The safe connection of precast units

Abstract

The connection of precast units is a special challenge for the development of mounting parts in precast concrete industry. In a connection between columns and walls shear forces must be transferred. It is required that a static connection can transfer these forces and that the mounting of the wall is easy and efficient, because time plays a more and more growing role in industry.

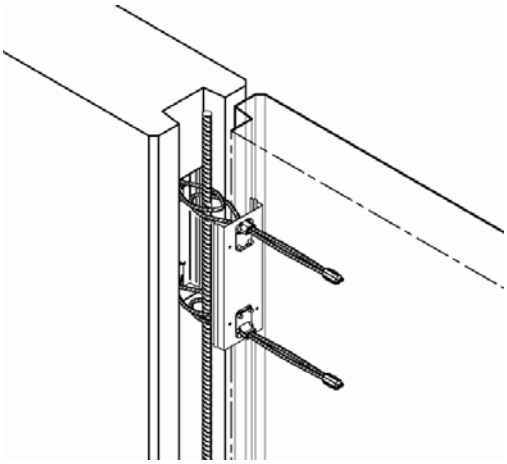
The Philipp connecting technique consists of rails or recess formers with integrated steel wire ropes which are crimped together with a ferrule and hot-clued or nailed onto the mould. During fabricating the concrete units the flexible loops are bent and kept in the recess former. After demoulding the panel the cover is removed and the loops are bent back so that the loops stick out of the unit under an angle of 90°. The loops are used to bridge the concrete units. At construction site the joint which is generated by the geometry of the units is filled with grouting mortar. Therewith a force and form fit connection is created.

The application of such a connecting technique gives the designer the possibility to avoid consoles in columns which is very attractive for modern architecture. An additional advantage is the possibility to install wall elements between columns due to the flexibility of the ropes. The connecting technique from Philipp Company consists of several systems which vary significantly. Altogether this technique convinces with its strengths such as a high bearing capacity, material quality, functionality and partly with a German Approval from DIBt.

Keywords: connection, precast units, flexible steel wire loops, high bearing capacity

Introduction

That steel wire ropes make sense in precast industry has been proofed already with the application of lifting devices such as lifting loop with threaded end and cast-in lifting hoops. Such transport and mounting systems are only applicable temporary within the transport chain. The use of steel wire ropes as permanent application was a completely new field which was investigated thoroughly over the years. However, the today's situation shows that this system has been established and is applied in a variety of applications.
The time efficient and simple installation goes with the increasing requirements regarding time management, economy and efficiency. Neither laborious rebending nor inconvenient screwing is necessary.
To use this product group sufficiently the approval for Philipp Power Rail System in year 2005 was an important support for designer and engineers. Also after achieving this approval the system was developed further on and improved. The result was the Power Box in year 2007 as next step in the connecting technique (see Picture 1).



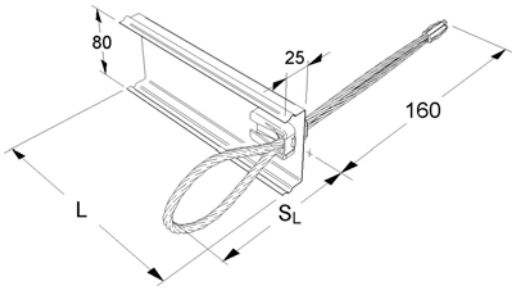
Picture 1: Cross Section of Philipp Power Box

A great development in the area of the connecting technique is now the Power Duo System. In this product the newest knowledge and experiences from industry were brought in such as modified geometry and assembly of the rails so that a higher functionality and bearing capacity are achieved.

The Connecting Loops

The first introductions of Philipp Connecting Technique into the market were connecting loops. These steps were an innovation which was completely new for the market in the early 90ies. The idea to use a flexible steel wire rope results from the fact that any solution to connect precast units so far such as cast-in channels or screwing are very time consuming.

The loops (steel wire rope with diameter of 6mm) are fixed in a plastic or metal box and therewith protected against the concrete (see Picture 2). The other end of the rope forms the anchorage which builds later a compound with the concrete.

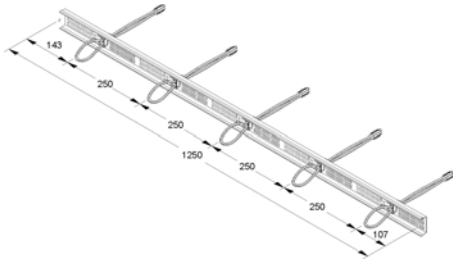


Picture 2: Connecting Loop (metal version)

The joint which is filled with mortar on construction site is generated by the use of a timber board. The connecting loops are fixed on the board by nailing or hot-gluing and are removed after demoulding the timber boards. Therewith a joint is built which is embedded in concrete flanges. These concrete flanges built in connection with the loops and its recess formers the basis of the form and force fit connection. The high bearing capacity of the ropes and its anchorage in the concrete was confirmed by several tests.

The Connecting Rails

The connecting loops were a great success. The flexibility of the ropes combined with its bearing capacity convinced the engineers. But the precast works had still a problem with fixing the timber boards on the mould and single boxes onto the timber board. The Philipp connecting technique was further developed and the results were connecting rails. These connecting rails were a line-up of five connecting loops in one element (see Picture 3).



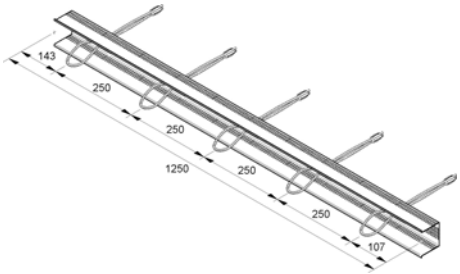
Picture 3: Connecting Rail

The height of it was sufficient so that the timber board could also be set aside. This rail indeed was structured so that it had a strong compound with the concrete and was fixed in the unit sufficiently.

The Power Rail System

Since the connecting loops and rails found its acceptation in the market and our own tests have shown that the bearing capacity was reliable an official approval was aspired.

Unfortunately was not possible to get an approval for just a rail or a loop. The whole connecting system should be approved. That meant a system was created which consists of two connecting rails and a defined mortar which fulfilled certain requirements. This system was called the Philipp Power Rail System (Power = high bearing capacity, rail = galvanized, structured steel plate rail, system = several components). The Power Rail (Picture 4) itself is 1.25m long and has a depth of 60mm and a width of 70mm.

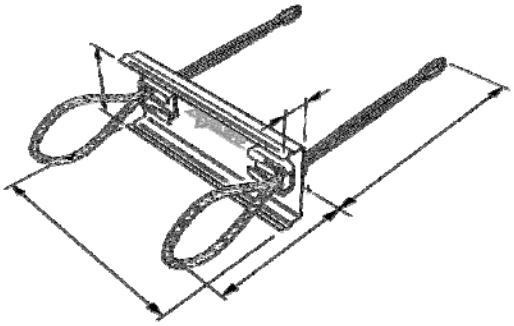


Picture 4: Philipp Power Rail

The Box System

The Philipp Power Box is a galvanized steel plate box with two integrated loop elements which lay opposite from each other. The Power Box System stands out due to its high bearing capacity regarding the shear force capacity parallel and at right angles to the joint.

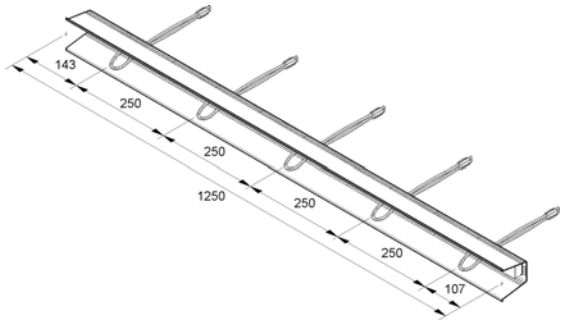
The box is 22 cm long, 2,5cm deep and can be installed with the aid of a timber board to create the joint. The distance between the boxes must be larger than 12cm and the edge distance must be larger than 15 cm.



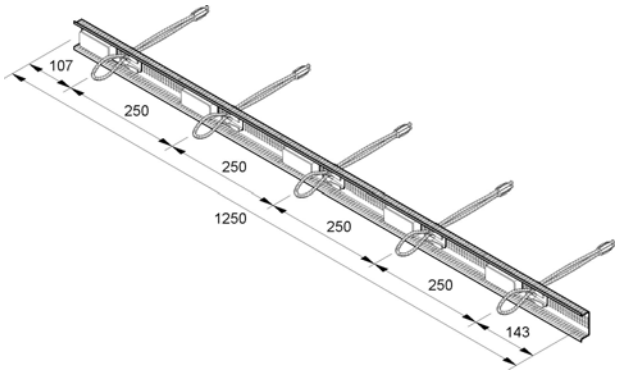
Picture 5: Philipp Power Box

The Power Duo System

The Philipp Power Duo System is the result of the further development of the existing above mentioned products in which long lasting experiences and the feedbacks from industry are brought in. The rail system was modified regarding geometry and optimized as bearing model so that a higher functionality and an enormous bearing capacity were achieved. Overall the Philipp Power Duo System convinces with its minimised grouting joint, a very high bearing capacity parallel and at right angles to the joint and the possibility toe realise wall/ column connections. The Power Duo consists of a 70mm deep rail (Picture 6) and a 20mm deep rail (Picture 7) and is designed for the connection of wall (deep rail) with columns (flat rails).



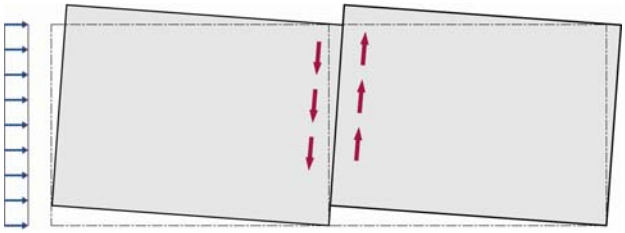
Picture 6: Philipp Power Duo System – deep rail



Picture 7: Philipp Power Duo System – flat rail

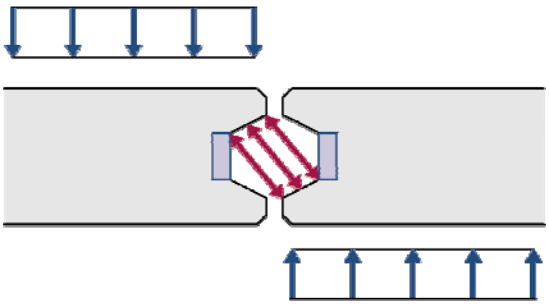
Load bearing capacities – calculation model

The observation of the calculation model has shown that it must be divided into two parts: On the one hand the shear force parallel to the joint ($v_{Rd,II,}$ see Picture 8) and on the second hand the shear force at right angles to the joint ($v_{Rd,\perp}$ depending on wall thickness and concrete class, see Picture 9). An interaction of both forces is possible. The shear force parallel to the wall occurs when bearing forces due to the dead weight of a wall are transferred or the wall is used as stiffener. This load is a distributed load along the joint.



Picture 8: Shear forces parallel to the joint

The shear force at right angles to the wall depends on the concrete strength and the wall thickness and occurs through wind or earth pressure.



Picture 9: Shear forces at right angles to the joint

Power Rail System

The bearing capacity of the shear force parallel to the joint is approved by the DIBt in Germany is 45kN/m and results form the overlapping loops, the structured steel plate rail and the high strength grouting mortar. The shear forces at right angles to the joint depend on wall thickness and concrete strength and are given in Table 1.

Wall thickness h [cm]	Shear Force Capacity at right angles to the wall $v_{Rd,\perp}$ in [kN/m]			
	C30/37	C35/45	C40/50	C45/55
14	7.3	8.4	9.0	9.6
18	13.2	15.0	16.1	17.2
22	19.9	22.6	22.5	25.9
24	23.5	26.8	28.7	30.6

Table 1: Design value of the shear force at right angles to the wall of Power Rail System

Power Box System

The loops which are set up on the upper and lower part of the Power Box generate together with the mortar a framework which results in a self contained capacity model. This framework bases on the mortar as compression strut whereas the loops form the tension tie. This system can achieve a bearing capacity of 35kN/ Power Box (according to German Approval from DIBt). For shear forces at right angles to the joint the concrete strength and wall thickness must be considered (see Table 2).

Wall thickness h [cm]	Shear Force Capacity at right angles to the wall $v_{Rd,\perp}$ in [kN/m]			
	C30/37	C35/45	C40/50	C45/55
18	11.9	13.5	14.5	15.4
20	15.0	17.1	18.4	19.6
22	18.4	21.0	22.5	24.0
24	22.0	25.0	26.9	28.6

Table 2: Design value of the shear force at right angles to the wall of Power Box System

Power Duo System

Plastic recess formers which are filled with concrete transfer in combination with the friction of the profiled rail and the tensile strength of the steel wire ropes a shear force parallel to the wall of 80kN/m into the concrete unit.

Wall thickness h [cm]	Shear Force Capacity at right angles to the wall $v_{Rd,\perp}$ in [kN/m]			
	C30/37	C35/45	C40/50	C45/55
14	9.7	11.1	11.9	12.6
18	15.9	18.1	19.4	20.7
22	22.8	26.0	27.9	29.7
24	26.6	30.3	32.5	34.6

Table 3: Design value of the shear force at right angles to the wall of Power Duo System

Interaction of forces

Both types of forces can occur at the same time. The interaction of these forces is also considered in the approval of Power Box System as shown in Diagram 1. If shear forces parallel and at right angles to the wall occur at the same time, the shear force at right angles to the wall has to be reduced. To calculate the reduced value of $v_{Rd,\perp}$ it must be multiplied with a reduction factor. Diagram 1 shows the interaction between the two shear forces whereas the y-axis shows the shear force parallel to the joint of one box and the x-axis shows the percentage of the shear fore at right angles to the wall per meter.

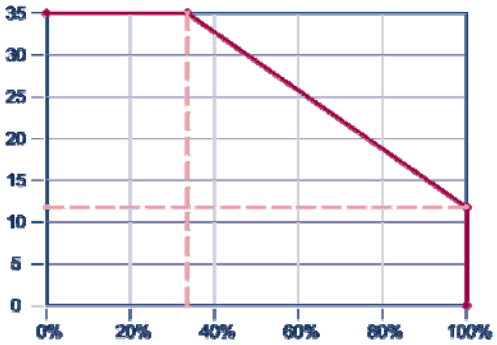


Diagram 1: Interaction of shear forces for Power Box

Grouting of all systems

The joint itself is filled with a low shrinkage grouting mortar. The Philipp grouting mortar has been used for the tests which were necessary for the approvals and provides the properties which are required for a well filled joint.

Table 4 shows the compression strengths of the mortar depending on the age. It can be seen that the mortar has very good values for the compression strength which again explains the high bearing capacities of the systems.

Characteristic	1 day	3 days	7 days	28 days
			[N/mm²]	
Compressive strength	44	55	70	80
Bending tensile strength	5.8	8	10	10

Table 4: Mechanical strength properties of PHILIPP grouting mortar

Summary

The PHILIPP Connecting Technique is an innovative solution for the connection of precast units. This type of connecting technique is absolutely time saving because no reverse bending or screwing is required. The Philipp Power Systems convince with their strengths such as a high bearing capacity, material quality, functionality and last but not least with a German Approval from the DIBt.

References

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