
2.1.3. Gerber bridge with a 65.00 m. central span and extreme compensation 53.00m. spans (to avoid vertical cables).
2.1.4. Repetition of the above mentioned sketch, keeping the non collapsed part (reconstruction).

3. COMMENT AND ECONOMICAL APPRAISAL OF THE STUDIED ALTERNATIVES.

3.1.Comment.

Alternatives 2.1.1 and 2.1.2 partly coincided, because both stated primarily to demolish part of the existing Gerber beam and a partial demolition of the collapsed Gerber beam that remained out of the water, with a cost of 10 000.00 Cuban pesos; secondly, creation of new supports was stated in order to create smaller spans; then, the bridge to construct would cost 204 000.00 Cuban pesos, and in case of 2.1.2 alternative, the road length to construct would cost 55 900.00 Cuban pesos. Summarizing, alternative 2.1.1 would cost 214 000.00 Cuban pesos, even without evaluating extra cost of foundations in the zone of submerged superstructure, and alternative 2.1.2 would cost 269 900.00 Cuban pesos. As for alternative 2.1.3, extreme 53.00 m. spans are necessary to compensate the central 65.00 m. span; so, this aternative will become a Gerber bridge with a length of 171.00 m. and taking into account demolitions, this alternative would cost 220 400.00 Cuban pesos. Analizing alternative 2.1.4, can be seen that the reason to build extreme 10.00 m. spans with vertical cables, anchored to the mass of the abutments, is to save 86.00 m.of bridge, that is, a bridgelength practically the same as the mentioned bridge (85.00 m.long) can be saved and taking into account that it would only be necessary to construct 55.00 m. of deck, without foundations and that it would not be necessary to demolish the non collapsed span, this alternative, 2.1.4, would only cost 68 000.00 Cuban pesos.

4. DIFFICULTIES FACED RESPECT TO THE ALTERNATIVE REPEATING THE EXISTING SKETCH AND KEEPING THE NON COLLAPSED PART.

4.1.Lack of confidence.

At the same time than distrust arisen with vertical cables, because this was not the first project where they have presented problems, there was the doubt about what could happen with the remaining in the non collapsed span, up to that moment.

4.2. How to conjugate joints, shortage of wood to make forms and limitations with the hoisting equipment.

At the time of the analysis of this topic, it was thought that deck concreting should be made directly on the site ("in situ") in order to solve the problem of conjugate joints in the transition section from box to precast "T"-shaped girders (see fig 2.7 and 2.8). At that time, there was no available wood for formwork, and precasting of the box-sectioned length would result in a huge member for which there was no joisting equipment.

5. SOLUTION OF THE PROBLEM WITH THE ALTERNATIVE OF THE REPETITION OF THE SKETCH, REMAINING THE NON COLLAPSED LENGTH.

5.1.Updating.

The first step was to check whether the non collapsed zone fulfilled the requirements of the Codes in force in Cuba (about critical sections); this turned out be satisfactory. The following was to undertake the solution of all the different problems (see fig 2.5).

5.2. Anticorrosive isolating sheaths.

In this case, it cannot only be relied on mortar grouting, because, in this section, it breaks and moisture can penetrate up the reinforcement; then, it is necessary to wrap the cables with a neoprene sheath and, afterwards, to inject the mortar.

5.3. Vertical anchoring holes and cable placing.

As this case is a postensioned structure, in the initial case cables were kept embedded in the mass of the abutment and anchored in the lower zone, reserving an upper zone for elongations; this was solved practicing vertical holes in the mass of the abutment and putting one cable in each one with fixed anchorage grips in their lower extremes. Later, cement gel was grouted, forming an embedding column for cables and of frictional force transference between the column and the drilled hole; the upper zone of the drills remained as elongation, anticorrosive or neoprene sheath zone, and final grouting (see fig 2.5 and 2.6).

5.4. Tests.

Though the heights of those mortar columns were calculated, as there was no previous experience, six test drillings were made, properly located in non interference zones. The outcomes of the tests were satisfactory, not being found slidings of the column until reached the breakage of the cables.

5.5. Vertical cable design.

According to the new analysis and using the standard loads in force, a total 8 000 kN anchoring force, for what 32 ϕ 18 mm. DYFORM cables were placed, working with an individual force of 250 kN and a 380 kN breaking force.

5.5.1. Reinforcing the non collapsed Gerber span.

In the presence of the uncertainty about what could happen with the non collapsed length, it was treated exactly like the reconstructed one, placing on it the same 32 DYFORM cables.

6. TOTALLY PRECAST SOLUTION OF THE NEW DECK, KEEPING THE SAME EXTERNAL FEATURES.

6.1. Box section length in the Gerber beam.

The first 15.00 m. of the Gerber beam length were fractioned in three boxes with a weight of 800kN, and wet longitudinal joints. Transverse sitffness was achieved postensioning the supporting diaphragms (see fig. 2.1 and 2.4).

6.2. Conjugate joints.

For the transition from box sections to "T"-shaped beams, a conjugate joint was designed, able to constraint the three degrees of freedom of the dowels when assembled in an appendix form or as longitudinally precontraint bosses (see fig 2).

6.3. "T"-shaped length in Gerber beam.

The extreme 15.00 m. cantilever in Gerber beam were achieved with precast "T" -shaped dowels weighing 200 kN (two per eachbox), because they are the extension of the vertical box walls. The longitudinal assembly was made with wet joints and the transverse stiffness was achieved with transverse postensioning of the slab and the extreme diaphragm (see fig 2.2 and 2.4).

6.4. Central simply supported length.

Six precast "T"-shaped beams were placed, longitudinally assembled by wet joints and the transverse stiffness was achieved by transverse postensioning of the slab and diaphragms (see fig 2.3 and 2.4).

CONCLUSIONS.

A technical and economical appraisal of the different alternatives is shown in this paper, with an exhaustive analysis of all the pro´s and con´s of each one and the reasons that guided to the selected one, though the reluctance of some people, finally and fortunately overcome. This paper shows a way regarding the use, in damaged structures, of non collapsed parts of them, with all the advantages and savings this technique could bring.

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