TECHNICAL MANUAL

Element Turning

With Peikko Lifting Systems

Version PEIKKO GROUP 12/2020

CONTENTS

About turning of precast elements

1. Introduction

Precast elements are subject of different and multiple lifting and handling procedures. Due to more demanding projects and possibilities offered by modern computer aided design systems, there are also more demanding lifting applications during the construction phase and delivery stage of precast elements. Often the element production happens in different orientation than the final installation of the precast element. One challenging lifting application is the rotation of elements in the air, by using the installed lifting inserts.

This Manual describes how precast elements can be rotated in the air by 90° while being lifted. A procedure that is regularly used on today's construction sites, either using two cranes, one crane with two winches or one crane together with a turning device.

This Manual is supplementary documentation to Peikko's Technical Product Manuals of our lifting systems such as JENKA, KK, RR, COLIFT and WILJA®. It must always be used together with these documents. The content of this Manual provides additional information related to the rotation process. Basic information for the use of the lifting items are given in the product specific Peikko Technical Manuals.

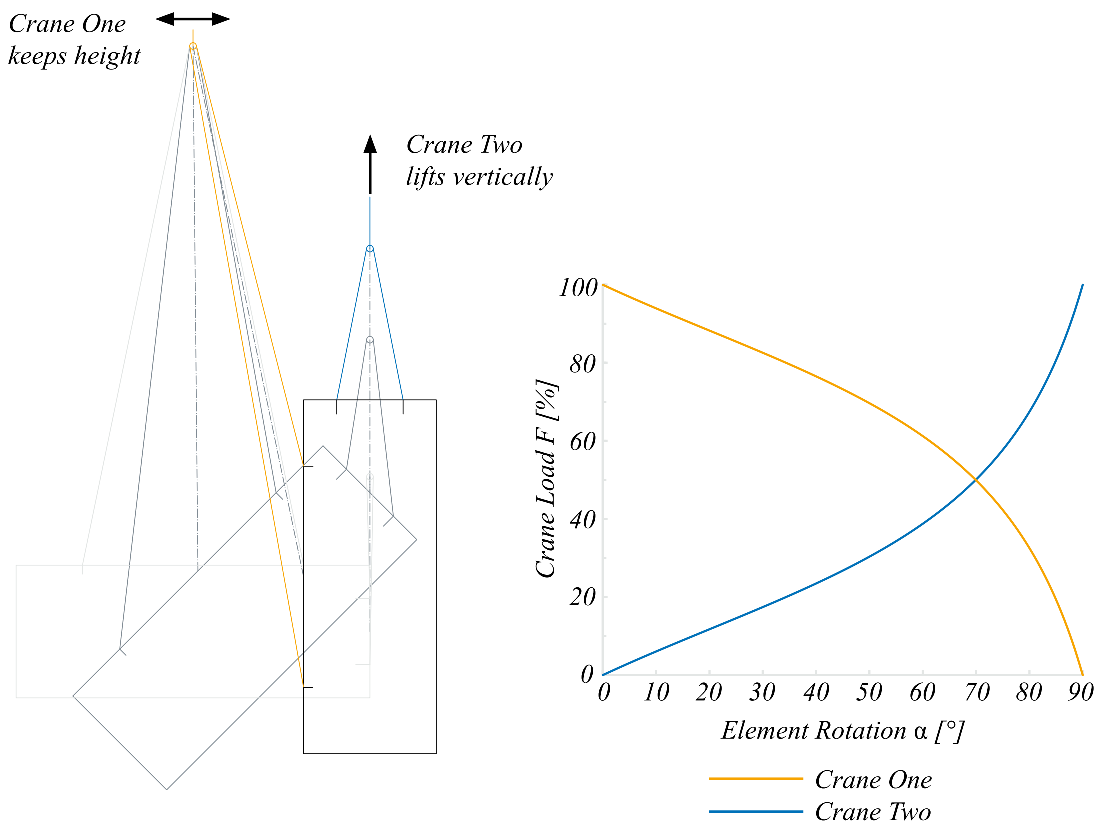


Figure 1. Precast wall element turning 90° into vertical position, rotation illustration and load distribution graph.

Figure 2. *Precast wall element turned 90° into vertical position, site pictures.*

1.1 Ways of turning

The turning process in which precast members are going to be rotated by 90° is a standard procedure on todays construction sites. Basically, there are different kinds of turning operations, that can be monitored. In this document, the following typical procedures are discussed.

Turning with four lifting inserts

The element turning with four lifting inserts is a popular way of turning heavy and long precast elements. There will be four lifting inserts installed. At the beginning, the element will be hoisted with F_1 until it is hanging free in the air. The rotation process is initiated by vertical pulling with F_2. It continues until the whole element is turned by 90°. F_1 secures the sufficient height of the element above the ground and moves carefully in horizontal direction in order to reduce additional forces resulting from horizontal pulling. The load is shared at the beginning to the lifting inserts loaded by F_1, and then, when the rotation process is initiated by F_2, the load is spread to unequal parts to all four lifting inserts. The more the rotation process continues, the more the permanent load change appears. The unequal distribution to the lifting inserts increases with continuous effect until at the end both lifting inserts loaded by F_2 take the full load.

Turning an element with two cranes (alt. one crane and two winches) and four lifting inserts is considered the safest and most uncomplicated way. The inserts are dimensioned for the initial state and the final state of the rotation, namely the moment when only the two anchors on the long or on the short side of the element bear the entire weight. During the rotation itself the weight of the element is shared to all four lifting inserts.

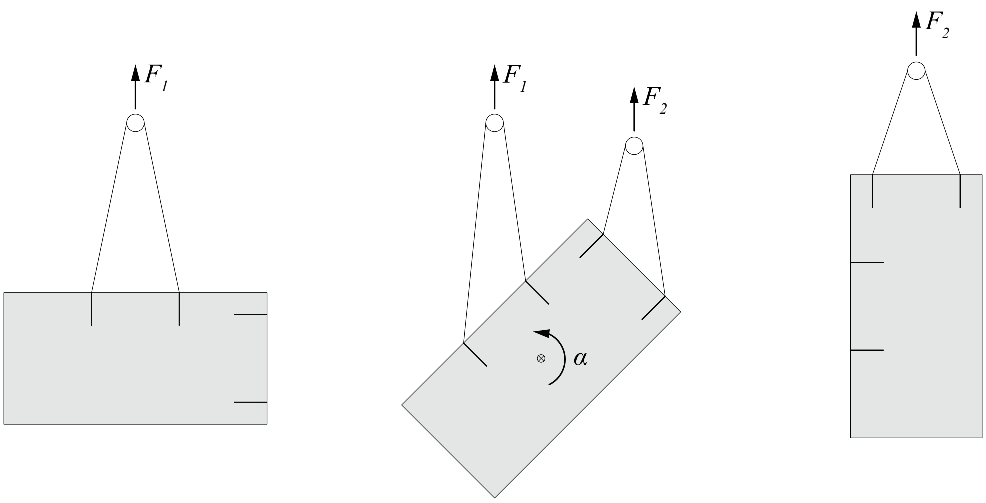


Figure 3. *Turning an element with four lifting inserts.*

Turning with three lifting inserts

The element turning with three lifting inserts is popular for turning medium heavy and long precast elements. There will be three lifting inserts installed. At the beginning, the element will be hoisted parallel with F_1 and F_2 until it is hanging free in the air. The load share is unequal to parts F_1 and F_2. The rotation process is initiated by starting pulling with F_2. It continues until the whole element is turned by 90°. The initial load shared to F_1 depends on the exact position of the insert F_1 and the position of the elements center of gravity. Typically, it is between 60% and 70% of the total weight. Openings in the element influence the position of the center of gravity. The more the rotation process continues, the more the permanent load change appears. The unequal load distribution to the lifting inserts increases with continuing effect until both lifting inserts loaded by F_2 take the full load.

An advantage of this method is that F_1 can be released from the element by one person without the help of a ladder or ascending aid.

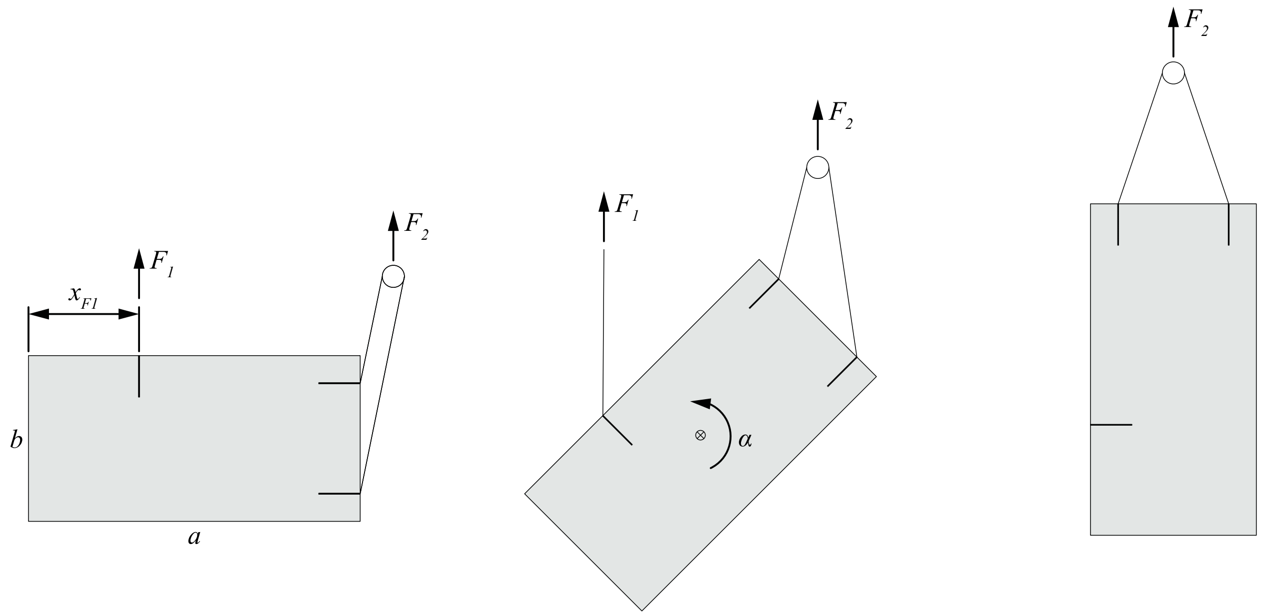


Figure 4. Turning an element with three lifting inserts.

In case CG is close to $a/2$, x_{F1} is recommended to be $a/3$ ... $a/4$.

Turning an element with COLIFT Mounting System

Turning with COLIFT Mounting System is a very easy and fast method to rotate elements by 90°. The element simply needs either just two openings (preferably round holes) in which the COLIFT is located or a lifting insert and a COLIFT. Then the lifting process is started with equal or unequal load share to F_1 and F_2, depending on the design. Especially long and heavy columns are hoisted, rotated and installed with the COLIFT Mounting System easily and in efficient manner.

The rotation process is initiated by starting the pulling with F_2. It continues until the whole element is turned by 90°. The more the rotation process continues, the more the permanent load change appears. The unequal load distribution increases with continuing effect until F_2 takes the full load.

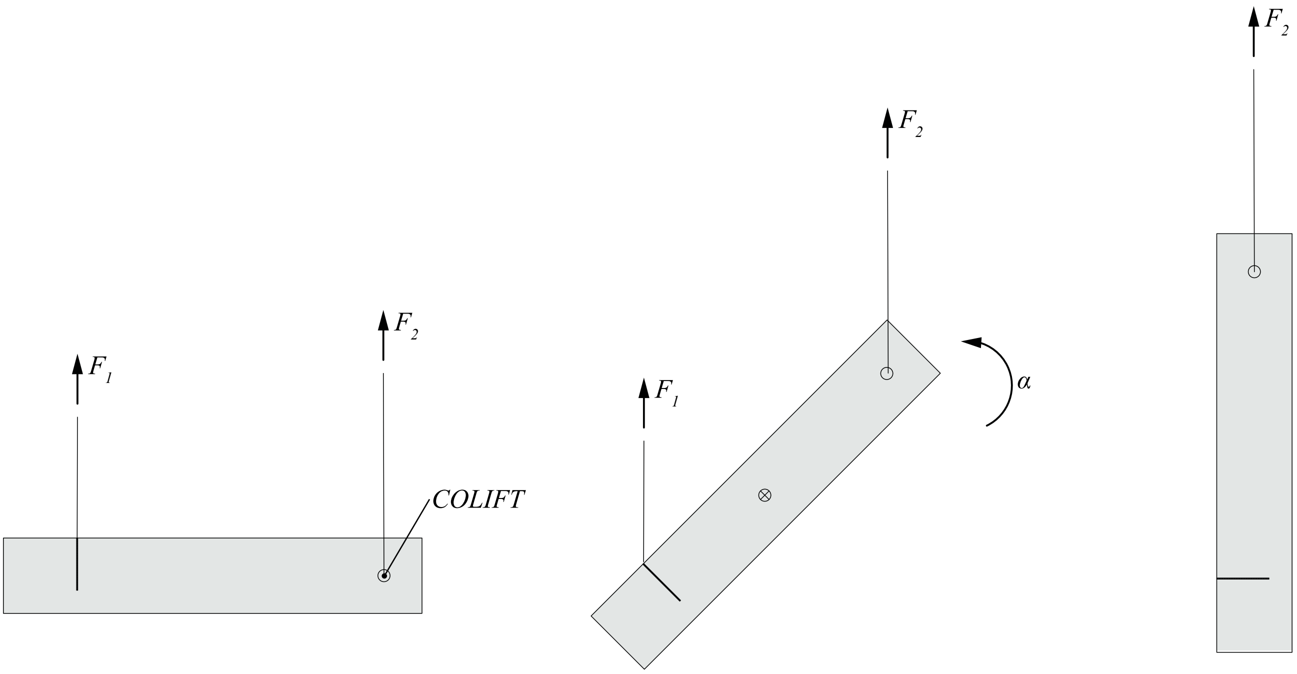


Figure 5. Turning an element with COLIFT Mounting System.

Turning an element with a turning device

Turning with a turning device is a very common way to turn elements when only one crane with one winch is available on site. The element will be placed into the turning device (F_1), secured against tipping sideways and then attached to F_2 only. The turning process is initiated by vertical lifting with F_2. The advantage here is, that only the rotation forces to initiate the turn must be applied because turning device rests on the ground and takes vertical loads. The disadvantage is that this procedure takes more time and the same amount of transport inserts is needed as for the turning with four lifting inserts. In addition to that, the transport of the turning device to the site must also be considered.

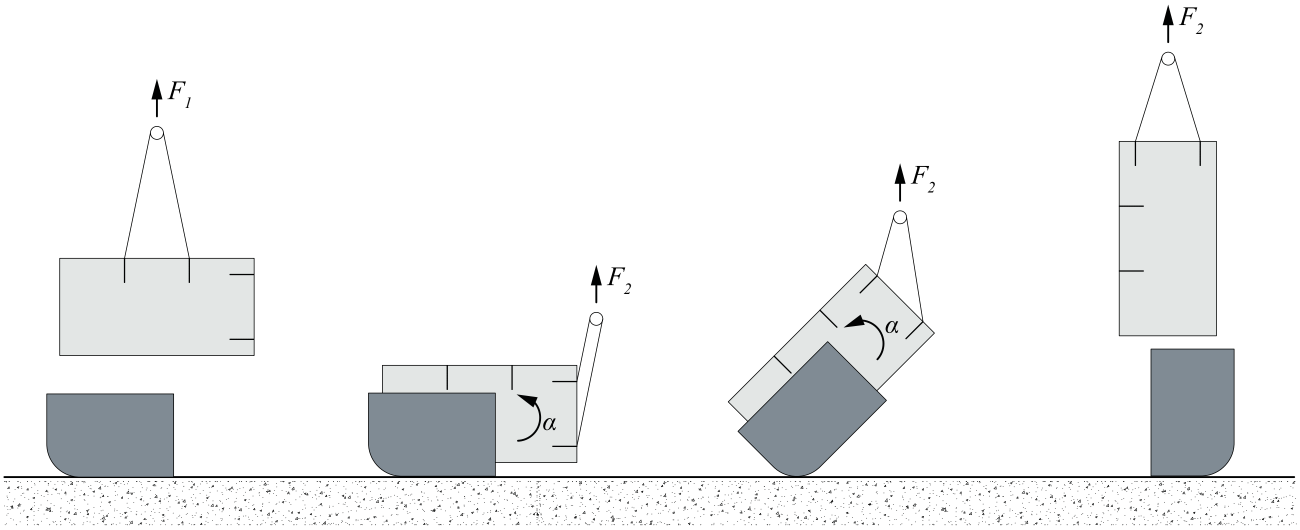


Figure 6. Turning an element with the help of a turning device.

1.2 General information for turning operations

1.2.1 Definition of rotation angle α and diagonal pull angle *β*

The dead load of the element is named F_G. F_1 and F_2 describe the forces carried by crane one and crane two. Rotation is assumed to take place around the elements' Center of Gravity (CG). For calculating realistic crane forces F_1 and F_2 during all phases of the rotation process, exact knowledge of the CG is necessary. In the case of a complex geometry of the precast element, it may be necessary to determine the center of gravity coordinates for all 3 dimensions (x, y, z).

Angle α describes the global rotation of the construction element itself, while β defines the inclination of the ropes regarding to the axis of the lifting insert. Both angles are on the same plane.

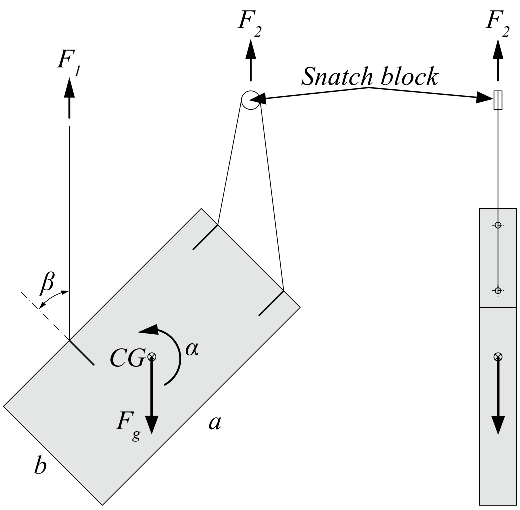


Figure 7. Rotation angle α and diagonal pull angle β.

1.2.2 Diagonal pull in changing directions

During rotation lifting inserts must resist diagonal pull β up to 90°. Some of them also have diagonal pull in changing directions as visible in *Figure 8*. This must be considered during design phase of the element. When necessary, additional reinforcement for diagonal pull must be installed for both directions. *Figure 9* shows how this can be achieved. This additional reinforcement must always have direct pressure contact with the lifting insert (JENKA, WILJA®) or the recess former (RR, KK). This can be achieved by wire fixing and precise installation.

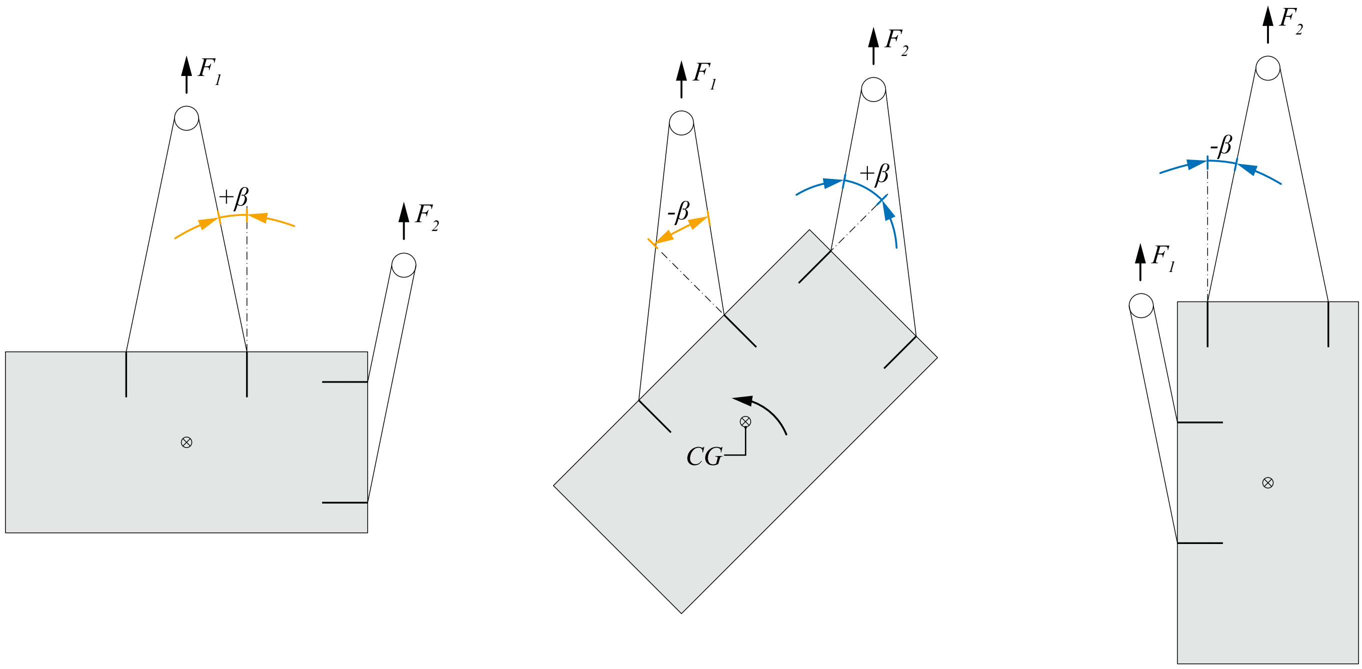


Figure 8. Diagonal pull angle β changes direction during rotation, which means the sign changes from plus to minus.

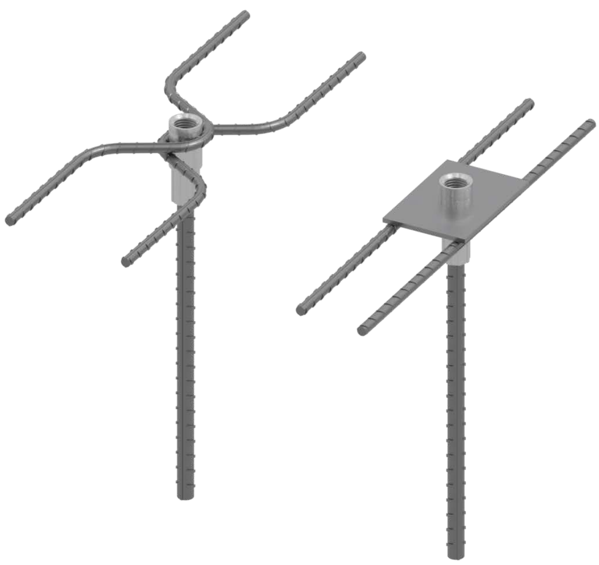


Figure 9. Additional reinforcement for diagonal pull in case of changing directions as example for JENKA lifting inserts.

1.2.3 Impact of the position of Center of Gravity (CG)

The exact position of the element's center of gravity in both the element plane (x, y) and the thickness direction (z) is essential for the design of transport processes. If the lifting inserts are not arranged symmetrically to the center of gravity, the element will hang tilted in the air when using a snatch block. Otherwise, unevenly distributed insert loads will occur.

With the help of the center of gravity it must also be ensured that during all phases of the rotation a tipping of the element out of the rotation plane can be excluded. In general, this is achieved when inserts are placed above CG as illustrated in *Figure 10 d*) and *e*). In case of two inserts per element edge, the connecting line between them must be above CG.

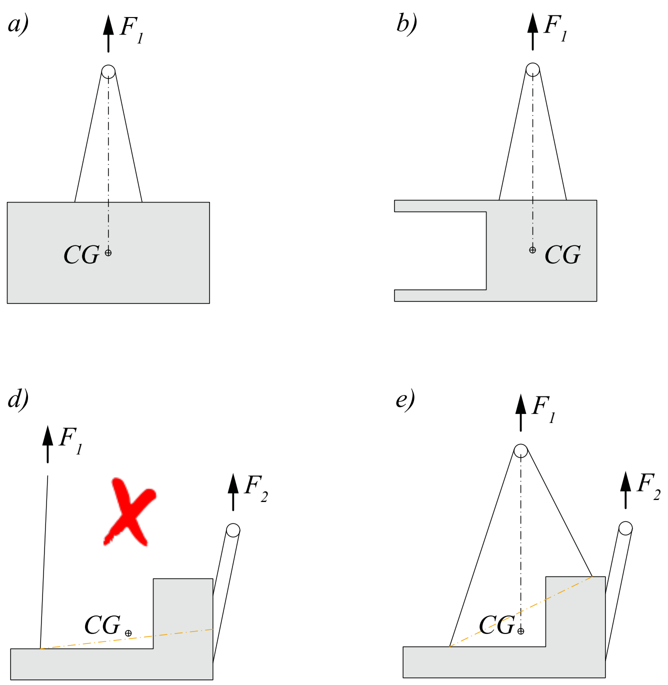


Figure 10. Impact of the position of the Center of Gravity.

1.2.4 Lifting hardware for turning operations

For turning operations, regular lifting hardware can be utilized. The lifting keys used for this process must be designed in such a way that a self-release during all stages of operation is impossible. Peikko standard lifting keys fulfill this requirement and have been proved in service. They can be used as specified in their Technical Manual.

Special attention is required when using our KK insert system. More details can be found in chapter 2.3.

NOTE:
In Technical Manuals, diagonal pull angle β is often limited to 45°. When turning elements, angles β larger than 45° occur. This happens in combination with smaller anchor forces and can be tolerated. More information can be found in Annex A.

INFORMATION

For equal load share to the lifting strands, snatch blocks (*Figure 11*) must always be utilized during the rotation process. Snatch blocks share the loads F_1 and F_2 (see *Figure 7*) to equal parts to the strand running over the pulley wheel of each snatch block. This reduces the load to the lifting system (lifting key and lifting insert). Even with extended angles of inclination, bigger than 45°, the pulley enables a rotation of the element without overloading the admissible lifting system resistances.

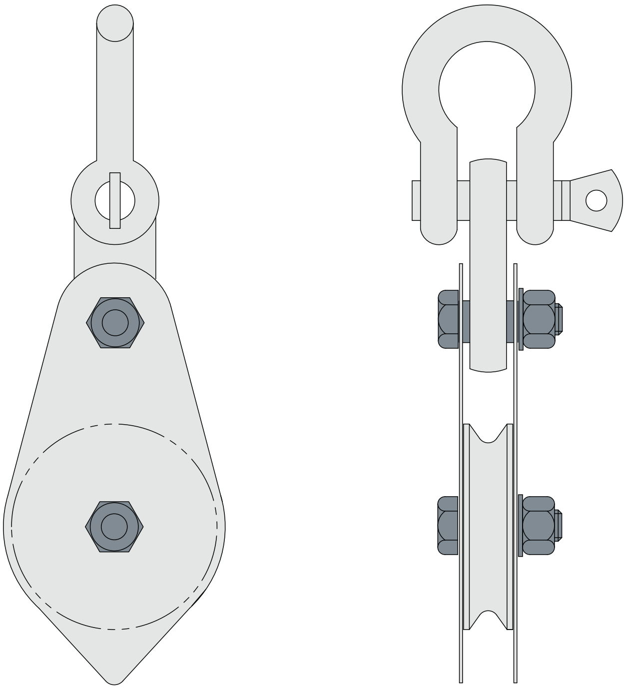


Figure 11. Snatch block example.

WARNING:
Never use self-made rolls in combination with shackles. The rope strand can jump from the roll and hinder the rotation process. There is a risk that the load share is not equal, which might cause overloading of the lifting system and severe accidents with collapsing elements.

The minimum rope length must be defined in the planning process because it is affecting the initial diagonal pull angle β (F_1) and the final diagonal pull angle β (F_2).

Only the needed lifting slings may be used in the turning process. All additional strands – not necessary for the lifting and rotation process must be removed for safety reasons.

Ropes and snatch blocks are part of the normal lifting hardware and local regulations are applicable for regular checking.

1.3 Lifting and turning operation

The rotation of an element in the air must be planned by an engineer. The selected turning procedure has significant impact on the design of the element. The precast element must be designed to securely withstand all impacts during rotation. The execution is to be led by a competent person who will communicate directly and unambiguously with the crane operator(s).

Dynamic effects of the drive and load increase caused by diagonal pull must be considered. Also, the impact of wind must be considered. In case of strong winds, lifting and rotation process cannot be carried out.

WARNING:
Before the elements are lifted, everybody must move away from the element. During lifting, rotating in the air, and installation of the element it must be ensured that nobody is in the danger zone.

It must also be ensured that the precast element hangs high enough above the ground so that it does not touch the ground during the turning process.

The turning itself must happen in the plane of the (wall-) element. Means α and β are on the same plane. Tipping out of this plane (lateral forces perpendicular to element thickness) is not covered by this Manual and requires further investigation with special attention to diagonal pull directions and corresponding reinforcement as well as to lifting devices that enable rotation around the axis of the lifting insert.

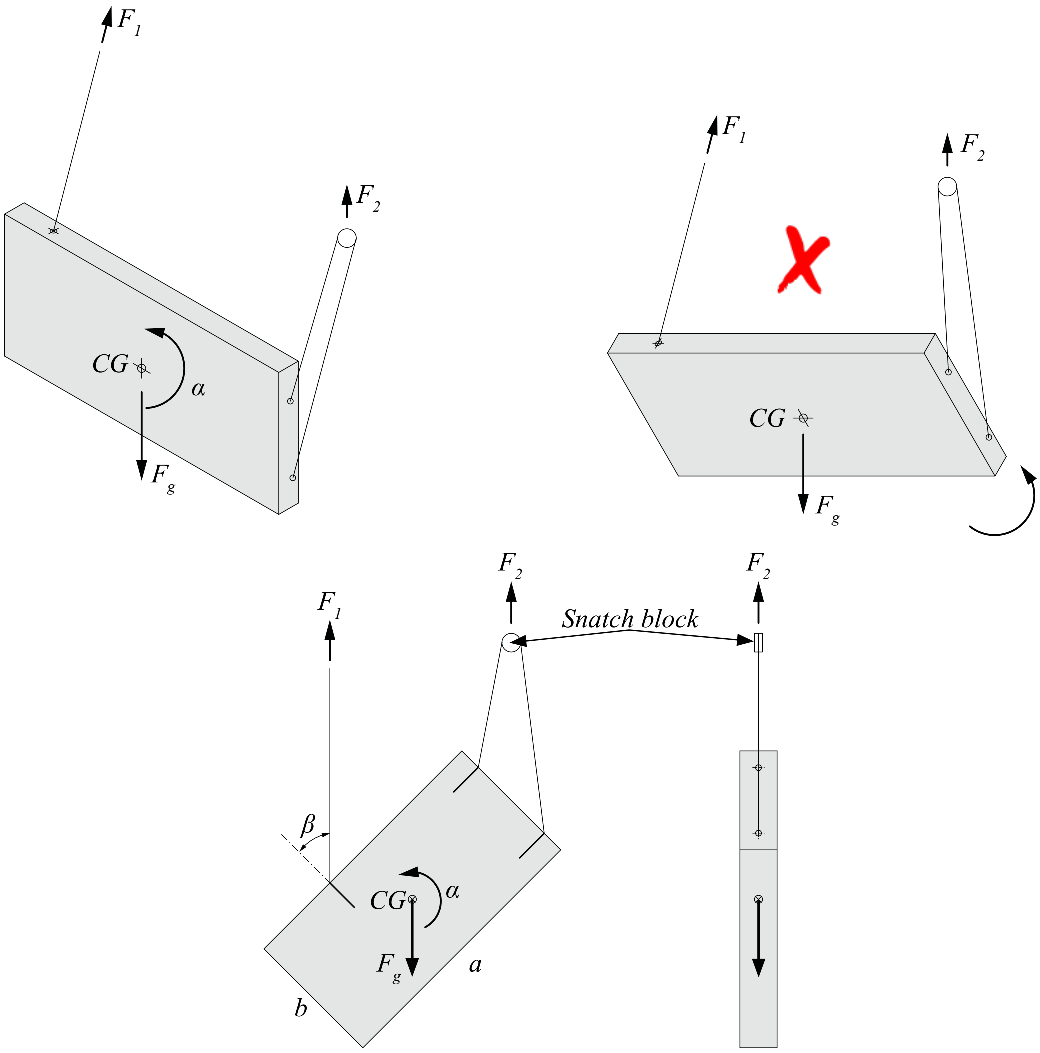


Figure 12. Turning in elements plane.

INFORMATION

Horizontal forces between cranes must be avoided during all stages of the rotation process by maintaining the position of the snatch blocks straight above the middle of the lifting inserts. Crane one starts and lifts the element sufficiently high. Crane two or winch two is positioned above the lifting inserts F_2 and starts to pull vertically. Crane one keeps its height and moves horizontally according to the progress of the turning process to avoid horizontal loads between cranes.

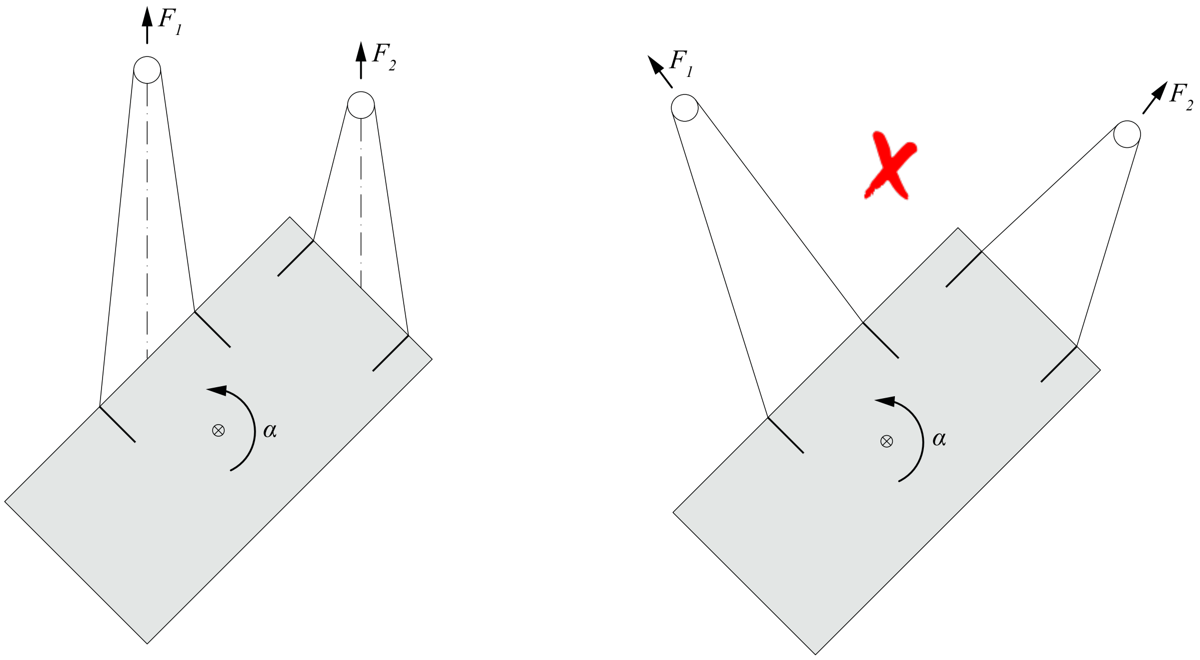


Figure 13. Horizontal forces between cranes.

The lifting speed must be selected so that all boundary conditions of the rotation process can be easily monitored and the rotation process runs under full control. The recommendation is 0.2 m/s or related to the rotation of the element 1.5°/s – 2.0°/s.

WARNING:

Shock-like impacts can cause damage to insert and load-bearing equipment, which reduces the load-bearing capacity. These must be avoided under all circumstances. If, despite of all caution, such an impact-like load occurs, the corresponding load handling attachment must be checked for damage before the next use.

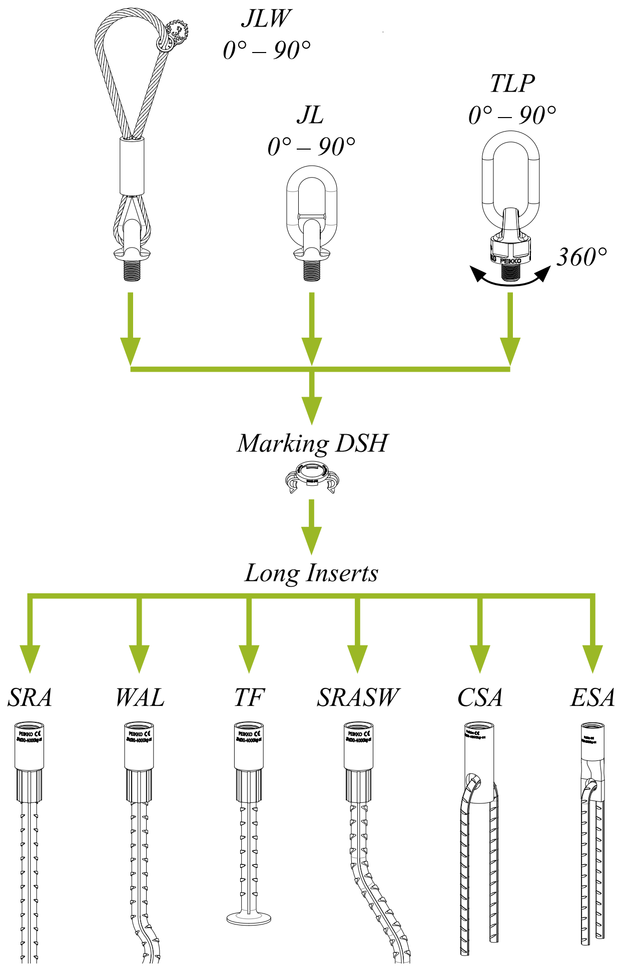
Selecting a Lifting System

2. Peikko Products for turning operations

2.1 JENKA Lifting System

Peikko's JENKA Lifting System offers the following products, which are suitable to be used for turning operations.

Figure 14. JENKA Lifting System items used in turning operations.



WARNING:
The use of TLL Lifting Key for turning operations is not allowed! The wire loop could be damaged when bending beyond 45°.

Resistance values for diagonal pull from 0° to 45° are specified in JENKA Technical Manual. For diagonal pull from 45° to 90°, only the horizontal share at 45° is used. See Annex A for detailed information.

Additional reinforcement for diagonal pull must always be considered. Depending on the position of the installation, lifting inserts require supplementary reinforcement for two directions. Chapter 1.2.2 contains further information.

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2.2 RR Lifting System

The RR Lifting System is a rapid coupling and release lifting system with flat steel inserts. Used with special Lifting Keys, RR Inserts offer a wide range of application, from slabs to columns, walls, and beams – with no limit on the lifting load direction.

Figure 15. RR Lifting System items used in turning operations.

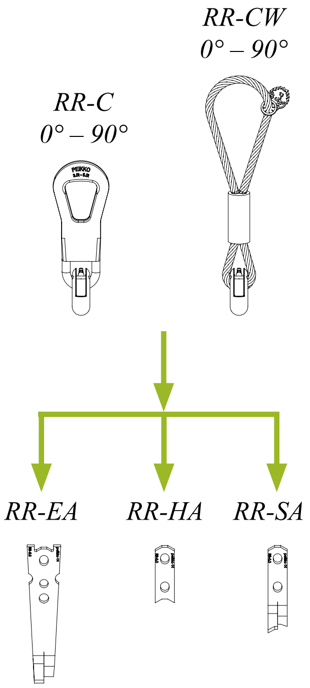
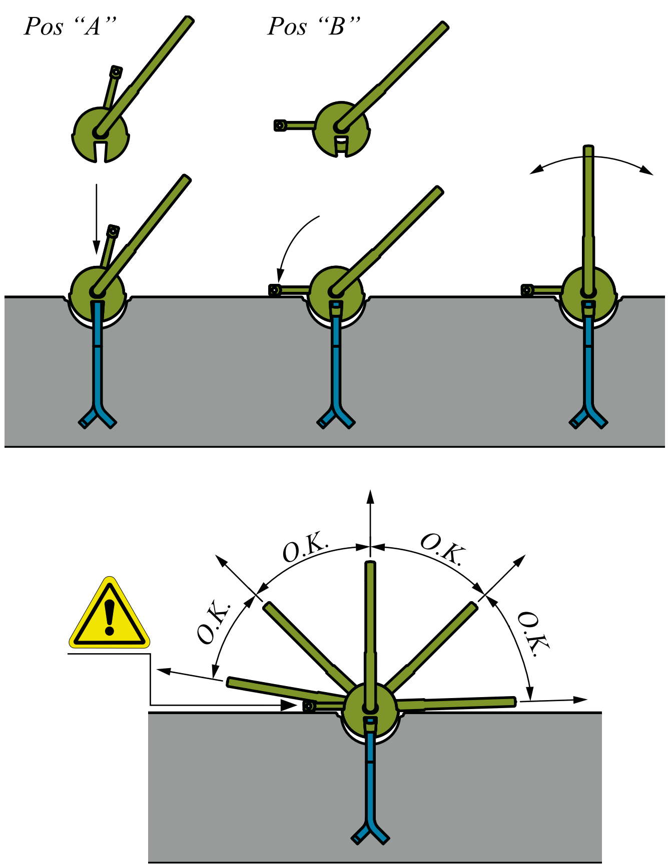


Figure 16. Connection detail of RR Lifting Keys and RR Lifting Inserts.



Resistance values for diagonal pull from 0° to 45° are specified in RR Technical Manual. For diagonal pull from 45° to 90°, only the horizontal share at 45° is used. See Annex A for more information.

Additional reinforcement for diagonal pull must always be considered. Depending on the position of the installation, lifting inserts require supplementary reinforcement for two directions. Chapter 1.2.2 contains further information.

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2.3 KK Lifting System

KK Lifting Inserts are widely used for all kinds of lifting operations (lifting, turning, rotating and tilting). With loads up to 90°, KK Inserts offer universal design possibilities.

Using KKL lifting key in turning operations self-release must be prevented. Self-release can happen when KKL Lifting Key is used in +90° sector as visible in red color in *Figure 18*. Operations in the +90° sector should be avoided or handled with extra care. If there is no experience with the KK lifting system or there is uncertainty about the self-release of the claw, Peikko recommends using the JENKA system instead.

Figure 17. KK Lifting System items used in turning operations.

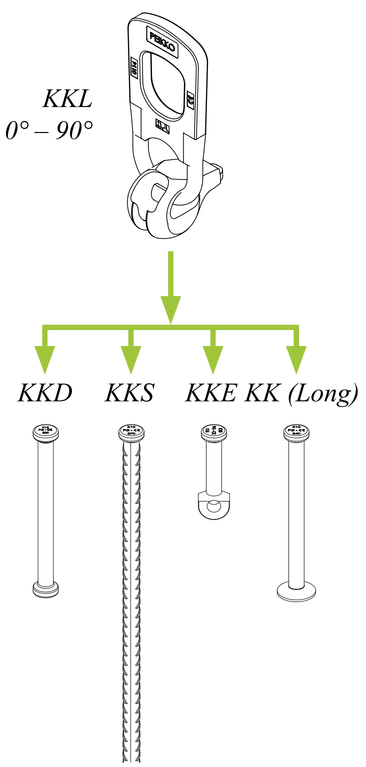
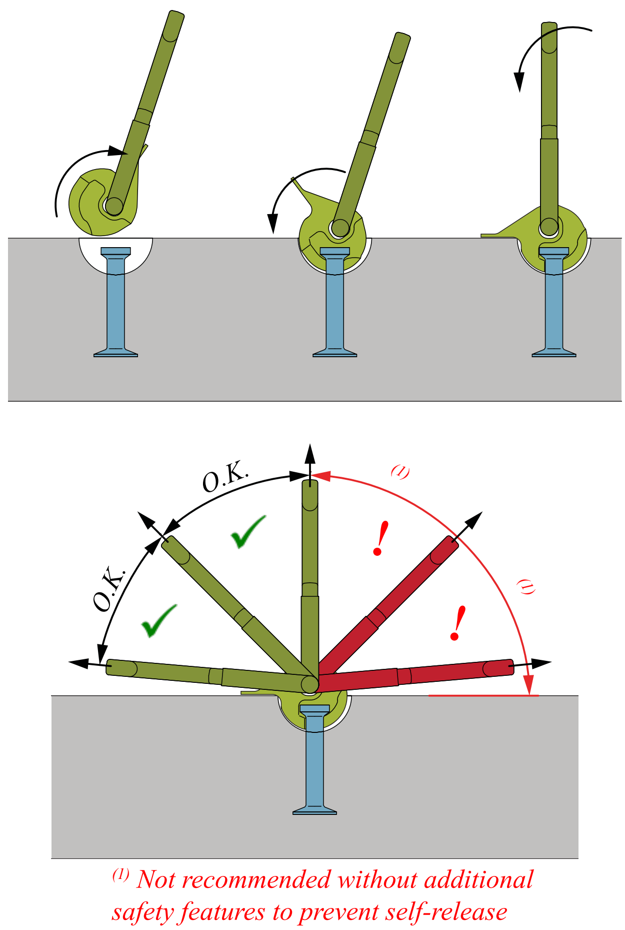


Figure 18. KKL Lifting key – intended use.



Resistance values for diagonal pull from 0° to 45° are specified in KK Technical Manual. For diagonal pull from 45° to 90°, only the horizontal share at 45° is used. See Annex A for more information.

Additional reinforcement for diagonal pull must always be considered. Depending on the position of the installation, lifting inserts require supplementary reinforcement for two directions. Chapter 1.2.2.

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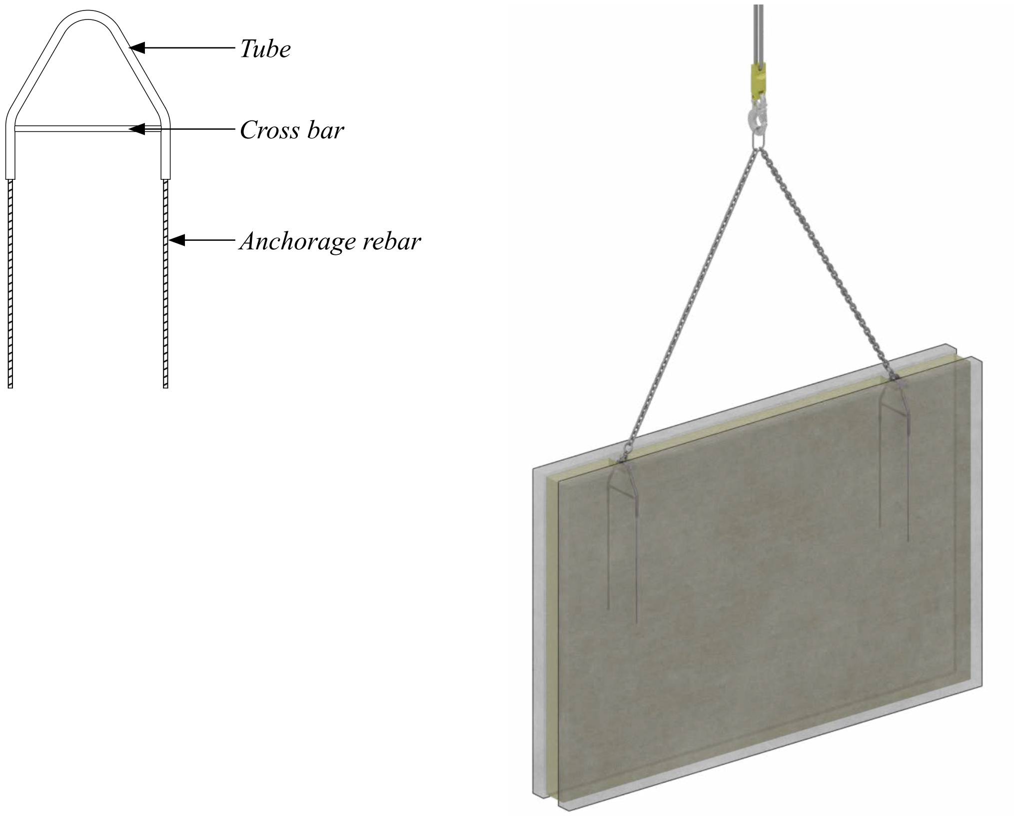
2.4 WILJA®

WILJA® Sandwich Wall Insert is designed for lifting and transporting precast sandwich wall elements. It is an efficient ready-to-use solution as no special lifting keys are needed.

Figure 19. WILJA® Lifting System.



Resistance values for diagonal pull from 0° to 45° are specified in WILJA® Technical Manual. They depend on insert size and insulation thickness. For diagonal pull from 45° to 90°, only the horizontal share at 45° is used. See Annex A for more information.

Additional reinforcement for diagonal pull must always be considered. Depending on the position of the installation, lifting inserts require supplementary reinforcement for two directions. Chapter 1.2.2 contains further information.

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2.5 COLIFT Mounting System

The COLIFT Mounting System is designed for easy and timesaving lifting and handling of precast concrete elements such as columns or precast beams. It can also be used for rotation processes with wall elements. The mounting system can be remotely released with a cord from the ground. Detailed information about available product sizes and resistances, as well as all relevant technical data can be found in the Technical Manual.

Figure 20. COLIFT Mounting System in use.

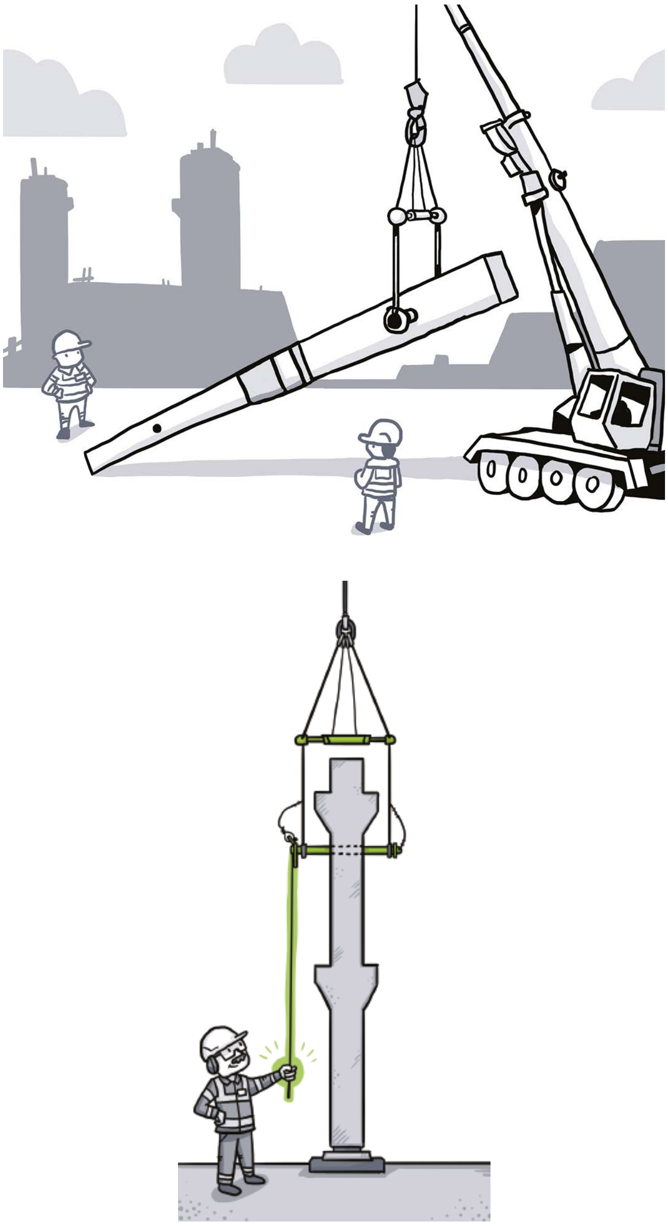
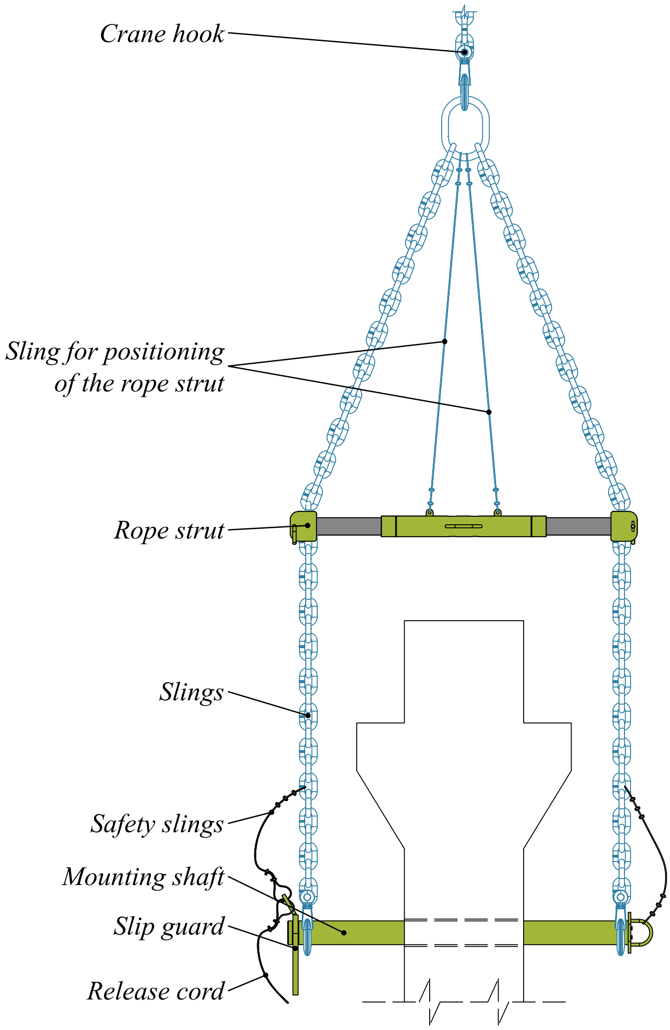


Figure 21. COLIFT Mounting System components.



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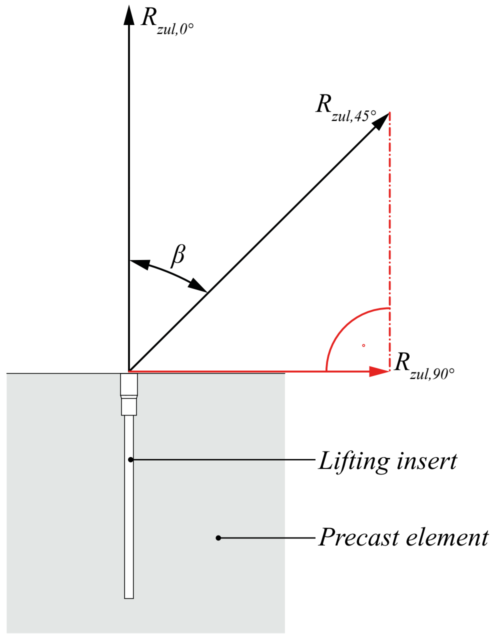
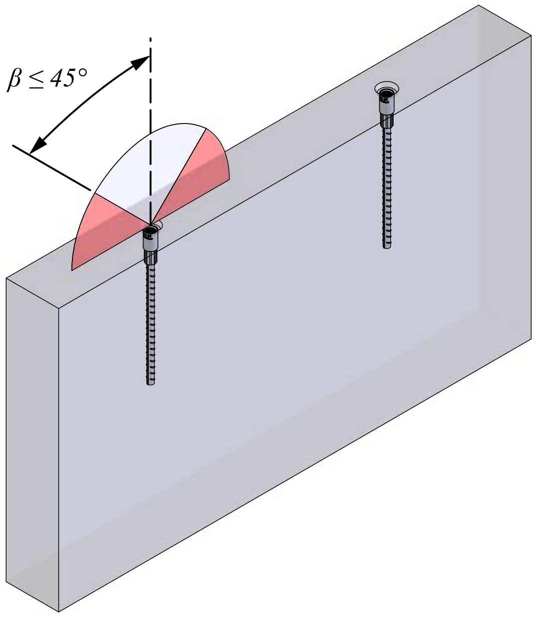
Annex A – Resistance values for diagonal pull β = 45° – 90°

In the case when a product-specific technical manual defines the diagonal pull resistance values $R_{zul,\beta}$ for angles β = 0° to 45° only, the following method can be used to define the values for 45° to 90°. This method is assumed to deliver resistance values on the safe side if additional reinforcement for diagonal pull is installed correctly.

$R_{zul,0°}$ see Technical Product Manual
$R_{zul,45°}$ see Technical Product Manual
$R_{zul,90°}$ $R_{zul,45°} \times 0.707$ [cos(45°) = 0.707]

Resistance values between β = 45° and β = 90° can be obtained by linear interpolation as visualized in the figure below.





Example for interpolation

$R_{zul,45°}$ = 1 kN
$R_{zul,90°}$ = 0.707 kN
$R_{zul,75°}$ = $R_{zul,90°}$ / cos(90° - 75°) = 0.707 / cos(15°) = 0.732 kN

Annex B – Reference Objects

B1. Turning a typical wall element




B2. Motion Gate, Dubai

Peikko's lifting systems, bolt connections, and rebar couplers were used in building the impressive precast dome for Flint's Imagination Lab Attraction. The technique of DfMA (Design for Manufacture and Assembly) was used alongside digital engineering to create the Flint's Dome.

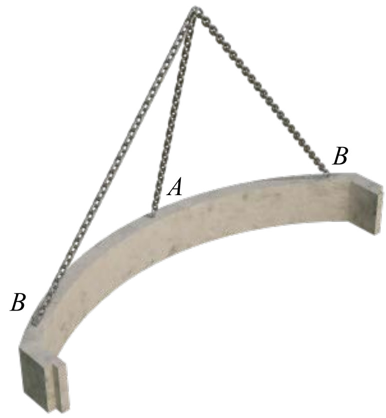
More Information

B3. Lifting and turning of a tunnel construction element

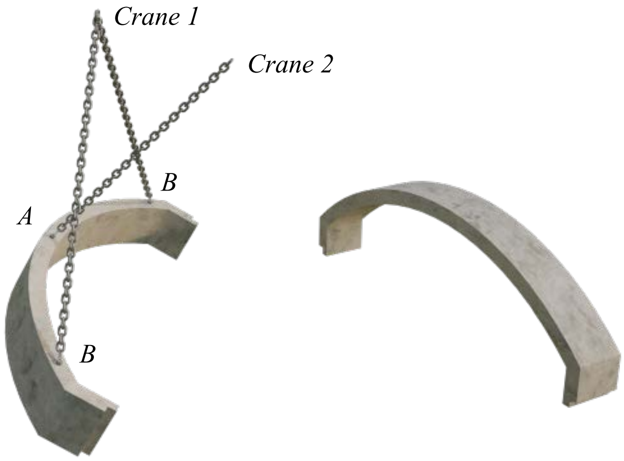
The following example shows the construction of a tunnel ceiling element. It was produced lying on one front side and was also transported in this position on the truck. For handling in factory and loading on truck three KK inserts were used. Unloading from truck was combined with turning the element 90 degree in the air into the upright position. During this, most of the weight was carried by two inserts (*B*) only, which are placed underneath the heavy axis, third insert (*A*) is mostly for keeping balance and for steering rotation during turning process. Therefore, two cranes were used. After rotation, the element was lifted by one crane into final position. This element contains in total five KK inserts.

Casting

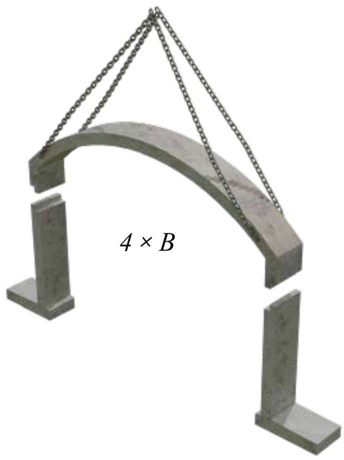
Transport



Turning 90° in to upright position



Installation on site



Tunnel construction

B4. COLIFT in combination with KK inserts for the erection of a column

This example shows the erection of a large column with two cranes directly from the truck using a KK insert and a COLIFT Mounting System. Once erected, the column is moved to the foundation with the COLIFT alone. The construction company here is using COLIFT in combination with extra self-made hardware that has been placed on the shaft to protect their wire loops from sharp bending to increase the lifetime of the wire loops.

Revisions

Version: PEIKKO GROUP 12/2020. Revision: 001

- First publication.

Resources

DESIGN TOOLS

Use our powerful software every day to make your work faster, easier and more reliable. Peikko design tools include design software, 3D components for modeling programs, installation instructions, technical manuals and product approvals of Peikko's products.

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TECHNICAL SUPPORT

Our technical support teams around the world are available to assist you with all of your questions regarding design, installation etc.

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APPROVALS

Approvals, certificates and documents related to CE-marking (DoP, DoC) can be found on our websites under each products' product page.

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EPDS AND MANAGEMENT SYSTEM CERTIFICATES

Environmental Product Declarations and management system certificates can be found at the quality section of our websites.

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MANAGEMENT SYSTEM CERTIFICATION
DNV·GL
ISO 9001 = ISO 14001
ISO 45001 = ISO 3834-2