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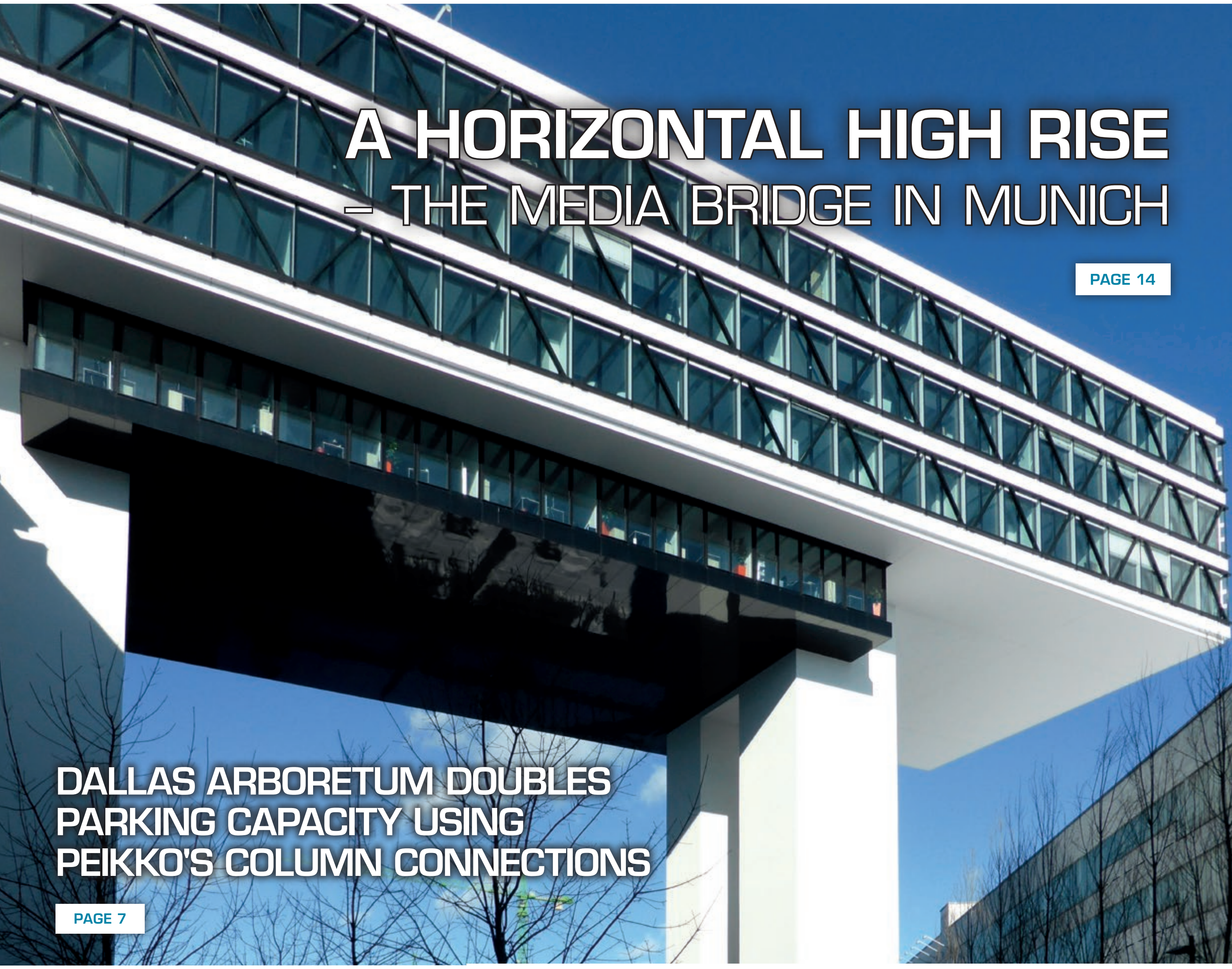
Customer Magazine

1/2015

CONCRETE CONNECTIONS



A HORIZONTAL HIGH RISE – THE MEDIA BRIDGE IN MUNICH

PAGE 14

DALLAS ARBORETUM DOUBLES PARKING CAPACITY USING PEIKKO'S COLUMN CONNECTIONS

PAGE 7

IKEA CONTINUES EXPANDING IN SPAIN

PAGE 4

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PAGE 14

ON THE COVER:
The Media Bridge in Munich – A Horizontal High Rise. Peikko's MODIX® Rebar Coupler System was used in the construction of the Media Bridge.

CONTENTS

REFERENCE STORIES

4 IKEA continues expanding in Spain

7 Dallas Arboretum doubles parking capacity using Peikko's Column Connections

10 Lauttasaari centre gets a makeover

14 A horizontal high rise – The Media Bridge in Munich

TECHNICAL ARTICLES

16 SUMO Wall Shoe A newcomer product in Peikko's product range

19 ETA 13/0151: Design of flat slabs with PSB Reinforcement Elements

PRODUCT NEWS

23 New Peikko innovation: TENLOC® Element Connector accelerates precast construction process

26 Peikko Designer® to expand further

27 New and updated Tools for Designers

PEIKKO GLOBALLY

28 Peikko projects from around the world

30 Peikko's new training series proves popular in Germany

PRODUCTION OF TENLOC® PANEL CONNECTOR HAS BEEN DISCONTINUED

IKEA CONTINUES EXPANDING IN SPAIN

PEIKKO'S COLUMN CONNECTIONS USED IN THE NEW VALENCIA OUTLET – THE BIGGEST IKEA STORE IN EUROPE

Text: Reeta Paakkinen

The Swedish furniture giant IKEA, opened a new outlet in Valencia, Spain, last year. The premises are IKEA's biggest store in Europe, and the sixth outlet in Spain, which has been built using Peikko's Column Connections.

The Swedish furniture giant IKEA's newest store in Valencia, Spain is the chain's largest retail premises in Europe at the moment. The store, which opened in June 2014, is a complicated structure covering some 90,000 square meters (970,000 ft^2). Many different types of concrete connections were used in the building of the huge precast multistorey frame of the structure. As Valencia is located in a seismic region, the store was constructed also following regulations on earthquake-proof buildings.

IKEA Valencia is the sixth IKEA store in Spain where Peikko's connections have been used. In addition to IKEA, the company's previous projects in Spain include premises for several large retailers like Decathlon, Leroy Merlin, Media Markt and Brico Depot.

For IKEA Valencia project, Peikko delivered approximately 5,000 Column Shoes and their corresponding Anchor Bolts. The connections were used in the foundations of the building as well as in the rigid connections between columns and beams.

PEIKKO CHOSEN FOR ITS SAFE, QUALITY PRODUCTS

The precast company of the IKEA Valencia project was Precon, of the global Cementos Molins Group and one of the most prominent companies in the Spanish construction sector with several factories in the country. Precon completes approximately 350 projects in Spain each year.

Precon's and Peikko's cooperation goes back to 2001 when Peikko Spain was established. Over the past 14 years, the two companies have cooperated on numerous projects, such as offices, shopping centers, cinemas, water tanks, pipe racks, and industrial and logistics buildings for large customers like IKEA.

Precon's Technical Director, **Miguel Ángel Santos**, told Concrete Connections, the company decided to use Peikko's products in IKEA Valencia project because of their safety and quality. "We chose to use Peikko's products also in this IKEA project because they are of very high quality and come with technical guarantees and quality certificates. Peikko has a wide range of precast connections, good technical service and logistical solutions – also at the global level," Santos said.

COMPLICATED STRUCTURE IN A SEISMIC LOCATION

At IKEA Valencia, there are various structural areas, communication galleries, designed with large overhangs or cantilevers, which meet strict technical requirements of deformations. The columns in these are very rigid, and their measures vary between 60 x 60 cm (1.9 x 1.9 ft) and 60 x 90 cm (1.9 x 3 ft). The communication stairs structures are executed with solid prefabricated wall panels and rigid joints that transmit forces through them, forming a rigid stair shaft that stiffens the building.

In addition to the complex structure of the building, Valencia's location in a seismic region, made the project rather challenging. Construction partners minimized the combined effects of a potential earthquake, which could result in deformations, pressure, and efforts within the building, by designing one of the floor slabs of the building as hyperstatic. Peikko's products matched the needs of the project also because of their seismic abilities. Peikko's Column Connections have been proven to function safely under seismic conditions by a research and development projects the company conducted with several universities and institutions in different European countries over the past years.

DEMANDING PROJECT

During a complicated construction process, smooth cooperation and coordination between all parties is of utmost importance, Santos said. "The planning of IKEA Valencia was a rigorous and thorough process, having eight phases of work - manufacturing, logistics and assembly – overlapping," he said.

The sheer size of the premises and all the different phases of planning makes the project unique. "It is difficult to compare this kind of a building to any other constructions from the civil engineering point of view," Santos noted. "In this type of construction of great volume, all phases of planning become the greatest cornerstone of the implementation. All industrial actors have to be so very coordinated in the long chain of assembly. Any setback in one of them causes delay in other parties' tasks," he explained. »

Enrique Hernández, Managing Director of Peikko Spain, agreed and noted Peikko was involved in the project from its design phase on. "We did a proper good planning at the beginning to give technical solutions and a good program of deliveries," he said. "Logistics coordination was essential. There were times, when there were up to ten cranes, including the assembly teams, at the construction site at the same time. In total, some 3,000 truck loads of items were sent to the site by all parties. Peikko arranged to send one full truck a month of its deliveries to the precast factory and also to the construction site so that the customer would have the products they needed at that point and our production team would have enough time to prepare the next delivery," Hernández said.

A ONE-YEAR PROJECT

Designing the structure of the building took eight months and required modelling in 3D, and numerous calculations to get the geometric design right given the large number of joints and connections at different levels between elements. Completing the project took one year in total.

In order to enable a quick start of the construction process, the first deliveries of Anchor Bolts were sent to the construction site from Peikko's Madrid warehouse. After the initial kick off of building work, the rest of the products were delivered to Valencia from Peikko's factory in Slovakia, "At Slovakia some 20 employees were working on these deliveries and they worked perfectly according to the customer's schedules," Hernández noted.

NEXT PROJECT ALREADY ON THE WAY

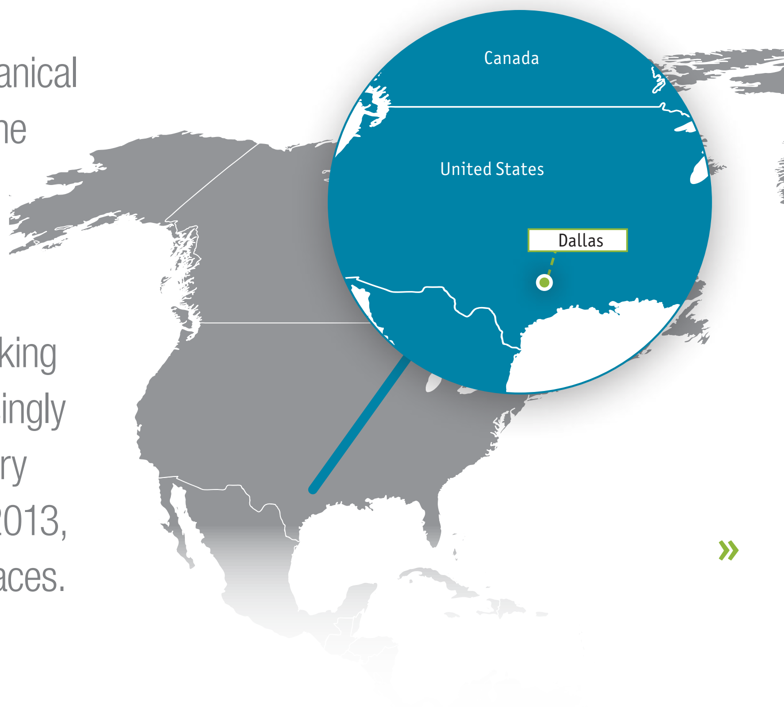
Since IKEA Valencia was completed, the two companies have already started on working on another new logistics project together, a 30,000 square meters (320,000 ft^2) large logistics centre in Barcelona for the global fashion company Mango. "We are very happy with our cooperation with Peikko. There is trust between Peikko and Precon. Of course, our collaboration will expand in the future. This new project is also a construction of a very significant volume," Santos said.

Peikko Spain is very keen to work on constructing more large retail outlets like IKEA in the future. "This is, after all, one of the sectors in which we are very experienced – building large, demanding shopping center structures," Hernandez said. "In this project, we had very good cooperation with all parties, including IKEA. Peikko is used to handle large and very complex buildings. But, of course, future projects – that is, investment decisions of large retailers for 2015 – will depend, by and large, on the global economy," he concluded.

DALLAS ARBORETUM DOUBLES PARKING CAPACITY USING PEIKKO'S COLUMN CONNECTIONS

Text: Reeta Paakkinen
Images: Dallas Arboretum and Southern Pan Structures

The world-famous Dallas Arboretum and Botanical Garden got a new parking garage to match the needs of growing number of visitors in late 2014. The garage was built using Peikko's column-beam bearing assembly. The Dallas Arboretum, ranked among the most breathtaking gardens in the world, has become an increasingly popular attraction after the opening of the Rory Meyers Children's Adventure Garden in late 2013, increasing the need for additional parking spaces.



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The children's adventure garden is designed to connect children with nature and teach them more about life and earth sciences in its seventeen indoor and outdoor galleries. In order to respond to the growing need of parking spaces, the Arboretum decided to build a hybrid post-tensioned parking structure. The new garage was constructed with precast concrete beam and column-components, Peikko's connections and a post-tensioning floor. The new structure doubled the parking capacity of Dallas Arboretum from 1,054 to 2,204 parking spaces.

FIVE LEVELS OF PARKING DOUBLE THE CAPACITY

The Dallas Arboretum and Botanical Garden is located in east Dallas, Texas, on the southeastern shore of White Rock Lake. Its new garage is across the street from the Rory Meyers Children's Adventure Garden with a secure underground walkway underneath Garland Road for safe access. The garage and underground walkway are both handicap accessible.

Some 300 PCs Corbels, 500 Beam Shoes and 400 Column Shoes from Peikko were used in the construction of the new parking garage. The structure has five levels of parking: two levels underground and three levels at street level and higher because of height restrictions in the area. The underground opening is 153-feet-long (46.6 m), 18-feet-wide (5.5 m) and 11-feet-high (3.4 m). The garage design complements the Dallas Arboretum's main public buildings by using similar materials for the garage façade, entrance, stairs and elevator enclosure for the garage. Keeping in line with the garden, the garage includes landscape planters on the second level that face the neighbourhood.

The architect of the project was Good Fulton & Farrall Architects, structural engineer Campbell & Associates and general contractor Rogers-O'Brien Construction. Southern Pan Services (SPS), the superstructure contractor, sourced the precast for the project from Enterprise Concrete Products of Texas (Structural) and Enterprise Precast Concrete of Texas (Architectural). Precast Erectors of Hurst was engaged by SPS for erection of the precast components.

Michal Horak, Director of Peikko's North American business, said the parking garage is a special project for Peikko, as it is the first beam and column garage that is built using Peikko's hidden corbels with high load beams. The combination between a column and beam frame with a post tensioned deck on top of the beams allows for a very high quality finishes on floors and drive areas and very low maintenance over long period of years. "It has the speed of building with prefabricated elements and the floor quality of a cast in place floor. We are bidding for more of this type of garages in the USA," Horak said.

ASSEMBLY THAT WORKS WITH POST-TENSIONED BUILDING SYSTEM

David M. Bobbitt, Vice President at Southern Pan Services, said Dallas Arboretum is the first hybrid project where his company has used Peikko's products. The decision to use Peikko's products came out after research and discussion with Southern Pan Services' customer, Rogers-O'Brien Construction, and the architect of the project, Good Fulton & Farrall during the preconstruction phase on the structural framing solution for the garage.

"It was a collaborative effort as the requirements for the project were very strict. In response to the architect's desire to eliminate exposed corbels in the garage, I researched the availability of bearing assemblies that would work with our hybrid post-tensioned building system," Bobbitt said.

"I first became aware of the Peikko's column-beam bearing assembly and met Peikko's representatives while attending the PCI Convention in Texas. I discussed

with them our needs on the local Dallas project and felt that the Peikko assembly provided the best field tolerances for our application. It also provided an additional level of safety during the erection of the structure," Bobbitt explained.

After the decision had been made to proceed with the Peikko assembly system, SPS conducted a live full scale load test which was administered by a third party testing agency. Peikko participated in the test.

CHALLENGES OF DELIVERING TO BELOW GRADE PREMISES

Sandra Beer, Project Architect at Good Fulton & Farrell Architects, noted the garage is very uniquely designed and it will be visited by thousands of visitors to the Dallas Arboretum each year. The overall form of the garage was developed based on strict zoning requirements and because of this, there were many complexities demanded of the concrete structure.

"These were addressed by the collaborative effort of everyone involved during the design phase," Beer said. "The precast structural engineer and erection contractor were able to work with the design team and preconstruction contractor early on to help develop a design that could be constructed in the tight schedule and the site constraints the Arboretum needed," she noted.

Planning and construction of the garage took approximately two years. Erection of the architectural and structural precast superstructure frame commenced in April 2014 and the 360,000 square feet (33,500 m^2) of elevated 7" (18 cm) post-tensioned slab was complete four months later in August 2014.

"When we received the order in March and started supplying the materials. We shipped every week a full container to Houston. All production dates were met without delay," Horak said.

Given that the project has two levels below grade with a singular point of access, careful coordination of precast deliveries and crane movements was necessary to avoid interference with other jobsite activities. "Access to the structure was limited to the interior footprint of the structure and below grade, which was very challenging," Bobbitt added.

A Peikko representative remained available throughout the casting process to assist the precast plant with assistance and training in using the Peikko's products.

A CLEANER BEAM TO COLUMN CONNECTION CREATES A LIGHTER FEELING

According to Beer, Peikko's connection products enabled the precast concrete engineer to detail the precast to column connections without corbels on all of the interior concrete. This provided a cleaner beam to column connection that allowed the structure to feel lighter. "On the exterior, some of the precast panels were reaching the maximum size limit that could be erected. These were full height, fire rated panels because of the proximity to the property line, and the vertical joint pattern was not aligned to the structural grid at all locations. Again, the precast structural engineer was able to detail a panel connection that worked with our design," she added.

ONE OF THE LARGEST COLUMN-BEAM ASSEMBLIES IN THE US

Bobbitt says he would happily work with Peikko on other projects in the future. "We are convinced that the use of the column/beam assembly adds considerable value to the owner and the builder," he said. "Peikko was very supportive during the process as there was a learning curve having not used the products before. Given that this project was probably the largest application of the column-beam assembly in the United States, it was at times challenging to make sure adequate quantities of the hardware was at the precast plant," he said.

Beer noted she was particularly pleased also at the smooth cooperation of all parties to the project. "This project is testament to how well a design can be implemented when all the right team members are in place during the design phase. Having the precast structural engineers and erection contractor present really paid off," she concluded. ■

Read more on Dallas Arboretum at www.dallasarboretum.org

LAUTTASAARI CENTRE GETS A MAKEOVER

Text: Vesa Tompuri
Images: YIT, Peikko Group

The construction of a new underground line in Lauttasaari in West Helsinki, the capital of Finland, has inspired new building projects along the new route. One of these is a new shopping centre and 130 flats above it, being built next to the future metro station of Lauttasaari. The project is advancing ahead of schedule thanks to Peikko's Composite Frame System made of DELTABEAM® Composite Beams and Composite Columns.

The new metroline connecting western Helsinki with neighbouring Espoo will start operating between Ruoholahti and Matinkylä in August 2016. Several of the most important construction projects along the new line are expected to be completed around the same time. Central Lauttasaari is, however, a particularly demanding location to construct at because of the very limited space available. Lauttasaari is an 3.85 square kilometre (1.49 mi^2) large island connected to mainland Helsinki by bridges.

"We started by pulling down the old shopping centre here and digging and hollowing out some 50,000 cubic

The new metroline tunnel will connect to neighbouring Espoo.

meters (65,400 yd^3). The digging had to be done very carefully because the area is inhabited and because the ground had already been excavated when the metro tunnel underneath was being built," says **Antti Nurmi**, engineer responsible for the project at YIT Rakennus construction company.

At the construction site, traffic on nearby streets had also to be taken into account when agreeing the delivery schedule of the orders as there was only a 15 minute window to load them off, and no storage space.

Peikko's products to the construction site at Lauttasaari arrive both from Lahti as well as the Lithuanian factory of the company. The latter delivers Composite Columns to the site, whereas DELTABEAM® Composite Beams and most of the connection and fastening items have been made at Peikko's Lahti factory.

"This is a major and important project for us with its hundreds of frame components and thousands of other connection components," says **Simo Hakkarainen**, responsible for the Lauttasaari project at Peikko Finland.

Hakkarainen considers it particularly noteworthy that the customer entrusted Peikko not only with the delivery of the frame components, but also the design of the composite frame and its installation.

"The share of this kind of sales seems to be continuously growing in Finland. Projects like this require a lot of effort but it is all worth it as the benefits in these projects are multiple like in this construction site," Hakkarainen explains.

WORKING AHEAD DEADLINES

Initially, Lauttasaari shopping centre was going to be built with a cast-in-situ frame. Technically, there were strong arguments favouring this solution – such as the shape and structure of the building as well as the scant space available at the site. The deadline of the project was, however, so close, that every month that could be cut down from the construction process was taken into consideration and appreciated.

When Peikko proposed the constructor its Composite Frame Solution and explained multiple benefits - how it meant a massive saving in time, use of space and expenses lower, a decision to change the in-situ frame to Peikko's solution was quickly made.

"We calculated that the frame can be finished as a composite frame five months earlier than when it would be possible to complete as cast-in-situ. This comparison inspired the constructor to change his mind although he was already in an advanced stage of the design process, Nurmi explains.

In practice, all plans about the structural frame design of the project had to be redone. This meant numerous, frequent meetings between structural designers, Wisegroup and Sweco.

"Wisegroup would send us drawings and we would comment on them, for example. We have discussed some details of the plans and then made some more detailed changes to the design taking into account both the installation of the frame as well as the production side of affairs, Project Manager of Sweco", **Ville Tarvainen** says.

Urpo Karesniemi, Head Designer at Wisegroup, notes that the same composite frame solution spans all the way to the garage of the complex.

"Time saving, from the customer's point of view, is such a notable benefit that it has been worth making a bit of effort for it. In this project, the shape of the structures is so exceptional that we really had to tailor-make part of the details in a very careful manner," he says.

Jussi Lukkari, Ville Tarvainen and Simo Hakkarainen at the Lauttasaari building site.

Peikko started designing the Composite Frame in autumn 2014, and the process took some six months. The delivery of Composite Columns and DELTABEAM® Composite Beams to Lauttasaari started in March and continued until August 2015. The heaviest beams delivered to Lauttasaari construction site weighed 15 tonnes (16.5 US Tons).

"Long spans were in a corresponding manner 15 meters (49 ft) at highest, so we are talking about very strong components. On the other hand, the same structure also includes short columns and beams. Columns range between some 6–15 metres (19.7–49.2 ft) from one another," says Hakkarainen.

FRAME NEEDS NO ADDITIONAL FIRE PROTECTION

An important factor at the time management of Lauttasaari project was also the full use of building information modeling, both at the construction site, in the

design process as well as Peikko's production. This has enabled optimizing the use of space of the frame structure, as well as the HVAC. This task has been made easier by the fact that in this project, the cross section dimensions of Peikko's Composite Frame are about one fifth smaller compared to cast-in-situ concrete structure.

"The slimness of the structure has the added benefit that it is not necessary to think from which point technology would be delivered to the site through the frame. All technology fits into the space reserved for it under and in between of the structure," says Tarvainen.

In addition to reaching remarkable time savings in the frame construction and wider open spaces, Peikko's Composite Frame was found to have also a third benefit. No additional fire protection of the frame is needed, because the in-built fire protection of the DELTABEAM® Composite Beams and Composite Beams makes the frame fire resistant up to R180, which has been proven in several full-scale fire tests.

The installation of the Composite Frame at the site at Lauttasaari is part of the delivery contract between Peikko and YIT. "I have a team of 17 people at the construction site, and they take care of both, the installation of the steel components, as well as reinforcing and casting. With an experienced team, even a demanding construction project proceeds smoothly," says **Jussi Lukkari**, who oversees the installation of the Composite Frame. ■

> ” We calculated that the frame can be finished as a composite frame five months earlier than when it would be possible to complete as cast-in-situ.

Antti Nurmi (left) and Simo Hakkarainen.

PETRA Slab Hangers were used on the site.

A HORIZONTAL HIGH RISE

– THE MEDIA BRIDGE IN MUNICH

Text: Claudia El Ahwany
Photos: AHert

The Media Bridge in Munich is an office building that is 90 meter (300 ft) in length, 23 meter (75 ft) in depth and is in a raised position approximately 45 meter (150 ft) above the ground. It is supported by two lattice framework structures. The office space is occupied first and foremost by media professionals. Here, the architects have designed a building that boasts the most unusual geometry and it is frequently referred to as a "horizontal high rise".




For the implementation of this project, some 1,350 tons (1,490 US Tons) of steel reinforcement were required. Due to transport and structural constraints, however, it was not always possible to deliver and assemble steel reinforcement bars of the required length. The rebars therefore had to be connected on site by Grossmann Bau GmbH of Rosenheim – the company commissioned to do the construction work.

REBAR SPLICING: TRADITIONAL METHODS

There are two classic methods for connecting rebars. The first method uses the lap splice: here the rebars are positioned next to each other in such a way that their ends overlap in compliance with the permissible values. When the concrete has hardened the applied forces (tensile and compression) are transferred via the overlap length. However, the greater the diameter of the rebars, the greater the required length of the lap. For the construction of the Media Bridge rebars were frequently required in diameters of 25–40 mm (1"–1 1/2"), and these could not be offset due to reasons concerning structural stability.

Consequently, the concrete cross section of the construction element was not large enough for the installation of the appropriate reinforcement. Even if it had been possible to accomplish this tricky job, the result would not have met the pertinent standards and the permissible maximum percentage of steel in reinforced concrete would have been exceeded.

As a second alternative method, the rebars are field-welded. This process, however, requires a relatively large amount of space. In addition to this, the work has to be carried out by trained specialists. This working method is also very time-consuming, expensive and difficult to implement under field conditions (wet, cold etc.).

THE ALTERNATIVE SOLUTION: REBAR COUPLER SYSTEM

The solution then found involved Peikko's MODIX® Rebar Coupling System. This screw system connects rebars in a few simple steps using positive engagement. Even connections between two bars of different diameters or the connection of straight and bent bars can be made with the greatest of ease. The rebars are fitted with MODIX® Rebar Couplers at the bending plant and just have to be screwed together at the site.

In contrast to most systems of this kind that are available on the market, a torque wrench is not required. Because MODIX® Rebar Couplers are designed with a specific control ring the assembly can take place using a conventional wrench.

Another advantage of this coupler system is that the secure connection can be checked by visual inspection. This facilitates work for the site manager and the structural engineer and offers a major advantage over similar products available on the market today, where the connection has to be checked manually by means of sampling. Such sampling methods are uncertain, unpleasant, expensive and time consuming.

For the project in Munich some 12,000 MODIX® Rebar Couplers were installed and the whole building reinforcement was positioned and assembled within a period of just 50 weeks. Without this efficient coupler system it would not have been possible to build the Media Bridge, according to parties involved in the construction. ■

Because of its unusual shape the Media Bridge is referred to by many as a horizontal high rise. The office block is supported by two 45 metres high reinforced concrete towers that also provide access to the building.


SUMO WALL SHOE
A NEWCOMER IN PEIKKO'S PRODUCT RANGE

Authors:

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INTRODUCTION

Peikko Wall Shoes are primarily used to create cost-effective bolted connections between precast concrete walls and foundations or between two precast concrete walls. They have been available for several years and are highly regarded by customers for the following reasons:

- Quick and easy erection of the wall with good adjustment possibilities
- Convenient, rapid bolt connection without welding
- High tensile capacity
- The connection is functional and able to transfer a tensile force immediately after the element is erected

In 2000, two separate types of Wall Shoe were developed to comply with the requirements of the Scandinavian market (PSK Wall Shoes) and the Central European market (HPEW/PPEW Wall Shoes). The implementation of Eurocodes removed most of the local requirements and the differences between the two product types, enabling the development of a single European Wall Shoe type: the SUMO Wall Shoe. Using one single model of Wall Shoe will enable Peikko to further improve the efficiency of its customer service and ensure the reliability and speed of deliveries.

ABOUT SUMO

A typical wall shoe connection consists of SUMO Wall Shoe elements, Anchor Bolts (HPM, PPM), and a suitable square washer (AL). SUMO Wall Shoes are cast into the bottom part of the concrete wall together with the main and supplementary reinforcement, while anchor bolts are cast into the foundations or into the top part of the lower wall (Figure 1).

The SUMO Wall Shoe consists of a bottom plate and anchor bars. The bottom plate of the wall shoe is made of a thick steel plate with an oval slotted hole. This hole allows the anchor bolts to be attached and tightened to the anchor plate.

Figure 1. SUMO Wall Shoe and HPM, PPM Anchor Bolts in wall connection.

The wall shoe is primary loaded by tensile forces that act on the bolt. These forces are transmitted through the bottom plate to the anchor bars. The anchor bars anchor the tensile force by lap splicing with the reinforcement of the wall (Figure 2).

The products are designed to comply with harmonized European Standards (EN 1990-1-1; EN 1992-1-1; EN 1993-1-1). The design and performance of existing wall shoe types has been optimised taking account of the market requirements that have been identified by Peikko Group's sales teams in various countries. The SUMO Wall Shoes now offer (in comparison to former Wall Shoe models):

- Bigger tolerances
- Easier casting with no additional tools such as styrofoam
- An extended range of models (SUMO may be combined with all available HPM and PPM Anchor Bolts) (Table 1)

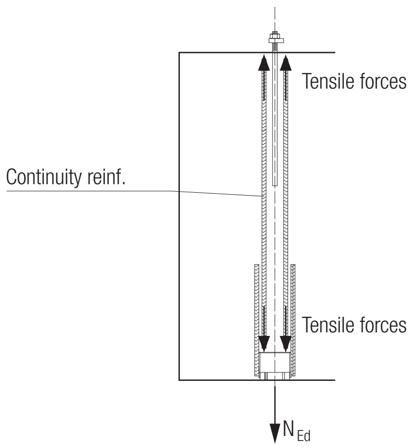


Figure 2. Structural behavior of the wall connection.

Table 1. Design values of resistances of individual SUMO Wall Shoes.

Wall Shoe	Anchor Bolt	N_{Rd} [kN]	Color code
SUMO 16H + AL 16*	HPM 16	62	Yellow
SUMO 20H + AL 20*	HPM 20	96	Blue
SUMO 24H + AL 24*	HPM 24	139	Gray
SUMO 30H + AL 30*	HPM 30	220	Green
SUMO 39H + AL 39*	HPM 39	383	Orange
SUMO 30P + AL 30*	PPM 30	299	Black
SUMO 36P + AL 36*	PPM 36	436	Red
SUMO 39P + AL 39*	PPM 39	521	Brown
SUMO 45P + AL 45*	PPM 45	670	Purple
SUMO 52P + AL 52*	PPM 52	938	White

*Special square washer

Modeling tools (Tekla Structures and AutoCAD) are available at www.peikko.com/software.

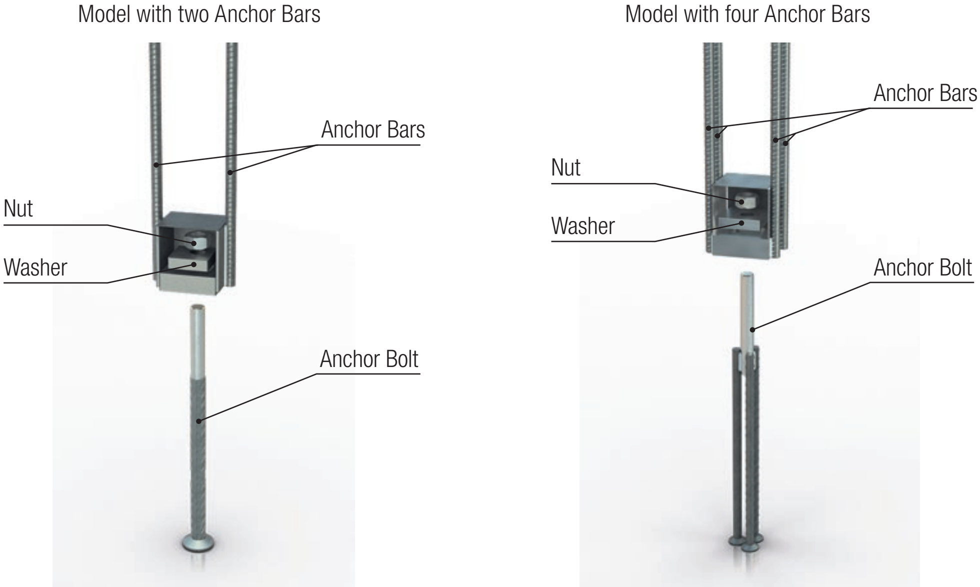


Figure 3. Connecting SUMO Wall Shoe and HPM, PPM Anchor Bolts.

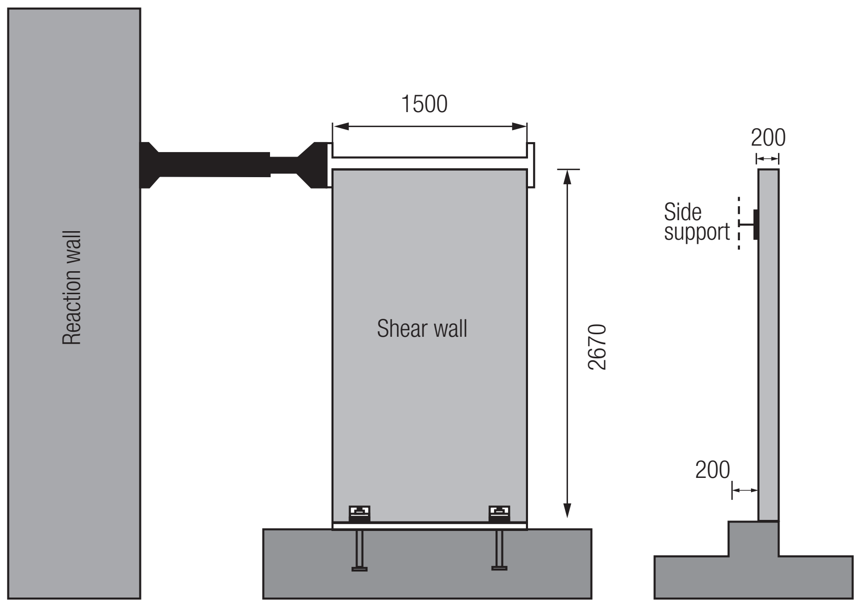
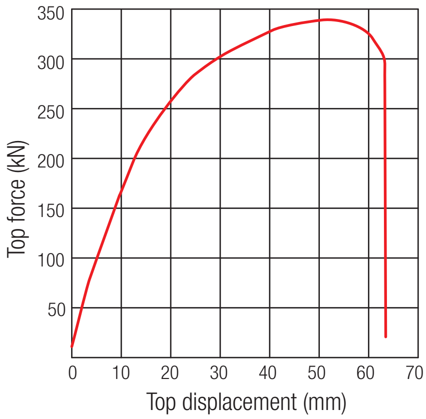


Figure 4. Indicative experimental setup, final view of the connection.

EXPERIMENTAL INVESTIGATIONS

Concrete walls bolted at their base with SUMO 39P Wall Shoes and HPM 39L Anchor Bolts were experimentally tested within the framework of the Safecladding project in the National Technical University of Athens, Greece. Safecladding is a European research project referring to the seismic behavior of cladding panels. The experimental setup consists of a 1500 x 2670 x 200 mm (59" x 105" x 8") concrete wall bolted eccentrically onto a T-shaped foundation beam. A 20 mm (3/4") joint between the foundation beam and the wall is filled with high strength, non-shrink grouted material. At the top of the concrete wall, a hydraulic jack imposes target displacements until the system completely collapses. The experimental set up and the final view of the wall shoe connection are shown in Figure 4.

The monotonic test revealed the highly ductile behavior of the wall shoe connection. In Figure 5 the force–displacement curve shows that the connection maintains its resistance by giving increased lateral deformations. The maximum top displacement of the wall before the fracture of the anchor bolt due to tension reached 62 mm (2 1/2"). The same figure shows the bolt force–elongation curve, enabling a comparison of the maximum tensile force (maxN = 750 kN) with the design from Table 1 (N_{Rd} = 521 kN).



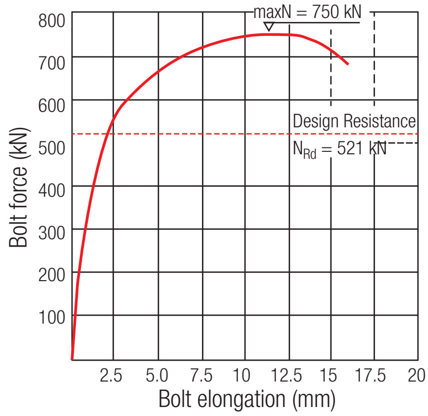
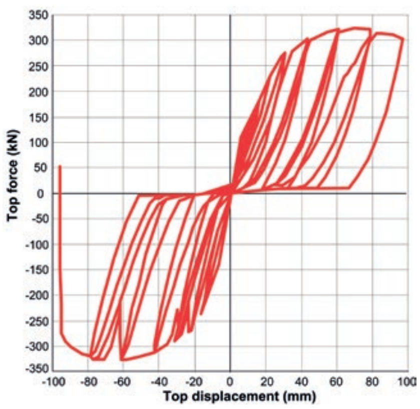


Figure 5. Monotonic test: Top force versus displacement, tensile bolt force versus elongation and damaged pattern after the test.

The HPKM® 39L Anchor Bolt demonstrated an overcapacity of 44% without causing any brittle failure modes in the foundation such as pry out phenomena or excessive cracks. At the end of the test, no deformations of the SUMO Wall Shoes were observed; there was only minor damage in the concrete due to the compressive stresses at the bottom face of the panel.

A cyclic test with imposed top deformations of increased magnitude was also conducted. The wall system demonstrated stable and ductile behavior by achieving a maximum top displacement of 100 mm (4"). In Figure 6 the hysteretic curve and the cracked pattern are demonstrated. The cyclic test ended due to the fracture of the bolts. A considerable number of inclined cracks were observed on the wall, which is quite typical for concrete walls under cyclic shear loadings.



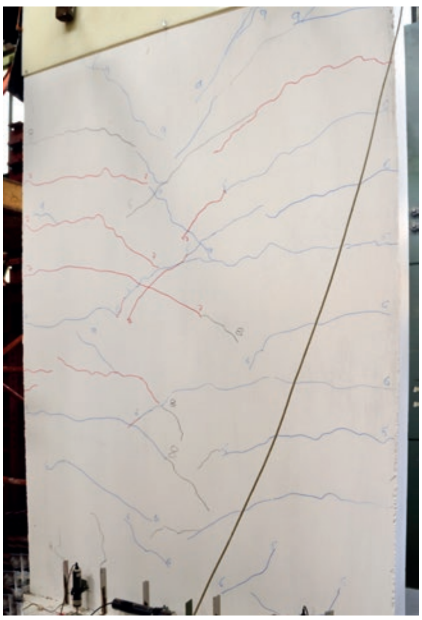


Figure 6. Cyclic: Top force versus displacement and crack pattern

CONCLUSIONS

The benefits of wall shoes have been known and highly regarded by Peikko's customers for years. SUMO Wall Shoes integrate all of the benefits of existing PSK and HPEW/PPEW Wall Shoe types while being further optimized to meet market requirements in all European countries. A research program on the static and cyclic behavior of the wall shoe connections started in 2014 and yielded promising results. The first results of the test program indicate that the SUMO Wall Shoe connection is at least equivalent to monolithic connections from the point of view of structural performance and resistance, while offering a wide range of practical benefits that are not available with traditional monolithic systems. Further tests are planned and the results will be published in forthcoming articles. The new SUMO Wall Shoes thus provide Peikko Group with the potential to further promote and develop the use of this product range in both traditional and new markets. ■

ETA 13/0151: DESIGN OF FLAT SLABS WITH PSB REINFORCEMENT ELEMENTS

Author:
Jan Bujnak,
PhD, R&D Manager,
Peikko Group

INTRODUCTION

PSB reinforcement elements consisting of double-headed studs welded onto an assembly profile (Figure 1) are currently one of the most competitive techniques for enhancing the resistance of reinforced concrete flat slabs against failure by punching. The system has been available on the European market for more than 20 years and has been highly popular. Despite this, the design methods for slabs reinforced by double-headed studs are not yet implemented in the harmonized European standard EN 1992-1-1 [1] for reinforced concrete structures.

Figure 1. PSB reinforcement elements.

Over the past couple of years, Peikko Group has invested significantly into several R&D projects related to PSB. These projects include experimental research into the performance of slabs reinforced by PSB, development of national and European technical approvals, and development of design tools.

Currently, the European Technical Approval ETA 13/0151 [16] is the only valid reference for the design of slabs reinforced with PSB reinforcement in Europe. This ETA is also a reference for the CE marking of PSB studs. ETA 13/0151 [16] entered into force in April 2013 and since then, hundreds of projects have been designed referring to it in about 20 European countries. The design has been generally well accepted by designers and local building authorities. Nevertheless, designers in a couple of countries have raised some questions, mainly regarding the official/administrative status of ETA 13/0151 [16] with regards to EN 1992-1-1. The purpose of this paper is to develop research-based arguments that could answer such questions.

DESIGN RECOMMENDATIONS OF EN 1992-1-1

The Eurocode EN 1992-1-1 defines the basic framework for the design of reinforced concrete structures in Europe. The design of punching shear reinforcement typically consists of the following steps:

1. Resistance of the slab without punching reinforcement ($V_{Rd,c}$)
2. Maximum resistance of slabs ($V_{Rd,max}$)
3. Number and diameter of reinforcement links in basic control perimeter
4. Number of perimeters or reinforcement links necessary to activate a sufficient resistance on the outer perimeter ($V_{Rd,out}$)

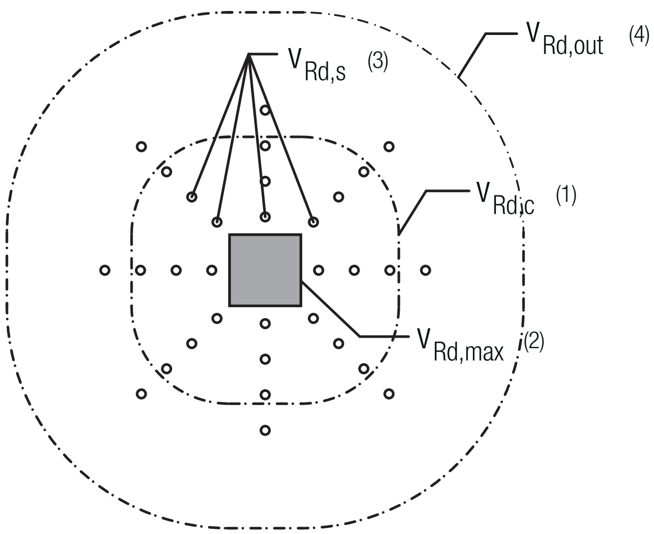


Figure 2. Resistance of slab reinforced with shear reinforcement.

Extensive information about the background of the design methods of EN 1992-1-1 may be found in reference 17. While verifications 1, 3 and 4 are relatively straightforward and consistent with practices that existed in former national codes preceding EN 1992-1-1, the verification of the maximum resistance of the slab seems to be more ambiguous. Indeed, according to reference 17, several alternative empirical models have been considered for theverification of $R_{d,max}$ during the development of EN 1992-1-1. The model implemented in EN 1992-1-1 and published in 2004 verifies the maximum resistance of the slab as follows:

$$V_{Rd,max} = 0.5 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \qquad (1)$$

According to the knowledge of the author of this paper, there is little or no reference or argument to validate the pertinence of this empirical model on research-based arguments. On the contrary, the model has been widely discussed and criticized among researchers and designers in several countries over the past couple of years (see references 10–14). Consequently, the approach of EN 1992-1-1 has been modified in a total of seven national annexes, each annex using its own national design approach. In parallel to national annexes, the formula has already been modified twice (references 2 and 3) in the basic document (EN 1992-1-1) since 2004, mainly due to concerns regarding its safety and overall pertinence (Table 1).

The summary in Table 1 shows that the design framework for slabs reinforced by such stirrups has been relatively unstable during the past ten years in Europe. One of the reasons behind this might be the lack of knowledge, common understanding, and proper scientific arguments concerning the behavior of slabs reinforced by stirrups. This observation has been one of the main motivating factors for Peikko Group's experimental program focusing on demonstrating the real performance of slabs reinforced with PSB studs. The experimental campaign performed in cooperation with EPFL Lausanne in Switzerland (see reference 15 for details) produced evidence that has been used by European building authorities to grant ETA 13/0151, which is currently the only official and valid reference for the design of slabs reinforced with PSB studs.

Table 1 Maximum resistance of the slabs according to EC2 and national annexes.

CEN versions since 2004		EN 1992-1-1 (2004) [1]	$0.5 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d$
		EN 1992-1-1/AC (2010) [2]	$0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d$
		EN 1992-1-1/A1 (2014) [3]	$min\begin{cases}0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ 1.5 \cdot v_{Rd,c} \cdot u_1 \cdot d\end{cases}$
National Annexes	Germany	DIN EN 1992-1-1 [4]	$1.4 \cdot v_{Rd,c} \cdot u_1 \cdot d$
	Austria	Onorm EN 1992-1-1 [5]	$min\begin{cases}0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ k \cdot v_{Rd,c} \cdot u_1 \cdot d\end{cases}$ $k = 1.4\ for\ d \leq 200mm$ $k = 1.6\ for\ d \geq 700mm$
	Finland	SFS EN 1992-1-1 [6]	Refers to former national standards
	Slovakia	STN EN 1992-1-1 [7]	$min\begin{cases}0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ k \cdot v_{Rd,c} \cdot u_1 \cdot d\end{cases}$ $k = 1.4\ for\ d \leq 200mm$ $k = 1.8\ for\ d \geq 700mm$
	United Kingdom	BS EN 1992-1-1 [8]	$min\begin{cases}0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ 2.0 \cdot v_{Rd,c} \cdot u_1 \cdot d\end{cases}$
	Sweden	SIS EN 1992-1-1 [9]	$min\begin{cases}0.5 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ 1.6 \cdot v_{Rd,c} \cdot \frac{u_1}{u_0} \cdot u_1 \cdot d\end{cases}$
	Switzerland	SN EN 1992-1-1 [18]	$min\begin{cases}0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ k_{max} \cdot v_{Rd,c} \cdot \left(\frac{5 \cdot d}{r_s}\right)^{1/3} \cdot u_1 \cdot d\end{cases}$

The scope of the EN 1992-1-1 is limited to structures reinforced with reinforcement links detailed in accordance with Figure 8.5 of EN 1992-1-1 (stirrups on Figure 3).

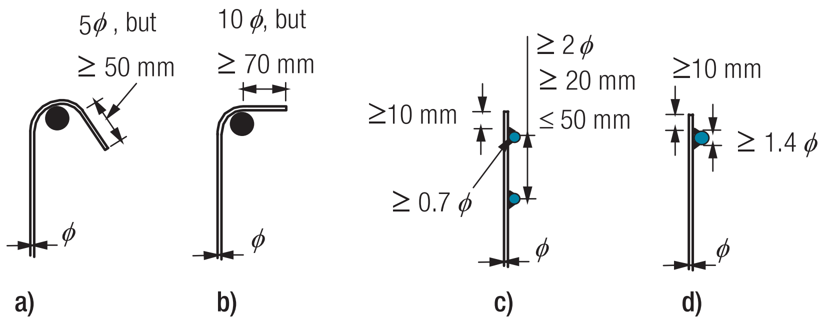


Figure 3 Types of reinforcement elements falling within the scope of EN 1992-1-1.

DESIGN RECOMMENDATIONS OF ETA 13/0151

In accordance with the Construction Products Regulation (EU No. 305/2011), the European Technical Approval (nowadays called European Technical Assessment) is defined as a "document providing information about the performance of a construction product, to be declared in relation to its essential characteristics". ETAs may be issued for products that are covered in whole or in part by any harmonized

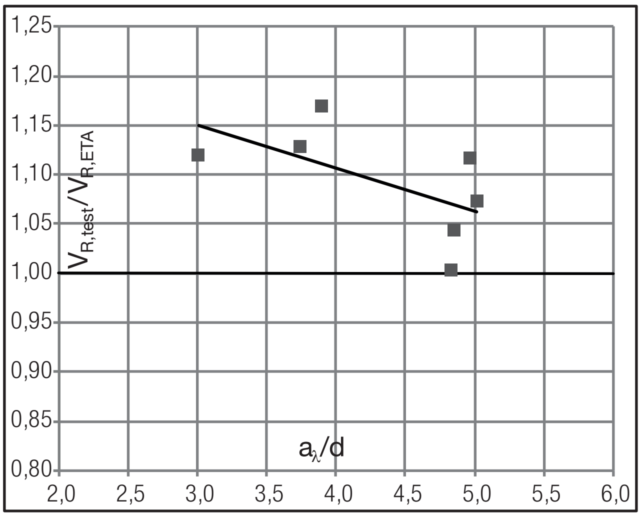


Figure 4. Safety level of formula 2 – ETA 13/0151.

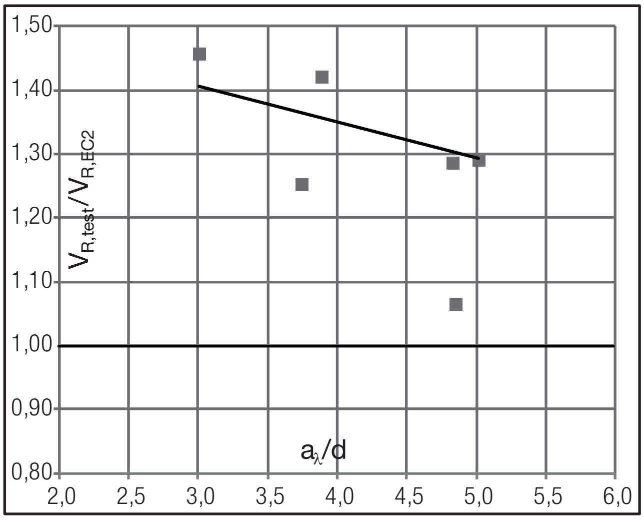


Figure 5. Safety model of formula 3.

technical specification. In order to obtain the ETA, the manufacturer needs to fulfill requirements formulated in European assessment documents (EADs, formerly known as CUAPs). The ETA and EAD/CUAP of each building product are validated by approval bodies from 28 member states of the EU.

The design recommendations implemented in ETA 13/0151 for PSB partly refer to the design concepts of EN 1992-1-1 and thus follow the design logic described in the previous paragraph. However, certain deviations have been implemented in order to represent the specific structural properties of slabs reinforced by PSB studs as demonstrated by tests. One of the differences between the design methods of EN 1992-1-1 and ETA 13/0151 lies in the verification of the maximum resistance of flat slabs, which is formulated in ETA 13/0151 as:

$$V_{Rd,max} = 1.96 \cdot v_{Rd,c} \cdot u_1 \cdot d \quad (2)$$

The resistance is thus formulated analogous to the concept used in DIN EN 1992-1-1 with a value 40% larger than the resistance of a slab reinforced with stirrups. The empirical factor 1.96 has been calibrated according to the results of full-scale tests on the basis of a statistical evaluation performed in accordance with EN 1990 (see reference 15 for details). So far, ETA 13/0151 has been well accepted and understood by designers. If any questions related to this design remain, they are mostly related to the status of ETA 13/0151 in relation to EN 1992-1-1.

More precisely, some designers tend to overlap the two design methods and formulate the resistance by defining the maximum resistance of the slab as the minimum of:

$$V_{Rd,max} = min\begin{cases} 0.4 \cdot \vartheta \cdot f_{cd} \cdot u_0 \cdot d \\ 1.96 \cdot v_{Rd,c} \cdot u_1 \cdot d \end{cases} \quad (3)$$

Such interpretation is probably based on the assumption that formula 1 describes a failure of the slab that occurs independent of the type of shear reinforcement used in the slab. This assumption is, however, not validated by research, at least not by the tests that have been used as a reference for the development of ETA 13/0151. The evaluation of test results in Table 2 shows that formula 2 alone leads to a 5% fractile of 1.0, meaning that the design model is safe and reliable with regards to the requirements of EN 1990. If the same evaluation is carried out with formula 3), the 5% fractile increases to 1.07, meaning that the design is still safe but the evaluation is unnecessarily conservative. In practice, the ultimate load in tests with PSB studs has been an average of 25% higher than that predicted by formula 3.

CONCLUSIONS

With ETA 13/0151, Peikko Group offers its customers the possibility to optimize the design of slabs using reliable design concepts that have been validated by extensive experimental research. The design methods implemented in ETA 13/0151 were approved by building authorities in all 27 member states of the EU during the process of development of the ETA approval. The approval covers both the design of the PSB stud and the design of slabs reinforced with PSB studs. Combining ETA with EN 1992-1-1 leads to an unnecessarily conservative design.

Table 2. Evaluation of design models (see reference [15] for details of tests).

	$V_{R,test}$	$V_{R,C}$	$V_{R,EC2}$	$V_{R,ETA}$	$V_{R,ETA}/V_{R,Ec2}$	$V_{R,test}/V_{R,ETA}$	$V_{R,test}/V_{R,EC2}$
PP1	864	395.3	554.9	774.9	1.40	1.12	1.56
PP2	1095	535.8	1027.7	1050.2	1.02	1.04	1.07
PP3	4754	2076.9	3346.2	4070.8	1.22	1.17	1.42
PP4	2076	946.9	1426.2	1856.0	1.30	1.12	1.46
PP5	1812	922.5	1408.7	1808.1	1.28	1.00	1.29
PL9	3132	1491.8	2429.1	2923.9	1.20	1.07	1.29
PL10	5193	2350.1	4150.0	4606.2	1.11	1.13	1.25
					AVG	1.09	1.33
					COV	0.05	0.15
					5%	1.00	1.07

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$V_{Rd,max}$	Maximum resistance of slabs with shear reinforcement
$v_{Rd,c}$	Resistance of slab with out shear reinforcement
u_1	Basic control perimeter
d	Effective depth of the slab
ϑ	Empirical factor
f_{cd}	Compressive strength of concrete
u_0	Column periphery
k_{max}	Parameter depending on the type of reinforcement
r_s	Parameter depending on the span of the slab

PRODUCTION OF TENLOC® PANEL CONNECTOR HAS BEEN DISCONTINUED

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PEIKKO DESIGNER® TO EXPAND FURTHER

Text: Reeta Paakkinen

Peikko's design tool Peikko Designer® is being developed further with the adding of seismic specifications to the column connection applications. The new version of the program is expected to be ready in 2016.

Taru Leinonen, Peikko's Research and Development Vice President, says background research for the seismic specifications took several years, but the writing of the specifications has now started.

Users of Peikko Designer® can fully trust its calculations because all its settings and components have been thoroughly tested. In fact, it is tested and trusted software, it is continuously crosschecked and we base our own daily design work on it as well," Leinonen said.

"Design programs are one of our priorities that we work on continuously - by updating the system, adding modules and characteristics. The structural designer can be sure that he or she has the most up-to-date information at hand, which brings added value to the design process," Leinonen added. Peikko's R&D team is keen to get user feedback on all aspects of the program so that it can keep it very up-to-date and make sure it serves the company's customers best.

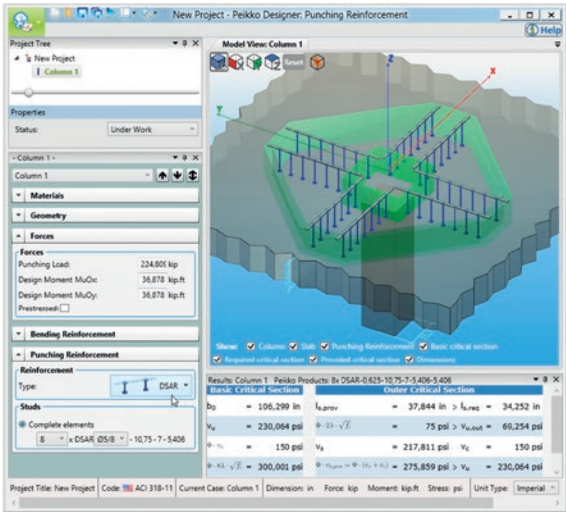
U.S. DESIGNING CODE ADDED

The other new addition to the program was in early 2015, the introduction of the U.S. designing code for Punching Prevention module. Peikko Designer® now offers calculations in inches and feet and the localized solution fully complies with U.S. requirement.

Anne Rissanen, R&D Manager responsible for Peikko's design tools, noted having localized versions for the programmes makes the designer's work easier. "The designer can make all the calculations with a few clicks and the print out is accepted by both, authorities and customers. Design result can also be transferred directly to the AutoCAD design program," she said.

SERVING DESIGNERS IN 70 COUNTRIES

Peikko Designer® is Peikko's own design software to help structural designers select the most suitable Peikko product for the structure. It was developed in 2009 on the basis of Peikko's earlier design program and today includes a wide range of European design norms and more than 10 languages.



Design view from Peikko Designer®

With Peikko Designer®, structural designers can easily calculate Column Connections, Punching Reinforcement and Fastening Plates. It helps in selecting the most suitable Peikko product for the structure in question.

Load cases can be copied from structural analysis and design software, and added to Peikko Designer®. The modern and intuitive user interface is based on interactive 3D graphics. All design cases can be printed easily and saved to one file. As the software updates automatically, designers can always benefit from the latest features. The program can be downloaded from Peikko's website for free.

NEW AND UPDATED TOOLS FOR DESIGNERS

Tools for Designers is Peikko's toolbox for structural designers to make their work faster, easier, and more reliable. The toolbox includes design software, 3D components for modeling programs and technical manuals of Peikko's products.

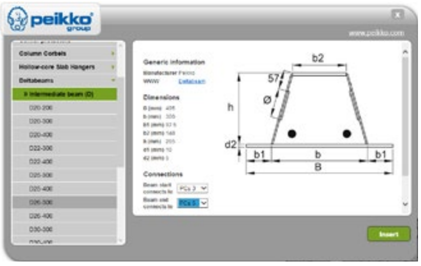
New and updated tools, can be found from Peikko's website at www.peikko.com/software. The Tools for Designers section has been recently updated with new and updated tools. On the website you can find more information on recent releases of our design software Peikko Designer® as well as other modeling tools.

PEIKKO DESIGNER® PUNCHING REINFORCEMENT

We have released Punching Reinforcement design according to ACI in Peikko Designer®. Design is based on ACI 318-14 and user can choose imperial units for designs.

DELTATOOL IS NOW DELTABEAMTOOL

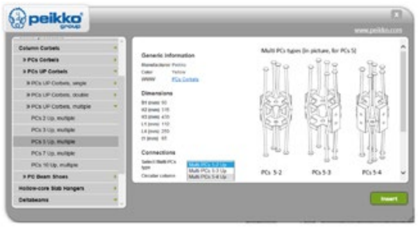
We have updated DeltabeamTool, The new version is compatible with AutoCAD 2014 and 2015. Drawing properties have been improved: modifying is now easier with the own layout of DELTABEAM® and the manually made changes to the technical fabrication requirement label are kept. Now it is possible to see gerber connection, rise and rotation around x-axis also in DELTABEAM® schedule.



3D MODELING TOOLS FOR TEKLA AND REVIT

The latest new plug-in for Tekla is SUMO Wall Shoes. The new plugin comes in the installation package of Anchor Bolts and Column Shoes.

We have released new product families for Revit plug-in. New families are SUMO Wall Shoe, PCs Column Corbel with supplementary reinforcement and PC Beam Shoe. Also DELTABEAM® has now end plate that can be solid or with matching hole for PCs Column Corbel.



TOOLS FOR DESIGNERS

Peikko's design tools, plug-ins and components can be downloaded from our websites. In the Software download center you will find short introductions on the tools and instructions how to register and download them. With the help of Tools for Designers, Peikko's goal is to make designing and detailing faster, easier, and more reliable!

Software download center:
www.peikko.com/software

NEWS ON PEIKKO'S DESIGN TOOLS TO YOUR EMAIL

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PEIKKO PROJECTS FROM AROUND THE WORLD

Peikko Sweden has received a substantial order for the composite frame structure of SEB Bank's new office buildings in Arenastaden in Solna close to the Swedish capital of Stockholm. The delivery consists of more than 13 kilometers (8 miles) of DELTABEAM® Composite Beams and Composite Columns. The deliveries take place between April 2015 and May 2016. The buildings will be finished in January 2018.

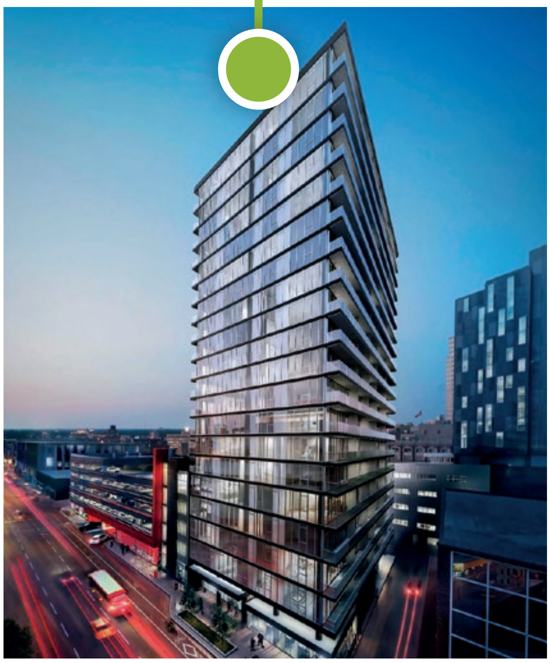
Peikko Spain was involved in design and supply of Column Connections to the Smurfit Kappa Group's Paper Mill project in Mexico. In total Peikko delivered 5 full containers (90 Tons, 100 US Tons) of PEC Column Shoes and PPM Anchor Bolts to Mexico by the end of 2014. The project will be finished during 2015.

Peikko Poland has received substantial orders for altogether 4.5 kilometers (2.8 miles) of DELTABEAM® Composite Beams to two large office building projects in cities of Wrocław and Warsaw. The investor in both of the projects is Vastint Poland, which is part of the Inter IKEA Property Division. In both projects the investor will apply for LEED Platinum certification.

Peikko Finland delivers 1.1 km (0.68 miles) METAFORM DUO Free Movement Joints to Prisma hypermarket in Jyväskylä, Finland. The new deliveries take place in July and August 2015. Prisma is one of the larges retail chains in Finland.

Peikko Germany delivers MODIX® Rebar Couplers to the world's third-largest mosque in Algeria. A special role in the architecture of the building is played by 618 white octagonal columns. The MODIX Rebar Couplers are used to splice the tall columns.

Peikko Canada has received substantial orders for a residential project named Glasshouse in downtown Winnipeg, Manitoba. The deliveries comprise of nearly 1.9 kilometers (1.2 miles) of DELTABEAM® Composite Beams and over 600 PCs Corbel connections. Peikko's patented hidden corbel connection allows DELTABEAM® to simply be dropped in place without welding or bolting which saves time especially during winter construction.



Peikko Austria delivers Anchor Bolts and Column Shoes to the Austrian soccer club SK Rapid's new home stadium in Vienna Hütteldorf, Austria The Stadium will be completed in summer 2016.

Peikko Germany delivers MODIX® Rebar Couplers to the ThyssenKrupp's new landmark test tower. The tower will be 244 meters (800 ft) high and it will be one of the tallest structures in Germany.

PEIKKO'S NEW TRAINING SERIES PROVES POPULAR IN GERMANY

– TRAINING FOR ENGINEERS AND ARCHITECTS: INNOVATIVE SLAB SYSTEMS FOR NEW AND EXISTING BUILDINGS

Text: Michael von Ahlen, ad-media

On May 7, 2015, the launch of the training series "Innovative slab systems for new and existing buildings" was hosted at the Science Park in Gelsenkirchen by Peikko Germany. The debut event was a great success, as the attendance of more than 50 people, mostly engineers, exceeded the expectations of the organizers. The numerous questions of the participants bore witness to the great interest and need for this training.

Oliver Beckmann, R&D Manager at Peikko Germany, welcomed the guests and introduced Peikko Group and its business briefly. He then presented the first speaker of the day, Peikko Germany's Project Development Manager **Sascha Schaaf.**

Sascha Schaaf opened the course with his lecture about Peikko Frame Systems. He explained the technical details of this modular structural system, consisting of DELTABEAM® Composite Beams, Composite Columns and additional steel components. He further elaborated on design principles in selecting the slab system and gave design instructions for Frame Systems and concluded with a view on its economy and sustainability.

Subsequently, Dr. **Karsten Pfeffer** of Cobiax Technologies explained a slab technology with hollow plastic body modules in the concrete slab. Savings in the amount of concrete and the weight of the construction allow slimmer structures and floors and thus lower building heights. After an introduction to the design, he illustrated this with reference projects, such as the Vodafone Campus or the Kö-Bogen in Dusseldorf.

Hartmut Fach, Marketing Manager at DW SYSYTEMBAU, explained the sustainability of building concepts with pre-stressed concrete slabs. Describing constructional principles by example of the slab, he highlighted the advantages of pre-stressed concrete slabs with the flexible, sustainable and future-oriented design of buildings.

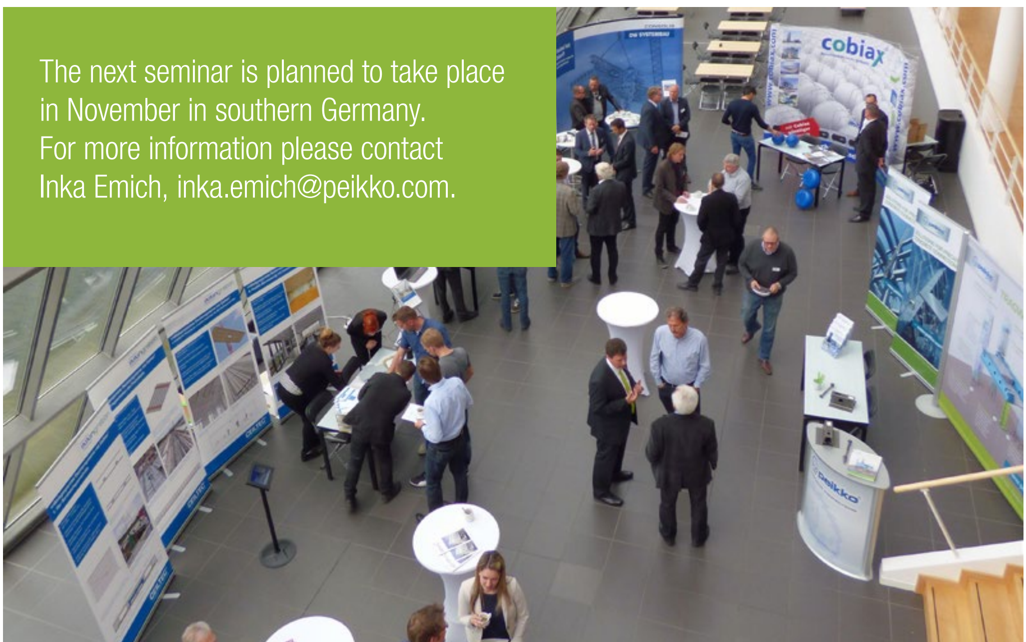
Prof. **L. A. Bathon** of the RhineMain University spoke on the development of timber-concrete composite structures. He provided design approaches and verified the broad range of applications of this construction method on the basis of own research projects, especially in bridge construction.

Wide span slim floors with multi-functional prefabricated slabs were the subject of Dipl.-Ing. **Thomas Friedrich**, CEO at Innogration. He gave an insight into the development of slim floors and the benefits of sandwich slabs with integrated building services. He emphasized that wide span slim floors result in weight savings of up to 55% compared to conventional solid slabs.

The final lecture of the training event was presented by Dipl.-Ing. **Roger Schmidt** of Wienerberger and dealt with brick slabs, a solution for restoration. He showed many practical examples and gave instructions for brick slab design. ■

Back row from left: Sascha Schaaf (Peikko), Roger Schmidt (Wienerberger), Hartmut Fach (DW Systembau)
Front row from left: Dr. Karsten Pfeffer (Cobiax), Thomas Friedrich (Innogration), Prof. L. A. Bathon (University of Applied Sciences RhineMain)

The next seminar is planned to take place in November in southern Germany. For more information please contact Inka Emich, inka.emich@peikko.com.



PEIKKO GROUP 50 YEARS
CONCRETE CONNECTIONS SINCE 1965

We at Peikko are proud that we have been serving the construction industry already for 50 years. Our success depends on our customers success. That is why we are determined to continue developing products and solutions that make our customers' building process faster, easier, and more reliable.

The second 2015 issue of Concrete Connections magazine is our anniversary publication telling the story of how Peikko has grown from a small Finnish company into a global player.

50 years 1965-2015 peikko group

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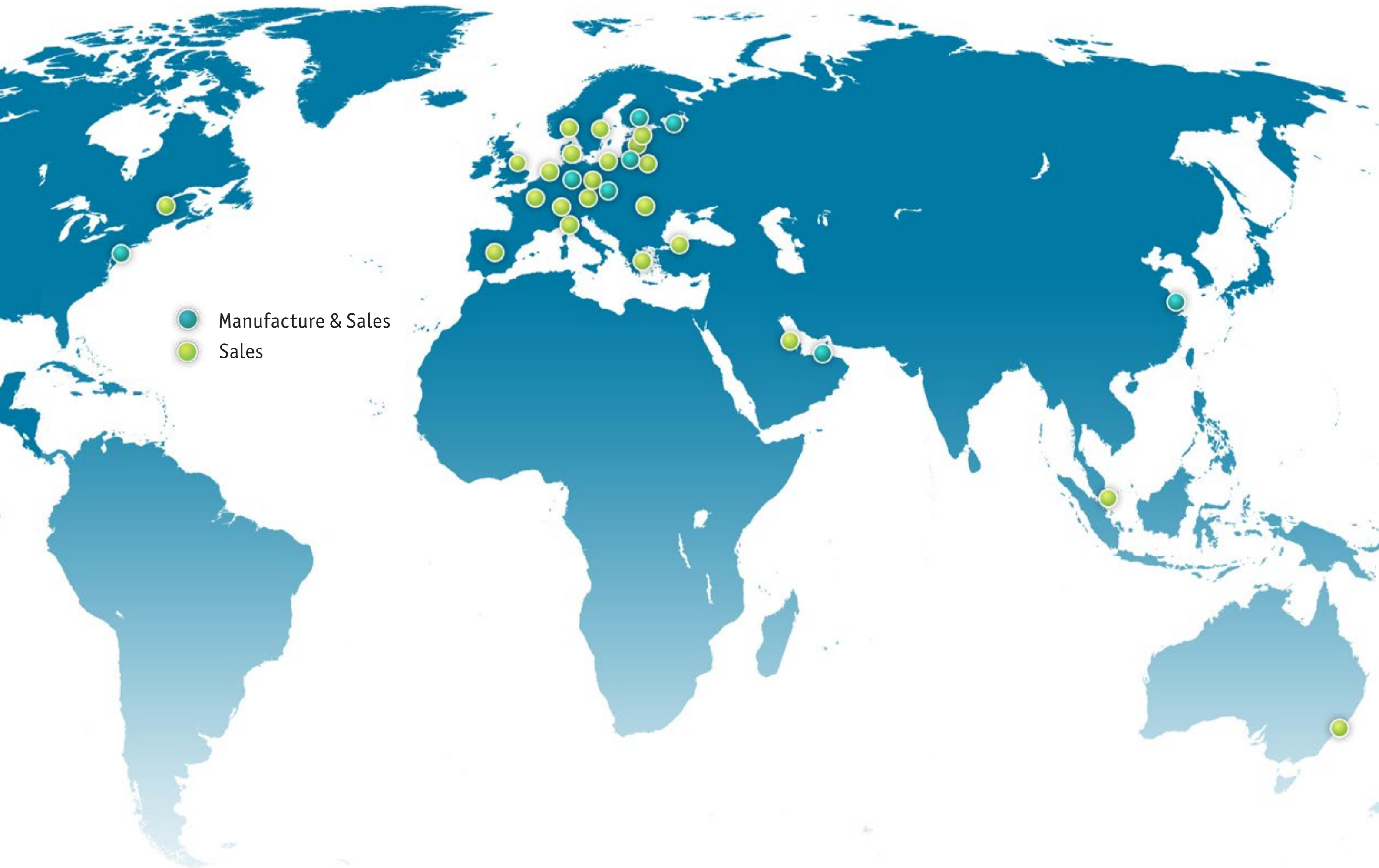

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