Saimaa University of Applied Sciences
Lappeenranta
Double Degree Programme in Civil and Construction Engineering

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ADAPTATION OF JENKA LIFTING SYSTEM TO RUSSIAN NORMATIVE DOCUMENTATION

Bachelor’s Thesis 2011

ABSTRACT

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The objective of the study was to prepare the base material necessary for Russian technical approval of Peikko Jenka system and develop a method of calculation applicable for Jenka anchors, according to Russian normative documentation. Received results were to be compared to the values received by calculations according to European norms. The work was commissioned by the Peikko Group company.

In the theoretical part of the study the main issues were the calculations of anchors with and without end strengthening according to Russian norms; description of main characteristics, materials and production of Jenka components; developing of recommendations for discarding criteria for Jenka Lifting devices; description of the designing of application of Jenka system. The information was gathered from literature, norms, regulations, hand books, producer's brochures, Internet, textbooks and interviews.

In the empirical part of the study the main concern was to calculate the Jenka anchors according to developed in this Thesis method and analyse the results in case of further Russian approving. The information was gathered from norms and regulations.

The results of the thesis are the developed method of calculation for Jenka anchors with comparative tables of results received by mentioned method and values received according to European regulations; collected base of materials necessary for Russian approval of Jenka system; recommendations for criteria for discarding of TLL loops.

Keywords: Peikko Jenka, Lifting system, Anchor, Anchorage length, Anchors cross section, Concrete breakout, Lifting device.

CONTENTS

1 INTRODUCTION

Production and erection of the precast concrete structures causes the necessity of usage of systems for lifting and transporting the precast elements after casting and during installation on the building site. Normally that task is solved by using the embedded details (”inserts”), which transport lifting forces from the lifting equipment to the concrete element. In main principle these details are working as anchors. There are different types and constructions of the embedded details for different work tasks, different shapes, structures and masses of the elements. One of these systems is anchor system with threaded sockets, which has such benefits, as the absence of the protruding parts, easy process of the installation to the formwork, economical usage, wide range of capacities and ability of application for every type of the precast elements. Peikko Group produces all the components of anchor lifting systems with threaded sockets by mark Peikko Jenka Lifting System.

In Russia, such systems, as Peikko Jenka, have not met a wide range of usage yet. Most likely it is combined with usage of simple lifting loops made of steel bars, which are habitual and most common lifting systems in Russia. Also, the absence of any technical specifications or calculations made according to Russian norms is a serious problem for usage of Peikko Jenka in Russia.

The other problem, which the Russian department of Peikko Group faced is an absence of precisely defined recommendations about criteria for discarding the wire ropes lifting loops (Jenka TLL) and threads of connection sockets of Peikko products (for example of Jenka TLL). The necessity of these recommendations was caused by safety considerations and planning of the expenses for amortization by some customers.

The main purpose of this thesis is to find the applicable to Peikko Jenka Lifting System methods of calculation according to Russian normative documentation and further analysis of the results received by calculations according to these methods. Hereafter the results of this work will be used for issuing the Technical Specification – the subject for approval of a product in Russian Federation.

The objectives of the study are:

- To describe the construction, production and design principles of the anchor lifting systems with threaded socket (according to European norms)
- To find the applicable methods of calculation of these systems in Russian normative documentation
- To compare the results of calculations received by European norms and Russian norms
- To find information and make applicable recommendations for criteria for discarding the wire lifting loops (Jenka TLL) and threads of Peikko products.

2 RUSSIAN NORMATIVE ADAPTATION

Most of the construction products imported in Russia or produced by foreign technology are have to have technical approval according to Russian normative regulations. Two most important documents which says about conformity of product and it's usage to Russian normative documents are GOST-R certificate and Technical Specification approved by Building Authorities. The process of receiving these two documents normally is a process of getting Russian approval.

GOST-R certificate (example in Appendix 6 figure 6.1) is a document which guarantees the accordance of products quality to normative regulations. For different types of products this certificate could be issued voluntarily or mandatory. Usually, mandatory issuing is necessary for products, which can influence the human's safety. Only specialized organisations approved by Russian Authorities for certification can issue such documents. To get the certificate, producer should provide product samples, production documentation and info to certification organisation.

Technical Approval is a document, which sets out technical requirements to be met by specific product. For construction elements this document consists of product purpose, dimensions, way and materials of production, mechanical characteristics with test results and methods of calculation, design principles, conditions of storage and transportation, quality control. All parts have to have links to normative documents and regulations (in case of construction product – GOST's, SNiP's, Eurocodes etc.). Technical Specification must be executed according to GOST system - main contents and form of document are set by this system. Technical specification can be prepared by producer's engineers, or by outsource company/engineer. After preparation, Technical Specification should be approved by authorised organisation, certified for such type of work. Usually, such organisations also provide preparation of Technical Specification.

In case of getting approval for Jenka, the way described below will be used. During work for Russian Department of Peikko it was the necessity to get approval for Peikko PVL wire lifting loop. For this purpose all necessary information were collected from Finnish, German and Russian departments of Peikko. All data were processed and adapted to requirements set by Russian normative regulations. Also, for the missing information, such as seismic activity influence on usage of PVL, additional work was provided – short report (Appendix 6, figure 6.3) were done also as an application to the Specification. After preparation, the Technical Specification was sent to V.A. Kucherenko Central Research Institute of Constructions and Buildings for approval. After some correction work Technical Specification for Peikko PVL was successfully approved (Appendix 6, figure 6.2). GOST-R certificate needed only correct collection of information and several samples for testing. Received approval helps such companies as YIT and Lemminnkainen to freely use Peikko wire loops for huge projects in Russia.

3 COMMON INFORMATION ABOUT LIFTING SYSTEM

There are different systems existed for the purpose of lifting of precast concrete elements. All these standard lifting systems consist of an insert embedded in the concrete element and a matching unit (key) that connects to the insert. The crane hook or hook of a lifting sling attaches to the key. Example of system construction is shown in figure 3.1. The combination of components from different systems is prohibited. Main types and descriptions of these systems (according to prCEN/TR 15728 Lifting and Design and Use of Inserts for Lifting and Handling of Precast Concrete elements) are listed below.

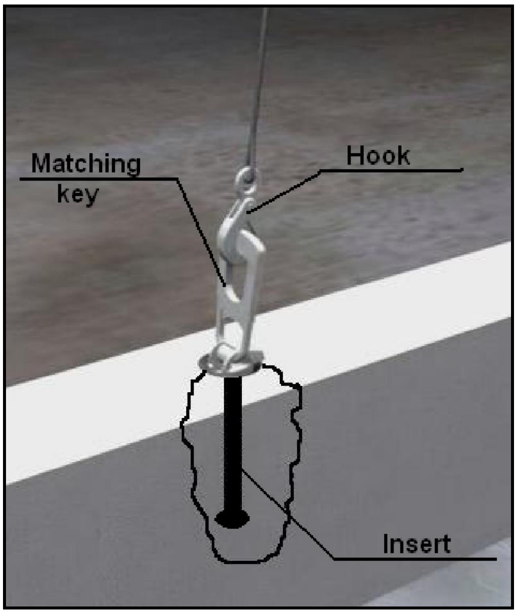


Figure 3.1 Example of lifting system construction

Systems with headed bolts and spread anchors

Headed bolts and spread anchors transfer axial load to the concrete through mechanical interlock at the built-in end while shear load is transferred more or less directly between the recessed lifting key and the concrete at the top end. Constructions of these types are shown in figure 3.2.

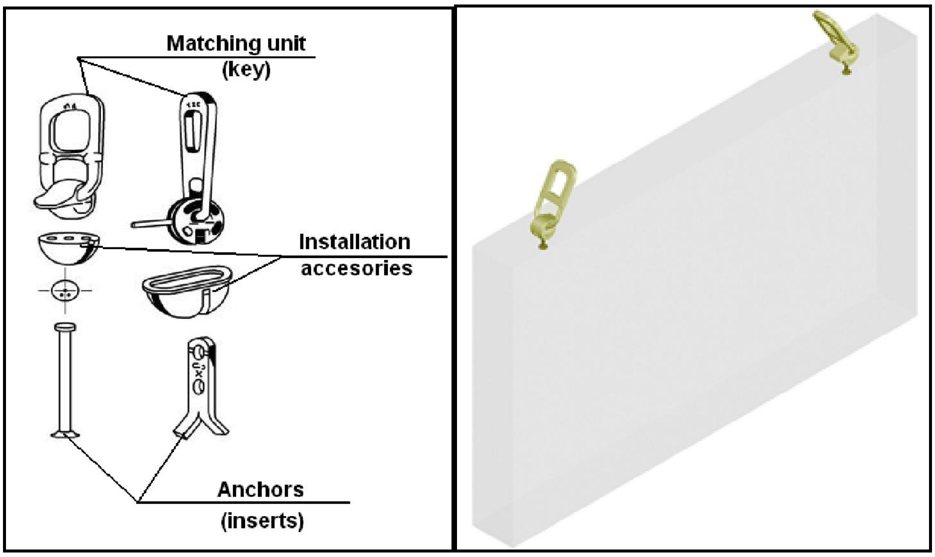


Figure 3.2 Headed bolts and spread anchors system

Systems with anchors with additional rebar

These inserts maintain the possibility of shear transfer directly from the lifting key to the concrete, while the axial load is transferred to the concrete through a separate reinforcement bar to be threaded into a hole in the insert. Matching unit is the same as for previous type. Example of construction of the anchors is shown in figure 3.3.

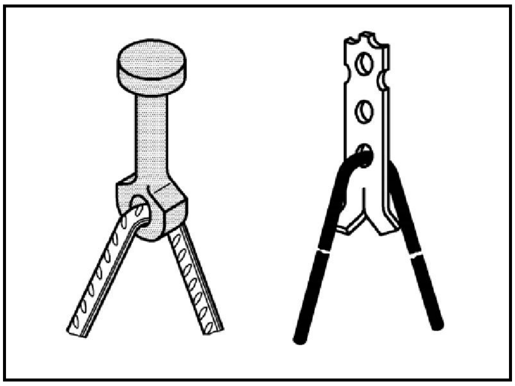


Figure 3.3 Anchors with additional rebar

Anchor systems with threaded sockets

These inserts may utilize a simpler, threaded key to transfer the load to the insert. The axial load is transferred to the concrete through a bonded rebar either in the form of a separate bar threaded into a hole or as a built in rebar (e.g. waved anchors) included in the system. The corresponding key may or may not be suitable for transfer of shear forces. Example of construction of the anchors is shown in figure 3.4.

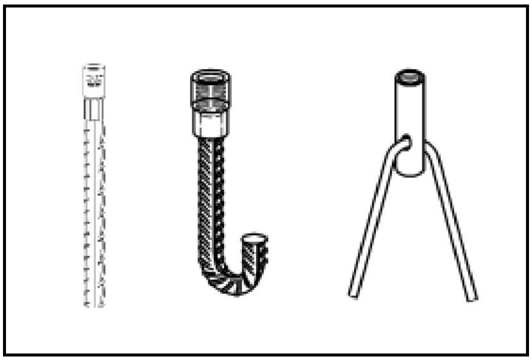


Figure 3.4 Anchors with threaded sockets

Systems with short anchors with headed bolts and spread anchors

These inserts are short versions of type inserts – possibly with an extended bearing area at the built-in end of the insert. They are intended for use in slabs and pipes to sustain axial load and shear load. Example of construction of the anchors is shown in figure 3.5.

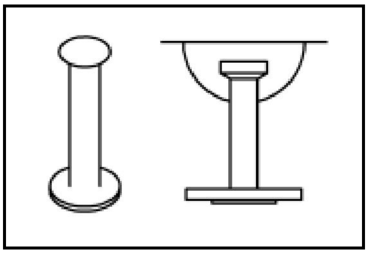


Figure 3.5 Short anchors (headed and spread)

Systems with short anchors with large bearing area

These inserts are intended for use in slabs and pipes with short embedment lengths and large bearing areas that are also suited for supporting the necessary minimum reinforcement. Axial load as well as shear load may be accommodated. Example of construction of the anchors is shown in figure 3.6.

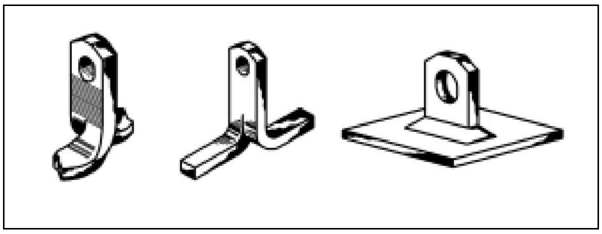


Figure 3.6 Short anchors with large bearing area

Systems with plate sockets

A threaded socket mounted on a plate providing a bearing area for axial load. The corresponding keys are usually not suited for transfer of shear, but special options exist. Construction of plate socket is shown in figure 3.7

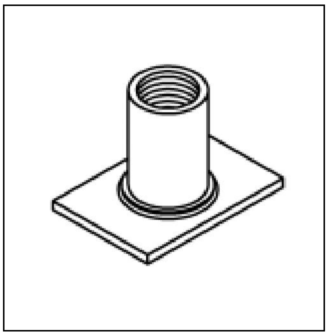


Figure 3.7 Plate socket

Lifting loops from smooth bars, prestressing strands or steel wire ropes

Lifting loops should only be used if the lifting angle is approximately the same in all lifting and handling situations. Furthermore, the lifting angle should be kept within the limits indicated in prCEN/TR 15728 Lifting and Design and Use of Inserts for Lifting and Handling of Precast Concrete elements, page 20. Most likely, these options of lifting systems are made by precaster himself. Examples of these systems are given in figure 3.8

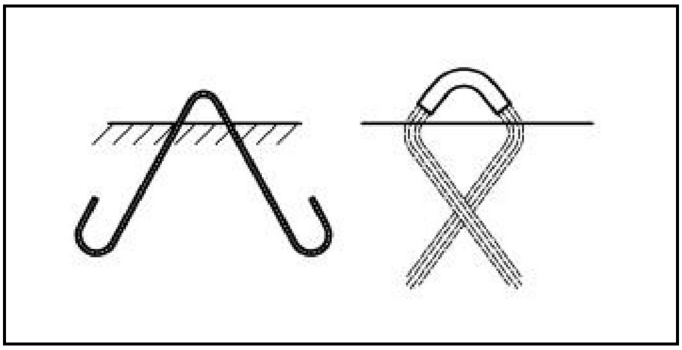


Figure 3.8 Lifting loops from smooth bars, prestressed strands or steel wire ropes

4 GENERAL INFORMATION ABOUT JENKA LIFTING SYSTEM

Basic information about designing, application, main characteristics, components and fabrication of Peikko Jenka are presented in this chapter. The designing of lifting components itself (for example, shape of anchors) is not covered by this chapter.

4.1 Common definitions and properties

The Peikko Jenka is a system designed for the transport of precast concrete construction components. Peikko Jenka consists of two main components: anchors and lifting devices. Also, there are additional secondary components, such as installation plates, identification rings and cover plugs (caps).

Anchors are the embedded parts of the system, which transport the lifting forces to the concrete of the element. Lifting devices are the connection links between anchors and lifting equipment (hooks and slings), which transport the lifting forces to the anchors. The connection between anchor and lifting device is threaded: metric thread or special round thread (Peikko Jenka Brochure, p. 8). The connection between concrete and anchor rebar is obtained by:

- hitches of the rebar ledges to the concrete
- frictional forces between the rebar and concrete - as the result of concrete shrinkage
- adhesion (”glueing together”) of the concrete and the rebar - as the result of cement glueing ability

(Reinforced Concrete Structures, 1978, p. 66)

The scheme is given in figure 4.1.

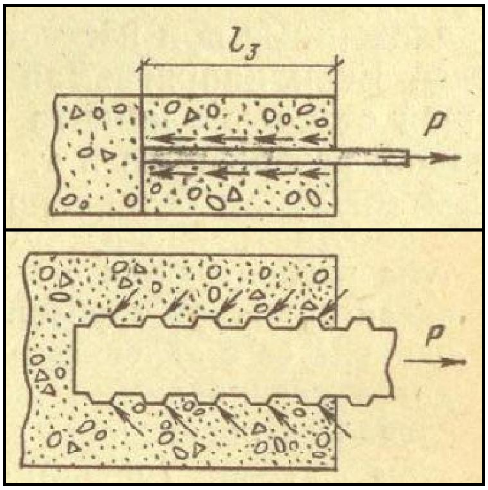


Figure 4.1 Bonding between concrete and reinforcement

4.2 Field of application

The most common fields of application are:

- walls and other linear elements (such as beams and columns), where the anchor is typically long compared to the edge distance (the smallest distance from the insert to a concrete surface parallel to anchor and where the concrete in the vicinity of the insert is uncracked;
- slabs and pipes, where the edge distance is large while the possible length of the insert is limited by the thickness of the element and where the concrete in the vicinity of the insert is uncracked (prCEN/TR 15728 Design and Use of Inserts for Lifting and Handling of Precast Concrete Elements, p. 16).

4.3 Anchors

Peikko Jenka Anchors are the components of Peikko Jenka system. Jenka Anchor consists of 2 parts: sleeve with inner thread and anchoring part. Sleeve provides the threaded connection between Jenka Anchor and lifting device. The anchor part provides the connection between Jenka Anchor and concrete element. The anchor part could be made as a straight or wavy reinforcement bar, welded plate, reinforcement bar with boss head, or a bent reinforcement bar, pushed through holes in the bottom part of the sleeve. The main function of the anchors in Jenka System is described in chapter 4.1.

Peikko produces Jenka Anchors with wide range of capacities (from 0,5 to 12,5 tons) and shapes, which allow to select anchors for any precast concrete element.

4.3.1 Standard types and dimensions

There are 8 main types, differing mainly by shapes of anchoring part of Jenka Anchors:

- Peikko Jenka SRA
- Peikko Jenka WAS
- Peikko Jenka WAL
- Peikko Jenka TF
- Peikko Jenka BSA
- Peikko Jenka CSA
- Peikko Jenka ESA
- Peikko Jenka PSA

In limits of one type group, anchors differ in sizes and load classes (load bearing ability).

Peikko Jenka SRA

The anchor part of Jenka SRA is a straight reinforcement bar. The construction of the product is presented in Appendix 1, Table 1.1. The length of the product varies from 195 to 950 mm, thread diameter from 12 to 52 mm and load class from 500 to 12500 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.1.

Peikko Jenka WAS

The anchor part of Jenka WAS is a wavy reinforcement bar. The construction of the product is presented in Appendix 1, Table 1.2. The length of the product varies from 105 to 450 mm, thread diameter from 12 to 42 mm and load class from 500 to 8000 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.2.

Peikko Jenka WAL

Anchor part of Jenka WAL has a combined form. The upper section of the anchor part is straight, the bottom section is wavy. The construction of the product is presented in Appendix 1, Table 1.3. The length of the product varies from 135 to 880 mm, thread diameter from 12 to 52 mm and load class from 500 to 12500 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.3.

Peikko Jenka TF

The anchor part of Jenka TF is a straight reinforcement bar with a boss head. The construction of the product is presented in Appendix 1, Table 1.4. The length of the product varies from 100 to 700 mm, thread diameter from 12 to 52 mm and load class from 500 to 12500 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.4.

Peikko Jenka BSA

The anchor part of Jenka BSA is a bolt with spherical head. The construction of the product is presented in Appendix 1, Table 1.5. The length of the product varies from 60 to 150 mm, thread diameter from 12 to 30 mm and load class from 500 to 4000 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.5.

Peikko Jenka CSA

Jenka CSA as a product has no anchor part. It is only a sleeve with inner thread in upper part. The bottom part has no thread, but it has two holes perpendicular to the axis of the sleeve. These holes are used to push through the reinforcement bar, which works as an anchorage in the concrete element. The construction of the product is presented in Appendix 1, Table 1.6. The length of the product varies from 40 to 195 mm, thread diameter from 12 to 52 mm and load class from 500 to 12500 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.6.

Peikko Jenka ESA

The construction of Jenka ESA in principle is similar to Jenka CSA – no anchor part, holes for anchor reinforcement bar. The difference is that the bottom part of Jenka ESA is flattened out so, that holes axes coincide with each other. The construction of the product is presented in Appendix 1, Table 1.7. The length of the product varies from 60 to 105 mm, thread diameter from 12 to 24 mm and load class from 500 to 2500 kg. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.7.

Peikko Jenka PSA

The anchor part of Jenka PSA is a square plate welded to the threaded sleeve. The construction of the product is presented in Appendix 1, Table 1.8. The length of the product varies from 30 to 117 mm, thread diameter from 12 to 52 mm and load class from 500 to 12500 kg. Dimensions of the anchor plate are from 35x25 to 150x130 mm. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.8.

4.3.2 Materials and production

Sleeves are constructed of precision steel tubes of exceptional quality. Steel tubes are made of steel S235 according to EN 10025. The anchor part of SRA, WAS, WAL, TF Jenka Anchors is crimped in a sleeve and made of reinforcement bar Bst500S according to EN 10080. In type TF the boss head is made by forging. The anchor part of BSA is made of steel bolt according to DIN 603 (Peikko production drawings, 2011).

4.3.3 Usage and safety considerations

A Peikko Jenka Anchor nailplate NPP and identification ring are used when installing the Anchor into the formwork. The nailplate is usually installed with either nails or with a hot glue gun. For steel forms Jenka NPM magnetic installation plate is used. The nailplate forms the recess so that the Peikko lifting device can be connected. The symmetrical Peikko's Jenka Anchor (Type SRA, TF, BSA) does not require further attention in Anchor installation. For all other Peikko Jenka Anchors, the waved ends and reinforcement must always respectively be parallel to one of the long direction of the concrete element. After the anchor's fixation in the formwork, casting is provided. After casting, the formwork sides are removed together with nailplates (Peikko Jenka Brochure, p. 8). Where no other indication of minimum concrete compressive strength is given, it is assumed that the concrete strength (at the time of lifting) is at least 15 MPa measured on cubes with side length 150 mm, or 12 MPa measured on cylinders (prCEN/TR 15728 Design and Use of Inserts for Lifting and Handling of Precast Concrete Elements, p. 16). For transportation, lifting devices are used. They should be fully screwed into the anchor's sockets. After usage, devices are screwed out and replaced with cover plugs or recess caps.

Angles of load application, load values, installation equipment and additional reinforcement have to be provided according to the project and Peikko`s guides. Precast concrete components with Jenka anchors should not see repeated operation. Construction components (specifically the transport Anchor) may undergo some erosion during the transport of a component from the place of production to the place of installation, however this is not considered as a repeated operation. A repeated operation is, for example, the use of precast concrete components as a removable dam, or as counterweight of a crane; this is only permissible if warranted by a structural engineer (Peikko Jenka Brochure, p. 4).

4.4 Lifting devices

Peikko Jenka lifting devices are the connection elements between Jenka anchors and lifting equipment (slings and hooks). Jenka lifting device could be a wire rope lifting loop or a 2-link chain element; both types have a threaded head. Similar to anchors, lifting devices are available in wide range of capacities from 0,5 to 12,5 tons. The function of Jenka lifting devices is described in chapter 4.3.

4.4.1 Standard types and dimensions

There are 2 types of Peikko Jenka lifting devices:

- Peikko Jenka TLL (wire lifting loop)
- Peikko Jenka JL (2-link chain lifter)

Differences, in principle, are presented by pull angles – for TLL the acceptable angle is between 0 and 45 degrees, while the JL device allows the angle of load application up to 90 degrees in case of lateral pull. The main advantage of Jenka TLL is price. Jenka TLL is about 6 times cheaper than Jenka JL.

<u>Peikko Jenka TLL</u>

Jenka TLL consists of a wire rope loop and a crimped steel shell. Upon the crimped shell an outside thread is established to allow the threaded connection between Jenka anchor and Jenka TLL. The construction and the dimensions of the product are presented in Appendix 1, Table 1.9. The thread diameter is from 12 to 52 mm and load class from 500 to 12500 kg. Pull angles are from 0 to 45 degrees. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.9.

<u>Peikko Jenka JL</u>

Jenka JL consists of two links. The first link is similar to the simple chain link, with a thin crosspiece in the bottom part. The second link is a ring with welded screw adapter. Screw adapter has a thread for connection to Jenka anchors. The construction and the dimensions of the product are presented in Appendix 1, Table 1.10. The thread diameter is from 12 to 52 mm and load class from 500 to 12500 kg. Pull angles are from 0 to 45 degrees and, in case of lateral pull, 90 degrees. All types, sizes and load-bearing characteristics are given in Appendix 1, Table 1.10.

4.4.2 Materials and production

This part contains the information about materials used for production. Also, normative standards and some production features are given in this part.

Jenka TLL

Steel wire rope standard is 16x19SE (d_s = 6-12 mm) or 6x36SE (d_s = 6-12 mm) according to DIN 12385-4. Rope grade is 1770 N/mm2. Rope is electro zinc plated. More information about the wire rope is given in Appendix 1, table 1.11. Free ends of the wire rope are reunited together and crimped in the shell. Shells are made according to DIN EN 13411-3 or of thick walled tube of steel S355. Shell's thread is metric according to DIN 13 or special round thread (Peikko production drawings).

Jenka JL

Lifters are made of tempered steel S235Q. Screw adapters are forged, of the same steel. Thread of the screw is metric according to DIN 13 or special round thread.

4.4.3 Usage and safety considerations

Main information about proper and safe usage of lifting devices is given in this part. Following this rules and recommendations will provide the safety while using Jenka lifting systems and will prolong the exploitation period of Jenka lifting devices.

Jenka TLL

After the concrete element is cast, formwork sides and nailplates/magnets are removed, Jenka lifting device should be used for lifting. Jenka TLL could be used only for load application angles of 0-45 degrees, and in case of lateral pull, application is not acceptable. To connect the Jenka TLL and the anchor the user must screw the threaded part of TLL into the anchor's socket. Jenka TLL is to be fully screwed into the Jenka anchor so that the threaded end is inside the socket of the anchor as shown in figure 4.2. The Jenka anchors are designed so that the Jenka TLL threads can always be completely screwed into the anchor (figure 4.2). Incompletely screwed lifting loops can not bear the nominal load. For connection between slings and Jenka TLL lifting hooks are used. Hook size, form, and curvature radius R of the hook must be the minimum of 2 times the cable diameter (figure 4.3)

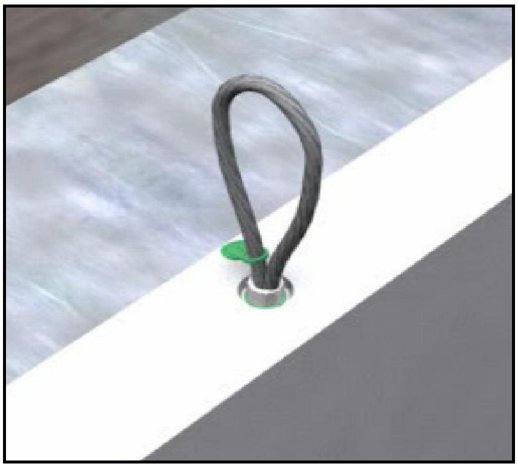


Figure 4.2 Fully screwed in TTL

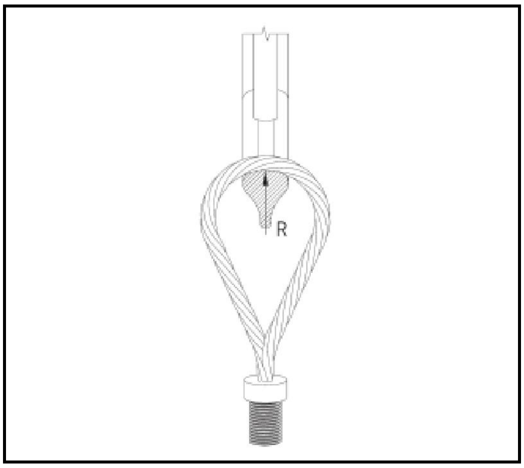


Figure 4.3 TLL and lifting hook

Angles of load application and directions of lifting should be as shown below in figure 4.4

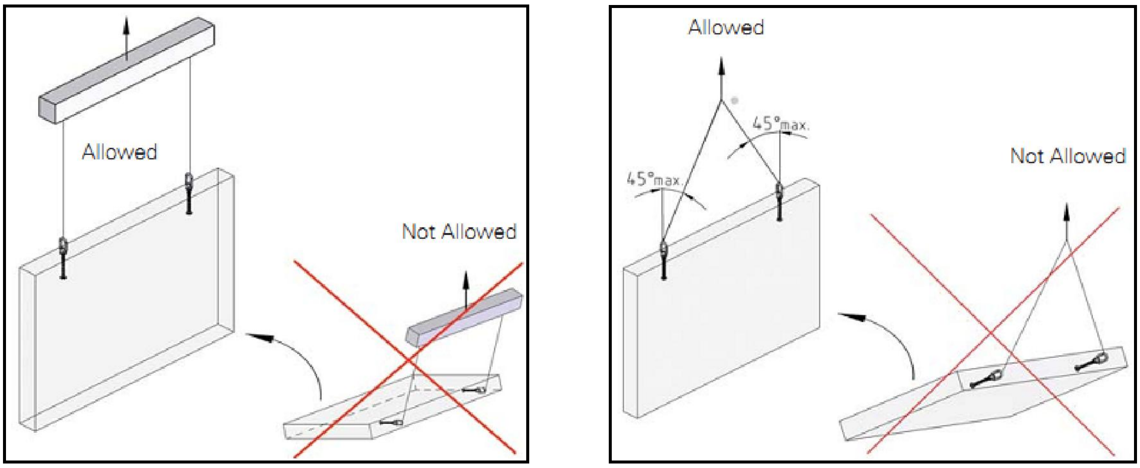


Figure 4.4 Acceptable and non-acceptable lifting with TLL

The Jenka TLL can be used multiple times. Improperly used, corroded, or otherwise damaged Peikko's Jenka components should not be installed or see further use. Welding or any other alterations are not acceptable.

The durability of reinforced concrete components with installed Peikko Jenka TLL load suspension components is assured, damage through corrosion is limited. Lifting loops can leave corrosion scars upon the surface of a concrete component. Corrosion of the Anchor can be reduced when Jenka Lifter is left in the Anchor socket while the concrete element is left in the yard.

Jenka TLL should meet periodical inspections, including mandatory yearly inspection. The main things to be checked are: operational wear and damages of wire rope and threaded shell. Wire rope should be checked for the following points (Peikko Jenka Brochure p. 16-17):

- Damage to the threads
- Form damages to the wire rope
- Deformations (rope extension, cross section area changing)
- Corrosion marks
- Operational wear of the product

More detailed information about the criteria is presented in chapter 4.4.4

Jenka JL

Usage and safety considerations are similar to given for TLL. Following points must be reviewed before and during installation:

- Damage to the threads
- Breakage along the ring head
- Tears or corrosion marks
- Deformation of the ring head (Appendix 4, figure 4.1)
- Reduction in ring width d_{min} at any location of more than 10% of width d (Appendix 4, table 4.1)
- Damage or heavy wear at the drop point (Appendix 4, figure 4.3)
- Lengthening of nominal dimensions T beyond 5%.
- The Peikko Jenka Lifter should only undergo loads applied in accordance with figures 4.5 – 4.6

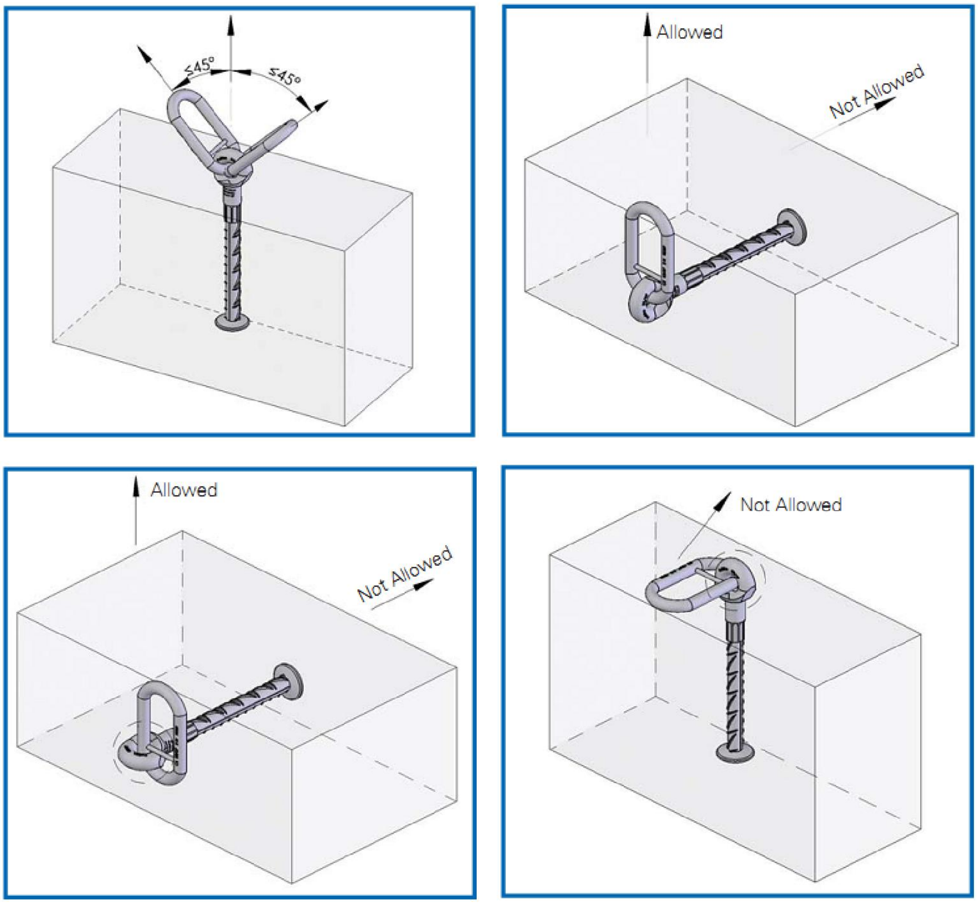


Figure 4.5 Acceptable and not acceptable force application for Jenka JL

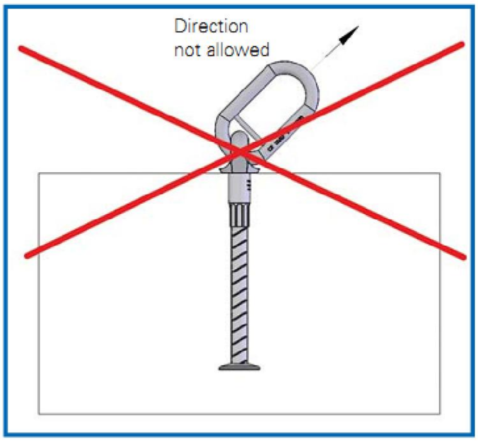


Figure 4.6 Not acceptable load application

4.4.4 Exploitation term overview and discarding criteria for Jenka TLL

During the technical support work for Peikko Russia customers the request for giving overview about exploitation period and discarding criteria for Jenka TLL was received. According to these request a short report was prepared. ISO 4309, DIN EN 12385-4, consultations with German colleagues and specialist from SPSUACE University were used to prepare the report. Main points from the report could be found above.

When talking about exploitation period of TLL wire loops its impossible to determine the exact terms, because it's necessary to take into account many factors, such as conditions of transportation and storage, abidance of the producer's guides, rate (1, 2, 3 times per day or once per week) and care of usage. All these factors are hard to strictly control during all the time of exploitation, which is duty of the user. For example, not all the workers on precast factories are highly-qualified and liable – there is usually somebody, who doesn't much care about the abidance of the guides. If loops are used carefully, in accordance with Peikko's guides and recommendations, storage conditions exclude fast corrosion and damages, they can be used for years. But, if, for example, TLL loops are used for lateral lifting (lateral force application), they will be discarded in a very short time.

The following criteria have to be taken into account in case of inspection of TLL wire loops:

- 1) For strands breakage: for wire's construction 6x19SE (TLL type RD12 – RD24) 2 broken strands are acceptable; for wire's construction 6x36SE (TLL type RD30 – RD52) 8 broken strands are acceptable
- 2) Maximum decreasing of the wire rope diameter as the result of the wear of the centre (inner) strands is 10%; in case of serious local damages of the inner strands – exploitation is not permitted
- Maximum decreasing of the wire rope diameter as the result of the wear of outer strands – 7%
- Exploitation is not permitted, if significant increasing of the wire rope flexibility is noticed, even if no other serious damages or defects of the rope are detected
- Maximal increasing of the rope diameter is 5% (in case of, for example, strands' untightening or centre strands' wear)
- No other damages as shown in Appendix 4 (figures 4.4-4.22) are acceptable

Also, if no one of these critical values are exceeded, but summary wear of the TLL loop is significant (for example, 2 strands are broken, 5% decreasing of inner strands diameter, and 4% decreasing of outer strands diameter etc), than the TLL loop should be discarded.

For threaded part of the TLL loop the following criteria are used:

- In case of viewable significant damages to the thread, the TLL loop should be discarded. TLL should allow to be screwed in smoothly, without any effort
- Acceptable decreasing of the height of thread's tine - 15%
- Acceptable decreasing of the thickness of thread's tine - 10%

5 DESIGN PRINCIPLES FOR USAGE OF JENKA SYSTEM

General information about the process of designing Jenka system for lifting concrete elements is given in this part. All steps of designing are described separately with all necessary formulas and definitions. Calculations are made on the example of lifting of concrete foundation block. The process of design has the purpose to determine, which anchor has to be applied for the element and its position in the element. This part does not include the calculations of anchors and concrete durability – readymade recommendations and tables with capacities are used from Appendix 1, tables 1.1-1.8.

5.1 Initial data for design

The following concrete element is used for example calculations:
Foundation block, L= 2380 mm, b= 500 mm, h = 580 mm, concrete B30.
Steel formwork is used for casting, lifting by portal/tower crane. For lifting by tower crane – 2 suspension gear is used. Straight lifting only is necessary.

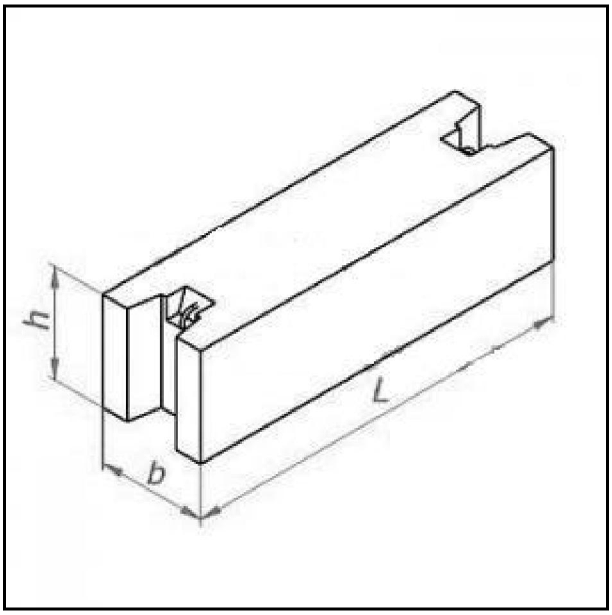


Figure 5.1 The source element

There are 7 factors, which are taken into account when designing a lifting system. They influence the lifting load, type and position of the anchors, amount of additional reinforcement. These factors are (Peikko Jenka Brochure p. 9):

- Element weight
- Element geometry
- Form adhesion
- Dynamic actions
- Force directions from anchor loads
- Influence from multiple slings
- Manipulations with transport slings

5.2 Element weight

The member weight is determined by the element volume and the specific weight. Usually 25kN/m3 is used for normal concrete. The weight of the reinforcement has to be additionally taken into account if the member is highly reinforced. The formula (5.1) below calculates the member weight through multiplication of volume and specific weight. Unsymmetric construction parts such as openings have to be taken into consideratio8 (Peikko Jenka Brochure p. 9).

$$G = V \times \gamma \qquad (5.1)$$

G - element weight, kN

V - element volume, m^3

γ - specific weight, kN/m^3

Presented foundation block is symmetrical, two notches on the lateral sides (volume of notches is 0,03 m^3).

$$V = (2{,}38 \times 0{,}5 \times 0{,}58) - 0{,}03 = 0{,}652\ m^3$$

$$G = V \times \gamma = 0{,}652 \times 25 = 16{,}3\ kN$$

5.3 Form adhesion

When lifting concrete elements out of a form, the form adhesion (suction) must be taken into account. Two methods can be used to estimate the form adhesion:

- By determination of the adhesion forces through contact area
- By determination of the adhesion forces through element weight multiplier

The form adhesion is chosen between these two options based on the experience of the designer.

5.3.1 Form adhesion determined by contact area

Table 5.1 indicates the reference values in pounds per square foot of equivalent suction weight for three types of form. The values in table 5.1 suppose that oil or grease has been applied on the form before pouring the concrete. For some types of uneven form surfaces (structured matrixes, reliefs, structured timber etc.) the forces may be much larger than given in the table, and should be considered separately. The forces may be zero if the concrete does not come in contact with the form at all, for example if the concrete is poured on a layer of bricks that has been laid out on the form bottom. Large vertical form surfaces may create extensive friction forces due to undulations in the form. Prestressed components will usually have a camber caused by the prestressing force, and will therefore have lower friction against the vertical sides of the form. All the formwork sides must be removed before stripping the member. The form adhesion is determined by multiplying the area of formwork by the reference value8 (prCEN/TR 15728 Design and Use of Inserts for Lifting and Handling of Precast Concrete Elements, p. 12):

$$H_{a1} = A_s \times h \qquad (5.2)$$

H_{a1} - adhesion equivalent weight (kN)

A_s - contact surface on the form (m^2)

h - reference value for form adhesion (see table 5.1)

Table 5.1 Reference values for form adhesion

Type of form	h (kN/m^2)
Rough timber formwork	3
Smooth timber formwork	2
Steel formwork	1

For presented concrete element:

$$A_s = 2{,}38 \times 0{,}5 = 1{,}19\ m^2$$

$$H_{a1} = 1{,}19 \times 1 = 1{,}19\ kN$$

5.3.2 Form adhesion determined by member weight multiplier

To account for the forces on the member caused by form suction, a multiplier to the member weight can be applied. The resulting force is then treated as an equivalent static load (Peikko Jenka Brochure p. 9).

.

$$H_{a2} = G \times m \qquad (5.3)$$

H_{a2} - adhesion equivalent weight (kN)

G - member weight (kN)

m - static load multiplier (see table 5.2)

Table 5.2 Equivalent static load multipliers (m)

Product type	Finish	
	Exposed aggregate with retarder	Smooth mold (form oil only)
Flat, with removable side forms, no false joints or reveals	0,2	0,3
Flat, with false joints and/or reveals	0,3	0,4
Fluted, with proper draft	0,4	0,6
Sculptured	0,5	0,7

$$H_{a2} = 16{,}3 \times 0{,}3 = 4{,}89\ kN$$

5.4 Dynamic actions

During lifting and handling the precast elements and the lifting devices are subjected to dynamic actions. The magnitude of the dynamic actions depends on the type of lifting machinery. The transport with an excavator on an uneven ground leads to a multiplication of the actual member weight through dynamic actions. The dynamic coefficient (f) is chosen depending on the type of equipment used to lift the concrete member (prCEN/TR 15728 Design and Use of Inserts for Lifting and Handling of Precast Concrete Elements, p. 13).

Table 5.3 Dynamic load coefficient (f)

Dynamic influences	Dynamic coefficient
Tower crane and portal crane	1,2 *
Mobile crane	1,4 *
Lifting and moving on flat terrain	2 to 2,5
Lifting and moving on rough terrain	3 to 4
* In precasting factories and if special provisions are made at the building site lower values may be appropriate.	

5.5 Anchor loads

Loading, hoisting and rotation processes of the member occur with the transport slings. The transport system has to be calculated and arranged for the most unfavourable loading condition. The consistency of the used anchor loads has an essential influence on the load incrementation on the anchor. Independent from the used anchor system the same regularity is valid also here. In principle, three different kinds of anchor loads can be differentiated:

- axial tension: occurs if the transport anchor is charged in longitudinal direction of its axis
- diagonal tension: means loading happens with an angle of inclination to vertically longitudinal axis of the anchor
- lateral tension: occurs when the front end anchors are lifted with an angle (90˚)

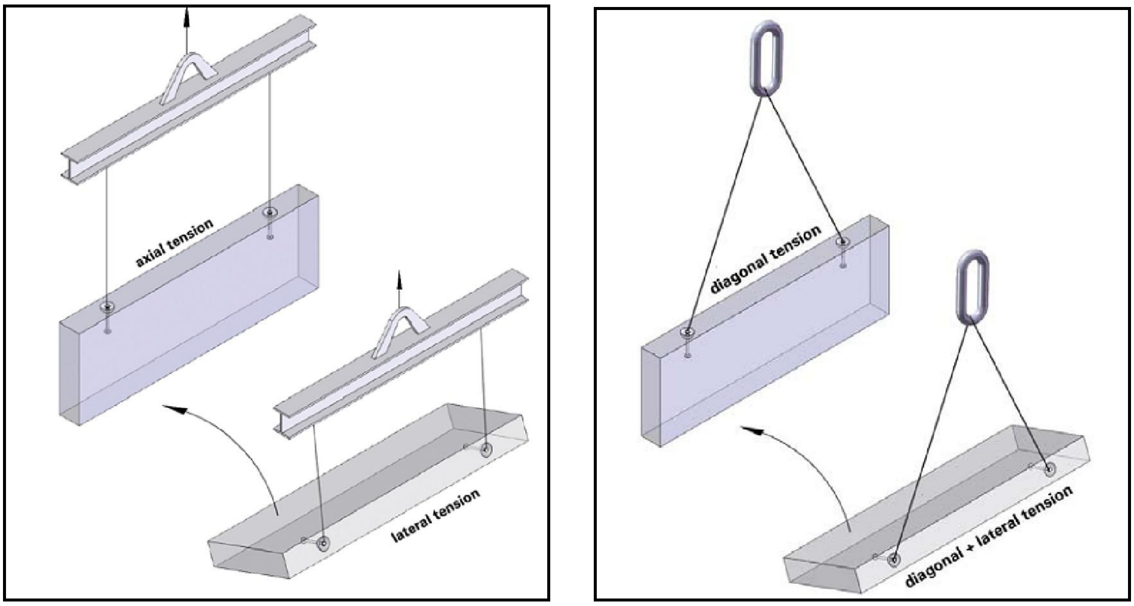


Figure 5.2 Different kinds of anchor loads

For the transport of the member, axial tension only (figure 5.2, left side) is preferable, as no load incrementation arises from the Anchor load. In the case of diagonal tension (figure 5.2, right side) the diagonal arising load from the anchor load increments the cable force. The amount of the load incrementation depends on the inclination angle of the anchor load, which can be inclined to a maximum of 45° to the vertical. An inclination angle ß > 45° is not allowed because of the high force incrementation. Diagonal tension factors for loads are given below in table 5.4 (Peikko Jenka Brochure p. 10).

Table 5.4 Diagonal tension factor (1/cos ß)

Inclinaison angle ß	Cos ß	Diagonal tension factor (1/cosß)
0,0°	1	1,00
15,0°	0,97	1,04
22,5°	0,92	1,08
30,0°	0,87	1,15
37,5°	0,79	1,26
45,0°	0,71	1,41

5.6 Influence from multiple slings

The lifting equipment should allow statically determinate load distribution to the anchors (see figure 5.3). To ensure that all anchors carry their required part of the load, sliding or rolling couplings between the lifting wires or chains should be used when there are more than two lifting points. In a statically indeterminate system the load distribution on the anchors depends in most cases on the unknown stiffness of the ropes and the position of the insert (see figure 5.4). Therefore only the statically determinated part of a system should be used in calculating the actions on the anchors.

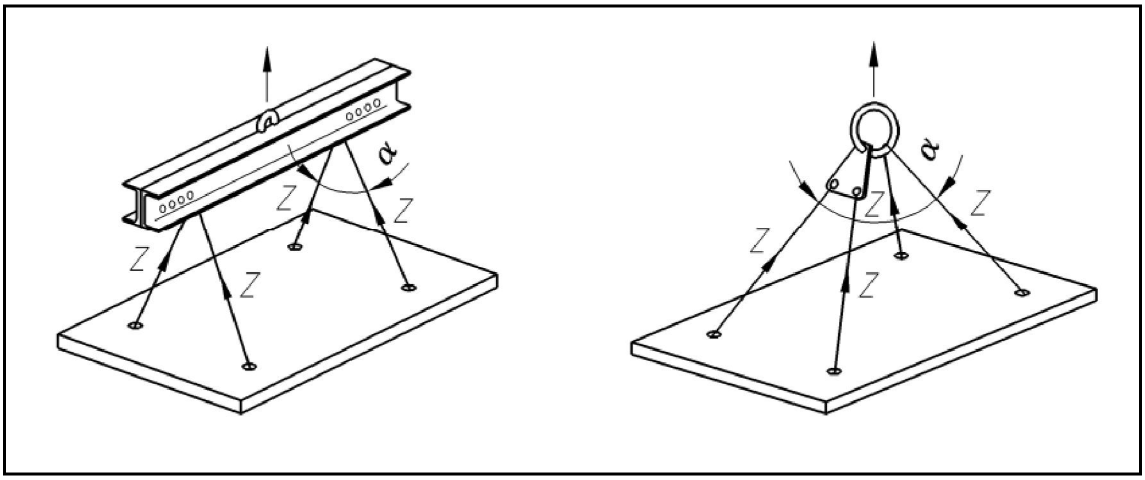


Figure 5.3 Examples of statically determinated load distribution to the anchors

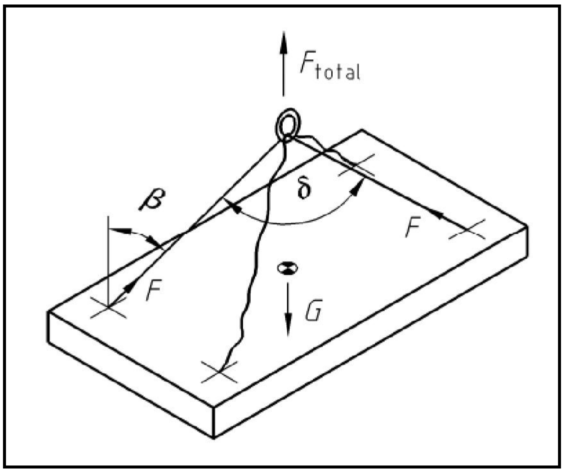


Figure 5.4 Statically indeterminate load distribution to the anchors

In case of statically determinate lifting conditions the exact arised anchor loads can be calculated. This is the case when using 2 suspension gears, 3 suspension gears (with symmetrical anchor distribution) or 4 suspension gears with compensation seesaw (see figure 5.3, right part). In case of statically indeterminate lifting conditions the anchor loads can not be calculated exactly. This is the case when more than two attachment points are given (wall element with three lines installed anchors or 4 suspension gears without compensation, see figure 5.4). In such case, a maximum of two attachment points can be the bearing ones. In the most unfavourable case anchor loads and anchor have to be put in a way that every single attachment point can carry the entire load (Peikko Jenka Brochure p. 11).

5.7 Component dimensions and edge distances

Load capacities for anchors mentioned before are only valid with specific dimensions, edge and axial distances (figure 5.5).

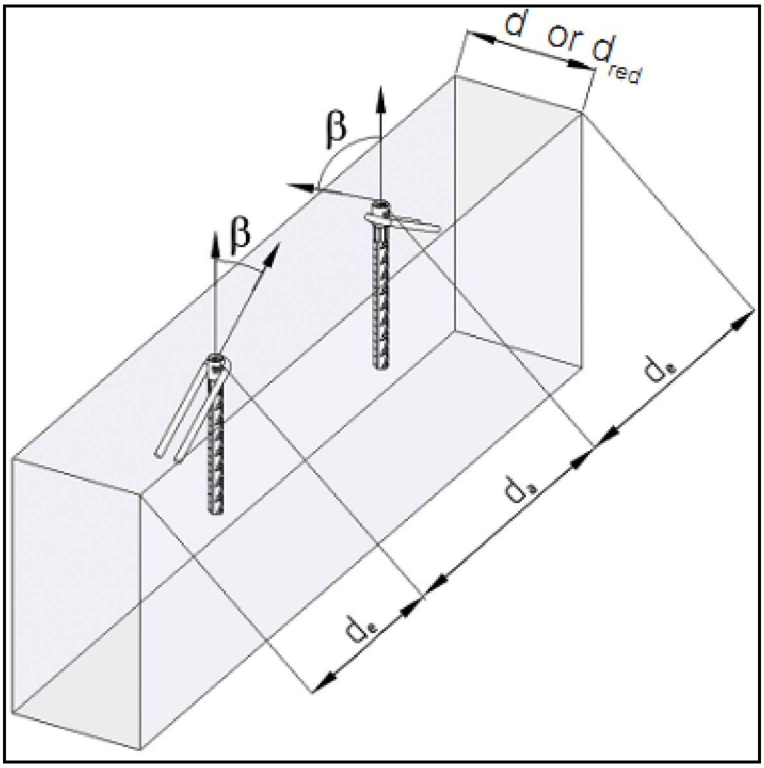


Figure 5.5 Edge and axial distances, element thickness

The necessary edge distances (d_e) and axial distances (d_a) for respective anchor types are given in Appendix 2 (tables 2.1-2.4). The details for d_{red} only apply when using the anchor types SRA (Peikko Jenka Brochure p. 12).

5.8 Selection of the anchors

The selection of the proper anchors takes into consideration all the above mentioned factors. The determination of the resulting force effecting on the anchor is calculated with the following formula:

$$F = f \times \frac{(G + H_a)}{(n \times \cos ß)} \qquad (5.4)$$

F = resultant force on the anchor (kN)

G = element weight (chapter 5.2)

H_a = adhesion equivalent weight (H_{a1} or H_{a2})

f = dynamic load coefficient (table 5.3)

n = amount of anchors in the member

$\cos ß$ = cos of angular pull angle ß (table 5.4, 2nd column)

For presented concrete element:

$$F = 1{,}2 \times \frac{(16{,}3 + 1{,}19)}{(2 \times 0{,}87)} = 12{,}06\ kN$$

After calculating the resulting force per anchor, producer specification tables should be used. From Appendix 1, table 1.1 SRA18x305 (F_s=16 kN) is chosen.

5.9 Reinforcement

Depending on the construction of the anchor and the load applied, the appropriate reinforcement should be provided. The following reinforcement has to be taken into account:

- minimal element reinforcement
- reinforcement for angular pull
- reinforcement for lateral pull

5.9.1 Minimal element reinforcement

For using Jenka anchors, minimal reinforcement should be provided according to tables 3.1-3.4 from Appendix 3. Mesh reinforcement and special stirrups (figure 5.6) are used. This reinforcement can be substituted with steel bars of the same diameter. If it is necessary to remove individual bars for the installation of the anchor, the bars must later be replaced by bars of the same diameter and reinforcement length. The reinforcement in the concrete can be taken into account (reinforcing steel mesh, stirrups, iron bars, etc). Minimum reinforcement is not necessary with Jenka BSA anchors (Peikko Jenka Brochure p. 13-14).

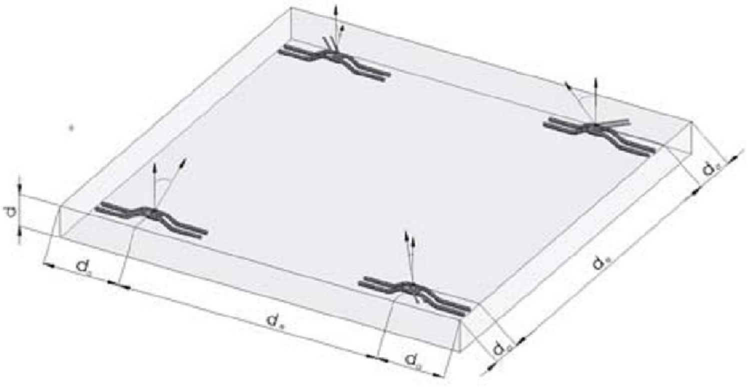


Figure 5.6 Minimal reinforcement: stirrups

5.9.2 Reinforcement for angular pull

In the case of loads in angular pull, a reinforcement stirrup must be applied with pressure contact at the angular point counteracting the direction of pull (as shown in figure 5.5). Stirrups are chosen according to table 3.3 in Appendix 3. In case of a maximum angular pull of 30° it is possible to adjust the reinforcement stirrup in length and diameter.

5.9.3 Reinforcement for lateral pull

A load in lateral pull with $\gamma \geq 15^{o}$ requires an additional reinforcement to be incorporated following Appendix 3 (table 3.4) in the face counteracting the direction of pull (figures 5.7, 5.8). Loads in lateral pull (with the use of chain overhead conveyors) require no further measures, as the stirrup provides for this load as well. During lowering and raising of the component, the direction of the reinforcement should always be checked. Lateral lifting is allowed only for components with minimum thickness “d” according to table (таблица 9 из брошюры UK) from Appendix 1. For Jenka anchors types BSA, PSA and WAS lateral pull is not permissible.

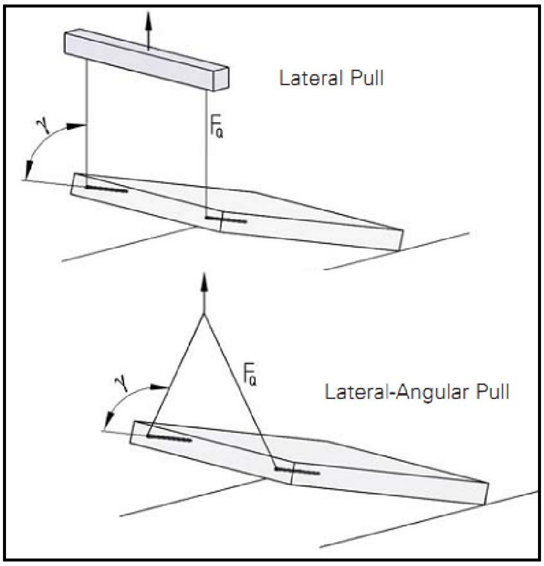


Figure 5.7 Angle of lateral pull γ

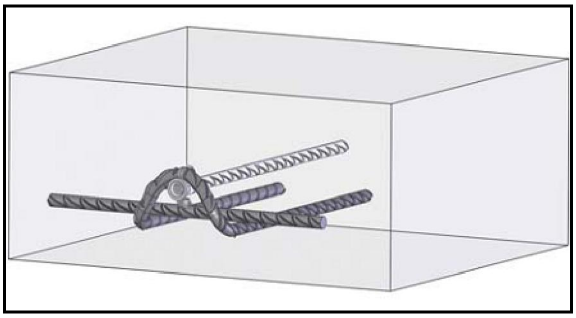


Figure 5.8 Reinforcement for lateral pull

6 CALCULATONS OF THE ANCHORS ACCORDING TO RUSSIAN NORMS

To calculate the SRA and TF Jenka anchors according to Russian norms "Recommendations for design of embedded steel details for reinforced concrete structures" was used. In case of the absence of calculations of similar details mentioned in any Russian normative documentation, the principles of calculations for embedded details shown in figure 6.1 were applied. The way of application of these principles is shown in figure 6.2. The anchor socket is taken into account as a plate part and not counted as an anchoring part.

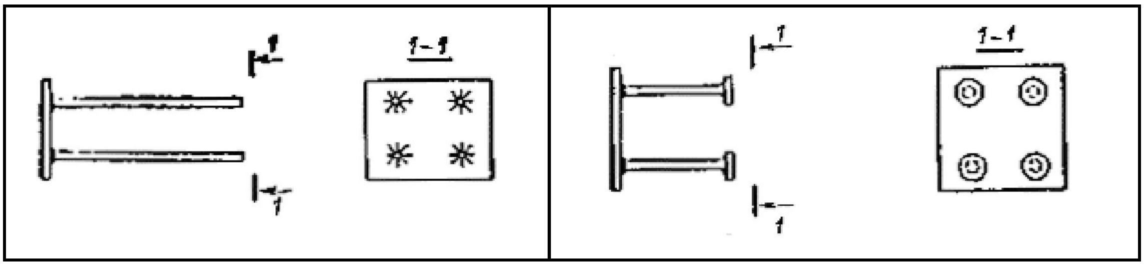


Figure 6.1 Typical embedded details

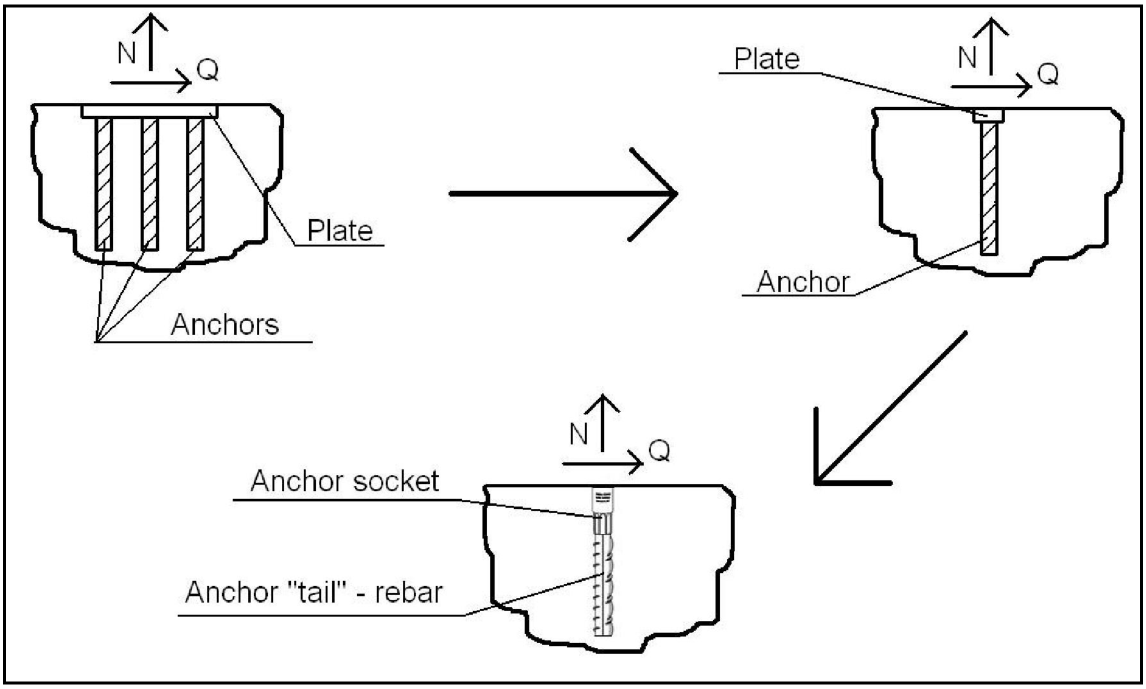


Figure 6.2 Way of application calculation principles

6.1 Anchor's cross section calculation

According to chapter 4.2 of "Recommendations for design of embedded steel details for reinforced concrete structures" the necessary area of the anchor's cross section (in case of detail symmetrical in both axes) is:

$$A_{an1} = \frac{1{,}1\sqrt{N_{an1}^2 + \left(\frac{Q_{an1}}{\varphi\varphi_1}\right)^2}}{R_s} \qquad (6.1)$$

A_{an1} - cross section area of the most loaded normal anchor

N_{an1} - the biggest tensile strength in a single normal anchor

Q_{an1} - the biggest shear force in a single normal anchor

R_s - design value of resistance of anchor's steel for first group limiting state

φ - coefficient, taken from table 2 chapter 4.2, "Recommendations for design of embedded steel details for reinforced concrete structures" 1984, p. 9.

φ_1 - coefficient, calculated by formula 3.5 but not less than 0,15

$$\varphi_1 = \frac{1}{\sqrt{1+\omega}} \qquad (6.2)$$

where:

$$\omega = 0{,}6\frac{N}{Q_{tot}} \text{ (in case of tensile force)} \qquad (6.3)$$

N - normal force acting the detail

Q_{tot} - resultant shear force acting the detail

6.2 Anchorage length calculation

The anchorage length according to chapter 5.7 of "Recommendations for design of embedded steel details for reinforced concrete structures" is:

$$l_{an} = \varphi_c\left(\omega_{an}\frac{R_s}{R_b} + \Delta\lambda_{an}\right)d \qquad (6.4)$$

but not less than: $l_{an} = \lambda_{an} d$ (6.5)

where:

l_{an} - anchorage length

ω_{an}, $\Delta\lambda_{an}$, λ_{an} - are taken from the table 4 from "Recommendations for design of embedded steel details for reinforced concrete structures"

R_b - design value of concrete resistance to compression for the first group limiting state

d – anchor rebar diameter

$$\varphi_c = [0{,}3/(1 + Q_{an1}/N_{an1})] + 0{,}7 \qquad (6.6)$$

If diameter d of the anchor rebar is taken bigger than the received by calculations d_{calc}, the design value R_s could be reduced by multipling the difference ratio $\frac{d_{calc}}{d}$.

According to chapter 5.8 of "Recommendations for design of embedded steel details for reinforced concrete structures" the anchorage length can also be reduced if an additional strengthening at the end of the anchor is presented. Strengthening could be made by forged heads or welded plates/short rebars. If forged head is used as a strengthening part, the diameter of the head should be at least 2 diameters of the anchor rebar. In case of using strengthening part the anchorage length is estimated by concrete breakout calculation. The anchorage length in that case should be at least 10*d*.

6.3 Concrete breakout calculation

The scheme of concrete breakout in case of normal force and shear force acting the anchor is presented in figure 6.3.

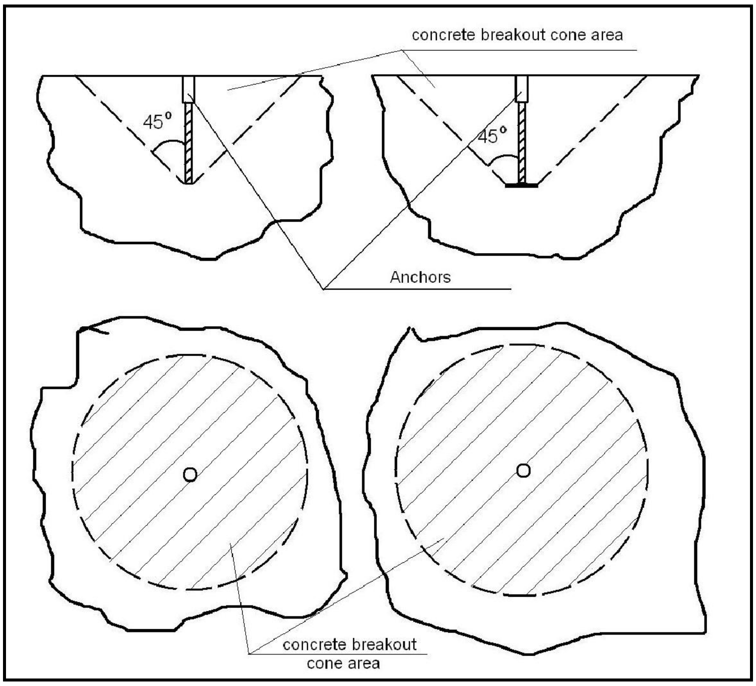


Figure 6.3 Concrete breakout for different constructions of anchors

Calculations for concrete breakout are different for anchors with strengthening at the end and without them. Also, for the option with strengthening there is a mandatory calculation for local concrete failure in the area of strengthening.

6.3.1 Anchors without strengthening at the end

According to chapter 4.7 (subchapter B) of "Recommendations for design of embedded steel details for reinforced concrete structures", in case of all anchors are tensioned:

$$N \le \frac{\varphi_2 \varphi_3 A_1 R_{bt}}{1 + 3{,}5\dfrac{e_{h1}}{a_{h1}} + 3{,}5\dfrac{e_{h2}}{a_{h2}}} + R_s A_{an,a} \frac{l_a - h}{l_{an}} \qquad (6.7)$$

φ_2 - coefficent taken for normal concrete 0,5; for light-weight concrete 0,4

φ_3 - coefficent taken depending on the compression forces in the concrete

A_1 - area of the projection going from the end of the anchors (or from the edges of the end strengthenings) to the surface perpendicular to the anchors with an angle of 45º to the anchor's axes.

R_{bt} - design value of concrete resistance to tension for the first group limiting state

e_{h1}, e_{h2} - eccentricity of the force N relatively to the projection surface

a_{h1}, a_{h2} - dimensions of the surface of projection area

$A_{an,a}$ - cross section area of all anchors which cross the breakout surface

l_a - anchor rebar length

h - height of the breakout cone;

The concete strength should be checked for different heights of the breakout cone. In case of a single anchor and the absence of a monent acting the anchor (e_{h1}, e_{h2} = 0):

$$N \le \varphi_2 \varphi_3 A_1 R_{bt} + R_s A_{an,a} \frac{l_a - h}{l_{an}} \qquad (6.8)$$

6.3.2 Anchors with strengthening at the end

According to chapter 4.7 (subchapter A) of "Recommendations for design of embedded steel details for reinforced concrete structures", in case of all anchors are tensioned:

$$N \le \frac{\varphi_2 \varphi_3 A R_{bt}}{1 + 3{,}5\dfrac{e_1}{a_1} + 3{,}5\dfrac{e_2}{a_2}} \qquad (6.9)$$

e_1, e_2 - the same as e_{h1}, e_{h2} in formula 3.10
a_1, a_2 - the same as a_{h1}, a_{h2} in formula 3.10

For single anchor without moment acting the anchor(e_1, e_2 = 0):

$$N \le \varphi_2 \varphi_3 A R_{bt} \qquad (6.10)$$

According to chapter 4.12 "Recommendations for design of embedded steel details for reinforced concrete structures", concrete near the anchor's strengthening should be calculated for local crushing:

$$N_{loc} \le \varphi_b \beta_b R_b A_{loc1} \qquad (6.11)$$

where: φ_b = 1 - for concrete class lower than B25; $\varphi_b = 13{,}5\frac{R_{bt}}{R_b}$ for concrete class B25 or higher.
β_b - coefficient taken similar to γ_b in chapter 3.95 "Guide for design of concrete and reinforced concrete structures made from normal concrete (without prestressing) Moscow, 1977":

$$\beta_b = \sqrt[3]{\frac{A_{loc2}}{A_{loc1}}} \qquad (6.12)$$

A_{loc1} - area of strengthening (without area of the anchor's crossection) as shown in figure 6.4
A_{loc2} - compressed zone area, distributed for distance d (diameter of the strengthening) around the anchor's strengthening, as shown in figure 5.4
N_{loc} - the local compression force, for anchors with $l_a \ge 15d$, $N_{loc} = N_{an1}$;
for anchors with $l_a < 15d$:

$$N_{loc} = N_{an1} + Q_{an1}\frac{15d - l_a}{l_{an}} \qquad (6.13)$$

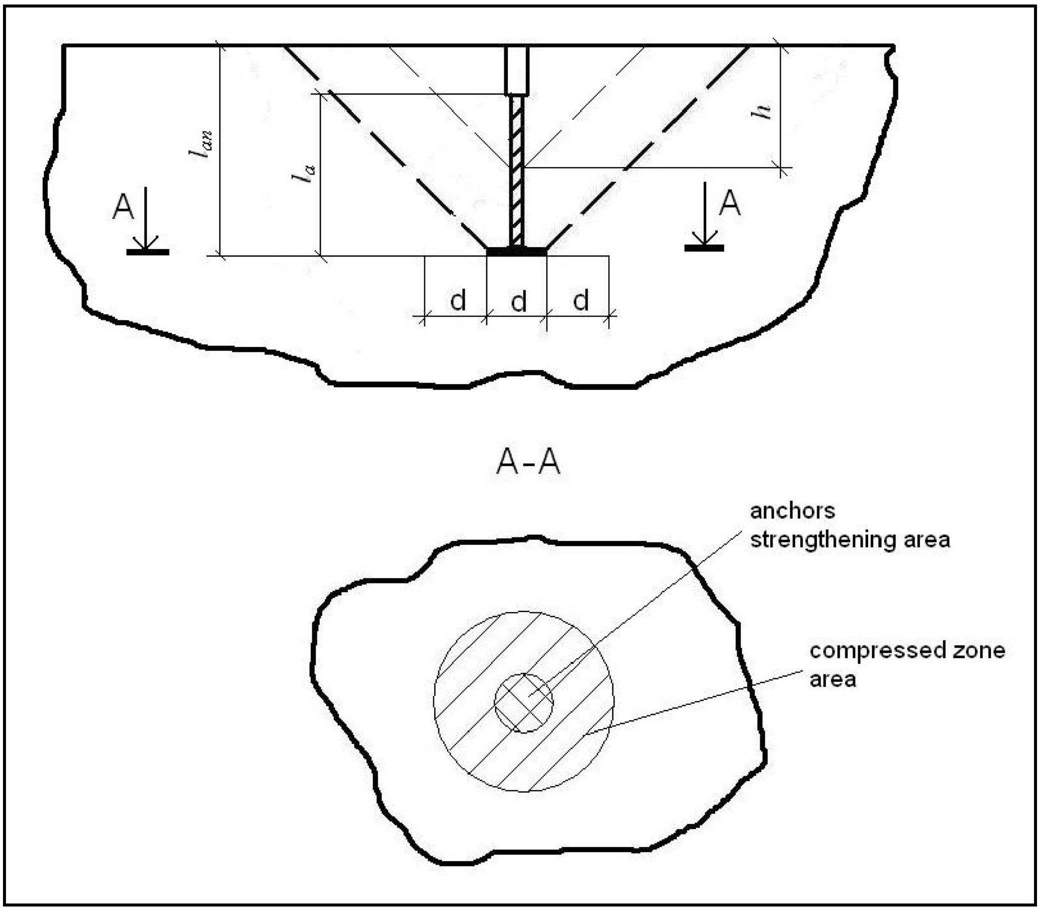


Figure 6.4 Calculation dimensions and areas

6.3.3 Example of calculation for SRA

SRA20x360 is taken as an example for calculations (anchors without strengthening). The characteristics of the anchor are taken from table 1.1 Appendix 1. The most unfavourable load conditions were applied:

- lifting force acting the anchor along the anchor's axis (N max)
- lifting force acting the anchor with a maximum application angle of 45º (Q max + N)

6.3.3.1 Lifting force acting the anchor with a maximum application angle of 45º (Q max + N)

The force application is shown in figure 6.5

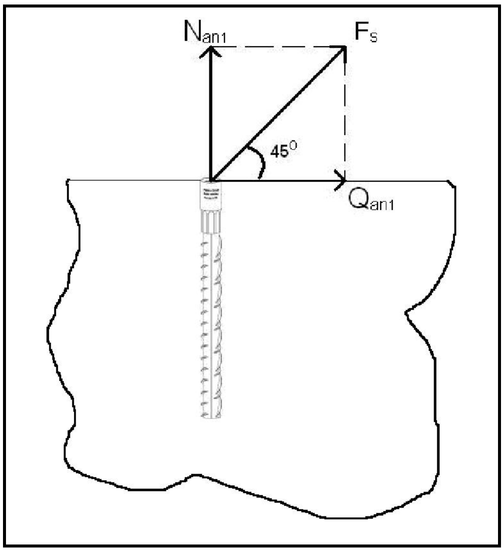


Figure 6.5

The permissible anchor's cross section area:

$$A_{an1} = \frac{1{,}1\sqrt{N_{an1}^2 + \left(\frac{Q_{an1}}{\varphi\varphi_1}\right)^2}}{R_s} = \frac{1{,}1\sqrt{14{,}142^2 + \left(\frac{14{,}142}{0{,}49 \cdot 0{,}7906}\right)^2}}{0{,}435} = 99mm^2$$

$$N_{an1} = Fs \cdot \cos 45 = 20 \cdot 0{,}7071 = 14{,}142kN$$

$$Q_{an1} = Fs \cdot \cos 45 = 20 \cdot 0{,}7071 = 14{,}142kN$$

$Fs = 20kN$ - maximum acceptable for SRA20x360

φ = 0,49 for anchor's bar diameter *d* = 14 *mm*

$R_s = 0{,}435kN/mm^2$ for steel A500

$$\varphi_1 = \frac{1}{\sqrt{1+\omega}} = \frac{1}{\sqrt{1+0{,}6}} = 0{,}7906$$

$$\omega = 0{,}6\frac{N}{Q_{tot}} = 0{,}6\frac{14{,}142}{14{,}142} = 0{,}6$$

The actual cross section area is $A = 153{,}86\ mm^2 > A_{an1} = 99\ mm^2$

The necessary anchorage length is:

$$l_{an} = \varphi_c\left(\omega_{an}\frac{R_s}{R_b} + \Delta\lambda_{an}\right)d = 0{,}85 \cdot \left(0{,}7\frac{349}{14{,}2} + 11\right) \cdot 14 = 335\ mm$$

ω_{an} =0,7; $\Delta\lambda_{an}$ =11 - according to table 6.2 ($\sigma_{bc} = 0$ - taken for safety margin)

$\varphi_c = [0,3/(1+Q_{an1}/N_{an1})] + 0,7 = [0,3/(1+14,142/14,142)] + 0,7 = 0,85$

$R_b = 14,2N/mm^2$ for concrete B25 (C20/25)

$R_s \times \frac{d_{calc}}{d} = R_s \times \sqrt{\frac{A_{an1}}{A_{actual}}} = 435 \times \sqrt{\frac{99}{153,86}} = 349\ N/mm^2$ - reduced as mentioned in chapter 6.2.

The actual anchorage length is $l_{an\ fact} = 360\ mm$ > $l_{an} = 335\ mm$

Permissible force in case of concrete breakout:

<u>for *h* = 360:</u>

$$N = \varphi_2 \varphi_3 A_1 R_{bt} + R_s A_{an,a} \frac{l_a - h}{l_{an}} = 0,5 \cdot 1 \cdot (3,14 \cdot 360^2) \cdot 1,19 + 435 \cdot 0 \cdot \frac{325-360}{360} = 242\ kN$$

<u>for *h* = 350:</u>

$$N = \varphi_2 \varphi_3 A_1 R_{bt} + R_s A_{an,a} \frac{l_a - h}{l_{an}} = 0,5 \cdot 1 \cdot (3,14 \cdot 350^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-350}{360} =$$

$$= 229 - 5 = 224\ kN$$

<u>for *h* = 325:</u>

$$N = 0,5 \cdot 1 \cdot (3,14 \cdot 325^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-325}{360} =$$

$$= 197 + 0 = 197\ kN$$

<u>for *h* = 250:</u>

$$N = 0,5 \cdot 1 \cdot (3,14 \cdot 250^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-250}{360} =$$

$$= 116 + 14 = 130\ kN$$

<u>for *h* = 200</u>

$$N = 0,5 \cdot 1 \cdot (3,14 \cdot 200^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-200}{360} =$$

$$= 75 + 92 = 98\ kN$$

<u>for *h* = 100</u>

$$N = 0,5 \cdot 1 \cdot (3,14 \cdot 100^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-100}{360} =$$

$$= 18,7 + 41,7 = 60\ kN$$

<u>for *h* = 50</u>

$$N = 0,5 \cdot 1 \cdot (3,14 \cdot 50^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-50}{360} =$$

$$= 4,6 + 51,1 = 56\ kN$$

for h = 20

$$N = 0,5 \cdot 1 \cdot (3,14 \cdot 20^2) \cdot 1,19 + 435 \cdot 153,86 \cdot \frac{325-20}{360} =$$
$$= 0,8 + 56,7 = 58\ kN$$

φ_2 = 0,5 - for normal concrete

φ_3 = 1 (compression forcess are not taken into account - for safety margin)

R_{bt} =1,19 N/mm^2 for concrete B25 (C20/25)

l_a = 360-35 = 325 mm (anchor socket is not taken into account as an anchorage part – for safety margin)

Table 6.1 Work condition coefficients for anchor rebar ("Recommendations for design of embedded steel details for reinforced concrete structures, M., Stroyizdat, 1984, p.)

№	Work conditions of anchor rebars	ω_{an}	$\Delta\lambda_{an}$	λ_{an}	l_{an}, мм
				Not less than	
1	Embedding into the compressed or tensile (for $\frac{\sigma_{bc}}{R_в}<0,25$ or $\frac{\sigma_{bc}}{R_в} > 0,75$) zone of concrete	0,7	11	20	250
2	Embedding into the compressed zone of concrete (for $0,75 \geq \frac{\sigma_{bc}}{R_в} \geq 0,25$)	0,5	8	12	200

Comparing to normal force acting the anchor: N_{min} ≈ 167kN >> N = 14,142 kN

Calculations for other SRA anchors are made in the same way with Microsoft Excel. Tables with calculations can be found in Appendix 5. The results are given below in table 6.2-6.4:

Table 6.2 Results of calculation of necessary cross section area for SRA anchors

Anchor*	$\mathbf{A_{an1}}$ **[mm]**	**Actual cross section area [mm]**
SRA12x195	21,76144176	50,24
SRA14x235	36,43336714	78,5
SRA16x275	56,43305738	113,04
SRA18x305	79,20143414	153,86
SRA20x360	99,00179268	153,86
SRA24x400	128,3434263	200,96
SRA30x505	231,9626048	314
SRA36x690	422,4161858	490,625

*For anchors SRA42x840 and SRA52x950 this type of calculation is not possible because of the absence of value for φ coefficent for anchor rebar's diameter more than 25 mm.

Table 6.3 Results of calculations for anchorage length for SRA anchors

Anchor	l_{an} **[mm]** (necessary anchorage length)	$l_{an\ fact}$ **[mm]** (actual anchorage length)
SRA12x195	171	195
SRA14x235	218	235
SRA16x275	267	275
SRA18x305	314	305
SRA20x360	336	360
SRA24x400	383	400
SRA30x505	500	505
SRA36x690	657	690
SRA42x840	772	840
SRA52x950	882	950

Table 6.4 Results of calculation for concrete breakout strength for SRA anchors

Anchor	**N [mm]** (approximate minimum value for concrete breakout cone)	**N_{an1} [mm]** (actually acting force)
SRA12x195	17,86	3,54
SRA14x235	27,81	5,66
SRA16x275	40,16	8,49
SRA18x305	53,03	11,31
SRA20x360	56,15	14,14
SRA24x400	72,27	17,68
SRA30x505	112,55	28,28
SRA36x690	179,94	44,59
SRA42x840	228,63	56,57
SRA52x950	294,78	88,39

6.3.3.2 Lifting force acting the anchor along the anchor's axis (N max)

The force application is shown in figure 6.6. Calculation principles are the same, the main differences are the absence of shear force and higher value of normal force.

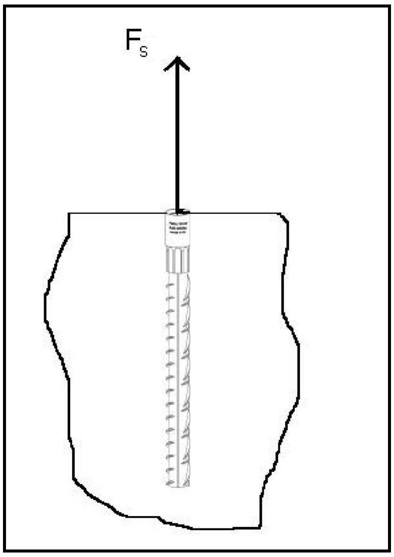


Figure 6.6

Full calculation tables can be found in Appendix 5. The results of calculations are given in tables 6.5 – 6.7

Table 6.5 Results of calculation of necessary cross section area for SRA anchors (maximum normal force)

Anchor	**A_{an1}** **[mm]**	**Actual cross section area** **[mm]**
SRA12x195	12,644	50,24
SRA14x235	20,230	78,50
SRA16x275	30,345	113,04
SRA18x305	40,460	153,86
SRA20x360	50,575	153,86
SRA24x400	63,218	200,96
SRA30x505	101,149	314,00
SRA36x690	159,310	490,63
SRA42x840	202,299	615,44
SRA52x950	316,092	803,84

Table 6.6 Results of calculations for anchorage length for SRA anchors (maximum normal force)

Anchor	**l_{an} [mm]** (necessary anchorage length)	**$l_{an\ fact}$ [mm]** (actual anchorage length)
SRA12x195	148	195
SRA14x235	186	235
SRA16x275	226	275
SRA18x305	262	305
SRA20x360	277	360
SRA24x400	313	400
SRA30x505	394	505
SRA36x690	493	690
SRA42x840	772	840
SRA52x950	882	950

Table 6.7 Results of calculation for concrete breakout strength for SRA anchors (maximum normal force)

Anchor	**N [mm]** (approximate minimum value for concrete breakout cone)	$\mathbf{N_{an1}}$ **[mm]** (actually acting force)
SRA12x195	17,86	5
SRA14x235	27,81	8
SRA16x275	40,16	12
SRA18x305	53,03	16
SRA20x360	56,15	20
SRA24x400	72,27	25
SRA30x505	112,55	40
SRA36x690	179,94	63
SRA42x840	228,63	80
SRA52x950	294,78	125

6.3.2 Example of calculation for TF

TF20x250 is taken as an example for calculations (anchors with strengthening). The characteristics of the anchor are taken from table 4.1 appendix 1. The most unfavourable load conditions were applied:

- lifting force acting the anchor along the anchor's axis (N max)
- lifting force acting the anchor with a maximum application angle of 45º (Q max + N)

6.3.4.1 Lifting force acting the anchor with a maximum application angle of 45º (Q max + N)

The force application the same as shown in figure 6.5

The permissible anchor's cross section area:

$$A_{an1} = \frac{1{,}1\sqrt{N_{an1}^2 + \left(\frac{Q_{an1}}{\varphi\varphi_1}\right)^2}}{R_s} = \frac{1{,}1\sqrt{14{,}142^2 + \left(\frac{14{,}142}{0{,}49 \cdot 0{,}7906}\right)^2}}{0{,}435} = 99{,}0\ mm^2$$

$$N_{an1} = Fs \cdot \cos 45 = 20 \cdot 0{,}7071 = 14{,}142kN$$

$$Q_{an1} = Fs \cdot \cos 45 = 20 \cdot 0{,}7071 = 14{,}142kN$$

$Fs = 20kN$ - maximum acceptable for TF20x250

φ = 0,49 for anchor's bar diameter *d* = 14 *mm*

$R_s = 0{,}435 kN/mm^2$ for steel A500

$$\varphi_1 = \frac{1}{\sqrt{1+\omega}} = \frac{1}{\sqrt{1+0{,}6}} = 0{,}7906$$

$$\omega = 0{,}6\frac{N}{Q_{tot}} = 0{,}6\frac{14{,}142}{14{,}142} = 0{,}6$$

The actual cross section area is $A = 153{,}86\ mm^2 > A_{an1} = 99{,}0\ mm^2$

The necessary anchorage length is:

$$l_{an} = \varphi_c\left(\omega_{an}\frac{R_s}{R_b} + \Delta\lambda_{an}\right)d = 0{,}85\cdot\left(0{,}7\frac{349}{14{,}2} + 11\right)\cdot 14 = 335\ mm$$

ω_{an} =0,7; $\Delta\lambda_{an}$ =11 - according to table 6.1 ($\sigma_{bc} = 0$ - taken for safety margin)

$$\varphi_c = [0{,}3/(1 + Q_{an1}/N_{an1})] + 0{,}7 = [0{,}3/(1 + 14{,}142/14{,}142)] + 0{,}7 = 0{,}85$$

$R_b = 14{,}2 N/mm^2$ for concrete B25 (C20/25)

$R_s \times \frac{d_{calc}}{d} = R_s \times \sqrt{\frac{A_{an1}}{A_{actual}}} = 435 \times \sqrt{\frac{99}{153{,}86}} = 349\ kN/mm^2$ - reduced as mentioned in chapter 6.2.

The actual anchorage length is $l_{an\ fact} = 250\ mm < l_{an} = 335\ mm$

Anchorage length could be reduced because of the forged head. The diameter of the head D_1 should be at least 2 diameters of the anchor rebar d_s:

$$\frac{D_1}{d_s} = \frac{42}{14} = 3$$

In that case the anchorage length is determined by cocnrete cone breakout calculations.

Permissible force in case of concrete breakout:

$$N = \varphi_2\varphi_3 A_1 R_{bt} = 0{,}5\cdot 1\cdot(3{,}14\cdot 271^2)\cdot 1{,}19 = 137{,}21\ kN$$

φ_2 = 0,5 - for normal concrete

φ_3 = 1 (compression forcess are not taken into account - for safety margin)

R_{bt} =1,19 N/mm^2 for concrete B25 (C20/25)

Permissible force is 137,21 *kN* > N_{an1} = 14,142 *kN*

Also, anchorage length should be at least 10*d* of the reinforcement bar:

$l_{an\ fact} = 250\ mm$ > $10d = 10 \times 14 = 140\ mm$

Check for of local crushing:

$\varphi_b = 13{,}5\frac{R_{bt}}{R_b} = 13{,}5\frac{1{,}19}{14{,}2} = 1{,}13$ for concrete class B25.

$$\beta_b = \sqrt[3]{\frac{A_{loc2}}{A_{loc1}}} = \sqrt[3]{\frac{((3{,}14 \cdot 21^2) - (3{,}14 \cdot 7^2))}{3{,}14 \cdot 63^2}} = \sqrt[3]{\frac{(1384{,}74 - 153{,}86)}{12462{,}66}} = 0{,}462$$

l_a = 215 *mm* > 15*d* = 15x14 = 210 *mm*

$N_{loc} = N_{an1}$ = 14,142 *kN* (for anchors with $l_a \geq 15d$)

$$N_{loc} = 14{,}142\ kN < \varphi_b \beta_b R_b A_{loc1} = 1{,}13 \cdot 0{,}462 \cdot 14{,}2 \cdot 12462{,}66 = 92{,}4\ kN$$

Calculations for other TF anchors are made in the same way with Microsoft Excel. Tables with calculations can be found in Appendix 5. The results are given below in table 6.8-6.10:

Table 6.8 Results of calculation of necessary cross section area for TF anchors

Anchor*	A_{an1} [mm]	Actual cross section area [mm]
TF12x100	21,761	50,24
TF12x150	21,761	50,24
TF14x105	36,433	78,50
TF14x155	36,433	78,50
TF16x130	56,433	113,04

TF16x175	56,433	113,04
TF18x150	79,201	153,86
TF18x225	79,201	153,86
TF20x185	99,002	153,86
TF20x250	99,002	153,86
TF24x200	128,343	200,96
TF24x275	128,343	200,96
TF30x275	231,963	314,00
TF30x350	231,963	314,00
TF36x335	422,416	490,63
TF36x450	422,416	490,63

*For anchors TF42x385 - TF52x700 this type of calculation is not possible because of the absence of value for φ coefficent for anchor rebar's diameter more than 25 mm.

Table 6.9 Results of calculations of anchorage length and concrete breakout cone for TF anchors

Anchor	**Anchorage length***		**Concrete breakout cone**	
	l_{an} **[mm]** (necessary anchorage length)	$l_{an\ fact}$ **[mm]** (actual anchorage length)	**N [kN]** (minimum value for concrete breakout cone)	N_{an1} **[kN]** (actually acting force)
TF12x100	171	100	23,43596	3,535534
TF12x150	171	150	49,03167	3,535534
TF14x105	218	105	26,90352	5,656854
TF14x155	218	155	53,99387	5,656854
TF16x130	267	130	40,92324	8,485281
TF16x175	267	175	69,59231	8,485281
TF18x150	314	150	54,63096	11,31371
TF18x225	314	225	113,062	11,31371
TF20x185	336	185	79,28318	14,14214
TF20x250	336	250	137,2098	14,14214
TF24x200	383	200	93,74382	17,67767
TF24x275	383	275	167,0279	17,67767
TF30x275	500	275	173,7986	28,28427
TF30x350	500	350	269,7825	28,28427
TF36x335	657	335	259,2383	44,54773
TF36x450	657	450	444,0132	44,54773
TF42x385	772	385	340,6453	56,56854
TF42x500	772	500	548,8393	56,56854
TF52x550	882	550	668,1116	88,38835
TF52x700	882	700	1045,321	88,38835

*As mentioned in chapter 5.2 anchorage length could be reduced by making strengthening at the end of the anchor, in that case availability of usage is defined by concrete breakout cone calculations and calculations for local crushing.

Table 6.10 Results of calculations of local concrete failure for TF anchors

Anchor	l_{an} **[mm]** (necessary anchorage length)	$l_{an\ fact}$ **[mm]** (actual anchorage length)
TF12x100	5,020	30,219
TF12x150	3,536	30,219
TF14x105	9,428	47,218
TF14x155	6,387	47,218
TF16x130	13,511	67,993
TF16x175	10,037	67,993
TF18x150	18,404	92,546
TF18x225	12,269	92,546
TF20x185	18,729	92,546
TF20x250	14,142	92,546
TF24x200	25,014	120,877
TF24x275	18,192	120,877
TF30x275	36,615	188,870
TF30x350	28,769	188,870
TF36x335	58,909	295,110
TF36x450	44,548	295,110
TF42x385	73,466	370,186
TF42x500	56,569	370,186
TF52x550	93,210	483,508
TF52x700	88,388	483,508

6.3.4.2 Lifting force acting the anchor along the anchor's axis (N max)

The force application is the same as shown in figure 5.6. Calculation principles are the same as for force application angle of 45º. Full calculation tables can be found in Appendix 5. The results of calculations are given in tables 5.11 – 5.13

Table 6.11 Results of calculation of necessary cross section area for TF anchors (maximum normal force)

Anchor*	A_{an1} [mm]	Actual cross section area [mm]
TF12x100	12,644	50,24
TF12x150	12,644	50,24
TF14x105	20,230	78,50
TF14x155	20,230	78,50
TF16x130	30,345	113,04
TF16x175	30,345	113,04
TF18x150	40,460	153,86
TF18x225	40,460	153,86
TF20x185	50,575	153,86
TF20x250	50,575	153,86
TF24x200	63,218	200,96
TF24x275	63,218	200,96
TF30x275	101,149	314,00
TF30x350	101,149	314,00
TF36x335	159,310	490,63
TF36x450	159,310	490,63

*For anchors TF42x385 - TF52x700 this type of calculation is not possible because of the absence of value for φ coefficent for anchor rebar's diameter more than 25 mm.

Table 6.12 Results of calculations of anchorage length and concrete breakout cone for TF anchors (maximum normal force)

Anchor	Anchorage length*		Concrete breakout cone	
	l_{an} [mm] (necessary anchorage length)	$l_{an\ fact}$ [mm] (actual anchorage length)	N [mm] (minimum value for concrete breakout cone)	N_{an1} [mm] (actually acting force)
TF12x100	174	100	23,436	5,000
TF12x150	174	150	49,032	5,000
TF14x105	219	105	26,904	8,000
TF14x155	219	155	53,994	8,000
TF16x130	265	130	40,923	12,000
TF16x175	265	175	69,592	12,000
TF18x150	308	150	54,631	16,000
TF18x225	308	225	113,062	16,000
TF20x185	326	185	79,283	20,000

TF20x250	326	250	137,210	20,000
TF24x200	368	200	93,744	25,000
TF24x275	368	275	167,028	25,000
TF30x275	463	275	173,799	40,000
TF30x350	463	350	269,783	40,000
TF36x335	580	335	259,238	63,000
TF36x450	580	450	444,013	63,000
TF42x385	908	385	340,645	80,000
TF42x500	908	500	548,839	80,000
TF52x550	1038	550	668,112	125,000
TF52x700	1038	700	1045,321	125,000

*As mentioned in chapter 6.2 anchorage length could be reduced by making strengthening at the end of the anchor, in that case the availability of usage is defined by concrete breakout cone calculations and calculations for local crushing.

Table 6.13 Results of calculations of local concrete failure for TF anchors (maximum normal force)

Anchor	**N** (permissible force)	**N$_{loc}$** (actual force)
TF12x100	30,219	5,000
TF12x150	30,219	5,000
TF14x105	47,218	8,000
TF14x155	47,218	8,000
TF16x130	67,993	12,000
TF16x175	67,993	12,000
TF18x150	92,546	16,000
TF18x225	92,546	16,000
TF20x185	92,546	20,000
TF20x250	92,546	20,000
TF24x200	120,877	25,000
TF24x275	120,877	25,000
TF30x275	188,870	40,000
TF30x350	188,870	40,000
TF36x335	295,110	63,000
TF36x450	295,110	63,000
TF42x385	370,186	80,000
TF42x500	370,186	80,000
TF52x550	483,508	125,000

7 CONCLUSIONS

Anchors with two different types of anchors rebar's construction were calculated according to "Recommendations for design of embedded steel details for reinforced concrete structures, M., Stroyizdat, 1984". Main points are distinguished below.

Comparing to European specification of Jenka:
Anchor's actual cross section area satisfies the values received by calculations. Safety margin for length is 30 - 80 mm^2 (depends on the length of the anchor) for length of the anchors without strengthening at the end. Safety margin for anchors with strengthening: 20 – 70 mm^2.

Anchor's actual anchorage length satisfies the values received by calculations. Safety margin is 30 - 80 mm (depends on the length of the anchor) for length of the anchors without strengthening at the end. Length of the anchors with strengthening at the end is not enough for necessary bonding forces between concrete and anchorage bar. In that case anchors are checked for concrete cone breakout and local failure near the strengthenings.

Anchors with strengthenings at the end passed the calculations for concrete cone breakout and local failure near the strengthenings. Safety margin for length is 20 – 400 mm (increases with increasing of the anchors size). Anchors without strengthening also passed the concrete cone breakout calculation with load safety margin 14 - 210 kN (increases with increasing of the anchors size).

Results written above are received for force application shown in figure 6.5 (angle load). For straight pull (figure 6.6) received safety margin is much higher.

It has to be noticed, that results are received for concrete class B25 (C20/25) and design values of concrete strength R_b = 14,2 N/mm^2, R_{bt} = 1,19 N/mm^2 (safety factor 1,3). For lower concrete characteristics recalculation should be provided. If less design values are taken for calculations, it is expected, that

SRA anchors will not pass the Russian normative limitations (because of the bonding strength calculation) - laboratory tests will be necessary in that case to get approval. Also expected, that anchors with strengthening at the end will satisfy the limitations due to predominant choice of anchorage length by concrete cone breakout calculation for such type of anchors.

Calculations of wavy tail anchors are not included in this work because there is nothing even a little bit similar in Russian normative documentation. Even a character of work of these anchors in construction is not described in available literature. Approval of this type of anchors will be based on laboratory tests.

Received methods of calculations (chapter 6) together with future laboratory test results will be used for design part of Russian approval. Method of choosing the necessary anchors will be also included in design part (chapter 5). Information about main types, dimension, way of production and materials (chapter 4) will be included in specification part of approval. Recommendations for usage of TLL lifting loops were prepared together with work on this Thesis. These recommendations were sent to customer and now are in use.

Main goals of this thesis work are fully achieved and the main result is a presence of a full base of material necessary for preparation of Russian Technical Approval. Further work for getting approval will be provided in summer 2011.

FIGURES

TABLES

REFERENCES

PrCEN/TR 15728. 2007. Lifting and Design and Use of Inserts for Lifting and Handling of Precast Concrete elements.

Recommendations for design of embedded steel details for reinforced concrete structures. 1984. Moscow: Stroyizdat.

Guide for design of concrete and reinforced concrete structures made from normal concrete (without prestressing). 1977. Moscow.

Peikko Jenka Brochure. 2011.

Baikov V.N., Sigalov E.E. 1978. Reinforced Concrete Structures. Common course. Moscow: Stroyizdat.

ISO 4309. 2008. Cranes - Wire ropes - Care, maintenance, installation, examination and discard.

Peikko production drawings for Jenka components, 2011.

DIN EN 12385-4. Steel wire ropes - Safety - Part 4: Stranded ropes for general lifting applications. 2003.

ADDITIONAL SOURCES

Reinforcing of elements of cast-in-situ concrete buildings. http://files.stroyinf.ru/Data1/51/51394/index.htm (Accessed on 8 May 2011)

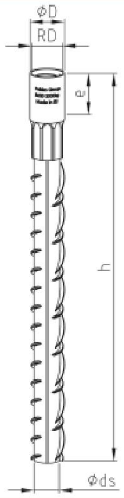
GOST 3070-88 Steel double lay rope construction type TK 6x19 (1+6+12)+1 axes. http://www.kanaty.metizka.ru/products/kanat-dvoinoi-svivki-tipa-tk-konstrukcii-6x19-1-6-12-1-o-s-gost-3070-88 (Accessed 31 March 2011)

Wear of coils of threaded connections. http://vak.ed.gov.ru/common/img/uploaded/files/vak/announcements/techn/14-04-2008/ProkofevAN.doc (Accessed 4 April 2011)

Standard types and dimensions of Jenka components

1 Jenka anchors

Table 1.1 SRA anchors

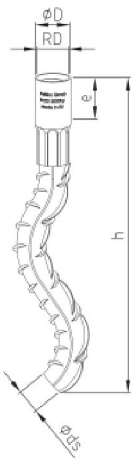


Article Nr.	Type	Dimensions ØD	h	e	Øds	Load Capacity	Fs *	Fq *
	RD	[mm]	[mm]	[mm]	[mm]	[kg]	[kN]	[kN]
SRA12x195	12	15,0	195	22	8	500	5	2,5
SRA14x235	14	18,0	235	25	10	800	8	4,0
SRA16x275	16	21,0	275	27	12	1200	12	6,0
SRA18x305	18	24,0	305	34	14	1600	16	8,0
SRA20x360	20	27,0	360	35	14	2000	20	10,0
SRA24x400	24	31,0	400	43	16	2500	25	12,5
SRA30x505	30	40,0	505	56	20	4000	40	20,0
SRA36x690	36	47,0	690	68	25	6300	63	31,5
SRA42x840	42	54,0	840	80	28	8000	80	40,0
SRA52x950	52	67,0	950	100	32	12500	125	62,5

* Fs= Allowed load force from 0° - 45°
* Fq= Allowed load force at 90°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA SRA-Anchor — Zinc Plated: SRA30x505; Stainless Steel: SRA30x505E

Table 1.2 WAS anchors

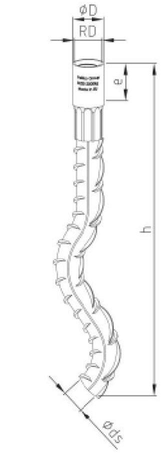


Article Nr.	Type	Dimensions ØD	h	e	Øds	Load Capacity	Fs *
	RD	[mm]	[mm]	[mm]	[mm]	[kg]	[kN]
WAS12x105	12	15,0	105	22	8	500	5
WAS14x130	14	18,0	130	25	10	800	8
WAS16x165	16	21,0	165	27	12	1200	12
WAS18x175	18	24,0	175	34	14	1600	16
WAS20x195	20	27,0	195	35	14	2000	20
WAS24x240	24	31,0	240	43	16	2500	25
WAS30x300	30	40,0	300	56	20	4000	40
WAS36x380	36	47,0	380	68	25	6300	63
WAS42x450	42	54,0	450	80	28	8000	80

* Fs= Allowed load force from 0° - 45°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA WAS-Anchor — Zinc Plated: WAS30x300; Stainless Steel: WAS30x300E

Table 1.3 WAL anchors

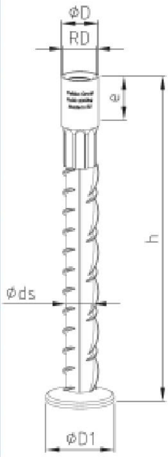


Article Nr.	Type RD	Dimensions ØD [mm]	h [mm]	e [mm]	Øds [mm]	Load Capacity [kg]	Fs * [kN]	Fq * [kN]
WAL12x135	12	15,0	135	22	8	500	5	2,5
WAL14x170	14	18,0	170	25	10	800	8	4,0
WAL16x215	16	21,0	215	27	12	1200	12	6,0
WAL18x235	18	24,0	235	34	14	1600	16	8,0
WAL20x270	20	27,0	270	35	14	2000	20	10,0
WAL24x350	24	31,0	350	43	16	2500	25	12,5
WAL30x450	30	40,0	450	56	20	4000	40	20,0
WAL36x570	36	47,0	570	68	25	6300	63	31,5
WAL42x620	42	54,0	620	80	28	8000	80	40,0
WAL52x880	52	67,0	880	100	32	12500	125	62,5

* Fs= Allowed load force from 0° - 45°
* Fq= Allowed load force at 90°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA WAL-Anchor — Zinc Plated: WAL30x450; Stainless Steel: WAL30x450E

Table 1.4 TF anchors

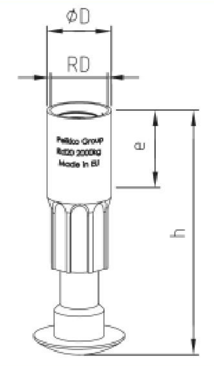


Article Nr.	Type RD	Dimensions ØD [mm]	h [mm]	e [mm]	Øds [mm]	ØD1 [mm]	Load Capacity [kg]	Fs * [kN]	Fq * [kN]
TF12x100	12	15,0	100	22	8	24	500	5	2,5
TF12x150	12	15,0	150	22	8	24	500	5	2,5
TF14x105	14	18,0	105	25	10	30	800	8	4,0
TF14x155	14	18,0	155	25	10	30	800	8	4,0
TF16x130	16	21,0	130	27	12	36	1200	12	6,0
TF16x175	16	21,0	175	27	12	36	1200	12	6,0
TF18x150	18	24,0	150	34	14	42	1600	16	8,0
TF18x225	18	24,0	225	34	14	42	1600	16	8,0
TF20x185	20	27,0	185	35	14	42	2000	20	10,0
TF20x250	20	27,0	250	35	14	42	2000	20	10,0
TF24x200	24	31,0	200	43	16	48	2500	25	12,5
TF24x275	24	31,0	275	43	16	48	2500	25	12,5
TF30x275	30	40,0	275	56	20	60	4000	40	20,0
TF30x350	30	40,0	350	56	20	60	4000	40	20,0
TF36x335	36	47,0	335	68	25	75	6300	63	31,5
TF36x450	36	47,0	450	68	25	75	6300	63	31,5
TF42x385	42	54,0	385	80	28	84	8000	80	40,0
TF42x500	42	54,0	500	80	28	84	8000	80	40,0
TF52x550	52	67,0	550	100	32	96	12500	125	62,5
TF52x700	52	67,0	700	100	32	96	12500	125	62,5

* Fs= Allowed load force from 0° - 45°
* Fq= Allowed load force at 90°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA TF-Anchor — Zinc Plated: TF30x350; Stainless Steel: TF30x350E

Table 1.5 BSA anchors

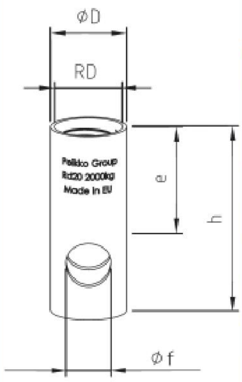


Article Nr.	Type RD	Dimensions ØD [mm]	h [mm]	e [mm]	Load Capacity [kg]	Fs * [kN]
BSA12x60	12	15,0	60	22	500	5
BSA14x70	14	18,0	70	25	800	8
BSA16x80	16	21,0	80	27	1200	12
BSA18x90	18	24,0	90	34	1600	16
BSA20x100	20	27,0	100	35	2000	20
BSA24x115	24	31,0	115	43	2500	25
BSA30x150	30	40,0	150	56	4000	40

* Fs= Allowed load force from 0° - 45°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA BSA-Anchor Zinc Plated: BSA30x150
Stainless Steel: BSA30x150E

Table 1.6 CSA anchors

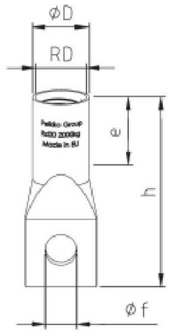


Article Nr.	Type RD	Dimensions ØD [mm]	h [mm]	e [mm]	Øf [mm]	Load Capacity [kg]	Fs * [kN]	Fq * [kN]
CSA12x40	12	15,0	40	22	8,0	500	5	2,5
CSA14x47	14	18,0	47	25	10,5	800	8	4,0
CSA16x54	16	21,0	54	27	13,0	1200	12	6,0
CSA18x65	18	24,0	65	34	13,0	1600	16	8,0
CSA20x67	20	27,0	67	35	15,5	2000	20	10,0
CSA24x77	24	31,0	77	43	18,0	2500	25	12,5
CSA30x105	30	40,0	105	56	22,5	4000	40	20,0
CSA36x125	36	47,0	125	68	27,5	6300	63	31,5
CSA42x145	42	54,0	145	80	32,0	8000	80	40,0
CSA52x195	52	67,0	195	100	40,0	12500	125	62,5

* Fs= Allowed load force from 0° - 45°
* Fq= Allowed load force at 90°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA CSA-Anchor Zinc Plated: CSA30x105
Stainless Steel: CSA30x105E

Table 1.7 ESA anchors

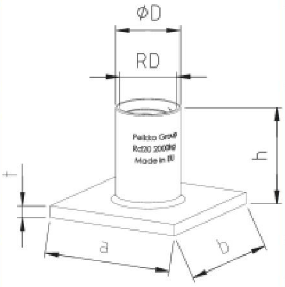


Article Nr.	Type RD	Dimensions ØD [mm]	h [mm]	e [mm]	Øf [mm]	Load Capacity [kg]	Fs * [kN]	Fq * [kN]
ESA12x60	12	15,0	60	22	8,0	500	5	2,5
ESA14x70	14	18,0	70	25	10,5	800	8	4,0
ESA16x77	16	21,0	77	27	13,0	1200	12	6,0
ESA18x85	18	24,0	85	34	13,0	1600	16	8,0
ESA20x92	20	27,0	92	35	15,5	2000	20	10,0
ESA24x105	24	31,0	105	43	18,0	2500	25	12,5

* Fs= Allowed load force from 0° - 45°
* Fq= Allowed load force at 90°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA ESA-Anchor	Zinc Plated:	ESA24x105
	Stainless Steel:	ESA24x105E

Table 1.8 PSA anchors



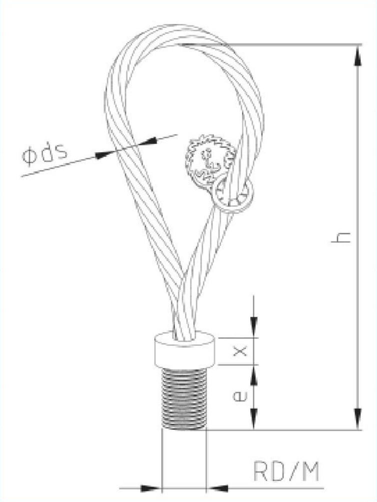
Article Nr.	Type RD	Dimensions ØD [mm]	h [mm]	a [mm]	b [mm]	t [mm]	Load Capacity [kg]	Fs * [kN]
PSA12x30	12	15,0	30	35	25	4	500	5
PSA14x33	14	18,0	33	35	35	4	800	8
PSA16x35	16	21,0	35	50	35	4	1200	12
PSA18x44	18	24,0	44	60	45	5	1600	16
PSA20x47	20	27,0	47	60	60	5	2000	20
PSA24x54	24	31,0	54	80	60	5	2500	25
PSA30x72	30	40,0	72	100	80	6	4000	40
PSA36x84	36	47,0	84	130	100	6	6300	63
PSA42x98	42	54,0	98	130	130	8	8000	80
PSA52x117	52	67,0	117	150	130	10	12500	125

* Fs= Allowed load force from 0° - 45°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA PSA-Anchor	Zinc Plated:	PSA30x72
	Stainless Steel:	PSA30x72E

2 Jenka lifting devices

Table 1.9 TLL lifting loop

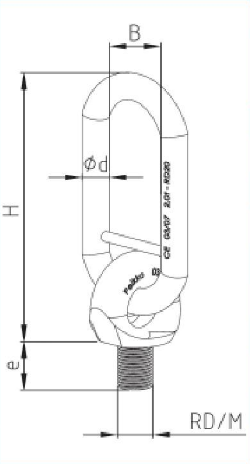


Article Nr.	Type RD or M	Dimensions h [mm]	e [mm]	Load Capacity [kg]	Fs * [kN]
TLL12	12	155	22	500	5
TLL14	14	155	25	800	8
TLL16	16	165	27	1200	12
TLL18	18	190	34	1600	16
TLL20	20	215	35	2000	20
TLL24	24	255	43	2500	25
TLL30	30	300	55	4000	40
TLL36	36	360	67	6300	63
TLL42	42	425	75	8000	80
TLL52	52	530	95	12500	125

* Fs= Allowed load force from 0° - 45°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA TLL — Round Thread: TLL30; Metric Thread: TLL30M

Table 1.10 JL lifting device



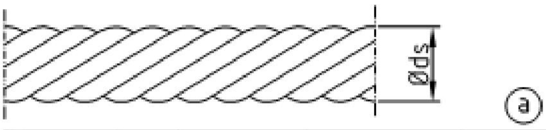
Article Nr.	Type R or M	Dimensions B [mm]	H [mm]	e [mm]	Ød [mm]	Load Capacity [kg]	Fs * [kN]	Fq * [kN]
JL12	12	50	150	19	13	500	5	2,5
JL14	14	50	150	21	13	800	8	4,0
JL16	16	50	150	24	13	1200	12	6,0
JL18	18	50	162	27	16	1600	16	8,0
JL20	20	50	162	29	16	2000	20	10,0
JL24	24	50	162	35	16	2500	25	12,5
JL30	30	50	177	43	22	4000	40	20,0
JL36	36	50	177	52	22	6300	63	31,5
JL42	42	65	218	60	26	8000	80	40,0
JL52	52	65	218	73	26	12500	125	62,5

* Fs= Allowed load force from 0° - 45°
* Fq= Allowed load force at 90°
(Note: A load force for a mass of 1 ton demands a force of approximately 10 kN)

Example for ordering Peikko JENKA Lifter — Round Thread: JL30; Metric Thread: JL30M

Table 1.11 Rope parameters for TLL

req. F= minimum breaking load of the loop
req. MBL= Mindestbruchlast Seil/ minimum breaking load rope



Type M/RD	Øds	rope acc. DIN EN	rope grade [N/mm²]	rope con-struction	req. MBL [kN]	req. F [kN]
M/RD12	6	12385-4	1770	6x19SE	14,72	25
M/RD14	7	12385-4	1770	6x19SE	23,54	40
M/RD16	8	12385-4	1770	6x19SE	35,32	60
M/RD18	9	12385-4	1770	6x19SE	44,15	80
M/RD20	10	12385-4	1770	6x19SE	58,86	100
M/RD24	12	12385-4	1770	6x19SE	73,58	125
M/RD30	15	12385-4	1770	6x36SE	117,72	200
M/RD36	18	12385-4	1770	6x36SE	185,41	315
M/RD42	20	12385-4	1770	6x36SE	235,44	400
M/RD52	26	12385-4	1770	6x36SE	367,88	625

Edge and axial distances, element thickness

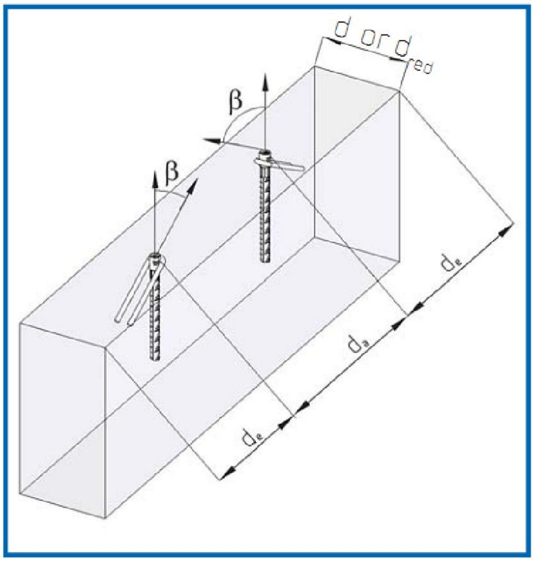


Figure 2.1 Edge and axial distances, element thickness

Table 2.1: Edge and axial distances, element thicknesses permissible for usage of SRA, WAL, TF, CSA and ESA in panels and beams

Size	d_a [mm]	d_e [mm]	d [mm]	d_{red}* [mm]
RD12	300	150	60	60
RD14	400	200	60	60
RD16	400	200	80	65
RD18	500	250	100	80
RD20	550	275	100	90
RD24	600	300	120	100
RD30	650	325	140	120
RD36	800	400	200	150
RD42	1000	500	240	160
RD52	1200	600	275	180

** only for SRA in angular pull angle ß of 12.5° to a max of 30°*

Table 2.2: Edge and axial distances, element thicknesses permissible for usage of WAS in slabs

Size	d_a [mm]	d_e [mm]	d [mm]
RD12	200	95	140
RD14	200	115	160
RD16	260	135	195
RD18	300	155	205
RD20	350	170	215
RD24	440	220	270
RD30	550	275	390
RD36	600	300	410
RD42	800	400	480

Table 2.3: Edge and axial distances, element thicknesses permissible for usage of BSA in slabs

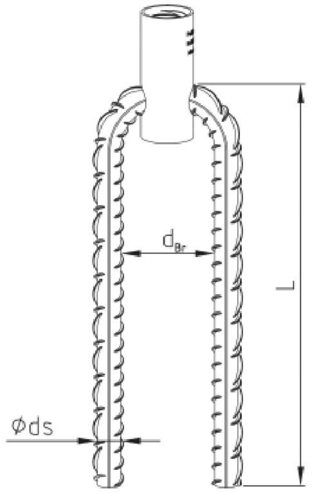
Size	d_a [mm]	d_e [mm]	d [mm]
RD12	360	180	80
RD14	420	210	90
RD16	180	240	100
RD18	540	270	110
RD20	600	300	120
RD24	690	345	135
RD30	900	450	170

Table 2.4 Edge and axial distances, element thicknesses permissible for usage of PSA in slabs

Size	d_a [mm]	d_e [mm]	d [mm]
RD12	350	180	70
RD14	350	180	80
RD16	500	250	85
RD18	600	300	95
RD20	600	300	100
RD24	800	400	115
RD30	1000	500	140
RD36	1300	650	160
RD42	1300	650	175
RD52	1500	750	215

Minimal reinforcement

Table 3.1 Minimum reinforcement for walls and beams valid for SRA, WAL, WAS, TF, CSA, and ESA



Size	Minimum mesh reinforcement [mm²/m]	BS 8666:2005	Reinforcement stirrups for CSA and ESA Øds [mm]	L [cm]	d_{Br} [mm]	Total length [cm]
RD12	131	A142	6	24	24	49
RD14	131	A142	8	28	32	57
RD16	131	A142	10	33	40	67
RD18	188	A193	10	42	40	85
RD20	188	A193	12	44	48	89
RD24	188	A193	14	48	56	97
RD30	188	A193	16	65	64	132
RD36	188	A193	20	82	140	167
RD42	188	A193	25	86	175	175
RD52	188	A193	28	120	196	244

Table 3.2: Minimum reinforcement of slabs valid for PSA

Size	Minimum mesh reinforcement [mm²/m]	BS 8666:2005	Basic reinforcement number [Pc.]	Øds [mm]	L [mm]	a [mm]	b [mm]
RD12	131	A142	2	6	250	60	60
RD14	131	A142	2	6	360	60	70
RD16	131	A142	2	8	420	90	70
RD18	188	A193	2	8	530	90	80
RD20	188	A193	2	8	640	90	80
RD24	188	A193	2	10	640	90	100
RD30	221	A252	2	12	830	90	110
RD36	221	A252	2	14	1140	140	120
RD42	513		2	16	1250	140	120
RD52	513		2	20	1530	140	150

Table 3.3 Angular pull reinforcement valid for all Peikko Jenka anchors

Size	For Component width d 12,5° ≤ β ≤ 45°			For Component width d or. dred 12,5° ≤ β ≤ 30°		
	Øds [mm]	L [mm]	d_{Br} [mm]	Øds [mm]	L [mm]	d_{Br} [mm]
RD12	6	150	24	6	150	24
RD14	6	200	24	6	200	24
RD16	8	200	32	6	250	24
RD18	8	250	32	8	200	32
RD20	8	300	32	8	250	32
RD24	10	300	40	8	300	32
RD30	12	400	48	10	350	40
RD36	14	550	56	12	450	48
RD42	16	600	64	14	600	56
RD52	20	750	140	16	700	64

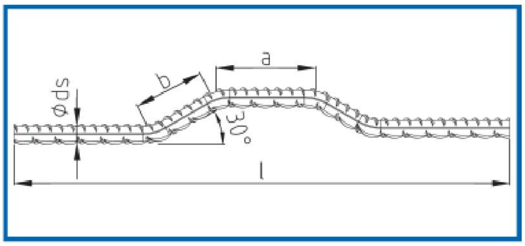


Figure 3.1 Reinforcement stirrups

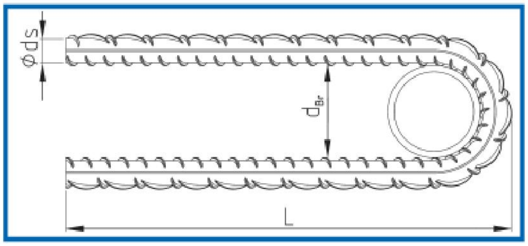


Figure 3.2 Reinforcement for angular pull

Size	$Ød_{s1}$ [mm]	L [mm]	h [mm]	H [mm]	d_{Br} [mm]	B [mm]	$Ød_{s2}$ [mm]
RD12	6	270	23	35	24	280	8
RD14	6	350	28	42	24	350	12
RD16	8	420	33	49	32	400	12
RD18	8	460	39	55	32	450	12
RD20	10	490	44	64	40	490	14
RD24	12	520	51	75	48	550	14
RD30	12	570	68	92	48	580	16
RD36	14	690	90	118	56	700	16
RD42	16	830	111	143	64	850	20
RD52	20	930	134	174	140	1000	20

Table 3.4 Reinforcement for lateral pull

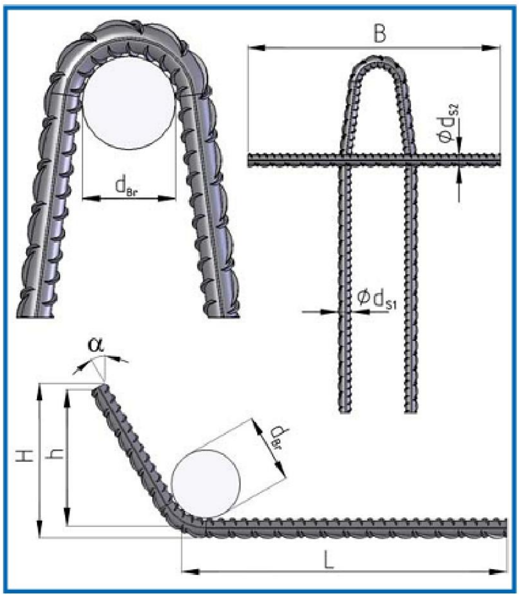


Figure 3.3 Reinforcement for lateral pull

Wear & tear parameters of Jenka lifting devices.

1 Jenka JL

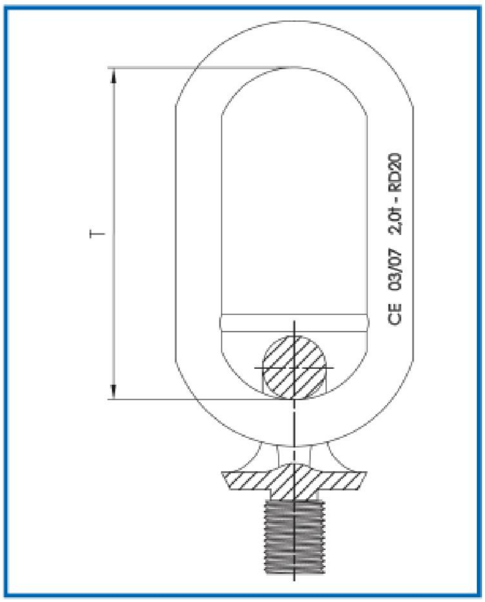


Figure 4.1 Deformation of chain link

Table 4.1 Wear & tear of chain link

Type	T [mm]	T_{max} = 1,05 x T [mm]	Ød [mm]	$Ød_{min}$ = 0,9 x Ød [mm]
RD/M12	115	121	13	11,7
RD/M14	115	121	13	11,7
RD/M16	115	121	13	11,7
RD/M18	115	121	16	14,4
RD/M20	115	121	16	14,4
RD/M24	115	121	16	14,4
RD/M30	115	121	22	19,8
RD/M36	115	121	22	19,8
RD/M42	139	146	26	23,4
RD/M52	139	146	26	23,4

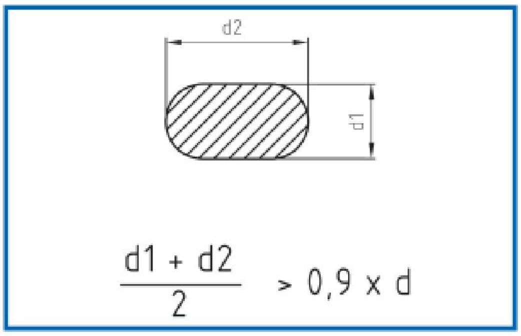


Figure 4.2 Average link thickness

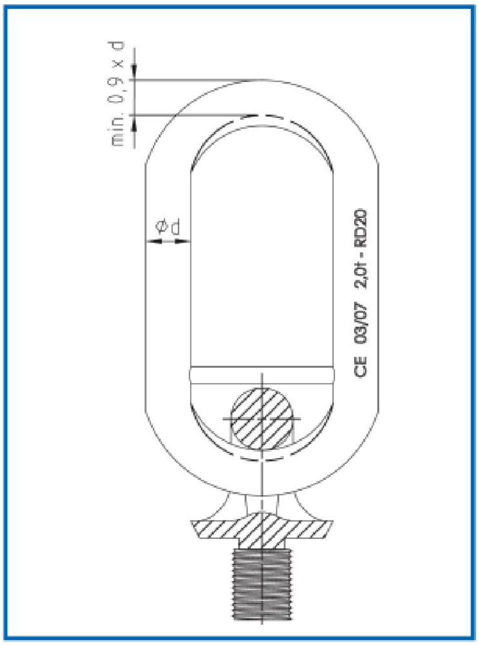


Figure 4.3 Wear & tear of drop point

2 Jenka TLL (rope damages)

Figure 4.4 Wire protrusion

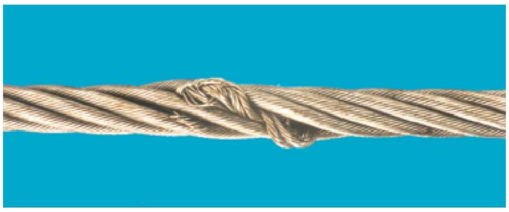


Figure 4.5 Core protrusion — Single-layer rope

Figure 4.6 Local reduction in rope diameter (sunken strand)

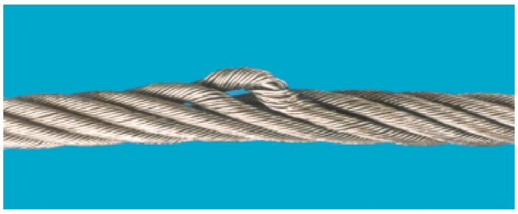


Figure 4.7 Strand protrusion/distortion

Figure 4.8 Flattened portion

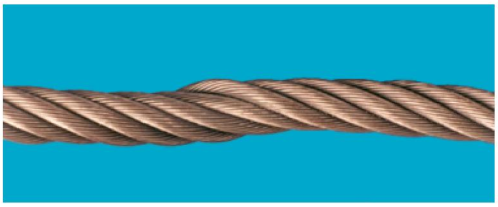


Figure 4.9 Kink (positive)

Figure 4.10 Kink (negative)

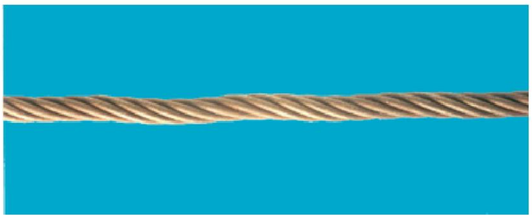


Figure 4.11 Waviness

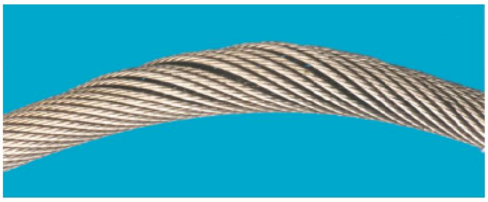


Figure 4.12 Basket deformation

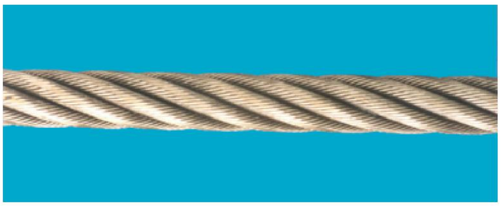


Figure 4.13 External wear

Figure 4.14 Enlargement of Figure 4.13

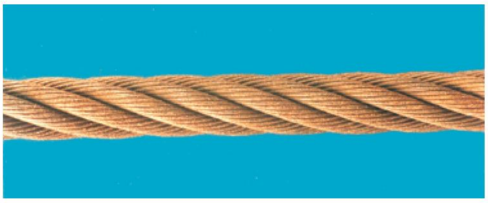


Figure 4.15 External corrosion

Figure 4.16 Enlargement of Figure 4.15

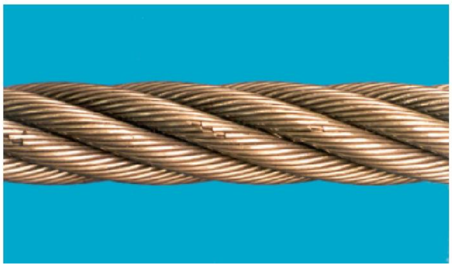


Figure 4.17 Crown wire breaks

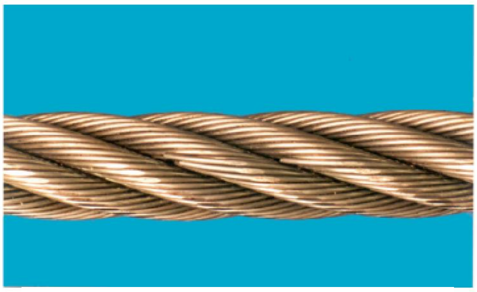


Figure 4.18 Valley wire breaks

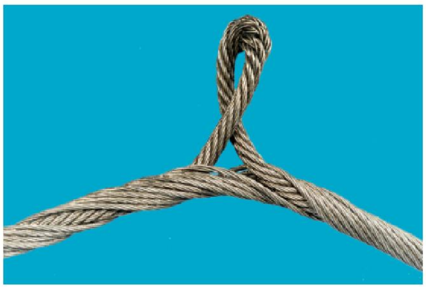


Figure 4.19 Protrusion of inner rope of rotation-resistant

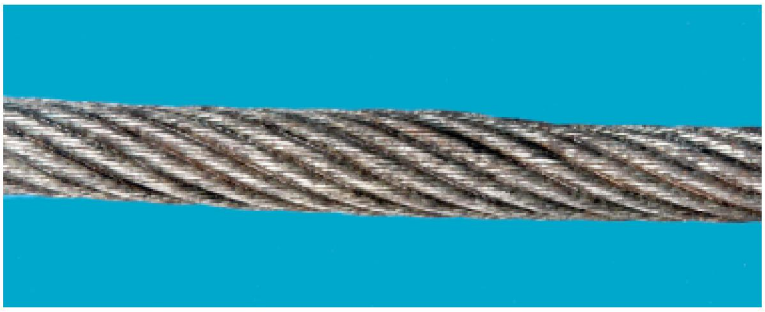


Figure 4.20 Local increase in rope diameter due to core distortion

Figure 4.21 Flattened portion

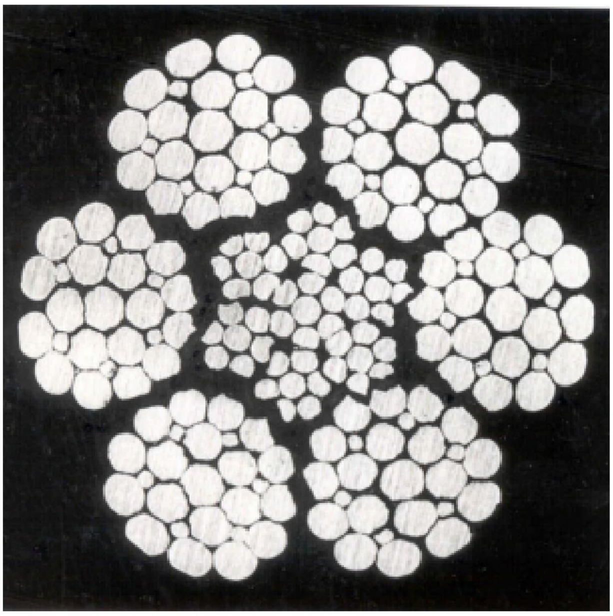
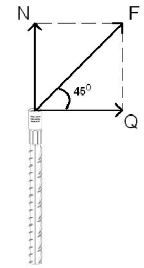


Figure 4.22 Internal corrosion

Excel calculations of the anchors

1 SRA anchors, angular load application

Anchor characteristics										
Anchor	**Type RD**	**D [mm]**	**h [mm]**	**e [mm]**	**d_S [mm]**	**Load capacity [kg]**	**Fs [kN]**	**Fq [kN]**	**N_{an1} [kN]**	**Q_{an2} [kN]**
SRA12x195	12	15	195	22	8	500	5	2,5	3,536	3,536
SRA14x235	14	18	235	25	10	800	8	4	5,657	5,657
SRA16x275	16	21	275	27	12	1200	12	6	8,485	8,485
SRA18x305	18	24	305	34	14	1600	16	8	11,314	11,314
SRA20x360	20	27	360	35	14	2000	20	10	14,142	14,142
SRA24x400	24	31	400	43	16	2500	25	12,5	17,678	17,678
SRA30x505	30	40	505	56	20	4000	40	20	28,284	28,284
SRA36x690	36	47	690	68	25	6300	63	31,5	44,548	44,548
SRA42x840	42	54	840	80	28	8000	80	40	56,569	56,569
SRA52x950	52	67	950	100	32	12500	125	62,5	88,388	88,388

Anchors cross section calculation

$\omega = 0{,}6 \frac{N}{Q_{tot}}$	$\varphi_1 = \frac{1}{\sqrt{1+\omega}}$	φ	Rs [kN/mm2]	$A_{an1} = \frac{1{,}1\sqrt{N_{an1}^2 + \left(\frac{Q_{an1}}{\varphi\varphi_1}\right)^2}}{R_s}$ $[mm^2]$	Afact $[mm^2]$
0,6	0,7906	0,57	0,435	21,761	50,24
0,6	0,7906	0,54	0,435	36,433	78,50
0,6	0,7906	0,52	0,435	56,433	113,04
0,6	0,7906	0,49	0,435	79,201	153,86
0,6	0,7906	0,49	0,435	99,002	153,86
0,6	0,7906	0,47	0,435	128,343	200,96
0,6	0,7906	0,41	0,435	231,963	314,00
0,6	0,7906	0,35	0,435	422,416	490,63
0,6	0,7906		0,435		615,44
0,6	0,7906		0,435		803,84

Anchorage length calculation

$R_s \times \sqrt{\frac{A_{an1}}{A_{actual}}}$ $[kN]$	R_b	φ_c	ω_{an}	$\Delta\lambda_{an}$	$l_{an} = \varphi_c\left(\omega_{an}\frac{R_s}{R_b} + \Delta\lambda_{an}\right)d$ $[mm]$	$l_{an\ fact}$ $[mm]$
0,286	0,014	0,85	0,7	11	171	195
0,296	0,014	0,85	0,7	11	218	235
0,307	0,014	0,85	0,7	11	267	275
0,312	0,014	0,85	0,7	11	314	305
0,349	0,014	0,85	0,7	11	336	360
0,348	0,014	0,85	0,7	11	383	400
0,374	0,014	0,85	0,7	11	500	505
0,404	0,014	0,85	0,7	11	657	690
0,435	0,014	0,85	0,7	11	772	840
0,435	0,014	0,85	0,7	11	882	950

Anchor	φ_2	φ_3	R_{bt}	l_{an} $[mm]$	l_a $[mm]$	$A_{an,a}$ $[mm^2]$	h $[mm]$	N $[kN]$	N_{fact} $[kN]$
SRA12x195	0,5	1	1,19	195	173	0	195	71,04211	3,536
						50,24	175,5	57,26392	
						50,24	156	47,3722	
						50,24	136,5	38,90133	
						50,24	117	31,85129	
						50,24	97,5	26,2221	
						50,24	78	22,01375	
						50,24	58,5	19,22625	
						50,24	39	17,85958	
						50,24	19,5	17,91376	
						50,24	9,75	18,47366	
SRA14x235	0,5	1	1,19	235	210	0	235	103,1769	5,657
						78,5	211,5	83,3553	
						78,5	188	69,22998	
						78,5	164,5	57,1682	
						78,5	141	47,16996	
						78,5	117,5	39,23525	
						78,5	94	33,36409	
						78,5	70,5	29,55646	
						78,5	47	27,81236	
						78,5	23,5	28,13181	
						78,5	11,75	29,06535	

SRA16x275	0,5	1	1,19	275	248	0	275	141,2902	8,485
						113,04	247,5	114,5345	
						113,04	220	95,43236	
						113,04	192,5	79,15608	
						113,04	165	65,70559	
						113,04	137,5	55,08091	
						113,04	110	47,28203	
						113,04	82,5	42,30896	
						113,04	55	40,16169	
						113,04	27,5	40,84023	
						113,04	13,75	42,23917	
SRA18x305	0,5	1	1,19	305	271	0	305	173,7986	11,314
						153,86	274,5	140,0088	
						153,86	244	117,156	
						153,86	213,5	97,7791	
						153,86	183	81,87819	
						153,86	152,5	69,45325	
						153,86	122	60,50429	
						153,86	91,5	55,0313	
						153,86	61	53,03428	
						153,86	30,5	54,51323	
						153,86	15,25	56,55619	

SRA20x360	0,5	1	1,19	360	325	0	360	242,1317	14,142
						153,86	324	196,3126	
						153,86	288	161,8431	
						153,86	252	132,2163	
						153,86	216	107,432	
						153,86	180	87,49047	
						153,86	144	72,39153	
						153,86	108	62,13523	
						153,86	72	56,72155	
						153,86	36	56,15051	
						153,86	18	57,68098	
SRA24x400	0,5	1	1,19	400	357	0	400	298,928	17,678
						200,96	360	241,476	
						200,96	320	199,4	
						200,96	280	163,3026	
						200,96	240	133,1837	
						200,96	200	109,0434	
						200,96	160	90,88165	
						200,96	120	78,69845	
						200,96	80	72,49381	
						200,96	40	72,26773	
						200,96	20	74,39665	

SRA30x505	0,5	1	1,19	505	449	0	505	476,4632	28,284
						314	454,5	384,4476	
						314	404	317,1078	
						314	353,5	259,2974	
						314	303	211,0161	
						314	252,5	172,2642	
						314	202	143,0415	
						314	151,5	123,3481	
						314	101	113,1839	
						314	50,5	112,549	
						314	25,25	115,805	
SRA36x690	0,5	1	1,19	690	622	0	690	889,4976	44,548
						490,63	621	720,8024	
						490,63	552	590,9302	
						490,63	483	478,848	
						490,63	414	384,5557	
						490,63	345	308,0533	
						490,63	276	249,341	
						490,63	207	208,4185	
						490,63	138	185,2861	
						490,63	69	179,9435	
						490,63	34,5	183,9435	

SRA42x840	0,5	1	1,19	840	760	0	840	1318,272	56,569
						615,44	756	1069,076	
						615,44	672	871,7409	
						615,44	588	700,7716	
						615,44	504	556,1679	
						615,44	420	437,9295	
						615,44	336	346,0566	
						615,44	252	280,5492	
						615,44	168	241,4072	
						615,44	84	228,6307	
						615,44	42	232,1295	
SRA42x840	0,5	1	1,19	950	850	0	950	1686,141	88,388
						803,84	855	1363,934	
						803,84	760	1112,257	
						803,84	665	894,3027	
						803,84	570	710,0714	
						803,84	475	559,563	
						803,84	380	442,7773	
						803,84	285	359,7145	
						803,84	190	310,3745	
						803,84	95	294,7574	
						803,84	47,5	299,5948	

2 SRA anchors, straight load application

Anchor characteristics								
Anchor	**Type RD**	**D [mm]**	**h [mm]**	**e [mm]**	**d_s [mm]**	**Load capacity [kg]**	**Fs [kN]**	**Fq [kN]**
SRA12x195	12	15	195	22	8	500	5	2,5
SRA14x235	14	18	235	25	10	800	8	4
SRA16x275	16	21	275	27	12	1200	12	6
SRA18x305	18	24	305	34	14	1600	16	8
SRA20x360	20	27	360	35	14	2000	20	10
SRA24x400	24	31	400	43	16	2500	25	12,5
SRA30x505	30	40	505	56	20	4000	40	20
SRA36x690	36	47	690	68	25	6300	63	31,5
SRA42x840	42	54	840	80	28	8000	80	40
SRA52x950	52	67	950	100	32	12500	125	62,5

Anchors cross section calculation

N_{an1} [kN]	**Q_{an2} [kN]**				**Rs [kN/mm2]**	$A_{an1} = \frac{1{,}1 \sqrt{N_{an1}^2}}{R_s}$ $[mm^2]$	**A**fact $[mm^2]$
5,000					0,435	12,644	50,24
8,000					0,435	20,230	78,50
12,000					0,435	30,345	113,04
16,000					0,435	40,460	153,86
20,000					0,435	50,575	153,86
25,000					0,435	63,218	200,96
40,000					0,435	101,149	314,00
63,000					0,435	159,310	490,63
80,000					0,435	202,299	615,44
125,000					0,435	316,092	803,84

Anchorage length calculation						
$R_s \times \sqrt{\frac{A_{an1}}{A_{actual}}}$ $[kN]$	R_b	φ_c	ω_{an}	$\Delta\lambda_{an}$	$l_{an} = \varphi_c \left(\omega_{an} \frac{R_s}{R_b} + \Delta\lambda_{an} \right) d$ $[mm]$	$l_{an\ fact}$ $[mm]$
0,218	0,014	1	0,7	11	174	195
0,221	0,014	1	0,7	11	219	235
0,225	0,014	1	0,7	11	265	275
0,223	0,014	1	0,7	11	308	305
0,249	0,014	1	0,7	11	326	360
0,244	0,014	1	0,7	11	368	400
0,247	0,014	1	0,7	11	463	505
0,248	0,014	1	0,7	11	580	690
0,249	0,014	1	0,7	11	652	840
0,273	0,014	1	0,7	11	782	950

Concrete cone breakout									
Anchor	φ_2	φ_3	R_{bt}	l_{an} $[mm]$	l_a $[mm]$	$A_{an,a}$ $[mm^2]$	h $[mm]$	N $[kN]$	N_{fact} $[kN]$
SRA12x195	0,5	1	1,19	195	173	0	195	71,04211	5,000
						50,24	175,5	57,26392	
						50,24	156	47,3722	
						50,24	136,5	38,90133	
						50,24	117	31,85129	
						50,24	97,5	26,2221	
						50,24	78	22,01375	
						50,24	58,5	19,22625	
						50,24	39	17,85958	
						50,24	19,5	17,91376	
						50,24	9,75	18,47366	

SRA14x235	0,5	1	1,19	235	210	0	235	103,1769	8,000
						78,5	211,5	83,3553	
						78,5	188	69,22998	
						78,5	164,5	57,1682	
						78,5	141	47,16996	
						78,5	117,5	39,23525	
						78,5	94	33,36409	
						78,5	70,5	29,55646	
						78,5	47	27,81236	
						78,5	23,5	28,13181	
						78,5	11,75	29,06535	
SRA16x275	0,5	1	1,19	275	248	0	275	141,2902	12,000
						113,04	247,5	114,5345	
						113,04	220	95,43236	
						113,04	192,5	79,15608	
						113,04	165	65,70559	
						113,04	137,5	55,08091	
						113,04	110	47,28203	
						113,04	82,5	42,30896	
						113,04	55	40,16169	
						113,04	27,5	40,84023	
						113,04	13,75	42,23917	

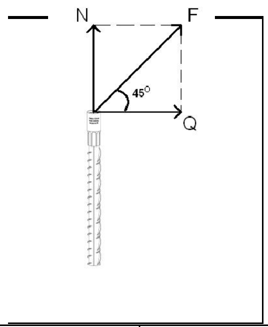
SRA18x305	0,5	1	1,19	305	271	0	305	173,7986	16,000
						153,86	274,5	140,0088	
						153,86	244	117,156	
						153,86	213,5	97,7791	
						153,86	183	81,87819	
						153,86	152,5	69,45325	
						153,86	122	60,50429	
						153,86	91,5	55,0313	
						153,86	61	53,03428	
						153,86	30,5	54,51323	
						153,86	15,25	56,55619	
SRA20x360	0,5	1	1,19	360	325	0	360	242,1317	20,000
						153,86	324	196,3126	
						153,86	288	161,8431	
						153,86	252	132,2163	
						153,86	216	107,432	
						153,86	180	87,49047	
						153,86	144	72,39153	
						153,86	108	62,13523	
						153,86	72	56,72155	
						153,86	36	56,15051	
						153,86	18	57,68098	

SRA24x400	0,5	1	1,19	400	357	0	400	298,928	25,000
						200,96	360	241,476	
						200,96	320	199,4	
						200,96	280	163,3026	
						200,96	240	133,1837	
						200,96	200	109,0434	
						200,96	160	90,88165	
						200,96	120	78,69845	
						200,96	80	72,49381	
						200,96	40	72,26773	
						200,96	20	74,39665	
SRA30x505	0,5	1	1,19	505	449	0	505	476,4632	40,000
						314	454,5	384,4476	
						314	404	317,1078	
						314	353,5	259,2974	
						314	303	211,0161	
						314	252,5	172,2642	
						314	202	143,0415	
						314	151,5	123,3481	
						314	101	113,1839	
						314	50,5	112,549	
						314	25,25	115,805	

SRA36x690	0,5	1	1,19	690	622	0	690	889,4976	63,000
						490,63	621	720,8024	
						490,63	552	590,9302	
						490,63	483	478,848	
						490,63	414	384,5557	
						490,63	345	308,0533	
						490,63	276	249,341	
						490,63	207	208,4185	
						490,63	138	185,2861	
						490,63	69	179,9435	
						490,63	34,5	183,9435	
SRA42x840	0,5	1	1,19	840	760	0	840	1318,272	80,000
						615,44	756	1069,076	
						615,44	672	871,7409	
						615,44	588	700,7716	
						615,44	504	556,1679	
						615,44	420	437,9295	
						615,44	336	346,0566	
						615,44	252	280,5492	
						615,44	168	241,4072	
						615,44	84	228,6307	
						615,44	42	232,1295	

SRA42x840	0,5	1	1,19	950	850	0	950	1686,141	125,000
						803,84	855	1363,934	
						803,84	760	1112,257	
						803,84	665	894,3027	
						803,84	570	710,0714	
						803,84	475	559,563	
						803,84	380	442,7773	
						803,84	285	359,7145	
						803,84	190	310,3745	
						803,84	95	294,7574	
						803,84	47,5	299,5948	

3 TF anchors, angular load application

Anchor characteristics										
Anchor	**Type RD**	**D [mm]**	**h [mm]**	**e [mm]**	**d_S [mm]**	**Load capacity [kg]**	**Fs [kN]**	**Fq [kN]**	**N_{an1} [kN]**	**Q_{an2} [kN]**
TF12x100	12	15	100	22	8	500	5	2,5	3,536	3,536
TF12x150	12	15	150	22	8	500	5	2,5	3,536	3,536
TF14x105	14	18	105	25	10	800	8	4	5,657	5,657
TF14x155	14	18	155	25	10	800	8	4	5,657	5,657
TF16x130	16	21	130	27	12	1200	12	6	8,485	8,485
TF16x175	16	21	175	27	12	1200	12	6	8,485	8,485
TF18x150	18	24	150	34	14	1600	16	8	11,314	11,314
TF18x225	18	24	225	34	14	1600	16	8	11,314	11,314
TF20x185	20	27	185	35	14	2000	20	10	14,142	14,142
TF20x250	20	27	250	35	14	2000	20	10	14,142	14,142
TF24x200	24	31	200	43	16	2500	25	12,5	17,678	17,678
TF24x275	24	31	275	43	16	2500	25	12,5	17,678	17,678
TF30x275	30	40	275	56	20	4000	40	20	28,284	28,284
TF30x350	30	40	350	56	20	4000	40	20	28,284	28,284

TF36x335	36	47	335	68	25	6300	63	31,5	44,548	44,548
TF36x450	36	47	450	68	25	6300	63	31,5	44,548	44,548
TF42x385	42	54	385	80	28	8000	80	40	56,569	56,569
TF42x500	42	54	500	80	28	8000	80	40	56,569	56,569
TF52x550	52	67	550	100	32	12500	125	62,5	88,388	88,388
TF52x700	52	67	700	100	32	12500	125	62,5	88,388	88,388

Anchors cross section calculation					
$\omega = 0,6\frac{N}{Q_{tot}}$	$\varphi_1 = \frac{1}{\sqrt{1+\omega}}$	φ	**Rs [kN/mm2]**	$A_{an1} = \frac{1,1\sqrt{N_{an1}^2 + \left(\frac{Q_{an1}}{\varphi\varphi_1}\right)^2}}{R_s}$ $[mm^2]$	**A**fact $[mm^2]$
0,6	0,7906	0,57	0,435	21,761	50,24
0,6	0,7906	0,57	0,435	21,761	50,24
0,6	0,7906	0,54	0,435	36,433	78,50
0,6	0,7906	0,54	0,435	36,433	78,50
0,6	0,7906	0,52	0,435	56,433	113,04
0,6	0,7906	0,52	0,435	56,433	113,04
0,6	0,7906	0,49	0,435	79,201	153,86
0,6	0,7906	0,49	0,435	79,201	153,86
0,6	0,7906	0,49	0,435	99,002	153,86
0,6	0,7906	0,49	0,435	99,002	153,86
0,6	0,7906	0,47	0,435	128,343	200,96

0,6	0,7906	0,47	0,435	128,343	200,96
0,6	0,7906	0,41	0,435	231,963	314,00
0,6	0,7906	0,41	0,435	231,963	314,00
0,6	0,7906	0,35	0,435	422,416	490,63
0,6	0,7906	0,35	0,435	422,416	490,63
0,6	0,7906		0,435		615,44
0,6	0,7906		0,435		615,44
0,6	0,7906		0,435		803,84
0,6	0,7906		0,435		803,84

Anchorage length calculation

$R_s \times \sqrt{\frac{A_{an1}}{A_{actual}}}$ $[kN]$	R_b	φ_c	ω_{an}	$\Delta\lambda_{an}$	$l_{an} = \varphi_c\left(\omega_{an}\frac{R_s}{R_b} + \Delta\lambda_{an}\right)d$ $[mm]$	$l_{an\ fact}$ $[mm]$
0,286	0,014	0,85	0,7	11	171	100
0,286	0,014	0,85	0,7	11	171	150
0,296	0,014	0,85	0,7	11	218	105
0,296	0,014	0,85	0,7	11	218	155
0,307	0,014	0,85	0,7	11	267	130
0,307	0,014	0,85	0,7	11	267	175
0,312	0,014	0,85	0,7	11	314	150
0,312	0,014	0,85	0,7	11	314	225

0,349	0,014	0,85	0,7	11	336	185
0,349	0,014	0,85	0,7	11	336	250
0,348	0,014	0,85	0,7	11	383	200
0,348	0,014	0,85	0,7	11	383	275
0,374	0,014	0,85	0,7	11	500	275
0,374	0,014	0,85	0,7	11	500	350
0,404	0,014	0,85	0,7	11	657	335
0,404	0,014	0,85	0,7	11	657	450
0,435	0,014	0,85	0,7	11	772	385
0,435	0,014	0,85	0,7	11	772	500
0,435	0,014	0,85	0,7	11	882	550
0,435	0,014	0,85	0,7	11	882	700

Local concrete breakout calculation							Concrete cone breakout calculation					
D1 $[mm]$	D1/ds	$\frac{l_a}{15d}$	$N_{loc} = N_{an}$ or $N_{loc} = N_{an} + Q_{an1}\frac{15d - l_a}{l_{an}}$	φ_b	β_b	$\varphi_b \beta_b R_b A_{loc1}$	φ_2	φ_3	R_{bt}	A_1	N	**Nan1 [kN]**
24	3	0,65	5,020	1,131	0,462	30,219	0,5	1	1,19	39388,16	23,436	3,536
24	3	1,067	3,536	1,131	0,462	30,219	0,5	1	1,19	82406,16	49,032	3,536
30	3	0,533	9,428	1,131	0,462	47,218	0,5	1	1,19	45216	26,904	5,657
30	3	0,867	6,387	1,131	0,462	47,218	0,5	1	1,19	90746	53,994	5,657
36	3	0,572	13,511	1,131	0,462	67,993	0,5	1	1,19	68778,56	40,923	8,485
36	3	0,822	10,037	1,131	0,462	67,993	0,5	1	1,19	116961,9	69,592	8,485
42	3	0,552	18,404	1,131	0,462	92,546	0,5	1	1,19	91816,74	54,631	11,314
42	3	0,91	12,269	1,131	0,462	92,546	0,5	1	1,19	190020,2	113,062	11,314
42	3	0,714	18,729	1,131	0,462	92,546	0,5	1	1,19	133249	79,283	14,142
42	3	1,024	14,142	1,131	0,462	92,546	0,5	1	1,19	230604,7	137,210	14,142
48	3	0,654	25,014	1,131	0,462	120,877	0,5	1	1,19	157552,6	93,744	17,678
48	3	0,967	18,192	1,131	0,462	120,877	0,5	1	1,19	280719,1	167,028	17,678
60	3	0,73	36,615	1,131	0,462	188,870	0,5	1	1,19	292098,5	173,799	28,284
60	3	0,98	28,769	1,131	0,462	188,870	0,5	1	1,19	453416	269,783	28,284
75	3	0,712	58,909	1,131	0,462	295,110	0,5	1	1,19	435694,6	259,238	44,548
75	3	1,019	44,548	1,131	0,462	295,110	0,5	1	1,19	746240,6	444,013	44,548
84	3	0,726	73,466	1,131	0,462	370,186	0,5	1	1,19	572513,1	340,645	56,569
84	3	1	56,569	1,131	0,462	370,186	0,5	1	1,19	922419	548,839	56,569
96	3	0,938	93,210	1,131	0,462	483,508	0,5	1	1,19	1122877	668,112	88,388
96	3	1,25	88,388	1,131	0,462	483,508	0,5	1	1,19	1756843	1045,321	88,388

4 TF anchors, straight load application

Anchor characteristics										
Anchor	Type RD	D [mm]	h [mm]	e [mm]	d_S [mm]	Load capacity [kg]	Fs [kN]	Fq [kN]	N_{an1} [kN]	Q_{an2} [kN]
TF12x100	12	15	100	22	8	500	5	2,5	5,000	
TF12x150	12	15	150	22	8	500	5	2,5	5,000	
TF14x105	14	18	105	25	10	800	8	4	8,000	
TF14x155	14	18	155	25	10	800	8	4	8,000	
TF16x130	16	21	130	27	12	1200	12	6	12,000	
TF16x175	16	21	175	27	12	1200	12	6	12,000	
TF18x150	18	24	150	34	14	1600	16	8	16,000	
TF18x225	18	24	225	34	14	1600	16	8	16,000	
TF20x185	20	27	185	35	14	2000	20	10	20,000	
TF20x250	20	27	250	35	14	2000	20	10	20,000	
TF24x200	24	31	200	43	16	2500	25	12,5	25,000	
TF24x275	24	31	275	43	16	2500	25	12,5	25,000	

TF30x275	30	40	275	56	20	4000	40	20	40,000	
TF30x350	30	40	350	56	20	4000	40	20	40,000	
TF36x335	36	47	335	68	25	6300	63	31,5	63,000	
TF36x450	36	47	450	68	25	6300	63	31,5	63,000	
TF42x385	42	54	385	80	28	8000	80	40	80,000	
TF42x500	42	54	500	80	28	8000	80	40	80,000	
TF52x550	52	67	550	100	32	12500	125	62,5	125,000	
TF52x700	52	67	700	100	32	12500	125	62,5	125,000	

Anchors cross section calculation			**Anchorage length calculation**						
Rs [kN/mm2]	$A_{an1} = \frac{1{,}1\sqrt{N_{an1}^2}}{R_s}$ $[mm^2]$	**A**fact $[mm^2]$	$R_s \times \sqrt{\frac{A_{an1}}{A_{actual}}}$ $[kN]$	R_b	φ_c	ω_{an}	$\Delta\lambda_{an}$	$l_{an} = \varphi_c\left(\omega_{an}\frac{R_s}{R_b} + \Delta\lambda_{an}\right)d$ $[mm]$	$l_{an\ fact}$ $[mm]$
0,435	12,644	50,24	0,218	0,014	1	0,7	11	174	100
0,435	12,644	50,24	0,218	0,014	1	0,7	11	174	150
0,435	20,230	78,50	0,221	0,014	1	0,7	11	219	105

0,435	20,230	78,50	0,221	0,014	1	0,7	11	219	155
0,435	30,345	113,04	0,225	0,014	1	0,7	11	265	130
0,435	30,345	113,04	0,225	0,014	1	0,7	11	265	175
0,435	40,460	153,86	0,223	0,014	1	0,7	11	308	150
0,435	40,460	153,86	0,223	0,014	1	0,7	11	308	225
0,435	50,575	153,86	0,249	0,014	1	0,7	11	326	185
0,435	50,575	153,86	0,249	0,014	1	0,7	11	326	250
0,435	63,218	200,96	0,244	0,014	1	0,7	11	368	200
0,435	63,218	200,96	0,244	0,014	1	0,7	11	368	275
0,435	101,149	314,00	0,247	0,014	1	0,7	11	463	275
0,435	101,149	314,00	0,247	0,014	1	0,7	11	463	350
0,435	159,310	490,63	0,248	0,014	1	0,7	11	580	335
0,435	159,310	490,63	0,248	0,014	1	0,7	11	580	450
0,435	202,299	615,44	0,435	0,014	1	0,7	11	908	385
0,435	202,299	615,44	0,435	0,014	1	0,7	11	908	500
0,435	316,092	803,84	0,435	0,014	1	0,7	11	1038	550
0,435	316,092	803,84	0,435	0,014	1	0,7	11	1038	700

Local concrete breakout calculation							Concrete cone breakout calculation					
D1 $[mm]$	D1/ds	$\frac{l_a}{15d}$	$N_{loc} = N_{an}$ **or** $N_{loc} = N_{an} + Q_{an1}\frac{15d - l_a}{l_{an}}$	φ_b	β_b	$\varphi_b \beta_b R_b A_{loc1}$	φ_2	φ_3	R_{bt}	A_1	N	**N_{an1} [kN]**
24	3	0,65	5,000	1,131	0,462	30,219	0,5	1	1,19	39388,16	23,436	5,000
24	3	1,067	5,000	1,131	0,462	30,219	0,5	1	1,19	82406,16	49,032	5,000
30	3	0,533	8,000	1,131	0,462	47,218	0,5	1	1,19	45216	26,904	8,000
30	3	0,867	8,000	1,131	0,462	47,218	0,5	1	1,19	90746	53,994	8,000
36	3	0,572	12,000	1,131	0,462	67,993	0,5	1	1,19	68778,56	40,923	12,000
36	3	0,822	12,000	1,131	0,462	67,993	0,5	1	1,19	116961,9	69,592	12,000
42	3	0,552	16,000	1,131	0,462	92,546	0,5	1	1,19	91816,74	54,631	16,000
42	3	0,91	16,000	1,131	0,462	92,546	0,5	1	1,19	190020,2	113,062	16,000
42	3	0,714	20,000	1,131	0,462	92,546	0,5	1	1,19	133249	79,283	20,000
42	3	1,024	20,000	1,131	0,462	92,546	0,5	1	1,19	230604,7	137,210	20,000
48	3	0,654	25,000	1,131	0,462	120,877	0,5	1	1,19	157552,6	93,744	25,000
48	3	0,967	25,000	1,131	0,462	120,877	0,5	1	1,19	280719,1	167,028	25,000
60	3	0,73	40,000	1,131	0,462	188,870	0,5	1	1,19	292098,5	173,799	40,000
60	3	0,98	40,000	1,131	0,462	188,870	0,5	1	1,19	453416	269,783	40,000
75	3	0,712	63,000	1,131	0,462	295,110	0,5	1	1,19	435694,6	259,238	63,000
75	3	1,019	63,000	1,131	0,462	295,110	0,5	1	1,19	746240,6	444,013	63,000
84	3	0,726	80,000	1,131	0,462	370,186	0,5	1	1,19	572513,1	340,645	80,000
84	3	1	80,000	1,131	0,462	370,186	0,5	1	1,19	922419	548,839	80,000
96	3	0,938	125,000	1,131	0,462	483,508	0,5	1	1,19	1122877	668,112	125,000
96	3	1,25	125,000	1,131	0,462	483,508	0,5	1	1,19	1756843	1045,321	125,000

Documents for approval

СИСТЕМА СЕРТИФИКАЦИИ ГОСТ Р

ФЕДЕРАЛЬНОЕ АГЕНТСТВО ПО ТЕХНИЧЕСКОМУ РЕГУЛИРОВАНИЮ И МЕТРОЛОГИИ

Добровольная сертификация

СЕРТИФИКАТ СООТВЕТСТВИЯ

№ РОСС RU.МЛ17.Н00155

Срок действия с 23.06.2010 по 22.06.2013

№ 0140994

ОРГАН ПО СЕРТИФИКАЦИИ РОСС RU.0001.11МЛ17
ПРОДУКЦИИ ООО "ЭТАЛОН-ТЕСТ"
117042, Россия, г. Москва, ул. Изюмская, д. 46, тел. (495) 645-80-61

ПРОДУКЦИЯ
Строительные металлические арматурные элементы для плит перекрытий, балконов и лоджий Peikko-NIRO TKM/TKA 2-9
ТУ 5290-001-94677387-2010
серийный выпуск.

код ОК 005 (ОКП): 52 8590

СООТВЕТСТВУЕТ ТРЕБОВАНИЯМ НОРМАТИВНЫХ ДОКУМЕНТОВ
ТУ 5290-001-94677387-2010

код ТН ВЭД России:

ИЗГОТОВИТЕЛЬ ООО «Пейкко». ИНН: 7841340350
197348, Санкт-Петербург, Коломяжский пр., 10, Литера Ф.
Телефон (812) 329-07-04 факс (812) 329-07-04

СЕРТИФИКАТ ВЫДАН ООО «Пейкко». ИНН: 7841340350
197348, Санкт-Петербург, Коломяжский пр., 10, Литера Ф, Россия
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НА ОСНОВАНИИ
протокола сертификационных испытаний № 047/06 от 22.06.2010 г. Испытательный центр ЗАО "ЦС "Композит-Тест", рег. РОСС RU.0001.21АЮ48, адрес 141070, Россия, Московская область, г. Королев, ул. Пионерская, 4.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Схема сертификации – 3.

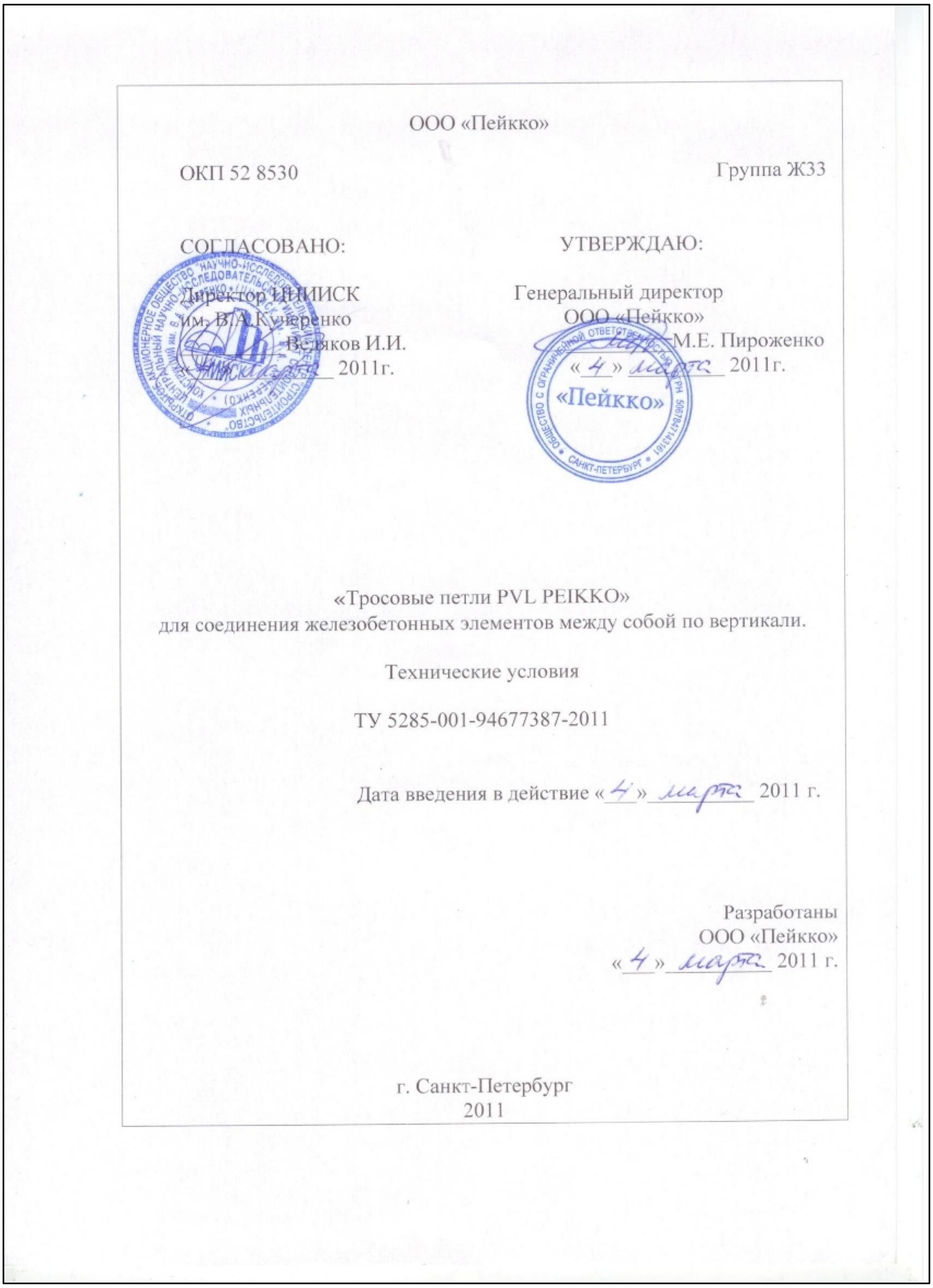
М.П.

Руководитель органа (подпись) Е. О. Азарова (инициалы, фамилия)

Эксперт (подпись) В. С. Митрохин (инициалы, фамилия)

Сертификат не применяется при обязательной сертификации

Figure 6.1 Example of GOST-R certificate



ООО «Пейкко»

ОКП 52 8530 Группа Ж33

СОГЛАСОВАНО:
Директор ЦНИИСК
им. В.А.Кучеренко
Ведяков И.И.
«__» ________ 2011г.

УТВЕРЖДАЮ:
Генеральный директор
ООО «Пейкко»
________ М.Е. Пироженко
«4» марта 2011г.

«Тросовые петли PVL PEIKKO»
для соединения железобетонных элементов между собой по вертикали.

Технические условия

ТУ 5285-001-94677387-2011

Дата введения в действие «4» марта 2011 г.

Разработаны
ООО «Пейкко»
«4» марта 2011 г.

г. Санкт-Петербург
2011

Figure 6.2 Title page of approved Technical Specification for PVL wire loops

Приложение 4

Примеры определения применимости тросовых петель PVL в соответствии с сейсмическим районированием.

Пример 1:

Место строительства – Санкт-Петербург.
Выдержка из СНиП II-7-81*(п.1.3, п.1.4) :

"Комплект карт ОСР-97 (А, В, С) позволяет оценивать на трех уровнях степень сейсмической опасности и предусматривает осуществление антисейсмических мероприятий при строительстве объектов трех категорий, учитывающих ответственность сооружений:

Карта А - массовое строительство;

Карты В и С - объекты повышенной ответственности и особо ответственные объекты.

Решение о выборе карты при проектировании конкретного объекта принимается заказчиком по представлению генерального проектировщика, за исключением случаев, оговоренных в других нормативных документах."

В соответствии с вышесказанным, по картам ОСР-97 и таблице "*Список населённых пунктов Российской Федерации, расположенных в сейсмических районах, с указанием расчетной сейсмической интенсивности в баллах шкалы MSK-64 для средних грунтовых условий и трех степеней сейсмической опасности - А (10 %), В (5 %), С (1 %) в течение 50 лет*" для СПб и ЛО:

Карты ОСР-97	Баллы
Карта А	-
Карта В	-
Карта С	6

Таким образом, использование тросовых петель PVL в Санкт-Петербурге возможно при строительстве объектов массового строительства, а также объектов повышенной ответственности(при надлежащем расчёте и согласовании). Исключение составляют особо ответственные объекты, отнесённые в соответствии с Градостроительным кодексом Российской Федерации к технически сложным, особо опасным или уникальным объектам (Федеральный закон от 30.12.2009 № 384-ФЗ).

Пример 2:

Место строительства – г. Кизляр, Дагестан.

В соответствии с картами ОСР-97 и таблицей "*Список населённых пунктов Российской Федерации, расположенных в сейсмических районах...* " , для г. Кизляр:

Подпись и дата | Инв. № | Взам. инв. | Подпись и дата | Инв. №

Изм | Лист | № докум. | Подп. | Дата

ТУ 5285-001-94677387-2011

Лист 26

Figure 6.3 Page from seismic loads application to Technical Approval for PVL