Journal of Building Technology, 2024, Volume 6, Issue 1
DOI: 10.32629/jbt.v6i1.1576
ISSN Online: 2717-5103
ISSN Print: 2705-1390

Removal of Support or Pier Without Jacks: Jimeno-Lleyda Methodology as a Derived Technology for Post-Tensioned Steel Structures

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Abstract: The removal of supports is a common necessity when there is a change of architectural use or a span change in a bridge. The present document proposes a simple technical solution that allows defining a procedure of cutting and bridging a support without the use of jacks. From this method statement, a post-tensioning technology for steel structures is derived.
Key words: removal of supports; without jacks; post-tensioned steel structure; patent

1. Introduction

The purpose of this article is to describe a constructive procedure for removing supports without using jacks as an auxiliary means of transferring goods. This technology is introduced through specific examples of eliminating support in single family homes. Its added value is to provide technology to the metal structure workshop to promote a method of performing bracket cutting and transferring loads to bridge structures, which can be undertaken through conventional means in the industry without the need for additional auxiliary professional industries.

The method is a variant adapted from the temporary chock forms of the large metallic structures made by MEGUSA. This particular idea embodies one of the many ideas that Mr. Miguel Silvestre unwittingly distilled in any technical conversation. Without the precedent of the technology of extending the spans of the highway decks by Mr. Julio Martínez Calzón and the MC2 team, this document would be impossible. The issues relating to control and commissioning were developed with the engineers Mr. Abraham Hidalgo and Mr. Carles Cots Coromina. The innovative vision of daring to do something new was provided by the site manager, Mr. Luis Mena. I never tire of thanking them all.

In addition, based on an overview of current technologies, the Jimeno-Lleyda post-tensioning method for steel structures is presented as a derived technology.

2. Removal of Supports

2.1 Cancellation of support: structural features of functional requirements

Due to changes in usage, the cutting of supports has almost no common and systematic characteristics, as it depends on the type of structure, the geometric shape of the structure itself, and new building and resistance requirements, which are specific to each building and each structure.

Usually, the gravity load above the support cut is transferred to the adjacent bridge pier through the new bridge beam. This means strengthening these adjacent supports by increasing the load, checking the existing foundation, and reinforcing it, if its bearing capacity is insufficient, or adding auxiliary load buffering structures, or both.

Common to all procedures is the need for an additional structure, usually metal (Rodríguez Santiago & Conde-Salazar, 1988) (Figure 1), but also reinforced concrete (González Serrano, 1991), mixed structure (Martínez Calzón & Ceriani, Sants Station in Barcelona - large shoring lintels for elimination of supports between tracks, 2008) (Figures 2 and 3) or post-tensioned concrete (Valladares López, 2012) (Figure 4) or serving for load bridging.

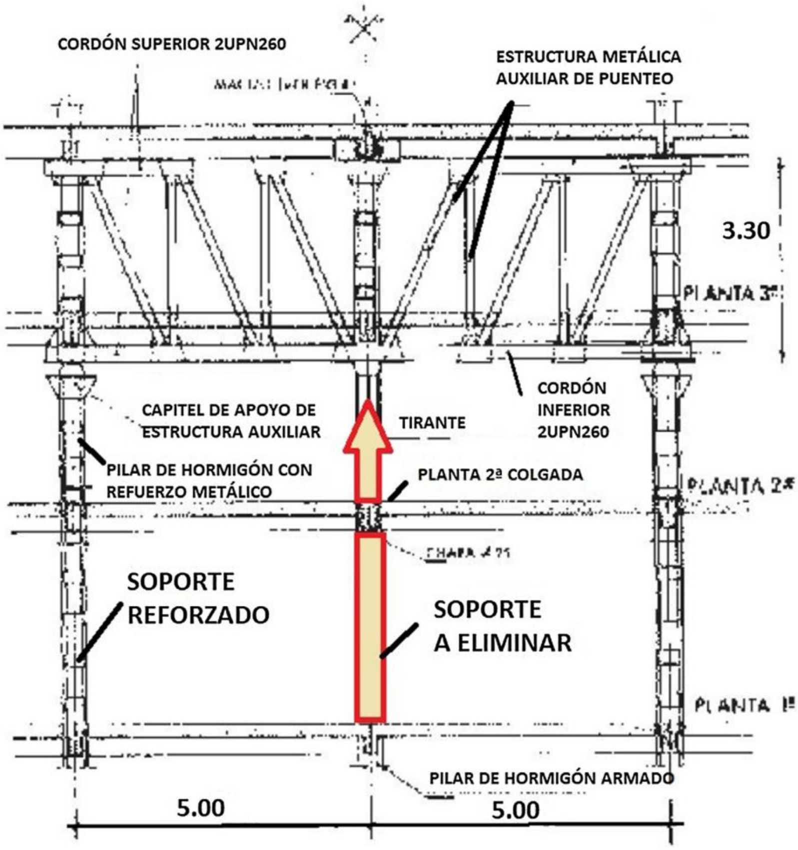
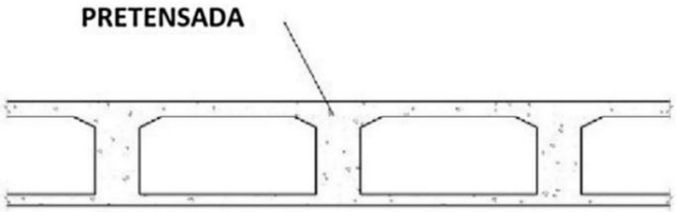
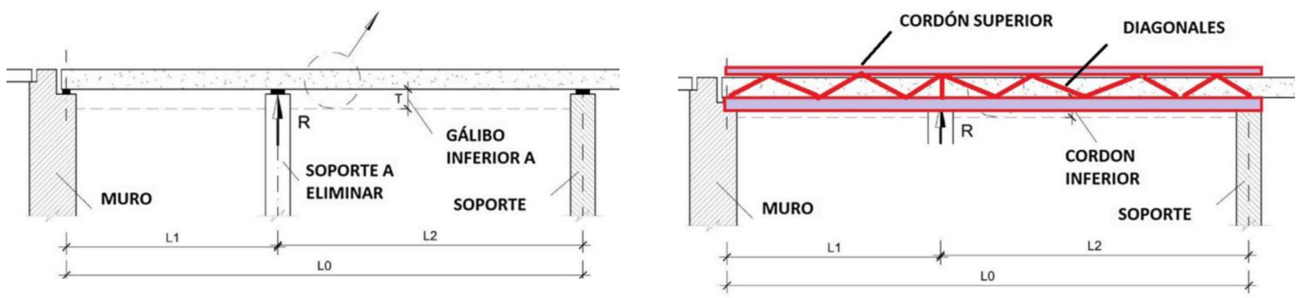


Figure 1. Abutment removal by means of a steel structure.

The structure in which the support is to be cut, usually has independent resistant resources to cope with the horizontal stresses, so this important requirement of the structure in the final state is considered solved and is not the subject of this work. In other words, a method for the transfer of vertical loads is proposed.

When the deformation of the new bridge structure is within the allowable range, that is, if the support is cut off, the L/500 will hardly deform and can directly transmit the load. However, this is only recommended for small loads. For the cost of strengthening the structure, this is uneconomical because it is necessary to check whether the total arrow is effective. On the contrary, the necessity of load transfer through jacks is obvious. In addition, the possibility of damaging existing building components in this situation is high and must be limited, so it is not recommended to use this procedure.





DINTEL	L_0 [m]	L_1 [m]	L_2 [m]	T [m]	$R_{cp,k}$ [kN]	$R_{sc,k}$ [kN]	$R_{tot,k}$ [kN]
A	33.40	20.40	13.00	0.80	5700	3700	9400
B	34.85	25.80	9.05	0.80	8200	5400	13600
C	32.25	14.80	17.45	2.00	6210	4050	10260
D	28.65	13.10	15.55	2.00	5650	3700	9330
E	30.35	16.70	13.65	2.00	6210	4050	10260
F	27.10	15.80	11.30	2.00	5520	3600	9120

Figure 2. Large shoring lintels for removal of supports between tracks, 2008.

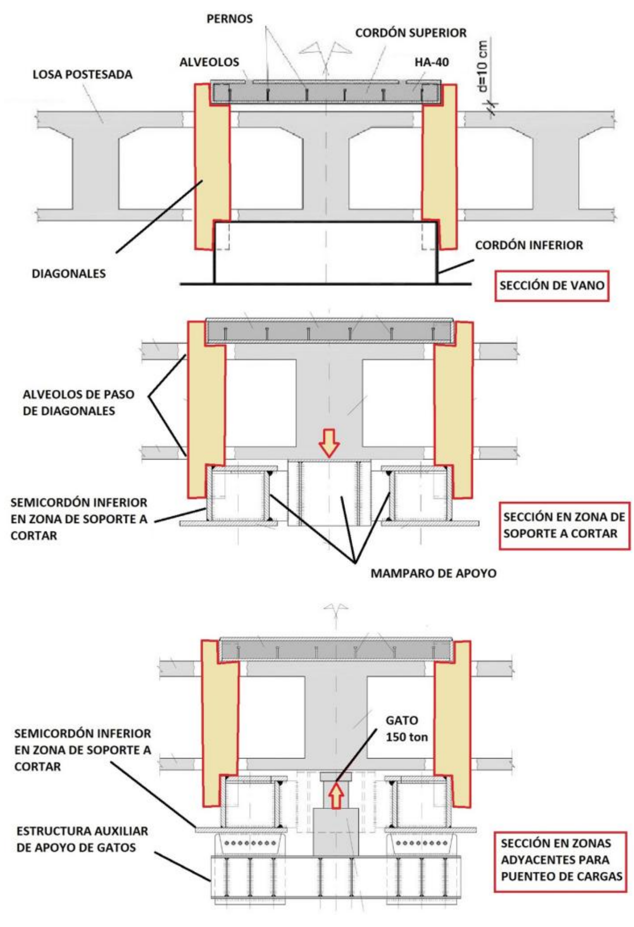


Figure 3. Large shoring lintels for removal of supports between tracks, 2008.

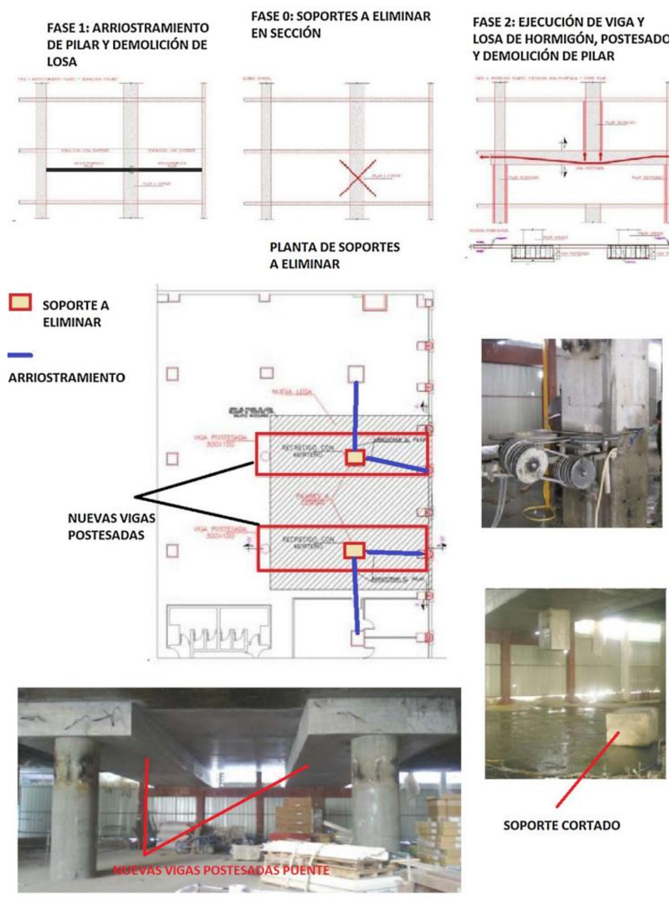


Figure 4. Abutment removal by means of a post-tensioned structure.

2.2 Examples of load bridging in civil works

Examples of load bridging in civil engineering works that can serve as inspiration in the design of support shear are found in the Methodologies for Bridge Support Changes (Asociación Científico-Técnica del Hormigón Estructural (ACHE), 2011), where different geometries of abutments and piers require the creation of prototypes of auxiliary structures for support replacement maneuvers, individual for each viaduct.

Of special interest is the solution for extending the spans of highway overpass panels (Martínez Calzón & Ladrón de Guevara Méndez, Ampliaciones de luces de pasos superiores de autopistas existentes. Solution applied on the AP-7 highway (BY-PASS) Valencia, 2002) (Figure 5), where the application presented here recognizes a clear conceptual precedent.

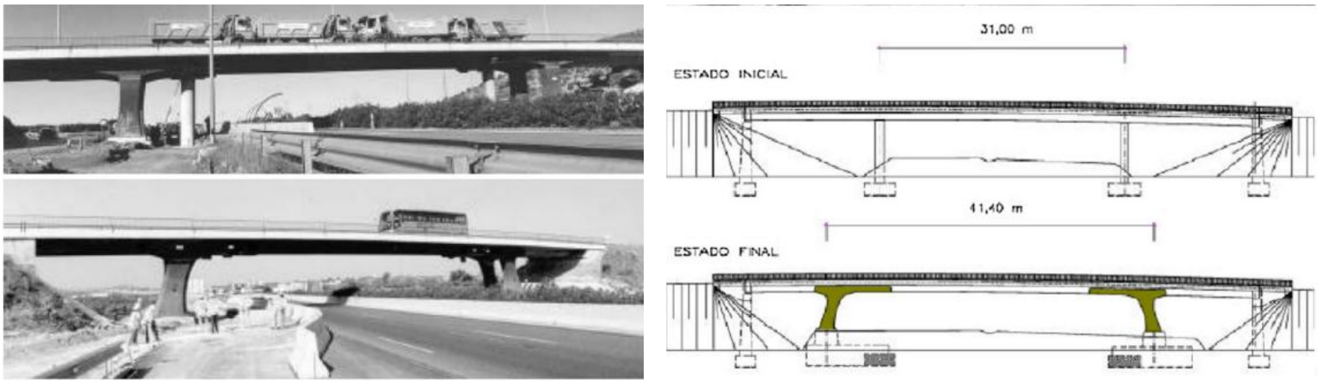


Figure 5. Extensions of spans of existing motorway overpasses. Solution applied on the AP-7 motorway (BY-PASS) Valencia, 2002).

3. Description of the Work and Construction Procedure

3.1 Description of the structure and object of the project

The typology of the building structure, a single-family house (Figure 6), is summarized below:

- The first floor slab is made of joist and ceramic vault with 12+5 edge and 40 cm spacing;
- The supports are made of reinforced concrete;
- Beams of 25 cm depth are also made of reinforced concrete;
- The footings are cubic foundation shafts, with a side of 1.10 m, made of mass concrete or cyclopean concrete, although from the previous measurements a side of 1.26 m is inferred;
- It is intended to eliminate the support in the middle of the hall, as shown in the figure.

Figure 6. Building and location of the support to be removed.

3.2 Project criteria

The series of prior standards (Figure 7) and load transfer details of the Puenteo structure are as follows:

- The dead loads to be placed on floors, partition walls and false ceilings are not increased with respect to those supported in the historical structure;

- The lowest possible cost solution is proposed;
- The usable clearance in the living room is agreed with the property.

Figure 7. Load transfer details of the Puenteo structure.

3.3 Description of the construction process

The following is a telegraphic description of the construction process, starting with the foundations (Figure 8):

- The excavation to introduce the rebar of the new foundation beam is executed. The excavation will be 0.80 m deep by 0.70 m wide approximately;
- A cleaning concrete of 0.10 m is poured;
- The new rebar is inserted and the anchor plates for the supports are placed;
- The foundation beam is concreted with embedded support anchor plates.

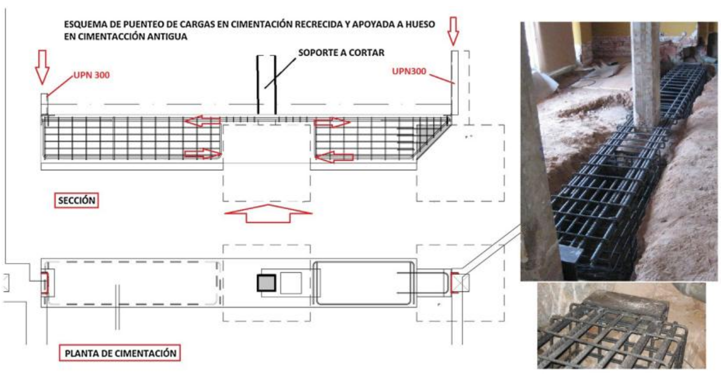


Figure 8. Diagram of bridged foundation.

The phases of bridging are described below (Figure 9):

- Drill holes on existing supports to introduce steel reinforcement;
- New metal beams have appeared on the ground;
- UPE300 S275JR bracket installed and ready;
- The new UPE400 S275JR steel beam is placed on both sides of the concrete support and supported on the beam of the UPE300 support;
- Welding of inverted U-shaped metal bridges and brackets between armed beams;
- The upper wedge is placed on the bone;

- The lower wedge clamping screw is passed under the upper wedges;
- Place the nail;
- The wedge is penetrated by tightening the screws on both sides until the strut enters traction force;
- The control of the change from compression to tension was acoustic, since it can be known by the variation of the sound of the concrete as if it were ceramic or glass;
- This avoids cracking of the support concrete under the bridging zone, which in turn would cause an undesirable reverse dynamic load to preserve existing architectural finishes;
- When the sound of the support changes, or when the wedge reaches its estimated stop based on analytical calculations, the support can be cut with appropriate means - in no case pick-axe or hammering;
- The closing cords are welded to protect the screw and locknuts are provided to prevent the screw from untightening;
- The remaining bracket is removed and the connection is disconnected.

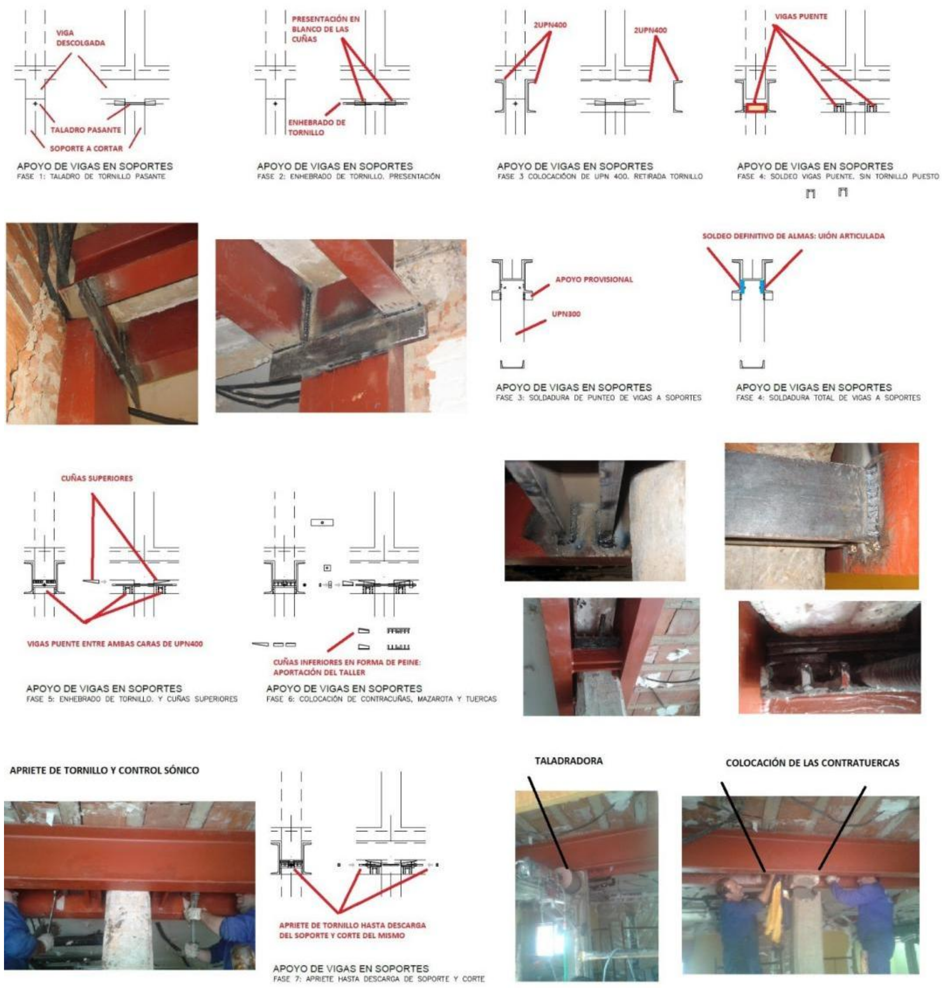


Figure 9. Construction procedure.

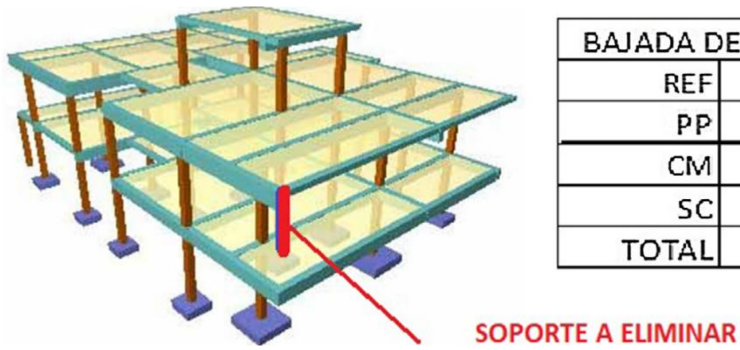
3.4 Additional important criteria

The following issues should be taken into account from a technical point of view:

- The hypotheses considered for the solution outline, especially geometry, must be checked on site;
- The visit of the technician to the site is recommended for the structural review at the time of the execution of the cut;
- The removal of the pillar is carried out in such a way that the architectural elements at the front suffer the least

possible damage, although the plaster ceilings in the affected area will almost certainly suffer damage;

- There remains a useful architectural height of 2.40 m between the lower face of the beam covering and the upper face of the architectural finish, which must be seriously checked, especially for the passage of installations through the false ceiling;
- The construction solution is estimated on the basis of the loads introduced in a spatial model (Figure 10) of the entire building which, although it has serious uncertainties in the location of supports and beams in the area where the column is removed, the loads have been studied with sufficient approximation;
- The design loads are based on the finishes observed on site, or at a higher level than those observed on site;
- Any structural rehabilitation solution is subject to uncertainties that should be minimized in the design but may require on-site technical assistance, so an allowance for uncertainties should be made so that, if not needed, it is not consumed, but does not create problems for the parties in the event that further engineering and work is required;
- In the specific case presented, a geotechnical survey is avoided because it preserves the historical structural form of collecting the loads through a foundation beam that carries the loads to the original footing.



BAJADA DE CARGAS DE SOPORTE			
REF	KN	KN	REF
PP	155		
CM	48	203	CP
SC	48	48	SC
TOTAL	251	251	TOTAL

Figure 11. Three-dimensional calculation model to estimate the loads to be bridged.

3.5 Criteria for control and implementation

The following is a list of control and commissioning operations (Figure 9):

- The counter wedges must be greased on the surfaces in contact with the wedges and bridge beams to reduce friction.
- The surfaces in contact between nuts and bolts must also be greased to reduce friction and allow tightening by means of a manual wrench with a lever lengthened by a tubular profile.
- Before and after shimming, the concrete must be sonically controlled, i.e., as a ceramic material, when it is in compression, the sound is low pitched and becomes higher pitched when it is in traction.
- With the acute angle of 9º for the defined wedges and normal grease, the tightening is done by manual means, as shown in the photo.
- It should also be noted that, for this 9º inclination of the wedges, it was demonstrated that the untightening of the screw was able to lower the structure to its original position. This allows, once the sonic change of the ceramic by which the concrete was known in traction, to loosen to reduce the vertical upward force that could be transmitted when cutting the support in traction.
- As a collateral effect, the drill used in the cutting of the pillar, does not suffer the pinching of the drill bit (220 mm diameter in our case) by the clamping effect of one part of the support against the other. In the case presented, no overexertion was necessary for the removal of the machinery to the surprise and celebration of the execution personnel, who were able to go home earlier.

- As an alternative method for cutting the column, the circumferential rubbing of the column was foreseen for cutting the reinforcement with a radial cutter, but the drilling machine proved to be effective in preserving all the architectural finishes of the first floor intact.
- A rough calculation model was used to estimate the permanent load to be bridged from the support under the first floor to the new steel structure.
- Due to the low stiffness of the supporting components, the steel structure is calculated as a simple support, which is very noble and allows for controlling deflection when the beam is loaded as a control mechanism for bridging loads.
- For an estimated deflection of 10 mm, a deflection of 8 mm was observed on site. This deflection was checked on both sides of the steel girder by measuring the relative displacement between the bottom of the slab and the upper flanges of the steel girders, since the load is transferred from the support as a prop to the steel girder, without displacement of the slab. Simple strips of graph paper were used for this purpose.
- The shortening of the wedges was also checked, which was set at 13 mm and measured at 10 mm when the column was being pulled.

3.6 Description of the calculation

By means of a calculation model with the commercial program METAL 3D from CYPE Ingenieros, the following calculation model (Figure 11) is made as shown in the figure for the steel bridge structure. The arranged loads are those obtained with the three-dimensional model.

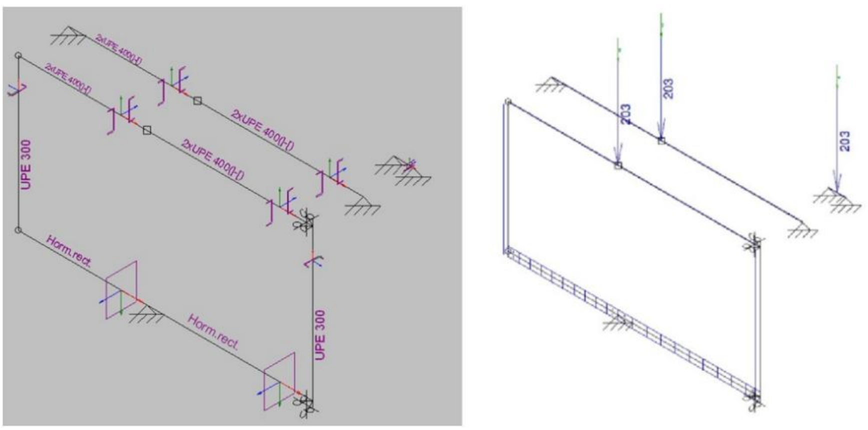


Figure 11. Calculation model of the bridge structure.

The model assumes that the entire load rests on the existing footing (Figure 8):

In the above model, two extreme assumptions are made, both on the security side:

- A framework operates in this way, where the load of the Riostra's self weight is collected by the ground - in fact, this means that the horizontal force (only compatible) is collected by the forging or its adjacent internal support at the head, and transmitted to the closure through the forging. Assuming that the remaining load from the support is absorbed by the elasticity of the beam, which is hinged on the support and supported on the Riostra beam during two hypothetical flights, this is the safety side.
- Another model assumes that the A-beam is hinged on the bracket and the bracket does not descend because the terrain is very suitable

In this way, both ends are covered.

The total center light arrow of the permanent load is limited to between 10 mm and 12 mm, so a wedge has been designed for the minimum arrow between the two, as it ignores the slight depression between the support and beam:

The maximum tension utilization rate of the lintel can reach 77%, so there is no need for reinforcement. The design bending moment of the foundation beam is 516 m.kN. The design shear force is 202 kN.

The following table is used to assemble the foundation beam:

Table 1. Checking of foundation beam

COMPROBACIÓN DE LA VIGA DE CIMENTACIÓN				
REF	**VALOR**	**UD**	**FÓRMULA**	**DESCRIPCIÓN**
Md	516	KN.m	Del modelo de cálculo	Momento de diseño del modelo
b	***0.60***	m		Ancho de viga
c	***0.70***	m		Canto de viga
r	***0.05***	m		Recubrimiento de viga
d	***0.65***	m		Canto útil
z	0.585	m		Brazo mecánico
Us	882	KN	Us=Md/z	Capacidad a tracción a coser
As	20	cm2	As=Us*1,15/50	Área de acero necesaria
f	25	mm		Diámetro de las barras a utilizar
Af	4.91	cm2	Af=PI()*(f/20)^2	Área del redondo
nf	4.13	nº	nf=As/Af	número de redondos necesarios
Vd	202	KN	Del modelo de cálculo	Cortante de diseño
Vcu	195	KN		Cortante último
Vsu	7	KN		Cortante a recoger por la armadura
Asv	0.3	cm2		Armadura de corte necesaria
fv	12	mm		Área del redondo
Arv	1.13	cm2	Arv=PI()*(fv/20)^2	Área del redondo
nºr	2	nº		Número de ramas
sv	0.2	m		Separación entre cercos
Avd	11.31	cm2		Armadura de corte dispuesta

The bridge beams (Figure 12) are dimensioned so that only one of them can support the totality of the loads coming from the support to be cut, which is on the safety side. The following table shows the dimension of these beams:

Table 2. Bridge girder dimensioning

DIMENSIONAMIENTO DE VIGAS PUENTE				
REF	**VALOR**	**UD**	**FORMULA**	**DESCRIPCIÓN**
Qd	353	KN		Carga mayorada de soporte
Vd	176.6	KN	Vd=Qd/2	Cortante de diseño
fyk	27.5	KN/cm2		Resistencia característica a tracción del acero
fyd	25.0		fyd=fyk/1,1	Resitencia minorada a tracción del acero
tyd	14.4		tyd=fyd/3^0,5	Resitencia minorada a cortante del acero
Asv	12.2	cm2	Asv=Vd/tyd	Resistencia a corte necesaria
a	1	cm		Garganta de soldadura
nºa	4	nº		Número de soldaduras verticales
la	6	cm		la=8-1-1 longitud efectiva de soldadura a corte
Asv_disp	24.0	cm2		Armadura a corte dispuesta

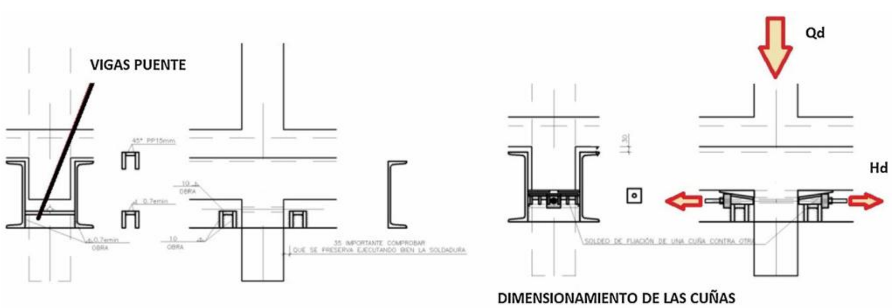


Figure 12. Dimensions of bridge beams and supports.

The following table is used to determine the geometric dimensions of the wedges and the screws that introduce them. The table examines the supporting surface of the wedges at the bottom of the beam and determines the size of the Macalloy rod or similar rod screws that will load the wedges. A 20 mm screw is used, but with a large thread length. This is very important. The inclination of the wedge-shaped plane is 9º.

Table 3. Calculation of wedges

DIMENSIONAMIENTO DE CUÑAS				
REF	**VALOR**	**UD**	**FORMULA**	**DESCRIPCIÓN**
Qd	*353*	KN		Carga mayorada de soporte
Vd	176.6	KN	Vd=Qd/2	Carga de cada cuña
fck	*2.5*	KN/cm2		Resistencia característica a tracción del hormigón
fcd	1.7	KN/cm2	fcd=fck/1,5	Resitencia minorada a tracción del hormigón
Ac	106.0	cm2	Ac=Vd/fcd	Area de apoyo de cuña en hormigón
Lc	10.3	cm	Lc=Ac^0,5	Lado del cuadrado de apoyo mínimo
a	10	cm		Lado de apoyo de un lado de la cuña
b	20	cm		Lado de apoyo del otro lado de la cuña
nº	2.0	nº		Número de cuñas por lado
Ac_disp	400	cm2		Área de superficie de contacto
tcd	0.442	KN/cm2	tcd=Bd/Ac_disp	Tensión mayorada en el hormigón de viga<0,4fck
m	0.5	-		Coeficiente de rozamiento máximo entre aceros
a	9	º		Ángulo de inclinación de cuña
Hd	232	KN	Hd=m*Qd+Qd*seno(a)	fuerza máxima a hacer por el tornillo
Tu	323	KN	<Hd	Tracción última según catálogo
Hd/Tu	0.718	1.39	>1,35	Se garantiza el deslizamiento de cuñas

3.7 Version of the described practical load bridging application

The practical load transfer solution described corresponds to a real construction site where the engineering cost more than the construction work. Among the many practical applications that a masterful designer could imagine with this new tool, which is nothing more than an economical way to transfer loads slowly and in a controlled manner, would be version 2.0 of the extension of highway deck spans without the use of an auxiliary structure (Figure 13), which would lead to the pure concept of structural self-generation that Julio Martínez Calzón has promulgated (Martínez Calzón, Puentes, estructuras, actitudes, 2006), and whose follow-up implies greater complexity for the designer, but a smaller carbon footprint and greater economy in the work.

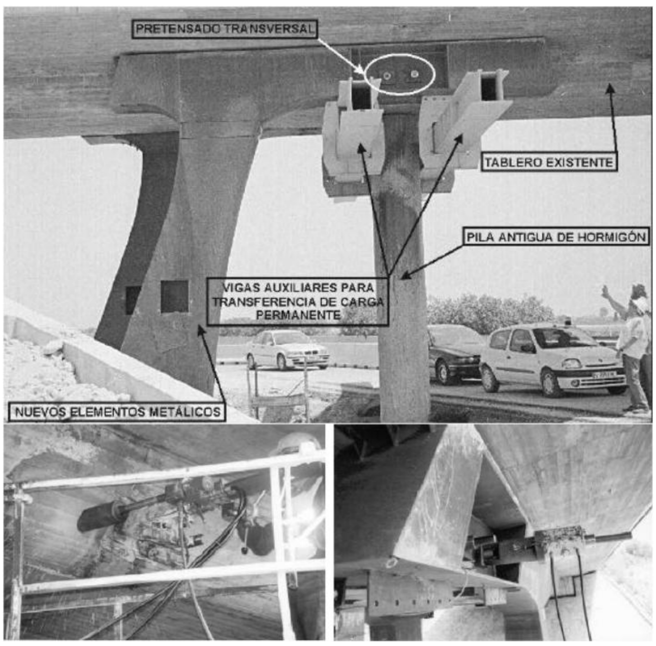


Figure 13. Solution for span extensions 1.0 (Martínez Calzón & Ladrón de Guevara Méndez, Ampliaciones de luces de pasos superiores de autopistas existentes. Solution applied to the AP-7 motorway (BY-PASS) Valencia, 2002).

4. New Typology of Derived Post-Tensioning

4.1 Historical background of post-tensioning

In the process of documenting the historical background, we found a document that clearly and brilliantly describes the state of the art in prestressing technology for the year 2004 by Mr. Juan Ayats Calsat, co-inventor of the patents (Figure 14) for prestressing (United States Patent No. US 6,578,328 B2, 2003). For this reason, reference is made in this section to this document, which can be consulted on the Internet. It is worth mentioning this thesis carried out at the UPC (Ayats Calsat, 2004), which is a must read for any technician, whether a teacher, contractor, specialist or designer involved in the subject, due to its great capacity for synthesis and graphic description.

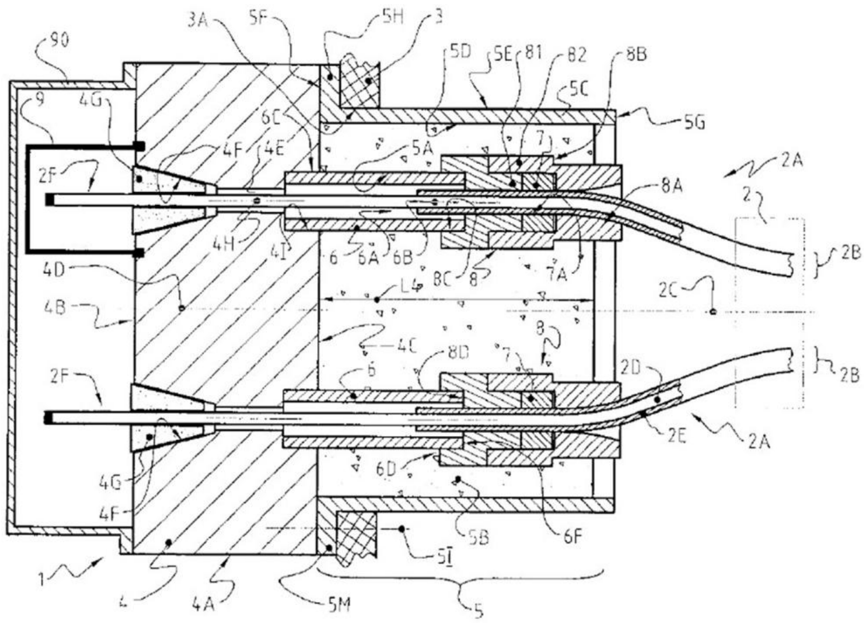


Figure 14. Technology belonging to VSL.

However, the following is a list of posting techniques, which mention very rare open knowledge sources in Ibero-American structural technology publications, and very rare paper sources related to structural themes. However, for those who want to expand their technical field, this is the foundation of knowledge content: patents.

However, the research and knowledge of civil engineering patents is currently a concern for the elders in our profession, as reflected in the article by the Institute of Architecture in this publication (Dobell, Patents and Codes related to Prestress Concrete, 1951). This is only a partial translation of the American reference (Dobell, Patents and Codes related to Prestress Concrete, 1950), which studies over 100 patents related to prestressing.

The following characteristics of patents are listed: firstly, they are public, followed by open and universal sources of knowledge; secondly, they are the honest efforts of a group of people who believe they have developed a valuable invention and intend to receive rewards; thirdly, they are used to honestly defend industrial knowledge; fourthly, they are independent and subject to sanctions from the international scientific community, thus obtained through honest competition; things that are difficult to achieve in the world we live in.

Regarding the post-processing system, the following patents extracted from Tesina (Ayats Calsat, 2004) up to 1964 (Figure 15) can be considered, of which only one is an Ibero-American patent:

No.	Sistema	País de origen	Fuerza (1)	Composición	(2)
1	**Anderson**	USA	m, g	cordones	todos
2	**Barredo**	España	p	alambres	3
3	**Baur-Leonhardt**	Alemania	G	alambres	todos
4	**Baur-Leonhardt y Grün-Bilfinger**	Alemania	G	alambres	todos
5	**Bauwens**	Alemania	p	alambres	-
6	**BBRV**	Suiza	m, g	alambres	todos
7	**Beton und Monierbau**	Alemania	m, g	alambres	todos
8	**Billner**	USA	m	alambres	todos
9	**Braunbock**	Austria	todas	alambres	todos
10	**CCL 1**	Gran Bretaña	p, m	alambres	1
11	**CCL 2**	Gran Bretaña	m	alambres	1
12	**CCL 3**	Gran Bretaña	m, g	cordones	1
13	**Chalos**	Francia	m, g	cordones	todos
14	**Coyne**	Francia	G	alambres	todos
15	**Crom**	USA	m	alambres	1
16	**DDR**	Alemania	m	alambres	todos
17	**Dywidag**	Alemania	m, g, G	barras	1
18	**Franki-Smet 1**	Bélgica	m	alambres	todos
19	**Franki-Smet 2**	Bélgica	m	alambres	1
20	**Freyssinet 1**	Francia	m	alambres	todos
21	**Freyssinet 2**	Francia	g	cordones	todos
22	**Grün & Bilfinger**	Alemania	m	alambres	todos
23	**Guifford-Burrow**	Gran Bretaña	m, g	cordones	1
24	**Guifford-Udall**	Gran Bretaña	p, m	alambres	1
25	**H.G.** (Holzmann)	Alemania	m	alambres	todos
26	**Hauser**	Italia	p	alambres	2-4
27	**Heilitbau**	Alemania	m, l	alambres	1
28	**Held & Franke 1**	Alemania	m	alambres	todos
29	**Held & Franke 2**	Alemania	m	barras	1
30	**Hochtiefbau**	Alemania	m	alambres	todos
31	**Holzmann-Zerna**	Alemania	m, g	alambres	todos
32	**International Raymond**	USA	m	alambres	todos
33	**K.A.** (Interspan)	Alemania	m, g	alambres	todos
34	**Kani-Barasel**	Alemania	m, g	alambres	todos
35	**Korowkin**	URSS	g	alambres	todos
36	**Kübler**	Alemania	p, m	alambres	todos
37	**Kübler-Volter**	Alemania	p, m	alambres	todos
38	**Leoba 1**	Alemania	m	alambres	todos
39	**Leoba 2**	Alemania	m, g	alambres	todos
40	**Lesage**	Bélgica	m, g	alambres	todos
41	**Macalloy**	Gran Bretaña	p, m, g	barras	1
42	**Magnel-Blaton**	Bélgica	p, m, g	alambres	2
43	**Morandi**	Italia	m	alambres	varios
44	**P.I.**	USA	m	alambres	todos
45	**P.S.C. 1**	Gran Bretaña	p, m	alambres	1
46	**P.S.C. 2**	Gran Bretaña	m, g	cordones	1
47	**Polensky & Zöllner**	Alemania	m	alambres	todos
48	**Prescon**	USA	m	alambres	todos
49	**Rheinhausen**	Alemania	m	alambres	todos
50	**Rinaldi**	Italia	m	alambres	1
51	**Roebling**	USA	g	cordones	todos
52	**S.E.E.E. 1**	Francia	p, m, g, G	cordones	todos
53	**S.E.E.E. 2**	Francia	G	cordones	todos
54	**Sager & Woerner**	Alemania	m	alambres	todos
55	**Stressblock**	Gran Bretaña	g, G	cordones	1
56	**Stressrod**	USA	m	barras	1
57	**Stressteel**	USA	m	barras	1
58	**Turntable System**	URSS	m	alambres	1
59	**V.S.L.** (Losinger)	Suiza	g, G	alambres	todos
60	**Vaessen**	Alemania	m	alambres	todos
61	**Wayss & Freytag**	Alemania	m	alambres	todos
62	**Wets**	Bélgica	m	alambres	todos
63	**Züblin**	Alemania	m, g	alambres	todos

(1) pequeña, p: hasta 133,5 kN; media, m: hasta 490 kN; grande, g: hasta 4.450 kN; muy grande, G: >
(2) Elementos tesados simultáneamente

Figure 15. Prestressing patents until 1964.

In the above list, only some exist, and all exist without exception, linking the development of products with the protection of knowledge through patents.

We would like to expressly rescue the Spanish patent given to the technical community by Mr. Antonio Angulo Ávarez, president for many years of the Association of Friends of the Autogiro (Goicolea, 2012), and described in the magazine of public works (Angulo Álvarez, Hormigón pretensado, modesta aportación a su técnica, 1957). This patent (Figure 16) is not included in the table above.

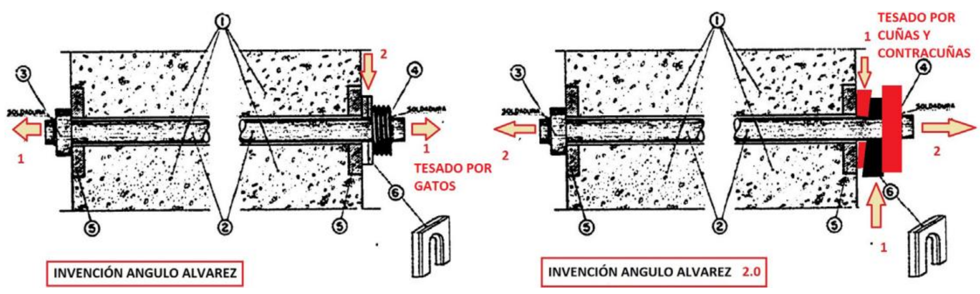


Figure 16. Ibero-American prestressing patent prior to 1957. Version 2.0 with transverse tensioning of the wedge and counterbracing.

If the jacked tensioning system of this Angulo Álvarez patent is replaced by the wedge and counter wedge tensioning system, threading a posteriori the same U-shaped wedge-sheet and conveniently adapted and designed in sheet thicknesses, this application can be modestly recovered.

The main advantage of using wedge and shrink nail methods for steel bar drawing is the possibility of performing horizontal drawing operations under the application of lateral forces, which may be appropriate when there is no space to place the drawing jack in the longitudinal position of the steel bar.

As an example of the development of this detail of wedge and counter wedge technology, we have found the patent (United States Patent No. US6328499 B1, 2001) of the figure (Figure 17), which is used to guarantee the transmission of compression of bars and prevent untightening, which we imagine will have its application in off-shore structures.

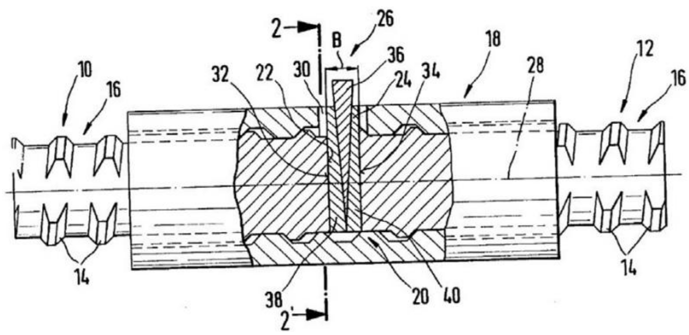


Figure 17. Teuton-Luxembourg patent.

4.2 Post-tensioning as structural equipment with high added value

The cost savings that can be achieved in civil engineering through the use of prestressing or bracing are well-known. This technology is led by structural engineers around the world. It is particularly developed in mainland Europe, the United States, and Japan.

The fact is that all the efforts made by these countries in completing infrastructure construction in terms of production infrastructure are aimed at fixing it on commercial and industrial heritage, so that it can be maintained within these built infrastructure and exported to technology developed in a way that maintains knowledge.

With the outbreak of the crisis, the same thing may happen in Iberia. Or not; in this situation, great opportunities will be lost again: the case of Mr. Isaac Peral (RTVE, 1973) and submarines or that of Mr. Juan de la Cierva with the autogyro (Angulo Álvarez, 2007) is the most obvious examples of the loss of industrial wealth creation opportunities. But if possible, this issue will be discussed in another article. As the Spanish-American philosopher (Santayana, 2005) wrote, "Those who do not remember the past are destined to repeat the same mistakes," as the philosophy professor Mr. Jean-Philibert Damiron (Damiron, 1843) said, "to know oneself in order to correct oneself".

A cable-stayed bridge can be seen in almost all geographical locations on Earth, but not all countries have an industry that provides lifting straps.

All leading postal supply companies continue to develop a technology learning curve and protect their progress through patents and/or proprietary technologies.

This is in the tradition of D. Eugène Freyssinet, who patented the pre-stressing technique first in France (French Patent No. FR680547, 1928) and later in the United States of America (U.S. Patent No. US2080074, 1937) (Fig. 17). Particularly typical is the development of the construction company created in 1943 to provide pre-tensioning services (FREYSSINET, 2017), which has brought significant added value to the company and to the construction industry, as well as to the societies that provide the services, and has created jobs in more than 70 countries. To give a typical example of the application of post-tensioning, the entire French nuclear fuel generation industry relies on post-tensioning techniques as a fundamental part of civil engineering.

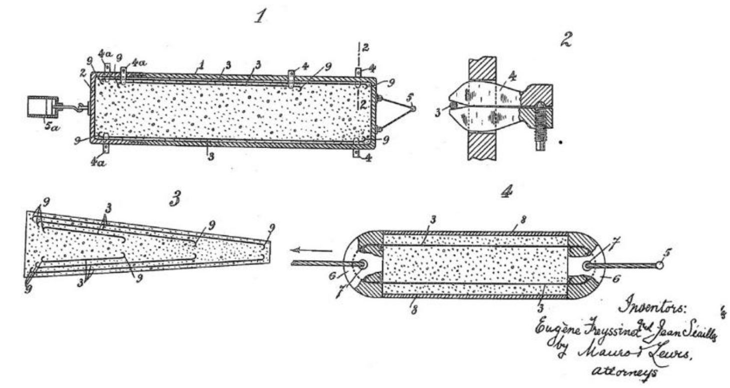


Figure 18. Freyssinet's American patent; the example to follow.

Swiss and German industrial developments are also of special relevance, where Swiss companies such as BBR (BBR, 2017) founded in 1944 by Mr. Max Birkenmaier, Mr. Antonio Brandestini and Mr. Mirko Robin Ros, which introduced its post-tensioning technology in Spain in 1963 and continues to introduce it and protect its improvements (United States Patent No. US4124321, 1978); and VSL (VSL, 2017). Mirko Robin Ros, which introduced its post-tensioning technology in Spain in 1963 and continues to introduce it and protect its improvements (United States Patent No. US4124321, 1978); and VSL (VSL, 2017) founded in 1943, a time when Mr. Hans Dietrich, inventor of the strand system, Mr. Hans Elsässer, special manager of construction methods; and the vice manager Mr. Giovanni Crivelli were protagonists. The German company DYWIDAG developed the first post-tensioning systems with Franz Dischinguer in 1925-1927 and began to license the French patents in 1950.

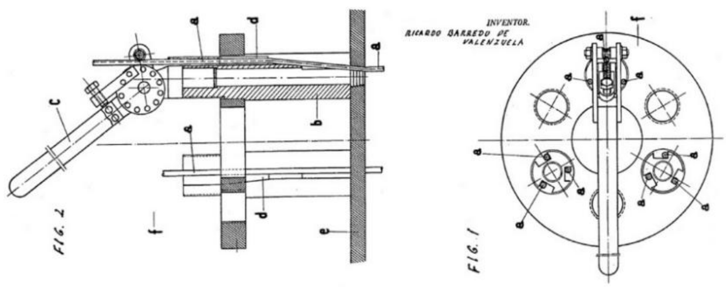


Figure 19. Patent of Mr. Ricardo Barredo de Valenzuela.

The Latin American countries in the south also have their own postal industry development; Just like Portugal, with the collapse of the company, ICQ Manuel Alves; Or Spain, along with Teamdam, is the successor to the 1958 patent of D. Ricardo Barredo de Valenzuela. Ricardo Barredo de Valenzuela (US patent number US28206061958) is a true pioneer in Spanish industrial tensioning technology (Figure 19), as it allows for the creation of an industry that provides and develops this product (US patent number US36052021971). Mekano4 (Mekano4, 2017) also carried out large-scale postal activities for over 25 years on the basis of a serious proprietary technology development plan. In Italy, Tensacciai (Tensain National, 2017), founded in 1951, has mainly developed the postal industry since 1964.

4.3 Back to the origins: the first post-tensioning system

Returning to its origins, just like submarines and autopilots, the first prestressing system in terms of prestressing was Iberian-American: in the Tempull Aqueduct (Figure 20). Contrary to what happened to the authors of previous milestones, the inventors did not believe in prestressing methods or started believing very late.

Due to the excellent technical promotion of structured portals (Agudelo Zapata & Boixander Cambronero, 2013), the author was not able to locate this article in the journal *Concrete Engineering*. This article was printed and belongs to the *Torroja Archives*. An excerpt from the explanation of the Aluz Aqueduct is as follows (original text): (Fig. 21) "Spanish technology uses, to varying degrees, high-quality steel strands as prestressing trusses in reinforced concrete. The first example is the same system used by Prof. Toroza in 1926 in the Tempul Aceducto (Antunia Bernardo, 2002) and the same system he used successfully in 1939 in the Aloz Aqueduct (JBT, 2016).

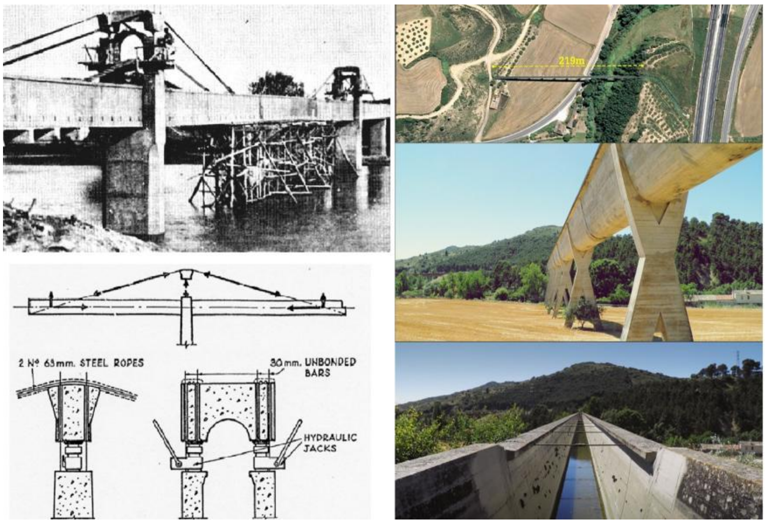


Figure 20. Tempull aqueduct versus Alloz aqueduct on the right.

From the previous paragraph, written in 1947, it can be inferred that the same post-tensioning system has been used in both aqueducts, but when you compare them with the naked eye, where is the same system? The transverse post-tensioning of the Alluz aqueduct is visible, but what about the longitudinal post-tensioning system? The answer is in the Figure 21, which is appended and in the reference reading. However, it is emphasized that it is a longitudinal post-tensioning system that is applied by means of a transverse load-bearing system. These beams, which will be 80 years old in 2019, are the oldest post-tensioned trough beams in the world for aqueducts.

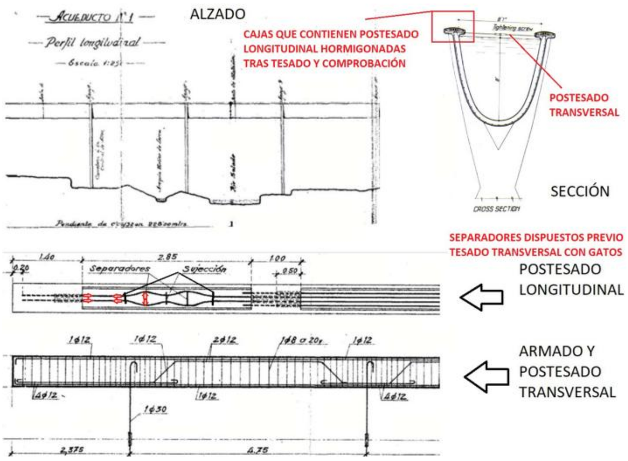


Figure 21. Aqueduct of Alloz. Original annotated plan by Mr. Eduardo Torroja Miret.

The teacher's conceptual approach is great: how to change the scale of structural concepts while retaining basic concepts. More importantly, he didn't appreciate it; Perhaps this was his mistake, he didn't value what he did, and he didn't make a mistake. Carlos Fernandez Casado: Give pre-stress the importance it deserves.

Perhaps this system is waiting for the recovery of D. Javier Manterola Armisén, who truly understood the explanation for the torsional performance of double T-beams (Timoshenko, 1957) and designed significant and necessary scale changes to enable the construction of bridges in the Basque region (Aguillo, Manterola, Onzai, and Rui Wamba, 2004).

4.4 The Jimeno-Lleyda system: methodology of conception and conceptual outline

The following is the column system for metal structures: the Jimeno Lleyda method.

In principle, the technical application that may lead to its use is the repair of metal or hybrid beams. In offshore structures, they may be useful as they may be very economical solutions for reinforcement. Therefore, it is a very gentle but easy to execute application system.

This idea was developed for VSL Construction Systems to repair the column anchoring of Hammersmith bridge columns. The intellectual concept of these anchorages comes entirely from D. Carles Cots Coromina (Figure 22), which began with technical research on this bridge in London.

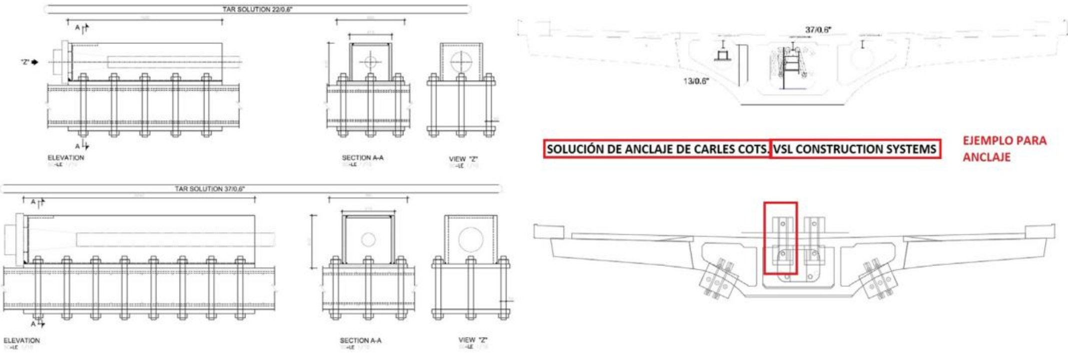


Figure 22. Carles Cots' basic solution for the rehabilitation of Hammersmith Bridge. VSL Construction Systems S.A.

The final repair solution implemented was provided by Freyssinnet, with prefabricated post cast concrete anchors, and received a well-deserved award in the UK (Clark, 2016) (Figure 23).

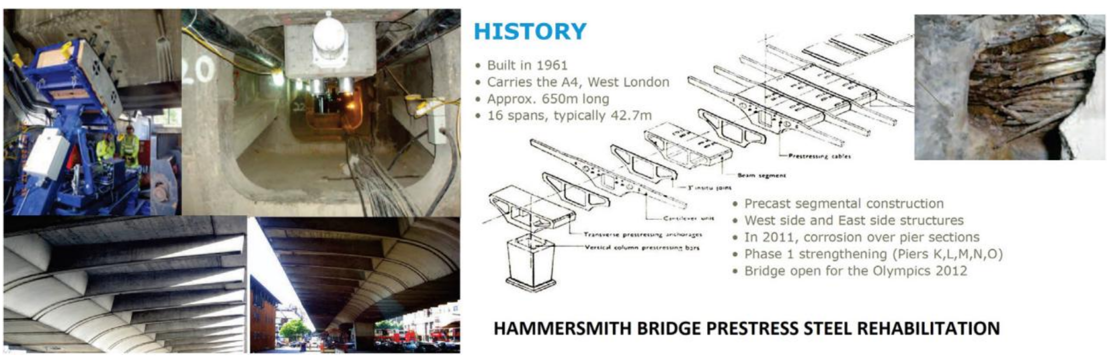


Figure 23. Solution executed for the rehabilitation of Hammersmith Bridge. Ramboll. Freyssinet.

Later, there was an opportunity to utilize all the work completed for the London project to moderately reinforce the outer columns of a forging plant, which was jointly developed with D. Gerardo Salazar.

From this work in 2015 (Figure 24), it can be inferred that using this type of reinforcement can save a lot of money in repairing the Hammersmith Bridge, as processing much lighter metal components can save a lot of operating time.

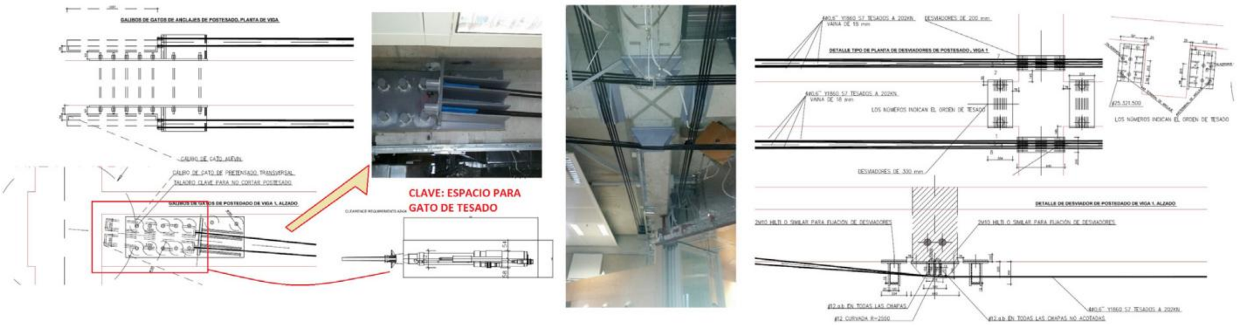


Figure 24. D. Carles Cots base solution for post-tensioning anchorage. VSL Construction Systems S.A.

From this work, there has also been a problem of leaving space for cats and their movement in the anchorage; Even with cats, there should be enough space for testing. Why not propose a column that can be carried out from half of the light, or even from any part of the light? The solution once again appears in Torosa: transverse pillars to generate longitudinal pillars.

It is not knowing what post-tensioning is, but how to perform post-tensioning in a repetitive and systematic way (-how), which has added value.

In order to make the half steel strip offset against the other half steel strip throughout its entire length and obtain the compressive force to reinforce the steel strip, it is necessary to use Jimeno wedges on one side and Lleyda anti wedges on the other side (Figure 25), working together like two friends. As shown in the figure.

The reason for the name of this modest method is to pay homage to the inventors of the trough beam for road bridges. Mr. José Emilio Jimeno Chueca and Mr. José Luis Lleyda Dionis. Thanks to their silent engineering, progress has been made in the state of our technique.

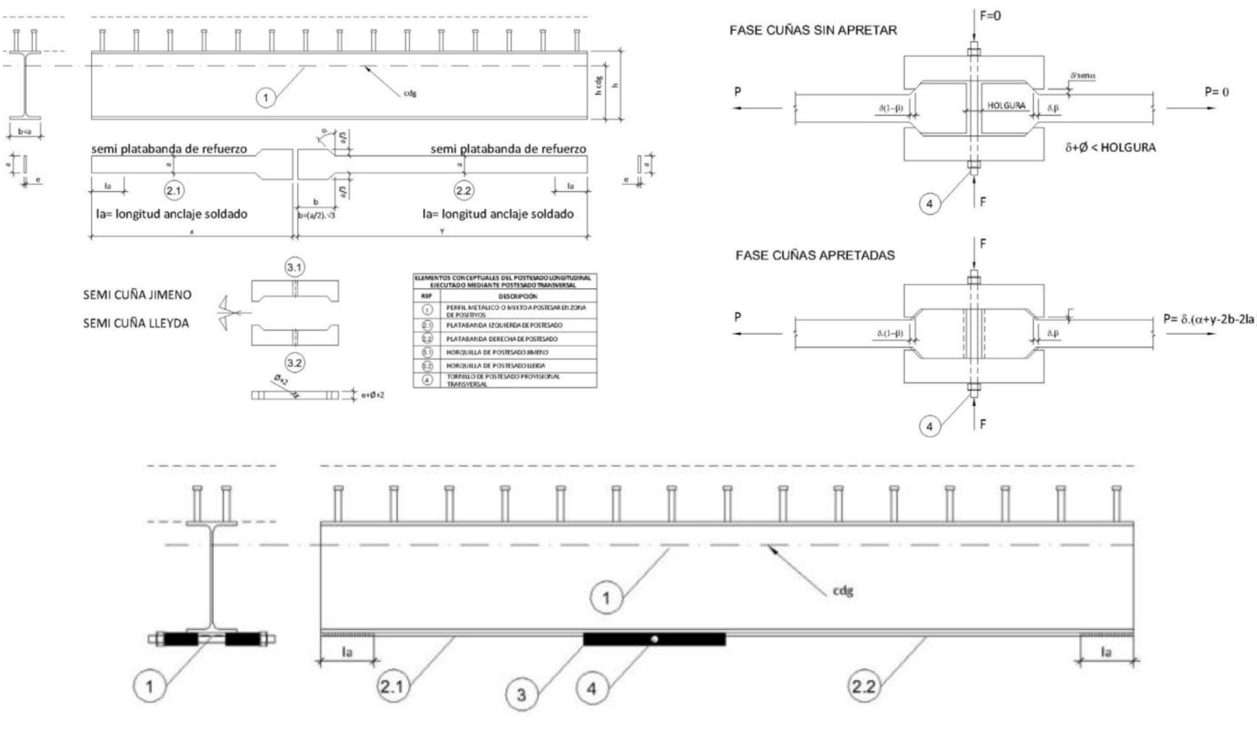


Figure 25. Jimeno-Lleyda post-tensioning method.

5. Conclusion

This paper described a load transfer system that makes cutting of structural supports more common by reducing the cutting of structural supports instead of using expensive auxiliary means.

The document found that postal technology is related to the existence of technology patents of companies operating the product. It has been proven that Ibero-American technological culture does not lack conceptual capabilities, but rather lacks protection of knowledge and the fixation of business and industry - how to replicate.

A system of post-tensioning of metallic structures (Jimeno-Lleyda method) based on the described procedure of load bridging for column cutting is proposed.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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