Specifications of Tecnaria DIAPASON Connectors for composite steel-concrete structures

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1. General

1.1 Composite steel-concrete structures

Tecnaria DIAPASON connectors create and ensure a mechanical bond between the steel beams and concrete slab which together form a composite steel-concrete structure. Composite steel-concrete structures offer numerous advantages from both the mechanical and economic point of view.

The steel supporting structure joined by connectors to the upper concrete slab, ensures a unitary static response of the two materials which express their individual characteristics in the best possible way.

When beams are placed on simple supports, the two materials have a better interaction with each other because the concrete is compressed and the steel is under tension. A composite steel-concrete section is stronger and stiffer than a steel section on its own. The most obvious advantages are a reduction in the weight of steel structure required, a reduced total height of floor structure, higher flexural strength and better stability contributing to a horizontal bracing of the structure.

1.2 Connectors fastened with a powder actuated tool

TECNARIA has designed a system that contemplates cold fastening of the connectors with special nails. The Diapason connector is made of galvanized steel plate, 3 mm thick folded and pressed into a “V” shaped form which can easily be easily nailed to the supporting beam. The upstanding “wings” ensure an excellent contact with the integrated concrete slab. Four fixing nails in high strength materials ensure, through the possible steel decking, the rigid assembly of the connector with the steel beam.

The nails are inserted by means of a nailing gun. No welding or electrical current is required. Therefore there is no release of toxic fumes when fixing on galvanized surfaces.

Installation is done on-site with a light and easily transportable nailer.

This document is intended as a guide for architects and design offices in the design phase and for construction companies during the installation of DIAPASON connectors.

This document has been developed after undertaking multiple laboratory tests and is backed up by 5 years of experience on construction sites.

The complete connection system consists of: DIAPASON connectors (see 3.1), fixed with nails (see 3.12) by means of a powder-actuated nailer (see 3.21 and 3.23).

The connectors are attached to metal profiles (see 3.31) with or without an intermediate steel decking (see 3.32). They form an efficient method of allowing the steel beams to interact with the concrete (see 3.33).

2. Applications

DIAPASON connectors can be used to create composite elements, that is for structural elements made of concrete and rolled or cold-formed structural steel, connected together to prevent any longitudinal sliding between the two materials, and their separation.

The sizing of composite beams using DIAPASON connectors must be made in accordance with Eurocodes, especially Eurocode 4 and its national annex (EN 1994-1 - 1: 2005).

Main applications:

2.1 Composite beams

- Steel beam + reinforced concrete solid slab;
- Steel beam + reinforced concrete slab with a haunch formed between the steel profile and the lower face of the concrete slab;
- Steel beam + slab cast on a structural steel deck;
- Steel beam + slab cast on a steel deck, used as permanent formwork;
- Steel beam + slab cast on prefabricated reinforced concrete elements.

2.2 Composite columns (profiles encased in concrete)

DIAPASON connectors can be used to ensure the connection between the metal core and the concrete encasement of composite steel-concrete columns.

2.3 Absorbing horizontal forces

The connectors can be used to transmit horizontal forces between the steel beams and a concrete slab and between this concrete slab and the stability systems.

2.4 Uses covered by the specifications

This document deals specifically with composite steel-concrete beams and their resistance under static loads (fire resistance is not considered), used in new constructions or in renovation work.

Other applications that may be mentioned above are beyond the scope of these specifications.

Moreover, it is assumed that these composite beams are to be used on indoor floors of buildings where there is no direct exposure to the elements.
3. Description of the procedure

3.1 DIAPASON connector

The DIAPASON connector consists of:

3.11 Steel plate

The Diapason connector is made of galvanised steel plate, 3 mm thick folded and pressed into a "V" shaped form which can easily be nailed to the supporting beam. The upstanding "wings" ensure an excellent contact with the integrated concrete slab. The 70 x 55 mm ribbed base plate has 4 holes into which high strength nails are placed to fix the connector to the metal structure. The holes in the wings are to be used to insert horizontally placed steel reinforcement bars. The connector is made of galvanised steel type DCO3 + ZE (complying with EN 10152).

All components are protected against corrosion by electroplating (average thickness 5 microns).

The range of DIAPASON connectors available is as follows:

<table>
<thead>
<tr>
<th>Height H (mm)</th>
<th>Weight (gr) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIAPASON 100</td>
<td>100</td>
</tr>
<tr>
<td>DIAPASON 125</td>
<td>125</td>
</tr>
</tbody>
</table>

* Weight of the connectors without nails (tolerance + or -5%)

Table 3.11

3.12 Additional reinforcement bars

Transversely placed steel reinforcement bars can be inserted through the holes in the wings of the connector when it is fixed transversely to the steel decking. This reinforcement increases the strength of the connector.

Three solutions are envisaged:

- Connector fixed without additional reinforcement bars

- Connector fixed with 1 transversely placed 10 mm reinforcement bar, 600mm long

- Connector fixed with 2 transversely placed 10 mm reinforcement bars, the upper 600mm long, the lower 780mm long.
3.13 Nails
DIAPASON connectors are attached to the metal support by means of four SPIT HSBR14 nails inserted into the four holes in the base plate. They are fixed using a Spitfire Spit P560 nailer fitted with a special kit made for this purpose. These nails are the only products to be used for fixing the connectors to the steel beams.

![HSBR14 nail](image)

- Fine carbon steel for fitting on steel S235, S275 and S355
- Ultimate tensile strength: 2300 N/mm²
- Yield strength: 1600 N/mm²
- Mechanical zinc plating, min zinc coating 10 μm
- Hardness > 57 HRc
- Knurled shank
- A steel washer, min 8 μm zinc coating

The dimensions of the nails are shown on the drawing above. Spit HSBR 14 nails are certified by the Deutsches Institut für Bautechnik (DIBt) ETA- 08/0040.

3.2 Specific nailing material

3.21 Spitfire P560 nail gun (ref. 013891)

The nails are fastened using a Spit P560 nailer, equipped with a specific kit (single shot pin drive and piston) specifically developed for this purpose (see 3.22).

![Fig. 3.21 Standard Spitfire P560 nailer](image)

**Technical characteristics of the Spitfire P560 nailer:**
- Tool with indirect action, class A
- Weight with kit for DIAPASON: 3.7 kg
- Total length: 365 mm
- Height: 215 mm
- Depth: 80 mm

3.22 Pin driver and piston for DIAPASON connector

![Fig. 3.22a Pin drive for DIAPASON connectors](image)

**Pin drive for DIAPASON connectors (Cod. 013955)**

**Technical characteristics:**
- Weight: 0.400 kg
- Total length: 102 mm

![Fig. 3.22b Piston for DIAPASON connectors and ring stop](image)

**Piston for DIAPASON connectors (Code 014137)**

**Technical characteristics:**
- Weight: 0.165 kg
- Total length: 180 mm

**Ring stop (Cod. 014136)**

- Weight: 0.210 kg
- Diameter: 22 mm

3.23 Cartridges
The propulsion power is provided by loads with different powers, in the form of a disc, to be inserted in the 6.3/16 mm calibre nailer.
3.3 Constitution of composite steel beams

3.3.1 Steel beams

DIAPASON connectors can be used on beams of hot-rolled steel or welded beams. The connectors can also be used for increasing the bearing capacity of floors.

- Structural steels: the properties of the materials used must be in accordance with EN1993-1-1, §3.1 and §3.2, in particular as regards ductility and fracture toughness.
- Minimum thickness of the beam flange: where nails are fixed, the steel thickness must be at least 8 mm.

3.3.2 Steel decking (composite floor decks or non-composite)

The connectors can be used in the presence of a steel deck. In this case they are nailed through the decking.

The decking must be manufactured according to Standard NF EN 10326 and have a yield strength between 220 and 355 N/mm².
- Nominal thickness between 0.50 and 1.25 mm
- Total nominal thickness: 2 mm (2 sheets max 1 mm)

3.3.3 Concrete

Concrete must conform to the requirements of standard NF EN 1992-1-1. The minimum strength of concrete usable is class C20/25. It is possible to use concrete with strength up to class C50/60. The density of the concrete used is 2400 kg/m³ (normal concrete).

3.3.4 Transverse reinforcements (or mesh reinforcement)

Transverse reinforcements are required to resist to the longitudinal shear stress associated with the connection and must be sized and implemented in accordance with the calculation standard (NF EN 1994-1-1 - 16.6.6).

It is possible to add transversely placed reinforcement bars through the specially made holes in the connector in order to increase the resistance of the connector. The bars must comply with EN 1994-1-1 and EN 1992-1-1, and placed in position as shown in figure 3.34 below.

4. Hypotheses on sizing

The type and number of connectors placed along the composite beam are determined by calculation.

The dimensioning of composite beams using DIAPASON connectors is carried out with reference to Eurocode 4: Design and sizing of composite steel and concrete structures and its national annex (Standards NF EN 1994 1-1-1 and NF EN 1994-1-1/NA).

The use of the Tecnaria DIAPASON connection system has been developed and evaluated with reference to clause 6.6.1.1 (12) of EN1994-1-1:

« ... (12) Where a method of interconnection, other than the shear connectors included in 6.6, is used to transfer shear between a steel element and a concrete element, the behaviour assumed in design should be based on tests and supported by a conceptual model. The design of the composite member should conform to the design of a similar member employing shear connectors included in 6.6, in so far as practicable. »

The geometry of the connectors is designed as such as to enable them to prevent separation of the concrete element and the steel one (see NF EN1994-1-1. 6.6.1.1 (7)).

4 Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1994-1-1/NA

Note out of specifications:

It is possible to download software for rapid sizing of composite steel and concrete structures on the website http://www.reinforcement-planchers.com. This software allows you to rapidly determine the number of DIAPASON connectors needed. This software has not been specifically validated by SOCOTEC.

1 Note of the translator: the mentioned Standard is the French version of the Standard EN 10326
2 Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1992-1-1
3 Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1994-1-1
4 Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1994-1-1/NA
5 For English version see www.floor-reinforcement.com
5. Choosing the connecting elements

5.1 Choosing the connector

5.11 Connector in a solid slab
The choice of connector depends on the minimal thickness of the slab.
The upper part of the connector must be covered with concrete corresponding to the minimum cover thickness.
However, where there is no risk of corrosion, no covering thickness is prescribed.
In other cases the covering must be calculated according to standard EN 1992-1-1.
Recommended heights where there is no risk of corrosion:

<table>
<thead>
<tr>
<th>Slab thickness</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 10 cm to 13</td>
<td>DIAPASON 100</td>
</tr>
<tr>
<td>greater than 13 cm</td>
<td>DIAPASON 125</td>
</tr>
</tbody>
</table>

Table 5.11

5.12 DIAPASON connector with steel decking
In choosing the DIAPASON connector, provisions for welded headed stud shear connectors must be respected, in particular:
- the nominal height of the connector must be sufficient to ensure that the connector extends 32 mm above the upper part of the steel profile.
- When the steel decks are such that the connectors cannot be placed in the centre of a trough which forms the lower part of the decking, it is advisable that they be staggered in relation to the two sides of the trough over the entire range.

For each steel decking, a check must be made that no stiffener prevents the positioning of the connector.
For each steel decking, a check must be made that the connector can be placed in position, and therefore that the width of the bottom of the deck profile is not less than 54 mm.

Since the resistance of connectors increases with height, it is advisable to choose the highest possible connector (while respecting the above conditions).

The table below shows the possible uses of the two models of DIAPASON connectors for the steel decking most commonly used in France:

<table>
<thead>
<tr>
<th></th>
<th>DIAPASON 100</th>
<th>DIAPASON 125</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cofrastra 40</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Cofraplus 60</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Cofrastra 70</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Cofraplus 77</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>PML 60 PC Joris Ide</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>60 PC Steel tray</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Hi bond 55.750</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Hi bond 55.800</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Hi bond 77.570</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

Table 5.12

Diapason connectors must not be used with the following steel deckings. The list is not exhaustive.

- ArcelorMittal Cofrastra 40
- Corus H1 bond 77.570
- Richard Lees Ribdeck AL
- Richard Lees Ribdeck 80
- Kingspan Multideck 60-V2 (Ward MD60)
- Kingspan Multideck 80-V2 (Ward MD 80)
- Structural Metal Decks ltd TR60
- Structural Metal Decks ltd TR80
- Corus –PMF Comfor 80
- Corus –PMF Comfor 100
- Marcegaglia – EGB 1200
- Metecno – Hibond 75
- Elcom – Solac75
- Unimet – genus 73
- Isolpack – R/C 400 AM
- Isolpack – S/c 2000 AM
- Hoesch E35
- Hoesch E40
- Hoesch E50
- Hoesch E85
- Aceralia PL59
- Hiansa MT60 invertida
- Incofluid P4-70
- Colaborante 70/210 Incofluis

Table 5.13

5.2 Choosing the cartridge
The type of cartridge to be used depends upon the thickness of the flange onto which the connectors are to be fixed and the steel grade of the profile. Consult the diagram below.

<table>
<thead>
<tr>
<th>Flange thickness</th>
<th>S235</th>
<th>S275</th>
<th>S355</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>Yellow</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>6.5</td>
<td>Yellow</td>
<td>Yellow</td>
<td>Blue</td>
</tr>
<tr>
<td>7.0</td>
<td>Yellow</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>7.5</td>
<td>Yellow</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>8.0</td>
<td>Yellow</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>8.5</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>9.0</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>10.0</td>
<td>Blue</td>
<td>Blue</td>
<td>Red</td>
</tr>
<tr>
<td>10.20</td>
<td>Blue</td>
<td>Blue</td>
<td>Red</td>
</tr>
<tr>
<td>10.70</td>
<td>Blue</td>
<td>Blue</td>
<td>Red</td>
</tr>
<tr>
<td>11.50</td>
<td>Blue</td>
<td>Blue</td>
<td>Red</td>
</tr>
<tr>
<td>12.70</td>
<td>Blue</td>
<td>Blue</td>
<td>Black</td>
</tr>
<tr>
<td>13.50</td>
<td>Blue</td>
<td>Red</td>
<td>Black</td>
</tr>
<tr>
<td>14.60</td>
<td>Blue</td>
<td>Red</td>
<td>Black</td>
</tr>
<tr>
<td>16.00</td>
<td>Red</td>
<td>Red</td>
<td>Black</td>
</tr>
<tr>
<td>17.50</td>
<td>Red</td>
<td>Red</td>
<td>Black</td>
</tr>
<tr>
<td>19.00</td>
<td>Red</td>
<td>Black</td>
<td>Black</td>
</tr>
</tbody>
</table>

Table 5.2a
Table 5.2a shows indicative values: we recommend carrying out tests on site to confirm the choice.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Code</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>031240</td>
<td>Medium</td>
</tr>
<tr>
<td>Blue</td>
<td>031230</td>
<td>Strong</td>
</tr>
<tr>
<td>Red</td>
<td>031220</td>
<td>Very strong</td>
</tr>
<tr>
<td>Black</td>
<td>031210</td>
<td>Extra strong</td>
</tr>
</tbody>
</table>

Checking nail penetration

The correct penetration of the nails must be checked, see the chapter «CHECKING CONFORMITY OF FIXING THE CONNECTORS» See 8.4

If the nail penetration is insufficient: use a more powerful load.
If the nail penetration is excessive: use a less powerful load.

6. Inserting the connectors

6.1 Composite beams without steel decking

As a rule, it is preferable to arrange the connectors transversely to the axis of the beam, as shown in figure 6.1a and 6.1b.

- Minimum thickness of the profile flange where the nails are to be fixed: 8 mm.
- Maximum longitudinal spacing of the connectors: 6 times the slab thickness or 800 mm
- Minimum spacing: 80 mm

6.2 Composite beams with steel decking

Diapason connectors must be fixed as in one of the following 3 ways.

- Pattern 1:
The connector is placed parallel to the ribs of the decking and perpendicular to the beam when the decking is positioned with the ribs perpendicular to the beam.

Figure 6.2a

- Pattern 2:
The connector is placed parallel to the ribs of the decking and the beam when the decking is positioned with the ribs parallel to the beam and runs unbrokenly over the beam (the sheet is continuous).

Figure 6.2b

- Pattern 3:
The connector is placed perpendicular to the ribs of the sheet decking and to the beam when the decking is not continuous i.e. there is a joint or gap between two sheets.

Figure 6.2c
Minimum width of the beam for Diapason 100 and 125:

- Maximum longitudinal spacing of the connectors: 6 times the slab thickness or 800 mm
- Minimum spacing: 80 mm

Minimum width of the beam for two Diapason 125:

Ductility:
The DIAPASON 100 and DIAPASON 125 connectors possess sufficient deformation capacity to justify the hypothesis of an ideal plastic behaviour of the connection in the structure considered in the calculation according to NF EN 1994-1-1 6.6.1.1. (4)\(^3\).

For further details, refer to paragraph 7.4.

### Table 7.1

<table>
<thead>
<tr>
<th>Concrete class</th>
<th>( P_{rd} ) (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C25/30</td>
<td>46.1</td>
</tr>
<tr>
<td>C30/37</td>
<td>53.8</td>
</tr>
<tr>
<td>C35/45</td>
<td>61.3</td>
</tr>
<tr>
<td>C40/50</td>
<td>61.3</td>
</tr>
</tbody>
</table>
7.2 Connector resistance with steel deck with ribs perpendicular to the beam

7.21 Steel decking that corresponds to that tested

The table below (7.21a) indicates the value of the resistance to be used in calculations, in accordance with Eurocode 4, when used with the following deckings:

<table>
<thead>
<tr>
<th>Type of Deck Concerned in Paragraph 7.21</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcelorMittal Cofraplus 60 Fr</td>
</tr>
<tr>
<td>Joris Ide PML 60 PC Fr</td>
</tr>
<tr>
<td>Steel tray 60 PC Fr</td>
</tr>
<tr>
<td>Corus Hi bond 55.750 Fr</td>
</tr>
<tr>
<td>Corus Hi bond 55.800 Fr</td>
</tr>
<tr>
<td>Haironville-Pab Haircol 59s Fr</td>
</tr>
<tr>
<td>Haironville-Pab Haircol 60s* Fr</td>
</tr>
<tr>
<td>Marcegaglia EGB210 It</td>
</tr>
<tr>
<td>Steelwave Metecno A55-P600 Hi Bond It</td>
</tr>
<tr>
<td>Elcom Solac 55 It</td>
</tr>
<tr>
<td>Fermetal FM 55/750 It</td>
</tr>
<tr>
<td>Richard Lees Holorib S280* Uk</td>
</tr>
<tr>
<td>Richard Lees Holorib S350* Uk</td>
</tr>
<tr>
<td>Richard Lees Ribdeck E60* Uk</td>
</tr>
<tr>
<td>Corus –PMF Comflor 70* Uk</td>
</tr>
<tr>
<td>Kingflor 70 * Aus</td>
</tr>
<tr>
<td>Hiasa HLM-60/220* Es</td>
</tr>
<tr>
<td>Hiansa MT60* Es</td>
</tr>
<tr>
<td>Hiansa MT76* Es</td>
</tr>
</tbody>
</table>

* Note: check that the base of the connector adheres well to the bottom of the steel decking.

The following decks conform with the above criteria:

Table 7.21a

- Steel decking concerned in 7.21:
  The resistances are those as in table 7.21a when the steel deck has the following characteristics:
  - Height of rib: maximum 60 mm
  - Base width: 55 mm or more
  - Width b₀ of rib (at mid point for open trough decking or at the top for re-entrant trough decking): minimum 70 mm.

Graph example:

7.22 Steel decking different to that tested

Note: the tests were carried out with Cofraplus 60 decking. The results are shown in table 7.21a.

The other sheet deckings have not been specifically tested. However references can be made to chapter 6.6.4.2 of Eurocode 4 EN 1994-1-1.

When using decking that does not conform to that shown in paragraph 7.21, a calculation of the sheer strength of the Diapason connector can be determined as follows:

\[ P_{Rd} = \frac{k_f}{k_{r0}} \cdot P_{table\,7.21a} \]

The calculated value of Prd to be used must not exceed those shown in Table 7.21a.

The calculations must be made with
- \( k_0 \) as indicated in table 7.22a.
7.3 Resistant of the connector with steel decking with ribs parallel to the beam

The resistances provided in the tables below are design values in accordance with the requirements of chapter 6.6.4.1 of the standard Eurocode 4 NF EN 1994-1-1 (June 2005).  

No specific laboratory tests have been undertaken in these situations. However, for these configurations, reference may be made to EN1994-1-1.

In this configuration, the shear resistance of DIAPASON connectors can be taken to be:

\[ P_{Rd} = \frac{k_i}{k_{i0}} \cdot P_{table7.21a} \]

However, it should be ensured that the value of the shear stress resistance is not greater than that obtained with a solid slab.

The above calculations must be made with:

- \( K_{i0} \) defined as follows:

\[ k_i = \frac{b_1 - b_0}{h_p} \cdot \left( \frac{h_{sc}}{h_p} - 1 \right) \leq 1 \]

Where:

\( h_{sc} \) is the overall height of the DIAPASON connector (100 mm or 125 mm), but not greater than \( h_p + 75 \) mm;
\( b_1 \) is the width of the connector at mid height, that is:
- for Diapason 100: \( b_1 = 100 \) mm
- for Diapason 125: \( b_1 = 107 \) mm
\( h_p \) : see figures below

The connectors are situated in a concrete area in the form of a haunch.

When the steel decking is continuous with the passage of the beam, the width of the haunch \( b_0 \) is equal to the width of the rib as shown in the following figures:

For further details, refer to paragraph 7.4.
7.4 Influence of ductility on calculation

The non-ductility of the connectors influences the sizing of the composite beam and the structural arrangements. Reference should be made to EN1994-1-1 §6.2.

Below is a simplified table of the main consequences:

<table>
<thead>
<tr>
<th>Ductile connectors</th>
<th>Non-ductile connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution of connectors:</td>
<td>Distribution of connectors:</td>
</tr>
<tr>
<td>a uniform distribution is acceptable</td>
<td>an elastic distribution is necessary</td>
</tr>
<tr>
<td>Calculation: a plastic calculation is allowed</td>
<td>Calculation: an elastic calculation is recommended (1)</td>
</tr>
</tbody>
</table>

(1): alternatively, it is also possible to use the method of non-linear resistance according to Eurocode 4. See EN1994-1-1 §6.2.1.4

8. Implementation

8.1 Implementation of the steel deck

It is necessary to position the steel decks carefully before installing the connectors, ensuring their flatness and adherence to the profiles.

Follow the indications below:

- In the area where two sheets overlap at the sides, the steel decks must be assembled with care.

- The steel decks must be fixed to the beams with the nails intended for this purpose (e.g. SBR14 or HSBR14 nails). These fixtures allow perfect adherence of the sheet on the metal profile.

- The connectors cannot be placed in areas where there are bolted joints.

- In areas where there are bolted joints the steel deck must be cut to maintain its overall flatness:

- When the steel trays overlap, the steel sheets must remain flat and adhere correctly to the profile. In these areas, it is permissible to overlap at the most two steel decks with a total thickness not exceeding 2mm.

- At the ends of the decks (sheet head area) the sheets will be joined together. Avoid overlapping the sheets (one on top of the other). If necessary, it is possible to cut the portions of sheets that overlap.

- In the overlapping area, it is necessary to seal the sheets (with adhesive, for example) to avoid the flow of concrete laitance.

Maximum sheet thickness: 1.25 mm

Reminder: the connector can be fixed on a maximum of two superimposed sheets having a maximum thickness of 1 mm each.

8.2 Implementation of the connector

Determination of the connector positioning points:
1) Draw a straight line (with a marker or thread) on the steel decks so as to fix the connectors as close as possible to the centre of the beam.

2) Determine the points where the connectors are to be fixed according to the results of the calculation.

3) The connectors must absolutely be installed before the mesh reinforcement. The positioning of the mesh can be very fast using a mesh that has the same spacing as the steel deck.

The connector must be placed in the centre of the bottom wave of the sheet. If the sheet has a rib in the centre of the wave, the connectors must be placed to one side or the other of the rib.

**8.3 Use of the nailer**

Before using the nailer, carefully read the operating instructions and the safety requirements supplied in the box:
- A Spitfire Spit P560 nail gun must be used, fitted with a special adapter for fixing DIAPASON connectors.
- 4 nails must be fixed for each connector. Attention: the nailer must be held perpendicular to the beam.
- Perform some fixing tests according to the documents supplied («orange card» and bending).

Application procedure:

8.31 Positioning of the circular disc cartridges

1) Open the cover by pressing the button (n° 24 – cover lock assembly)
2) Pull back the pin drive (n°1 – single shot pin drive)
3) Position the circular disc cartridges in the housing provided, carefully observing the appropriate direction.
4) Close the cover (n° 23 – cover assembly)

8.32 Inserting the nail

Pull back the pin drive, holding the handle at the bottom. Insert the nail in the barrel. A magnet will hold it in the correct firing position. The gun is ready to fire.

8.33 Fastening the connector

Place the pin drive perpendicular to the support and in contact with the base of the connector. Exert a slight pressure to deactivate the safety catch. Fire the first nail; repeat the operation to fix the other nails.

8.4 Checking the conformity of the connector fastening

The fastening of the connectors must be checked by the installing company.

This check must be carried out at the beginning of each nailing sequence, then while work is in progress. Two tests should be considered: a visual test and a mechanical test.
8.41 Choosing the cartridge

For each fixing situation*, the appropriate load level must be chosen following the recommendations in paragraph 5.2.

To confirm this choice, two tests should be performed:
- a visual check, as in paragraph 8.44.
- a mechanical check, as in paragraph 8.45

To confirm the choice of cartridge, the two tests must be satisfactory.

* A fixing situation is characterised by a set of parameters that can influence the nailing result: thickness of the profile flange, steel grade, etc. Each time one of these characteristics changes, the nailing system must be reconfirmed.

8.42 Check while work is in progress

- During nailing, a continuous visual check should be performed as described in paragraph 8.44.
- In addition, a mechanical check (§ 8.45) is to be performed after every 250 nailed connectors.

8.43 Treatment of connector assemblies with insufficient penetration

When work is in progress, when the visual test is not satisfactory, a mechanical inspection can be performed to ensure the validity of nailing.

If the mechanical check is satisfactory, the series can be kept. Otherwise the faulty connectors must be replaced.

8.44 Visual check

To ensure that the connectors are properly fixed, the penetration of the nails should be checked by measuring the distance from the head of the nail to the flat part of the base plate of the connector.

This measurement is performed using the indicator (orange) supplied with the connectors.

The admissible value varies from 4.5 mm (maximum) to 8.5 mm (minimum).

Values < 4.5 mm (maximum):
In this case the nail is pushed too far in. However, these values do not cast doubt on the resistance of the connector. However, it would be advisable to lower the power level of the loads used in order to avoid any risk of premature breakage of the gun.

Values > 8.5 mm (minimum):
When the 8.5 mm limit value is exceeded, the nail is not pushed far enough in and the test is considered unsatisfactory.

8.45 Mechanical check of the connector resistance

This check is partly destructive for the connector. It will therefore be necessary to fit a new one next to the connector tested.

1) Fasten the DIAPASON connector with 4 nails.
2) Insert a 12 mm diam steel reinforcement bar through the 2 holes in the upper part of the connectors
3) Tap the front of the bar with a hammer. When the connector is deformed, yet the nails remain firmly fixed, the test can be considered to be concluded and the result positive.

On the other hand, if the nails become lose, it is necessary to increase the power of the nailing gun to give a deeper fixing, and to check that the decking is correctly installed.

The installation of connectors must be entrusted to qualified persons who have read and understood the information in this manual for their implementation.

9. Bibliography

- NF EN 1994-1-1 June 2005 Eurocode 4 Design of composite steel and concrete structures
• Test Report 2012: Experimental Campaign on Tecnaria connectors. 13/11/2012 University of Padua, Italy.
Dear Sirs,

Please find herewith our new technique survey report concerning your Specifications for "DIAPASON Connectors".

Wishing you good reception of this document.

Please accept our best regards.

M.PIERRE MAITRE
Agency Director

TECNARIA S.P.A.
ATT. Mr. GUAZZO AND Mr. MURA
VIALE PECORI GIRALDI 55
36061 BASSANO DEL GRAPPA (VI)
ITALY

Montigny le Bretonneux, 18 July 2013
Technical verification
Survey Report on New Technique

Specifications
"DIAPASON" Connectors

Date of issue of the report: 18 July 2013
Dossier Socotec n°: EAB 9660 / 1
Report reference: ANC 13-1787-MB-BK

The report, drawn up in the context of the mission defined at our Technical Audit Agreement of 28 March 2012, concerns the procedure for Tecnaria DIAPASON connectors for composite steel and concrete beams.

We thank you for using our services.
For all additional information, your Socotec contact is at your disposal

Your contact: Maxime BOCOURT (ANC)

The original document is in French language. This a translation made by Tecnaria.
SUMMARY

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1- OBJECT

On request of the company TECNARIA S.P.A., SOCOTEC conducted a New Technique Survey for the application of the TECNARIA DIAPASON product as a connector for composite steel and concrete beams.

Tecnaria DIAPASON connectors are an exclusive product of the company TECNARIA S.P.A whose head office is at the following address:

TECNARIA S.P.A.
Viale Pecori Giraldi 55
36061 BASSANO DEL GRAPPA (VI)
ITALY

The mission was carried out in accordance with the terms of our technical audit agreement n° ANC 12-779-PM-BK of 27 March 2012.

2- DESCRIPTION OF THE PROCEDURE

TECNARIA DIAPASON connectors are connectors for composite steel and concrete beams.

They are made from a 3 mm thick plate bent to a U-shape with two small bent angles at each of the two ends of the upstands. There are two holes in each upstand through which reinforcement bars can be placed. The connector height varies according to the model (100mm and 125mm). The base has four holes through which HSBR14 SPIT nails are used to fix the connector to the supporting steel structure.

Specific nailing hardware, adapting to the shape of the connector, has been developed in collaboration with the SPIT company.

3- SPECIAL FEATURES OF THE DIAPASON CONNECTOR

Unlike conventional studs, TECNARIA DIAPASON connectors are not welded onto the metal beam but nailed on using SPIT HSBR14 nails.

This procedure allows a less restrictive installation and enables the connectors to be secured avoiding the implementation constraints imposed by welding (corrosion, gas discharge, etc.).

The special U-shape gives the connector a double contact with the concrete to increase the resistance compared to that of a conventional stud. It also permits the use of transversely placed reinforcement bars.
4- FIELD OF USE ACCEPTED

TECNARIA DIAPASON connectors can be used as connecting elements for composite steel-concrete beams, implemented for indoor floors in buildings without direct exposure to the elements. They can be used in new constructions or in renovation work.

Their resistance has only been studied for static loads. It has not been studied for the case of fire.

Their implementation is carried out in compliance with the provisions stipulated in the specifications established by TECNARIA on 17 July 2013 and directly associated with this report.

The sizing of the composite beams must be conducted in accordance with Eurocodes, in particular with NF EN 1994-1-1.

The concrete used must be minimum class C20/25 and maximum class C50/60.

5- REFERENCE TESTS

The results of this survey are based on a series of tests conducted by the company TECNARIA S.P.A. in collaboration with the University of Padua in Italy between 2012 and 2013.

These tests were conducted with reference to the "push out" test described in Annex B of the standard NF EN 1994-1-1. As this test only concerns solid slabs on a metal profile, additional tests were conducted on specimens with a transverse steel deck. Since the constructive arrangements described in the standard were not suited to the dimensions of DIAPASON connectors, and in the absence of a specific reference, the samples were slightly adapted for the tests to be feasible.

Resistance and displacement measurements were taken. The detachment of the slab from the metal profile and the longitudinal sliding between the two elements could thus be measured.

The test results were treated in accordance with paragraph B.2.5 of standard NF EN 1994-1-1.

SOCOTEC monitored the implementation of the samples at the time of casting the concrete, visiting the workshops of the Company TECNARIA S.P.A., and followed a series of tests in the laboratories of the University of Padua.

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6 Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1994-1-1
Ref. ANC 13-1767-MB-BK
6- REFERENCE CHARACTERISTICS

The results allowing the sizing values indicated in the specifications to be obtained are the outcome of test data processing in accordance with annex B of standard NF EN 1994-1-1\(^6\).

As regards the results of test pieces with a solid slab, the values are derived directly from the tests performed. In fact, only the Diapason D100 was tested, the resistance of model D125 being taken, for safety's sake, as equal to the smaller model. In addition, only two types of concrete (C25/30 and C35/45) were tested, the values indicated are obtained using a law of linear regression.

As regards the test pieces with transverse steel deck, DIAPASON D100 and D125 connectors were tested with a Cofraplus 60 steel deck. Three configurations were tested for each connector; without transverse rebar, with one rebar, with two rebars. Only one concrete class was tested (C30/37). Linear regression allows values to be obtained for the other types of concrete (confirmed by tests prior to this campaign).

7- REFERENCE DOCUMENTS

- NF EN 1994-1-1\(^6\)
- NF EN 1994-1-1/NA\(^7\)
- NF EN 1992-1-1\(^8\)
- NF EN 1992-1-1/NA\(^9\)
- NF EN 206-1\(^10\)
- Test report 2012: Experimental Campaign on Tecnaria connectors. 13/11/12 University of Padua, Italy.
- Test report 2013: Experimental Campaign on Tecnaria connectors. 01/02/13 University of Padua, Italy.

8- SPECIAL REQUIREMENTS

The constructive requirements for stud-type connectors described in standard NF EN 1994-1-1\(^6\) should be followed for the implementation of TECNARIA DIAPASON products. The specifications define additional requirements for the implementation and monitoring of DIAPASON connectors.

Particular attention should be paid to the ductility of the connectors used and to its consequences. The use of non ductile connectors implies restrictions in calculation and implementation which are defined in standard NF EN 1994-1-1\(^6\), which should be followed.

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\(^7\) Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1994-1-1/NA
\(^8\) Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1992-1-1
\(^9\) Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 1992-1-1/NA
\(^10\) Note of the translator: the mentioned Standard is the French version of the British Standard BS EN 206
Dear sir,

Please find enclosed our “ERRATA” of the Tecnaria Diapason connector for steel concrete structures specifications.

Best regards.

Maxime BOCOURT
The engineer in charge of the dossier

The original document is in French language. This a translation made by Tecnaria.
ERRATA

of

Specifications of

Tecnaria DIAPASON Connectors for

composite steel-concrete structures

accepted by SOCOTEC under No. EAB 9660/1
to the notice issued on 18 July 2013

§6.2 Page 9 of 16
- Pattern 2:

In the example where the decking is placed parallel to the
beam and passes continuously over it, the connector is placed
parallel to the ribs of the decking.

The fixing position of the connector is the allowed even
when the decking is not continuous.

§7.3 Page 12 of 16

b₁ is the size of the connector at mid height, that is:
- for Diapason 100: b₁ = 54.5 mm in the pattern 2
of §6.2, b₁ = 100 mm in the pattern 3 of §6.2,
- for Diapason 125: b₁ = 54.5 mm in the pattern 2
of §6.2, b₁ = 107 mm in the pattern 3 of §6.2.

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Date: February 10th, 2014