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TECHNICAL SUITABILITY: Nº 270R/09

Generic area/Use envisaged:	**SLAB BEAMS REPAIR SYSTEM**
Commercial number:	**EXTEND**
Beneficiary:	**SENETON, S.A.**
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This document contains 22 pages

MIEMBRO DE:

UNIÓN EUROPEA PARA LA EVALUACIÓN DE LA IDONEIDAD TÉCNICA
UNION EUROPEENNE POUR L'AGREMENT TECHNIQUE DANS LA CONSTRUCTION
EUROPEAN UNION OF AGREMENT
EUROPÄISCHE UNION FÜR DAS AGREMENT IN BAUWESEN

VERY IMPORTANT

THE TECHNICAL SUITABILITY DOCUMENT constitutes, by definition, a favorable technical assessment by the Eduardo Torroja construction Institute of the suitability of certain specific use of materials, systems and non-traditional procedures in construction. It does not, per se, have any administrative effect, nor does it represent authorization for use or a guarantee.

Before using the material, system or procedure to which it relates, it is necessary to have full knowledge of the document. Consequently, the document must be provided by its owner in its entirety.

Any modification of the characteristics of the products or failure to comply with the conditions of use, as well as the observations of the Committee of experts, invalidates the present technical assessment.

C.D.U.: 69.022.325
Sistemas de construcción
Systèmes de Construction
Building System

DECISION NO. 270R/09

THE DIRECTOR OF THE EDUARDO TORROJA CONSTRUCTION INSTITUTE,

- by virtue of Decree nº.3.6521963 of 26 December, of the Presidency of the Government, which empowers the Eduardo Torroja construction Institute, to extend the technical suitability document of materials, systems and non-traditional procedures used in buildings and public works, and order No. 1.2651988 of 23 December of the Ministry of relations with the courts and the Secretary of the Government, which regulates the granting of approval,

- considering article 5(2), paragraph 5, of the technical building code (herein after referred to as CTE) on conformity with the CTE of the products, equipment and innovative systems, which establishes that a construction system is compliant with the CTE if it has a favourable technical assessment of its suitability for the intended use,

- considering the specifications laid down in the rules for the monitoring of the DIT of 28 October 1998,

- considering the request made by the Company SENETON, S.A., for the replacement and modification of the technical suitability document No. 270, by including typographical corrections, modification of the title of the document and updating of the text for **the repair system of slabs with EXTEND aluminous cement beams,**

- under the current statutes of the European Union for the technical approval in the area of construction (UEAtc),

- taking into account the reports of visits to construction sites undertaken by the representatives of the Eduardo Torroja construction Institute, reports of the tests conducted at the IETcc as well as observations made by the committee of experts, meeting on 26 July 1993,

DECIDES

To replace the technical suitability document number 270, with number 270R/09, adapting it to **the EXTEND joists slabs repair system,** considering that,

The technical evaluation conducted makes it possible to conclude that **THE SYSTEM IS COMPLIANT WITH THE TECHNICAL CODE OF THE BUILDING**, while respecting the entire contents of the present document and in particular the following conditions

GENERAL TERMS AND CONDITIONS

The present TECHNICAL SUITABILITY DOCUMENT only evaluates the construction system proposed by the applicant which, in each case, should, in accordance with the regulations in force, be accompanied by the building project description and completed through the corresponding construction management. The building project will, in each case, define the actions that the system transmits to the general structure of the building, by ensuring that they are acceptable.

In each case, SENETON, S.A., will provide geometric and mechanical characteristics of the profiles in the system, as well as adequate technical assistance, that will enable the author of the project and/or the project management to calculate and define for its implementation, by including all necessary information on each of the components.

In any case, the technical project, which should be performed by a qualified technician, will justify compliance with the regulations in force, providing the corresponding table of calculation and the graphic documentation outlining the geometry of all the parts, the conditions of connection of the parts between themselves and conditions of support in the existing structure.

CALCULATION CONDITIONS

In each case and in line with the conditions for calculation contained in the technical report of this document, the stability, resistance and acceptable defects will be checked in order to justify the suitability of the system to withstand mechanical stress that may arise from corresponding actions in accordance with the conditions laid down by the legislation in force and the specific geographical situation.

Similarly, the actions that the system transmits to the general structure of the building should be studied to ensure that the increase in loads due to the repair system and the transmission of stress derived are admissible.

CONDITIONS OF MANUFACTURE AND CONTROL

The manufacturer must ensure that the raw materials, the manufacturing process and the finished product are controlled by him, in accordance with the instructions given in section 6 of this document.

CONDITIONS OF USE AND INSTALLATION

EXTEND beams slabs repair system evaluated in this document is intended for the repair of unidirectional beams slab through their functional replacement by means of beams composed of aluminium parts assembled on-site.

The implementation of the system must be carried out by SENETON, S.A., or by qualified companies recognized by it under its technical control, which will ensure that the use of the system is carried out under the conditions and areas of application covered by the present document, in compliance with the observations made by the Committee of experts. A copy of the updated list of installation companies recognized by SENETON S.A. will be available at the ITcc.

All necessary measures relating to the stability of the buildings shall be taken during the installation. As regards the EXTEND, SENETON, S.A. slabs repair system with the approval of the Director of works, the risks of fall of suspended loads, protection of persons shall, in general, take into account the provisions contained in the regulations of safety and health at the work site.

VALIDITY

This technical suitability document number 270R/O9 shall replace and cancel the document No. 270 and is valid for a period of five years provided:

-that the manufacturers do not modify any of the characteristics of the product indicated in the present document of technical suitability,

-that the manufacturer shall conduct a systematic production control as indicated in the technical report,

-that annual control shall be carried out by the Institute, to ensure compliance whith the above conditions, by visiting, if it deems it appropriate, any of the works carried out.

With the favorable outcome of the monitoring exercise, the IETcc shall annually issue a certificate which shall accompany the DIT, to make it valid.

This document shall, therefore, be renewed before December 14, 2014.

Madrid, December 2009

THE DIRECTOR OF THE EDUARDO TORROJA
CONSTRUCTION INSTITUTE

Víctor R. Velasco Rodríguez.

TECHNICAL REPORT

1. OBJECT

Uni-directional ribbed slabs reinforcement system of beams, consisting of a functional replacement of damaged beams by placing, under the same, or flanking them laterally, with EXTEND extensible aluminium beams, capable of ensuring the stability of the slab in case of total loss of resistance of the affected beam.
The system does not take into account the use of the damaged beam, leaving aside, for purposes of calculation of the possible resistance contribution of the beams of the slab under repair.
This technical evaluation, as reflected in DIT No. 270, was carried out for slabs of reinforced or prestressed concrete beams made with aluminous cement. In the said document it was indicated that the technical evaluation would enable one to conclude that the system is valid for the repair of other types of unidirectional slabs while complying with the prescriptions of the technical report, the compatibility of the materials and the observations of the Committee of experts.

2. PRINCIPLE AND DESCRIPTION OF THE SYSTEM

El Sistema presenta dos variantes:

A. Installation under the affected beam of an EXTEND reinforcement beam, achieving the transmission of loads from the slab to the reinforced beam through the filled space between them with controlled retraction mortar (Figure 1).It is possible, if the conditions of the building make it possible, to carry out the physical replacement of the affected beam.

B. Installation under a damaged beam of a galvanized U -shaped steel tray which transmits the loads to two EXTEND reinforced beams, located on both sides of the beam, through transversal profiles (ties), supported on both and arranged every meter of rectangular section (figures 2 and 3). The space between the affected beam and the galvanized steel tray is filled with controlled retraction mortar, thus ensuring the transmission of loads.
The fitting and hanging from the transversal profiles to the EXTEND beam is carried out by using clamps in the form of oblate omega attached to each other with threaded rods, which at the same time is used to adjust the height of the ties. In order to prevent the galvanic torque that might occur, contact of the steel clamps with the aluminium profile should be avoided by placing between the two a plastic gasket.

The transmission of stress to the walls, beams or bands where the slab lies, is performed through supports tied to these elements using chemical or mechanical type anchors depending on the cases. These supports receive directly the reinforcement profiles.
Depending on the existing support structure, there are various possibilities of connecting the EXTEND reinforcement beam in its two variants (see figures 4 to 7).
In any case, the choice of the type of anchor between the support part and the support element (wall or beam) will be made on the basis of the material, the type and state of the support and the loads to be transmitted.
Given the characteristics of the materials to be used, the system presupposes a slight increase of the weight of the building. The telescopic nature of the reinforcement beam makes for an easy and comfortable transport, handling and installation.

3. MATERIALS AND COMPONENTS

3.1 **Aluminium**

The characteristics of the aluminium alloy used in the manufacture of profiles of extruded aluminium and the support parts, are contained in table 1 below:

Table 1. ALUMINIUM DATA

Alloy and treatment		
Alloy supplier		EN AW-606035
Approximate correspondence	Symbolic	EN AW-6063
	Numerical	EN AW-AL Mg0,7Si
	DIN	AlMgSi0,5 F22
Treatment		T6
Physical properties		
Specific weight		2.700 kg/m^3
Coefficient of linear thermal expansion (20 a 100 ºC)		$23 \cdot 10^{-6}$ K^{-1}
Elasticity module		69.000 MPa
Poison coefficient		0,3
Mechanical properties		
Resistance to traction (Rm)		≥ 215 MPa
Elastic limit (Rp0,2)		≥ 190 MPa
Stretching (A)		≥ 10 %
Brinell hardness (HB)		67

3.2 **Galvanized steel**

Special parts for solution B (profiles, trays, clamps and rods) are manufactured in non-alloy hot laminated steel S235JR according to UNE-EN1 0025, hot dip galvanized by immersion according to standard UNE-ENI SO 1461.

3.3 **Controlled hydraulic retraction mortar EMACO S88 thixotropic.**

Thixotropic mortar based on hydraulic cement, aggregates selected, additions and polyacrylonitrile synthetic fibres high compatibility with the concrete for structural repair supplied by BASF Construction Chemicals Spain, S.L. It is used for the filling between the beam to be reinforced and the EXTEND beam in order to guarantee the transmission of loads.
The mortar has CE marking according to the standard UNE-EN1 504-3 class R4.

Characteristics:

- Density of the kneading Mortar approx. 2,2 g/cm3.
- Water for kneading: 3,8 l/sack of 25 kg.
- Temperature of application: between 5 C and 30 C. ºC.
- Workability time: 60 min.
- Applicable thickness: from 10 to 40 mm.
- Capillary absorption (UNE-EN 13057): < 0,5 kg/m2·√h
- Flexural strength 28 days (UNE-EN 12190): 10 N/mm2.
- Resistance to compression 28 ays (UNE-EN 12190): 70 N/mm2.
- Elasticity module 28 days (UNE-EN 13412): > 20.000 MPa.
- Adhesion to concrete (UNE-EN 1542): ≥ 2,0 MPa.
- Adhesion to concrete after Thermal cycles (UNE-EN 13687): ≥ 2,0 MPa.
- Expansion (UNE-EN 12617-4): < 0,08 %.
- Retraction (UNE-EN 12617-4): < 0,08 %.
- Chloride content (UNE-EN 1015-17): ≤ 0,05 %.
- Resistance to carbonation (UNE-EN 13295): approx. 1 mm.

According to the certificate issued by the supplier of the mortar, this is compatible with the allready hardened aluminous cement of the beams to be reinforced.

4. THE COMPONENTS OF THE SYSTEM

4.1 **Beam EXTEND**

The extensible aluminium beam made of tube-like profiles with variable thickness, is composed of two or three segments, fitting into each other with ease. The connection between the different sections is made by simple penetration (Figure 8).

The characteristics and properties of aluminium were defined in section 3.1. The geometric and mechanical characteristics are specified in tables 2, 3 and Figure 8.

There are five types of basic profiles of rectangular section (Figure 8; table 2) for the constitution of the four types of beams (table 3).

TABLE 2: BASIC PROFILE CHARACTERISTICS

Profile Type	**Dimension** (mm) h	b	**Área** cm^2	I_x cm^4	W_x cm^3	I_y cm^4	W_y cm^3	**Weight** kg/m
P-14	145	62	17,85	568,72	69,01	101,33	31,44	4,82
P-16	162	73	20,41	813,58	100,92	162,83	44,79	5,55
P-18	179	84	22,79	1113,29	124,91	249,22	59,27	6,20
P-20	197	95	27,65	1681,65	170,73	380,53	79,90	7,52
P-22	218	107	32,92	2499,49	229,57	566,81	105,70	8,95
P-24	242	120	40,95	3922,98	324,21	866,14	144,36	11,14

TABLE 3: TYPE OF BEAMS

Beam Type	**Profiles**	
V-16	P-14	P-16
V-18	P-16	P-18
V-20	P-18	P-20
V-22	P-20	P-22
V-24	P-22	P-24

The relationship between the lengths of the profiles comprising the EXTEND beam shall be subject to specific calculation in each case.

However, in general, the beam will have the following form:

- **Beam of three section**s:
  Central section of L/2 and lateral sections of L/4 in addition to the minimum length of embedment, with L the total length of the beam (Figure 9).

- **Beam with two sections:**
  Profile of greater height of 2 L/3 and the minor height L/3 plus the minimum length of recess, where L is the total length of the beam (Figure 10).

The minimum lenght of embedment is fixed into the largest of the profiles at least three times and will be subject to testing after its installation since the rigid behaviour of the knot depends on it. Optionally, at the request of the user the profiles may have marks or perforations which will facilitate the checking.

4.2 Supports

Piece of aluminium that transmits through the loads of the EXTEND reinforcement beam to the resistant element.

The characteristics and properties of aluminium they were defined in section 3. 1.
There are fifteen different types, depending on the type of beam and the support solution adopted (figures 11 to 15).

4.3 Filling mortar

It is used for filling the space between the beam to be reinforce and the EXTEND, with the aim of ensuring the transmission of loads.

The range of thicknesses accepted for this material will enable its installation both in small spaces such as the centre of the reinforcement as well as large spaces, such as those that can be found at the ends. This last aspect will facilitate the correct transmission of loads between the slab and the reinforcement.
The minimum required resistance to compression is 17.5 MPa.

4.4 Anchors

The definition of the type, position and number of anchors for the fixing of the anchor to the support plates will be made according to the support base material and on the basis of the stress transmitted, and must be reflected in the technical project.
This information will be provided by the person in charge of the system, based on the recommendations of the manufacturer of the support anchor for each support base material .
It is the responsibility of the contractor and the project management, to check the adequacy of the anchor, defined in the technical project, with the support element executed

4.5 Special parts. Solution B

All these parts are made of galvanized steel, the dimensions and thicknesses of the same shall be determined by calculation in each case.

The parts, as shown in Figure 2, are:

7. U-shape tray, in support of the beam.
8. Installation Kit, consisting of clamps and threaded rods:
   Clamps: 40 mm wide strips in the form of omega.
   Threaded rots with their corresponding nuts and washers. They facillitate the leveling of the transversal profiles.
9. Cross sections in U profiles, located every meter, to transmit the loads to EXTEND beams, placed laterally to the beam under repair.

For each EXTEND beam the parts composing solution B are contained in figures 16 to 20.

5. MANUFACTURE

The materials and components used in the system are supplied by:

Profiles and aluminium brackets:
Hydro Aluminium La Roca, S.A., from the preheated base material, extruded with 7200 and 5500 tons press according to section, conform profiles. They have heat and traction equipment.

EMACO S88 thixotropic filling mortar:
BASF Construction Chemicals Spain, S.L.

Any of the materials or components used in the manufacture of the system may be supplied by different manufacturers to the appropriate customer provided that they ensure, through certification, that the new materials or components comply with the same conditions as those referred to in the document, in particular with regard to the chemical compatibility of the mortar. Any change of supplier shall be notified accordingly for approval by IETcc.

6. QUALITY CONTROL

SENETON, S.A., has registered the controls and certificates listed below to guarantee the quality and traceability of the products.
They will be at the disposal of the IETcc.

6.1 **Acceptance controls of raw materials or components**

6.1.1 *Profiles and aluminium brackets*

Certificates with each batch, issued by the supplier, guaranteeing:

- Chemical composition of the material.
- Mechanical properties of the material.
- Geometric features of the part (dimension tolerance according to standard DIN 7615).

The supplying company Hydro Aluminium La Roca, S.A has a certificate of quality according to ISO 9001, with number ES97/0702, issued by SGS, for the manufacture of aluminium profiles, and assembly of profiles with thermal bridge break.

Hydro Aluminium La Roca, S.A., also has an environmental management certificate according to ISO 14001, with number ES04/0862/MA, issued by SGS.

6. 1.2 *Galvanized steel parts*

Certificates with each batch, issued by the supplier, guaranteeing:

- Chemical composition of the material.
- Mechanical properties of the material.
- Geometric characteristics of the part.
- Minimum thickness of the coating.

6. 1.3 *Anchors*

Certificate of the characteristics of the product delivered by the supplier. Where appropriate, the anchor must have CE marking.

6. 1.4 *Mortar filling*

Certificate of the characteristics of the product delivered by the supplier.
The mortar manufacturer should guarantee the chemical compatibility between the mortar supplied and the hardened concrete of the beam to be reinforced.

6.2 **Control of implementation of the system**

As indicated in the general conditions of this document, the works shall be completed subject to the prescriptions of the directives of the project management.
The implementation will be carried out by SENETON, S.A., or by authorized fitters for this, according to the technical specifications of this document. SENETON, S.A., shall provide technical assistance during the project phases and execution.

7. LABELLING, SHIPMENT AND STORAGE

7.1 **Labelling**

Profiles shall bear a label stating:

- Trade mark of the manufacturer.
- Type of profile.
- Length.
- Logo and number of DIT.

7.2 **Aluminium profiles**

- They shall be transported and stored in a manner that they will not have any deformations. When a profile, because of some accident is deformed, it should be rejected. Its streghtening or repair will not be permitted.
- Avoid contact with water or snow.
- Avoid water condensation.
- Once opened, the packaging should be emptied on the same day.
- Open or closed packages should not be stored in damp environments.
- Have good ventilation.

  In case of risk of condensation of water, the packages must not be covered by plastic on all sides. In particular, care must be taken to leave sufficient free space between the upper surface of the stored material and the packaging.

  Aluminium parts that have spots of water or corrosion, may only be cleaned with a mechanical surface treatment (sand) when the geometric shape of the part makes it possible.

7.**3 Filling mortar, epoxy resin and anchors**

The recommendations of the manufacturers of the mortar, resin and anchors relating to the conditions of storage and conservation of such products will be complied with.

The mortar, resin and anchors will be stored following the recommendations of the manufacturer.

8 WORKS IMPLEMENTATION

8.1 **General specifications**

The implementation of the system must be carried out by SENETON, S.A., or by qualified companies specialized in installation of reinforcement systems and repair of structural elements, recognized by SENETON, S.A., under its control and technical assistance, in accordance with the specifications of this document.

In any case, SENETON, S.A., provides all the data required to carry out the project and implementation of the beam reinforcement project; and must provide, if requested, technical assistance during the project phases and its implementation, including the resolution of the specifique issues.

8.**2 Anchors**

The anchors for fixing anchor plates to the support are not part of the system and therefore have not been evaluated. However, in the technical project the position and number of anchors must be defined depending on the type and state of the support and the stresses transmitted.

During implementation the type and state of the support, should be verified and ensure that the anchors provided for the technical project are suitable. In the event that the expected anchor is not appropriate, it should be replaced with the approval of the project management.

8.3 **Installation**

Each case will require a particular study, but by rule, includes the following phases (see Figure 21):

(a) Shoring of the beam to be reinforced, if necessary for safety purposes.
(b) Locate and discover the damaged nerves of the beam from end to end the, by removing the suspended ceiling, chopping the coatings, etc. depending on the type of finishing of the lowest surface of the slab to be treated.
(c) Diversion of existing installations if necessary.
(d) Treatment of the damaged parts of the beams to be repaired, by eliminating the damaged areas.
(e) Recomposition, if necessary, of the lower part of the beam to be reinforced, by removing dust and grease.
(f) Chopping of coatings in the area of location of the brackets.
(g) Layout and placement of supports.
(h) Installation of EXTEND beam. Rigorously ensure that the lengths of embedment of the profiles are at least three times the edge of the larger segment. Verification of the correct beam delivery in the supports.
(i) Filling of space between the EXTEND beam and the reinforced beam with controlled retraction mortar EMACO S88 thixotropic, making sure that it completely fills the space between the two.

The recommendations provided by the manufacturers of the mortars and resin concerning the use of these products should be followed.

In solution B (see Figure 22), after the installation of the EXTEND beam the ties and the tray located under the beam will be installed. The space between these and the beam as indicated in paragraph (i) will be filled.

9 USE REFERENCES

The manufacture and use of the EXTEND beam repair system started since 1993.

As references the following beam repair works can be cited by the manufacturer:

1992/1993:
. Residential building in Avda. Marques de Montroig, Polygono Sant Roc. Badalona. (Barcelona) 90 m2.
. Residential building in Avda. Les Corts. Barcelona. 4.359 m2.
. Residential buildings in barrio el XUP. Manresa (Barcelona)2. 26 m2.
. Residential buildings in C/. Ntra. Sra. de los Ángeles. Barcelona 162 m2.
. Residential buildings in C/. Juventud. L´ Hospitalet de Llobregat (Barcelona). 201 m2.
. Residential buildings in C/. Mas. L´ Hospitalet de Llobregat (Barcelona). 2 28 m2.

2003:
. Restaurant in Rambla Guipúzcoa. Barcelona. 145 m2.
. Residential building in C/. Mareny. Blau. Sueca (Valencia). 360 m2.
2004:
. Residential building in C/. Lincoln. Barcelona. 556 m2.
. Residential building in C/. Pau Alcover. Barcelona. 750 m2.
. Sanitary slab in an IES in Caravaca. Murcia 800 m2.
2005:
. Sanitary slab in an IES in Cartagena (Murcia)1. 120 m2.
. Residential building in calle Conception Delcloux. Ripoll (Barcelona).630 m2.
2006:
. Residential building in Paseo Maragall. Barcelona. 600 m2.
. Building in C/. Mayor. Caldes de Montbui. (Barcelona) 120 m2.
2007:
. Residential building in Avda. Bourbon. Barcelona. 300 m2.
. Building in Recinto Rogelio Rojo Masquefa (Barcelona). 200 m2.
2008:
. Residential building C/. Les Moles. Barcelona. 480 m2.
. Residential building C/. Miquel del Prat. Barcelona. 90 m2.

10. CALCULATION REPORT

In each case the stability and resistance of the system shall be checked, by deducing from this study the dimensioning of the profiles. Similarly, the appropriateness of the procedure to support the mechanical stresses and deformations that may occur from the actions to which the system will be subjected to will be justified.

As shown under the object of this DIT, the model of calculation used does not take into account the possible resistant contribution of the beams of the existing slab.

The beams shall be deemed to be supported by variable inertia, made up of sections of different inertia, and for its calculation the general theory of resistance of materials will be applied. The arrow shall be subject to the regulations enforced.

The calculation and dimensioning of the structure shall be carried out according to Eurocode 9, aluminium structures project and the basic documents of the CTE on structural safety (DB-SE) and actions in the building (DB-ES-AE).

The manufacturer has records of use depending on different distance between beams, distance between supports, maximum load and deformation. Such data should be analyzed and considered by the technical author of the repair project and the director of works.

11. TESTS

Part of the test has been conducted in the Eduardo Torroja construction Institute (IETcc) whose results are reflected in the report NO. 16.493; and the other part of the test has been conducted in other laboratories.

11.1 **Identification tests of materials**

The suppliers of materials or components contributed, through certification, the characteristic values.

11.2 **Use proficiency tests**

11.2.1 *Mechanical behaviour tests of EXTEND beam*

Tests have been conducted by the test Laboratory of the “Direcció General d´Arquitectura i Habitatge del Departament de Política Territorial i Obres Publicas de la Generalitat de Catalunya” (references numbers 3168, June 12, 1992; 3543,October 28, 1992; 3717 and 3726, November 9, 1992; 3726), and by the Materials Laboratory of the E.U.P.B. of the “Universitat Politècnica de Catalunya” (references 1-32.1; 1-32.2, February 1993; 1-32.3, April 1993; 1-32.4, April - 1993) on supported aluminium beams, composed of three profiles installed in a telescopic manner, varying the length penetration among them.

The load stroke deformation graphs obtained from different load configurations, lead us to the conclusion that for embedment lengths between the beam profiles of 3 times or more the edge of the largest section, the deformation values obtained are consistent with the corresponding values of the theoretical calculation of a supported beam, composed of different inertia sections, rigidly joined together.

11.2.2 *Tests of mechanical behaviour of the system*

Tests carried out in the Eduardo Torroja Construction Institute (IETcc)), report No. 16.493.

(a) Object to tests

This is to test the beam reinforcement and repair, simulating the most unfavorable conditions that can be encountered.

(b) Conduct of tests

On half foot thick double hollow and 50 cm wide break walls, plastered and separated between external faces of 4.00 m and internal faces of 3.75 m, beams were placed with the characteristics given below and which constitutes the part to be reinforced.

To simulate the weight of the upper slabs, metallic profiles were placed on the upper face of the break walls and leveled with the beams. These profiles are anchored to the ground by steel cables.

For the tests beams manufactured at the Institute were used. They were made of concrete of 96 kp/cm2 resistence with compression reinforcement of 8 mm ø, and traction of 4 mm which was extended to 2/3 of the total length of the beam in its central zone.

An EXTEND reinforcement bram of the type V-20 was placed under each of the beams, being the ratio of lengths between the profiles defined in general as in paragraph 3.1 for beams of three sections. The supports used are of the type 200x200x90/C and anchors five for support of chemical type, System HIT of HILTI (rods HIT M12/115, cartridge HIT C-20 and sieve sleeve ø 16.)

(c) Device for loads application

For these tests, there was an equipment for the application of loads consisting of a jack of 20 Mp and a dynamometer, arranged in a way that the maximum load would add up to 10 Mp.

The pressure of the jack was measured by a pressure guage located at the head of the guage and the reading recorded by computer every three seconds. Also fleximeters placed under the beams to measure arrows were read through the computer. One in the center of the span and others two to 10 cm. from the supports.

The load was applied using a distribution profile placed under the jack, which unloaded in two rollers which were supported by plates under the beam and received with plaster.
These plates, which were at the loading points on the beam, were placed at a third of the light in the flexion tested beams and at 50 cm of the supports in the tested beams.

(d) Load faces

After placing all load devices (plates, rollers, jacks, distribution profile...) on a beam, the load process was initiated. Both in the flexion tests and in cutting the load was applied in scales of 200 kp up to 600 kp. At that time it unloaded. Once the arrow was stabilized the load process in scales of 200 kp was initiated and continued until the rupture of the system tested.

The arrow that is given in the results of the tests, corresponds to the arrow at the load time indicated, less the residual arrow obtained in the download of the first phase of the test.

The load value of 1500 kp of the arrow, would correspond to the total load without any adition that acts on a slab band of 0.70 m, with a light span of 3.75 m and a load of 570 kpm2 uniformly distributed (own weight plus overloads).

(e) Test results

The following is a summary of the test of the most significant values:

FLEXION 1
- Arrow in 1.500 kp: 6,94 mm.
- Breaking load: 54,40 kN.
- Type of breakage: crushing of the wall.

FLEXIN 2
- Arrow in 1.500 kp: 7,85 mm.
- Breaking load: 62,00 kN.
- Type of breakage: crushing of the wall.

INCISIVE 1
- Arrow in braces in 1.500 kp: 0 and 0,29 mm.
- Breaking load: 72,50 kN.
- Type of breakage: c rushing of the wall.

INCISIVE 2

- Arrow in braces
  1.500 kp: 0 and 0 mm.
- Breaking load: 67,44 kN.
- Type of breakage: crushing of the wall

It was observed that in none of the four tests conducted, at the time of breakage, there was no local effect (bump, crushing of wing, etc.) in the profiles, nor in the connections between them. There was neither important deformations in the connection between the profiles, making it possible after the test for them to slide into each other. The support did not show significant deformations.

The total load graphs/corresponding arrow are attached to the flexion tests (graphs 1 and 2), indicating the arrows in the center of the span (F1) and the supports (F2 and F3).

Gráfico 1: Flexión 1

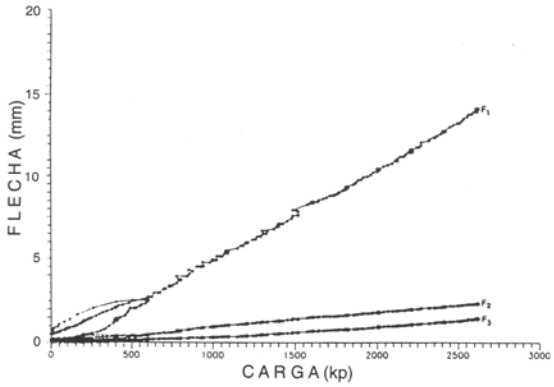
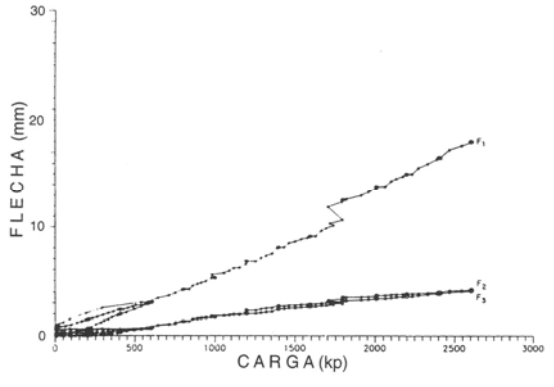


Gráfico 2: Flexión 2



F_1 = Flecha en el centro del vano
F_2, F_3 = Flecha en apoyo

12. EVALUATION OF USABILITY

The system, as described in this document, is suitable for the repair of the intended slabs.
The system presupposes a reduction of the free height of the space located under the slab to be reinforced.

12.1 **Compliance with national regulations**

12.1.1 *Structural safety*

This technical evaluation and the test conducted have revealed that the model of calculation proposed is consistent with the behaviour of the system, as described in paragraph 8.

The technical project must be accompanied by the corresponding calculation of the structures, where the adopted calculation criteria are specified, which should be in conformity with those set out in the present document and justify the compliance with the basic requirements of resistance and stability (SE 1) and suitability for service (SE 2) under the CTE.

Although the system is a system of repair of slabs, it should not be forgotten that the slab forms part of a wider structural organization, that of the building. Consequently the global capacity of the building, the adequacy of the rest of elements that transmit the loads up to the foundation and the impact of the reinforcement must be verified.

As a result of the low weight of the material used, aluminium, the system represents a slight increase in gravitational loads on the vertical structural elements and ultimately on the foundation; however, in each case, the capacity resistance to the increase in loads mentioned earlier, as well as the level of tensions on the ground should be checked.

The system does not provide for the recovery of the existing deformations in the slab to be repair. The designer of the reinforcement must consider that deformations and arrow that produce the loads and overloads evaluated in the calculation of the reinforcement will be added to the already existing items of the element to be repaired.

12.1.2 SI - *Fire safety*

The structure of reinforcements, including anchors, must be properly protected against fire, in a manner that adhere to the basic requirement of fire resistance of the structure (SI 6) depending on the concrete characteristics of the building, as provided in the CTE-DB-SI.

12.1.3 SU - *Safety of use*

Not applicable.

12.1.4 HS – *Health*

The components of the system, once installed, according to the declaration of the manufacturer, shall not contain nor release dangerous substances in accordance to the national and european legislation.

12.1.5 HR - *Protection against noise*

As set out in the scope of application of the CTE-DB-HR, concerning protection against noise, are excluded from the scope of application of the said document the works of extension, amendment, reform or rehabilitation in existing buildings, except in cases of comprehensive rehabilitation.

12.1.6 HE *Energy saving*

Not applicable

12.2. **Use of the product. Implementation and limitations of use**

12.2.1 Implementation

It should be thoroughly verified that the length of embedment between the profiles of the EXTEND beam, is not lower than the minimum, set at three times the edge of the largest, because on it depends the rigid behaviour of the knot and, accordingly, the consistency of the model of calculation defined with the actual behaviour of the system.
In case of use of the reinforcement system, in solution B, under conditions of high exposure to the presence of chlorides, e.g. closed to the sea, stainless steel parts should be used instead of galvanized steel.
Special care must be taken with the application of the refill material (mortar EMACO S88 Thixotropic) between the affected beam and the reinforcement, verifying that it covers the hole space between them, because the guarantee of an adequate transmission of loads depends on this.
Prior to the installation of the system, the type and state of the support for the definition of the type and number of anchors shall be verified.
The instructions for handling and the safety of mortars and resin provided by the suppliers of the products shall be complied with.

12.2.2. Limitations of use

This technical assessment covers only applications of the system listed in this document.

This assessment does not cover the slabs of wooden beams.

12.3 **Waste management**

The specifications of the Royal Decree 105/2008 under which the production and management of construction waste and demolition are regulated, as well as the regional and local regulations shall apply.

12.4 **Maintenance and conditions of service**

The use of aluminium as raw material for reinforcement provides the best durability against corrosion.

The provisions on durability contained in EUROCODE 9 on project of aluminium structures (Sections 2.4 and 3.4) shall be followed.

13 CONCLUSIONS

During the manufacture of the profiles the manufacturer should verify the existence of a quality control that includes a system of self control of the suitability of the raw materials, manufacturing process and product control.
Considering that the manufacturing and implementation process are sufficiently contrasted by practice and tests, it is deemed, that the suitability of use of the system proposed by the manufacturer is favorable under this DIT.

PROPONENTS:

Antonio Blázquez,
Arquitecto.

Rosa Senent
Arquitecto

14. COMMENTS OF THE COMMITTEE OF EXPERTS

The main observations of the Committee of Experts, meeting at the Eduardo Torroja construction Institute 26 July 1993 (1), were as follows:

- It must be ensured before work on the evaluated reinforcement system, that the causes of damage on the existing slabs (dampness, losses of the sanitary or water supply installations, etc.) have been corrected.
- The ease of installation of the system, makes for rapid implementation.
- Due to the geometric characteristics and in line with the tests conducted, the system has demonstrated a good resistant and deformacional behaviour suitable for supporting overloads to some extend.
- It is recommended to make visible marks in the profiles of the EXTEND beam, with a view to facilitating during the installation the verification of the correct assembly of the beams, while ensuring the correct dimension of the length of embedment.
- The implementation recommendations of the manufacturer of the filling mortar should be followed.
- The obligation to comply with the technical code for building (CTE) should be borne in mind as it relates to protection against fire and thereby the need to protect the structure against fire. This precaution should be extended to the anchors.
- As any work of a building Unit, it is advisable, in general, to carry out periodic reviews.
- On the presented solution B, no test of mechanical behavior in the IETcc has been conducted; the evaluation on the suitability of this solution depends on the correct calibration of each of the parts, based on the solutions envisaged.
- The evaluation carried out on the system has not referred to particular solutions of outriggers, bracing, etc.; which shall, in each case, be analysed, taking into account the possibilities of the system by the project management.
- It is recommended that a copy of the present technical suitability document should be incorporated into the book of the building.
- Se debe asegurar antes de la actuación con el sistema de refuerzo evaluado, que las causas que originaron la degradación de los forjados existentes (humedades, pérdidas de las instalaciones de saneamiento o abastecimiento de agua, etc.) han sido corregidas.
-

1

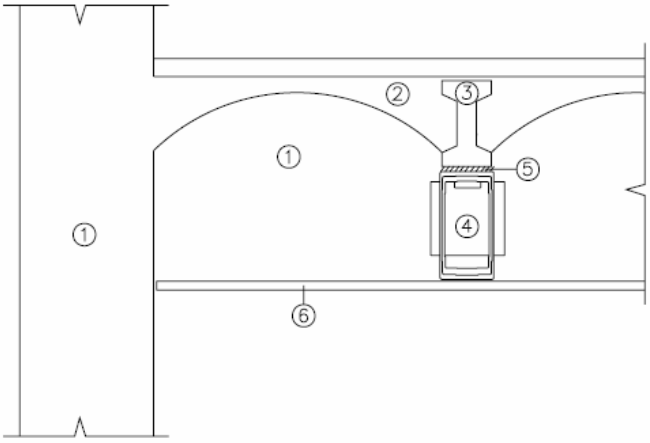
(1) La Comisión de Expertos estuvo integrada por representantes de los siguientes Organismos y Entidades:

- ADIGSA - Generalitat de Catalunya.
- Ayuntamiento de Madrid.
- CEDEX.
- C.E.N.I.M. (C.S.I.C.).
- CIETAN.
- Colegio de Aparejadores y Arquitectos Técnicos de Barcelona.
- Consejo General de la Arquitectura Técnica de España.
- Consejo Superior de Colegios de Arquitectos de España.
- Dirección General de Arquitectura y Habitatge de la Generalitat de Catalunya.
- Dirección General para la Vivienda y Arquitectura. Ministerio de Obras Públicas, Transporte y Medio Ambiente.
- Escuela Técnica Superior de Arquitectura de Barcelona.
- Escuela Técnica Superior de Ingenieros de Caminos de Madrid.
- Institut de Tecnologia de la Construcció. Generalitat de Catalunya.
- Instituto Técnico de Materiales de Construcción (INTEMAC).
- Laboratorio de Ingenieros del Ejército.
- Instituto de Ciencias de la Construcción Eduardo Torroja (IETcc).

DESCRIPCIÓN DEL SISTEMA

SISTEMA - A

FIGURA 1.



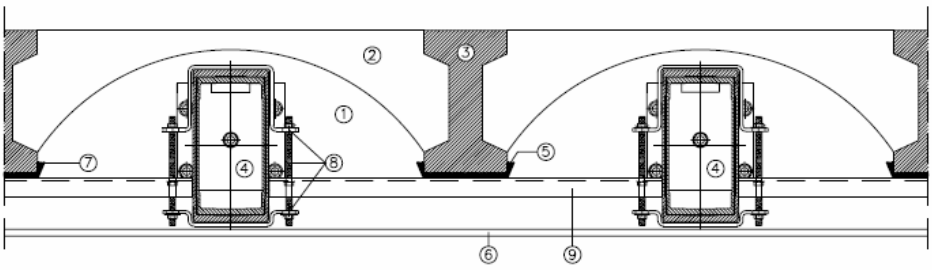
LEYENDA

① Pared de carga existente
② Techo existente
③ Vigueta a reforzar
④ Vigueta de refuerzo
⑤ Relleno con mortero sin retracción
⑥ Falso techo

SECCIÓN REFUERZO - VIGA BAJO VIGA

SISTEMA - B

FIGURA 2.

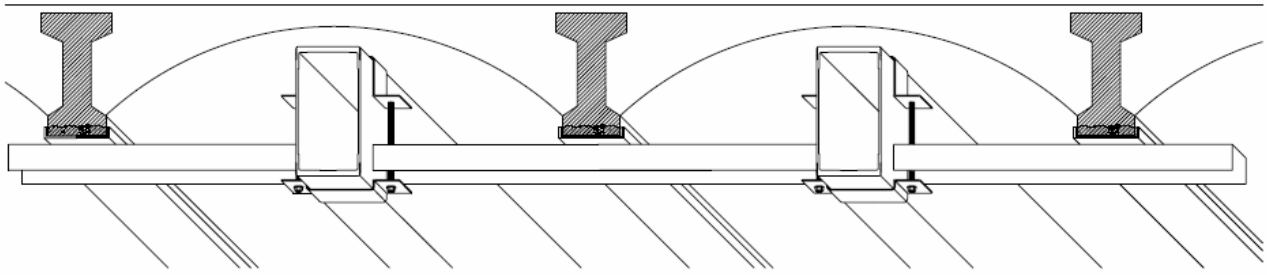


DETALLE MONTAJE DE VIGAS PARALELAS EMBEBIDAS EN EL FORJADO

LEYENDA

① Pared de carga
② Techo existente
③ Vigueta a reforzar
④ Viguetas de refuerzo
⑤ Relleno con mortero sin retracción
⑥ Falso techo
⑦ Bandeja forma de U
⑧ Kit de montaje:
Abrazaderas en forma de omegas
Varillas roscadas
⑨ Perfiles transversales

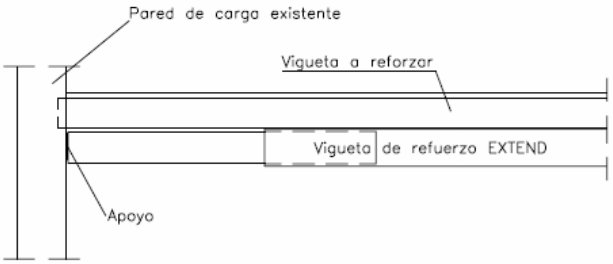
FIGURA 3.



DETALLE MONTAJE DE VIGAS PARALELAS EMBEBIDAS EN EL FORJADO

DESCRIPCIÓN DEL SISTEMA - TIPOS DE ESTRUCTURA PORTANTE

FIGURA 4. MURO DE CARGA



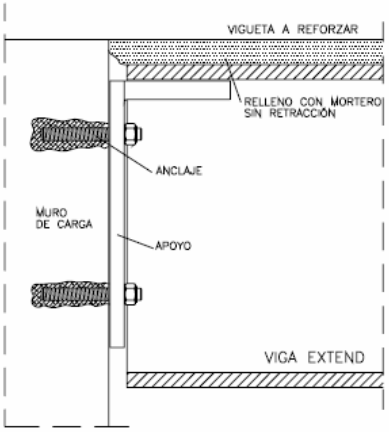
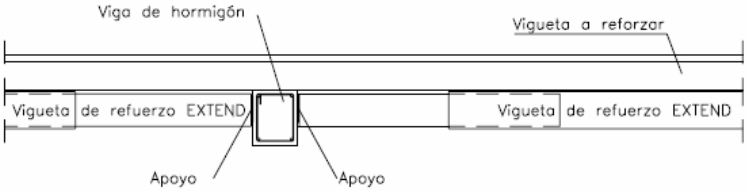


FIGURA 5. VIGA DE HORMIGÓN



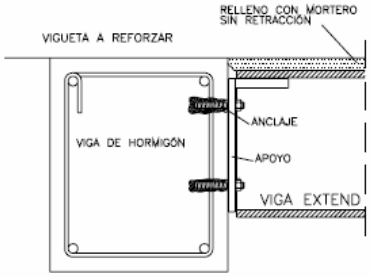
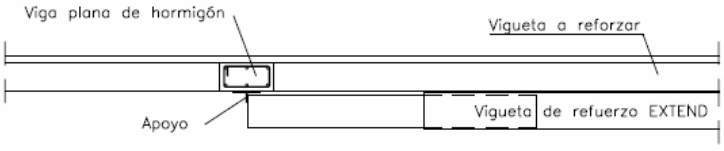


FIGURA 6. VIGA PLANA DE HORMIGÓN



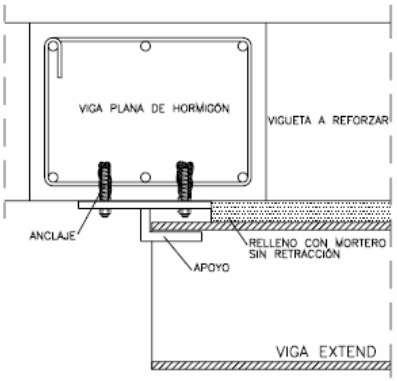
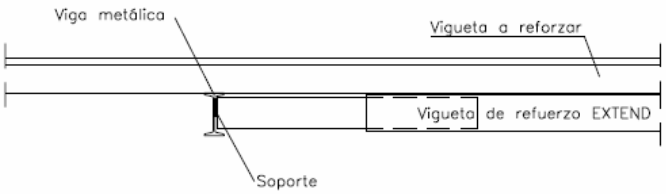
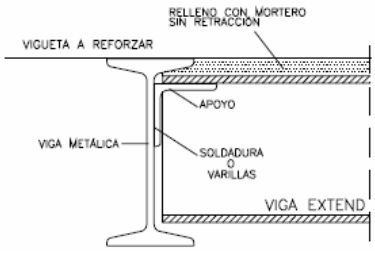


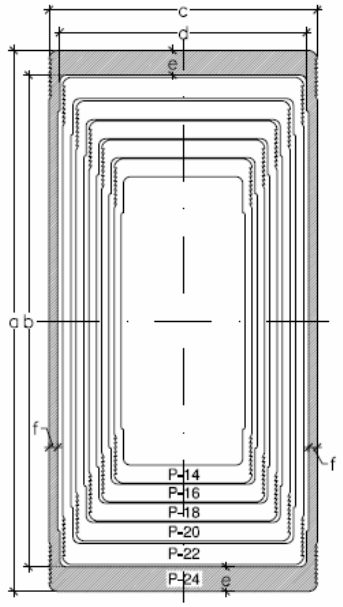
FIGURA 7. VIGA METÁLICA





COMPONENTES DE LAS VIGAS

FIGURA 8.



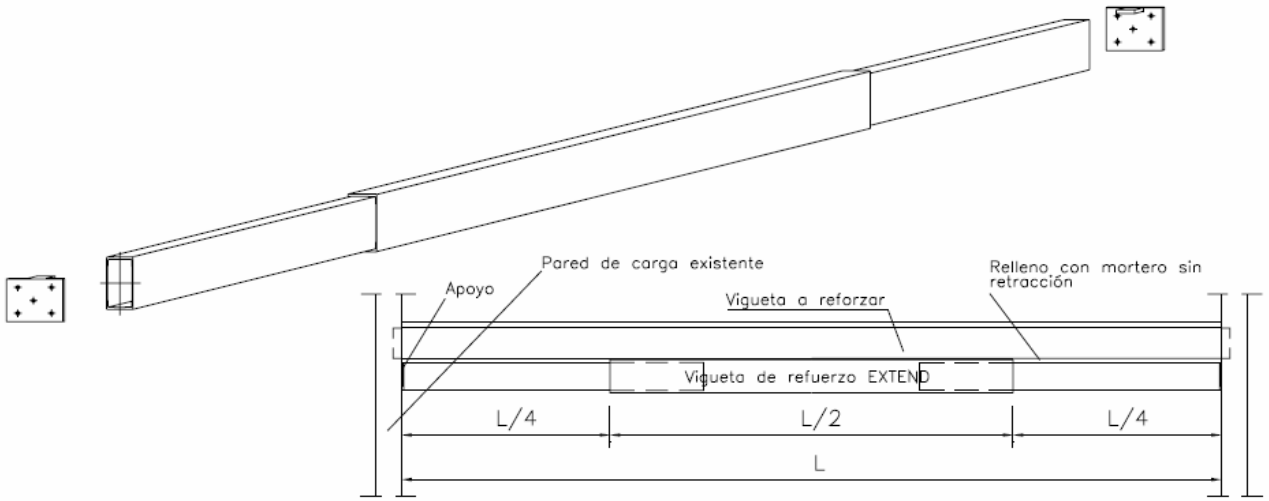
mm.	a	b	c	d	e	f
P-14	145	129	62	53,2	8,0	3,1
P-16	162	146	73	64,2	8,0	3,2
P-18	179	163	84	75,2	8,0	3,3
P-20	197	180	95	86,5	8,5	3,5
P-22	218	199	107	98,3	9,5	3,6
P-24	242	220	120	110,0	11,0	3,8

TOLERANCIAS SEGUN NORMA DIN-7615

VIGA TIPO	PERFILES	
V-16	P-14	P-16
V-18	P-16	P-18
V-20	P-18	P-20
V-22	P-20	P-22
V-24	P-22	P-24

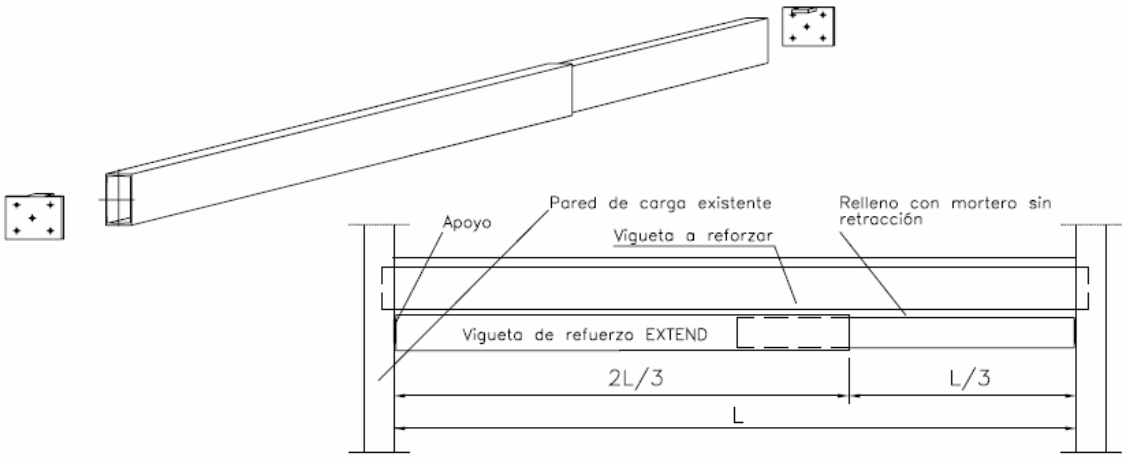
PERFILES P-14, P-16, P-18, P-20, P-22, P-24

FIGURA 9.



VIGA EXTEND (3 TRAMOS)

FIGURA 10.

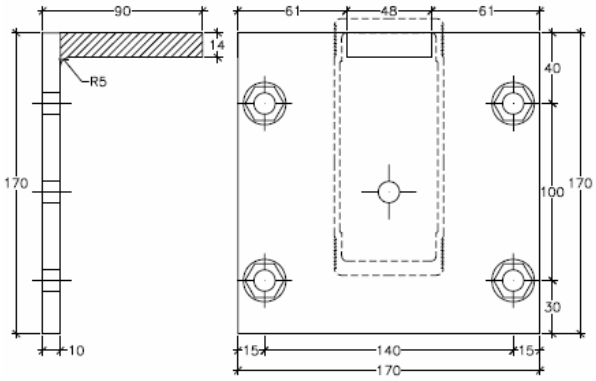


VIGA EXTEND (2 TRAMOS)

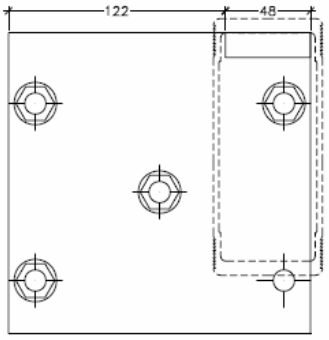
APOYOS

FIGURA 11.

APOYO EXTEND 170x170x45 / C
Perfil P-14



APOYO EXTEND 170x170x45 / D
Perfil P-14



APOYO EXTEND 170x170x45 / I
Perfil P-14

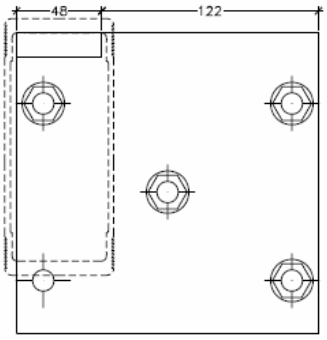
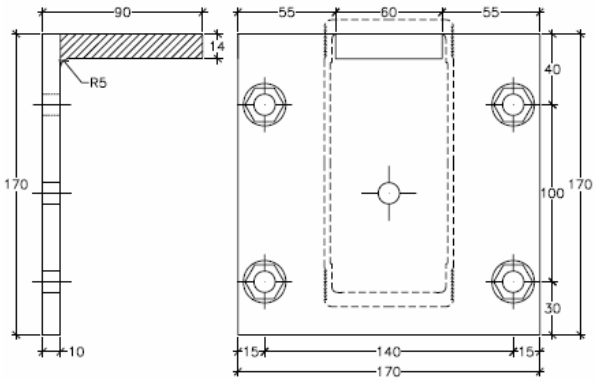
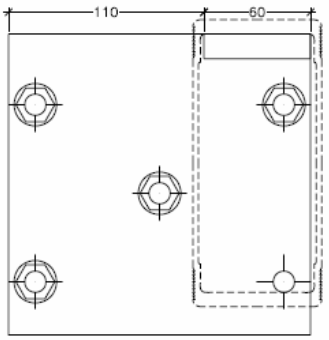


FIGURA 12.

APOYO EXTEND 170x170x60 / C
Perfil P-16



APOYO EXTEND 170x170x60 / D
Perfil P-16



APOYO EXTEND 170x170x60 / I
Perfil P-16

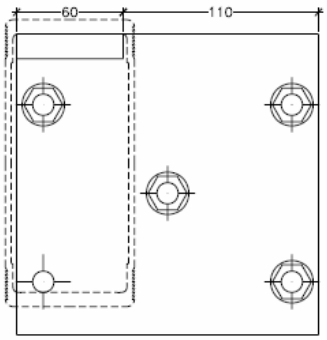
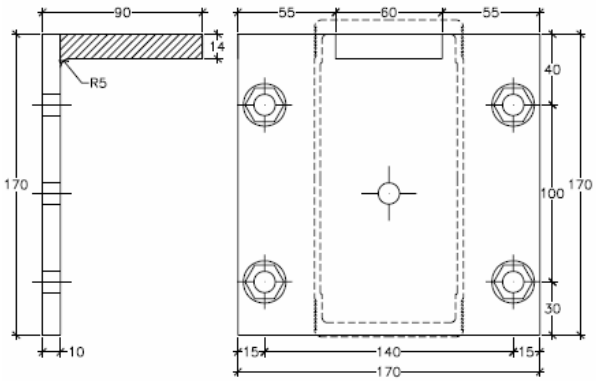
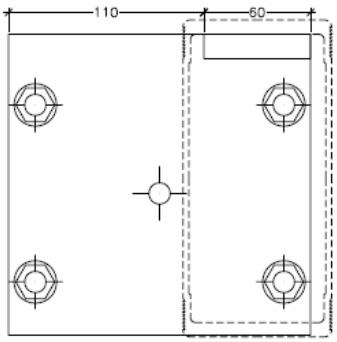


FIGURA 13.

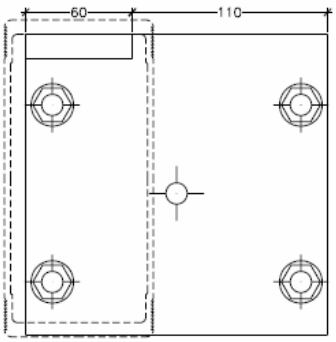
APOYO EXTEND 170x170x60 / C
Perfil P-18



APOYO EXTEND 170x170x60 / D
Perfil P-18



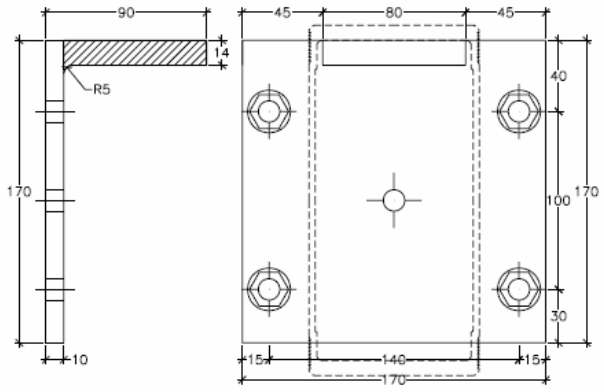
APOYO EXTEND 170x170x60 / I
Perfil P-18



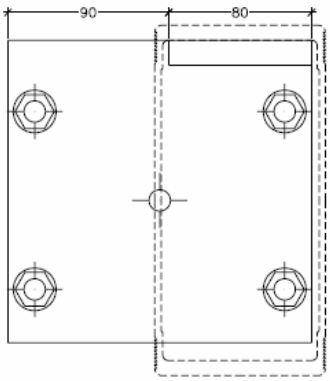
APOYOS

FIGURA 14.

APOYO EXTEND 170x170x80 / C
Perfil P-20



APOYO EXTEND 170x170x80 / D
Perfil P-20



APOYO EXTEND 170x170x80 / I
Perfil P-20

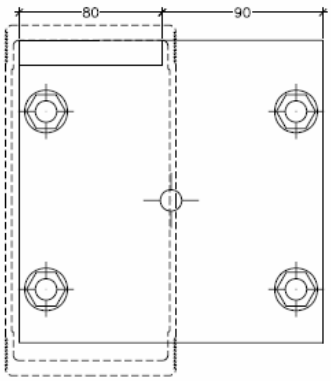
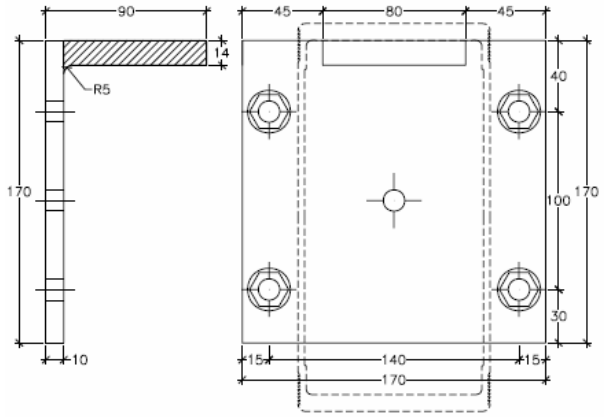
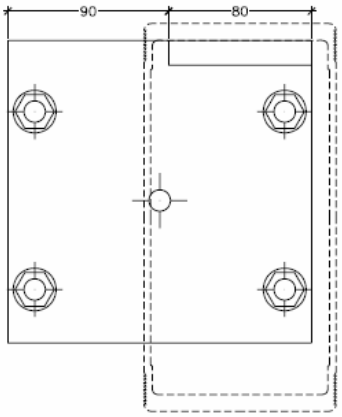


FIGURA 15.

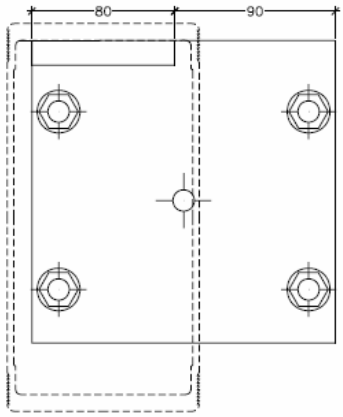
APOYO EXTEND 170x170x80 / C
Perfil P-22 y P-22



APOYO EXTEND 170x170x80 / D
Perfil P-22 y P-22

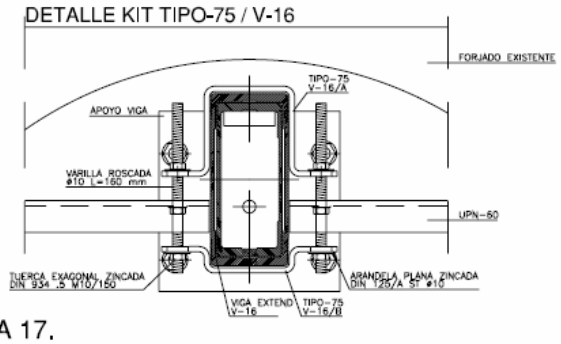


APOYO EXTEND 170x170x80 / I
Perfil P-22 y P-22



PIEZAS ESPECIALES. SOLUCIÓN - B

FIGURA 16.



DETALLE TIPO-75 / V-16

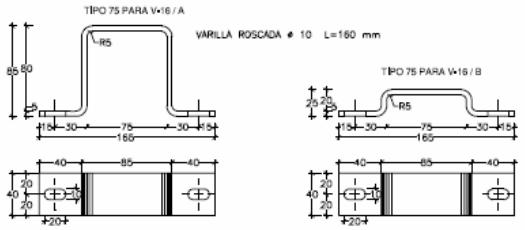
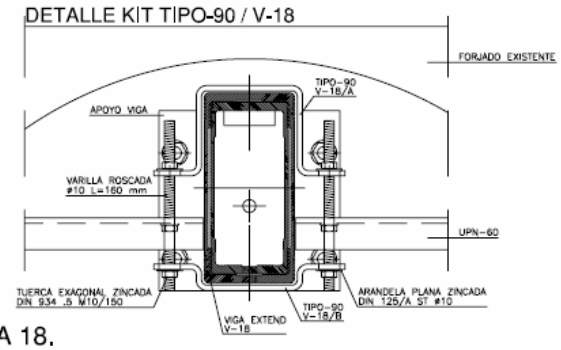


FIGURA 17.



DETALLE TIPO-90 / V-18

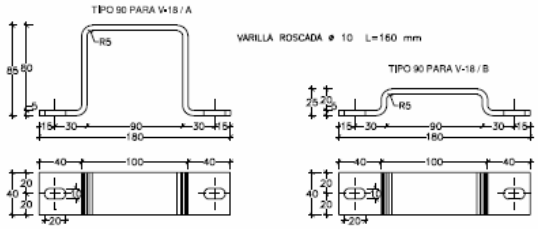
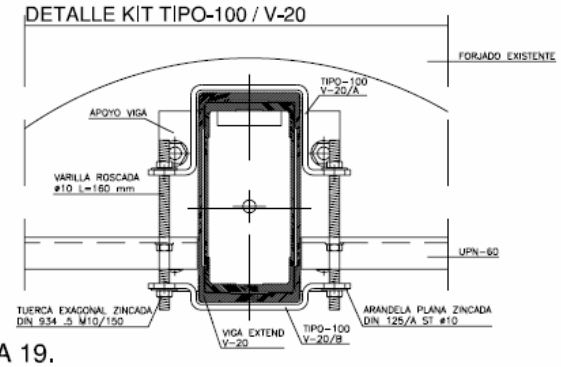


FIGURA 18.



DETALLE TIPO-100 / V-20

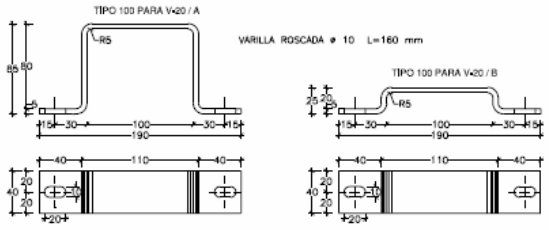
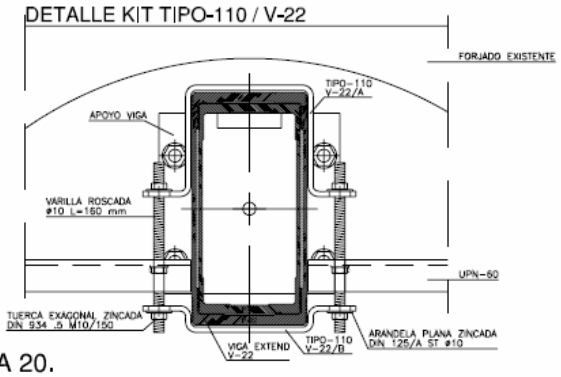


FIGURA 19.



DETALLE TIPO-110 / V-22

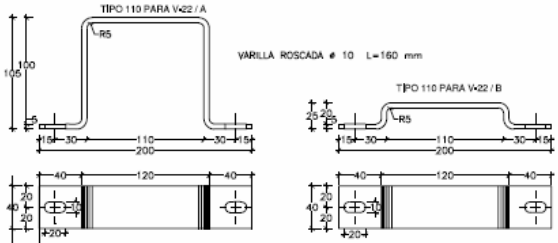
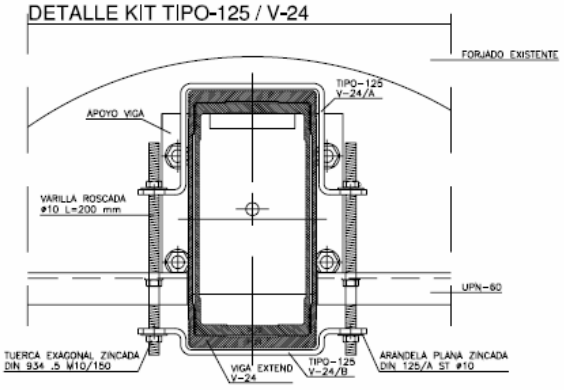
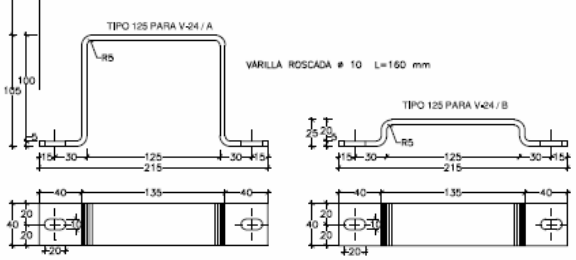


FIGURA 20.



DETALLE TIPO-125 / V-24

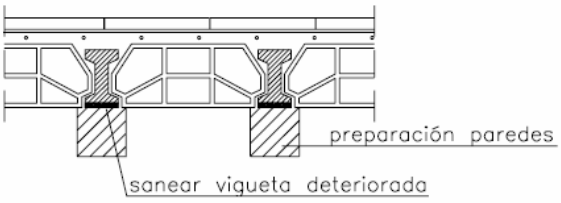


ESQUEMA DE MONTAJE Y PUESTA EN OBRA

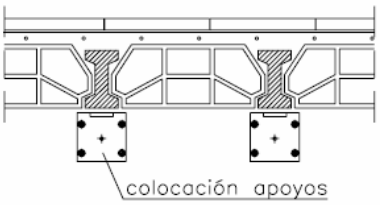
VIGA BAJO VIGA / SISTEMA - A

FIGURA 21.

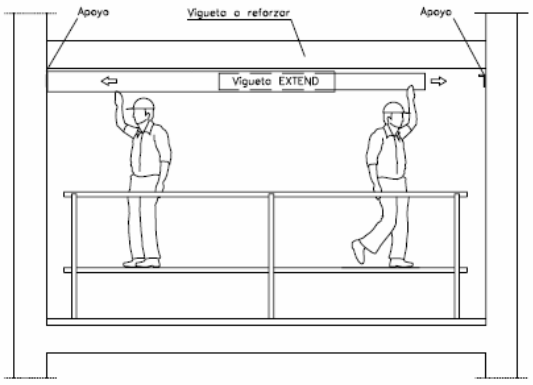
1. Sanear vigueta deteriorada y preparación de las paredes para colocación del soporte



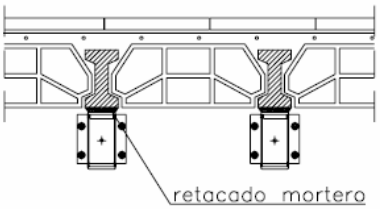
2. Colocación de apoyos en la estructura portante



3. Colocación de la viga



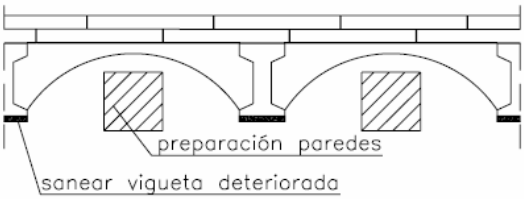
4. Retacado con mortero sin retracción



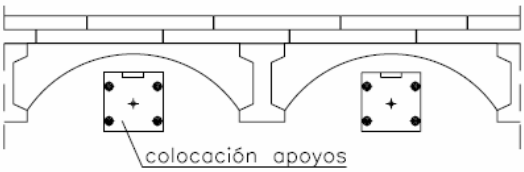
VIGA ENTRE VIGA / SISTEMA - B

FIGURA 22.

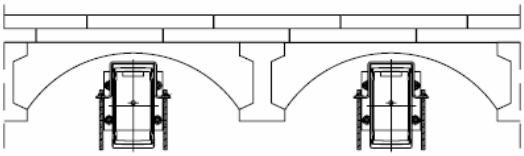
1. Sanear vigueta deteriorada y preparación de las paredes para colocación del soporte



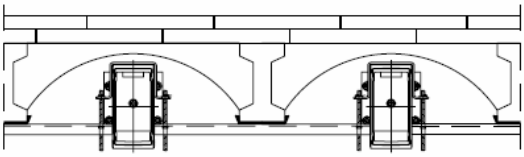
2. Colocación de apoyos en la estructura portante



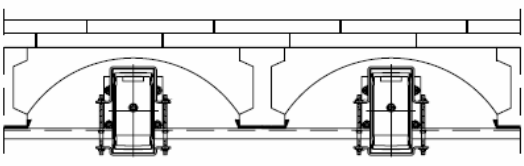
3. Colocación de viga con kit superior y varillas colgando



4. Colocaclón de bandejas, travlesas y retacado

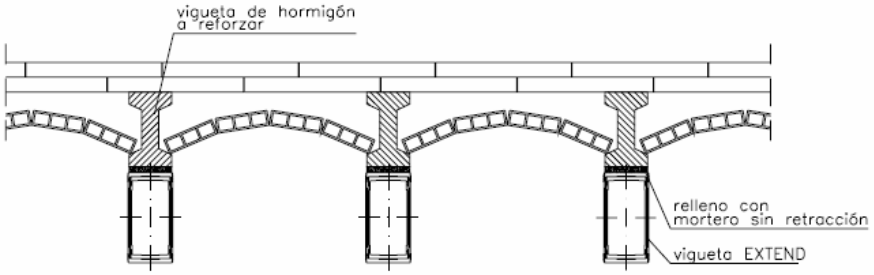


5. Colocación de kit inferior y nivelación



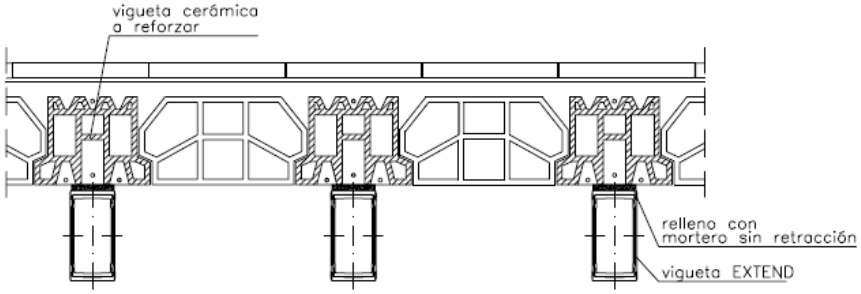
SOLUCIONES CONSTRUCTIVAS

FIGURA 23.



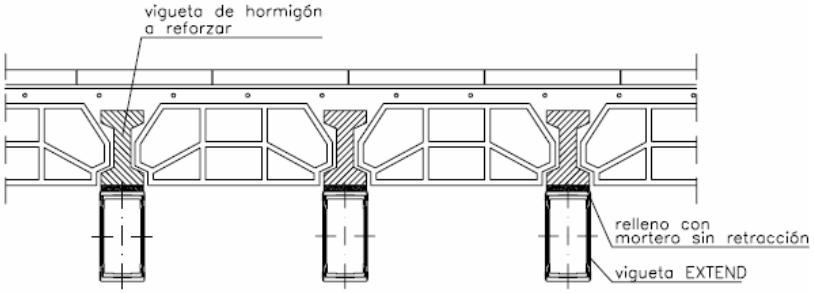
SECCIÓN REFUERZO. VIGUETA DE HORMIGÓN CON REVOLTÓN

FIGURA 24.



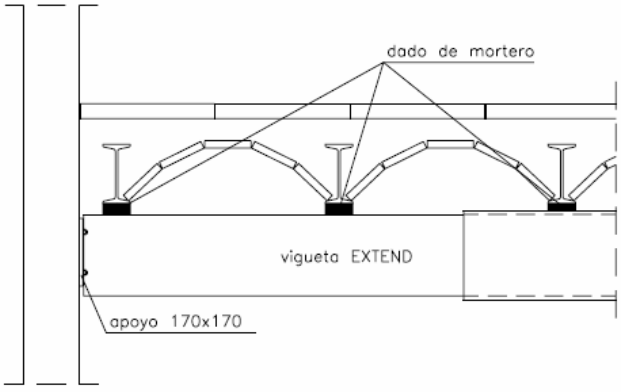
SECCIÓN REFUERZO. VIGUETA DE CERÁMICA ARMADA

FIGURA 25.



SECCIÓN REFUERZO, VIGUETA DE HORMIGÓN CON BOVEDILLA

FIGURA 26.



REFUERZO DE FORJADO DE VIGUETAS DE HIERRO
A PARTE LUZ O VIGA RIÑONERA