Ladies and Gentlemen,
Dear Customer,

Timber construction continues to make advances. Modern and innovative designs are increasingly characterized by the use of composite components. The timber-concrete construction method is now being increasingly used, particularly in the realization of ceiling systems. The resource-saving and renewable building material that is wood, as well as the faster construction time involved, are just a couple of reasons that give it an advantage. Economic solutions are also achieved that combine both excellent load-bearing capacity and serviceability.

Würth is the market leader in connection technology, and is therefore called upon to meet the ever-increasing demands of timber-concrete composite construction. At all stages of the planning and construction process, we have a wide range of options, support services and modern products to meet your exact needs. Whether you are renovating, converting, adding storeys or building new – Würth always has a suitable solution for you!

With a very high degree of prefabrication options, we offer you an economical alternative for the production of ceiling structures in residential, commercial or industrial buildings. With transportable, easy-to-handle prefabricated part variants, we will support you in being able to achieve a modern and sustainable construction method both quickly and efficiently. In this context, Würth now offers far more than the familiar competencies associated with a fastener manufacturer. Würth can offer you everything from planning the supporting structure to smooth construction site management!

Thanks to our many years of experience and countless successfully completed reference projects, Würth will support you in finding the optimum solution for modern composite timber constructions. Würth supports you throughout the entire planning and construction process, right through to providing up-to-date, modern construction documentation. Realize your next building project with us – we look forward to hearing from you.

Kind regards from Künzelsau,

Torsten Elias
Hans Peter Trehkopf
In recent years, the timber-concrete composite has grown as a construction method in its own right thanks to its outstanding properties – through the combination of the two building materials timber and concrete.

Timber-concrete composite refers to a construction method in which two separate cross-sections of timber and concrete are joined together by means of special fasteners to form a composite cross-section. This is why this type of construction is also called hybrid construction.

The combination of the two construction materials makes optimum use of their properties. Under bending stress, the tensile forces are absorbed by the timber, while the concrete is located in the compression zone. The fasteners used between the two cross-sections create a connection on the one hand, and on the other hand they transfer the shear forces between the timber and the concrete. In addition, the composite imparts a significantly higher load-bearing capacity on the construction.

Via our technical department at Würth, we can dimension you an economical solution for a timber-concrete composite system. Send inquiries to bpm-holzbau@wuerth.com

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>Pressure zone</td>
</tr>
<tr>
<td>THICKNESS</td>
<td>70 – 120 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>Intermediate layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>THICKNESS</td>
<td>max. 50 mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>Wooden beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>AREA</td>
<td>Tensile zone</td>
</tr>
<tr>
<td>THICKNESS</td>
<td>min. 100 mm</td>
</tr>
</tbody>
</table>
POSSIBILITIES FOR USING TIMBER-CONCRETE COMPOSITE

Multi-storey construction
The advantage of timber-concrete composite in terms of sound insulation is of great importance in multi-storey construction. Because it is precisely in this area that increased demands are placed on this physical property of a building.

Bridge construction
Compared with conventional timber bridges, timber-concrete composite bridges stand out by virtue of their greater rigidity and load-bearing capacity, and are also more efficient than steel-concrete bridges. The concrete slab on top protects the timber beam underneath, which in turn results in an extension of the service life.

Old building renovation / Ceiling strengthening
Wooden beams in old buildings are often no longer up to what is required in terms of load-bearing capacity, deflection, sound insulation and fire protection. Through the additional concrete slab and the bond with the old beam layer, the existing ceiling can be upgraded and its serviceability condition established.

Source: The Schaffitzel company
PROCEDURE FOR TIMBER-CONCRETE COMPOSITE

We provide support – from the idea right through to completion
bpm-holzbau@wuerth.com

IDEA

The first step is the collection of ideas. You already receive our support at this point. Through professional and individual advice, we would like to accompany you in achieving a safe, economical and constructively realizable solution.

For more information, see under the heading
▶ NOTES FOR ARCHITECTS

PLANNING/STRUCTURAL ANALYSIS

The Technical Key Account Manager is also available to support you during the planning phase.

- Structural pre-analysis

For more information, see under the heading:
▶ NOTES FOR PLANNERS/ENGINEERS
COMPOSITE PROJECTS

TENDERING
Editing of service specifications, tender texts and recoding
• Re-measurement
• Evidence of equivalence

START OF CONSTRUCTION
BAULOC® – Logistics solutions for construction sites, e.g. through prefabricated and pre-commissioned goods delivered directly to the construction site and place of installation.

For more information, go to www.wuerth.de/BAULOC

COMPLETION
Following implementation of the idea, we will accompany and advise you even further. It goes without saying that we are at your disposal to answer any questions that you might have. In addition, processor training courses can be held on request.

For more information, see under the heading ▶ NOTEP FOR PROCESSORS
Project H7
Planning .......... Arup Deutschland GmbH
Processor ........ Brüninghoff GmbH & Co. KG
Products .......... ASSY® plus VG + FT connector
Process .......... Factory-prefabricated elements
Stade office project
Planning ........ Gebr. Schütt Ingenieur-Büro GmbH
Processor .......... Gebr. Schütt KG
Products ........... ASSY® plus VG 10 × 480 mm + FT connectors
Process ............. Factory-prefabricated elements, installation on beam layer, max. span 6.5 m
Project: Deutsches Biomasseforschungszentrum, Leipzig

Planning ............ Mathes Beratende Ingenieure GmbH
Processor.......... Kunert Dächer und Bau GmbH
Products .......... ASSY® plus VG + FT connector
Process .............. On-site concreting, 10,000 m², 4-storey

Image courtesy of Mathes Beratende Ingenieure
NOTES FOR ARCHITECTS

TIMBER-CONCRETE COMPOSITE
Building large-span, lightweight structures is no problem given the materials and dimensions available in timber construction. In addition to the load-bearing capacity of the structures, properties that influence the feeling of living or use are very important. The requirements on these properties have to be determined at a very early planning stage and have a decisive impact on what structure will be chosen. For wood structures in particular, there is an especially critical focus on the properties mentioned above. Therefore, users must be provided with a choice of effective and cost-efficient solutions for ceiling constructions that meet the requirements for fire and sound protection and also have favorable vibration behavior.
Thanks to the combined arrangement of the two building materials timber and concrete, it is possible to achieve more efficient and – above all – more resource-saving alternatives for the creating of ceiling systems. When using the timber-concrete composite construction method, the timber component can be designed either as a linear or flat support element.

1. Solid timber ceiling
   - Spans of up to 12 m and more
   - Fire protection R90
   - Visual quality possible

2. Beam ceiling
   - Spans of up to 10 m and more
   - Fire protection R60
   - Visual quality possible (face formwork or exposed concrete)

The required thickness of the concrete slab depends on the requirements regarding load-bearing capacity, serviceability and sound insulation. The fire protection requirements also have a decisive influence on the panel thickness.

<table>
<thead>
<tr>
<th>Ø 8 mm SCREW</th>
<th>Concrete slab thickness min. (50 mm), structural recommendation 70 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø 10 mm SCREW</td>
<td>Concrete slab thickness min. 70 mm</td>
</tr>
<tr>
<td>MINIMUM WOODEN ELEMENT THICKNESS</td>
<td>100 mm</td>
</tr>
<tr>
<td>CONCRETE SLAB THICKNESS</td>
<td>Maximum 70 % of the thickness of the wooden elements</td>
</tr>
<tr>
<td></td>
<td>Prefabricated panel thicknesses 70 mm to 120 mm</td>
</tr>
</tbody>
</table>
ADVANTAGES OF TIMBER-CONCRETE COMPOSITE

Improved sound insulation

Sound insulation is an important parameter for all floor structures. In the case of ceilings, this is decisively influenced by their structure, i.e. by the sequence of layers. Usually, the layers consist of flooring, floating screed and footfall sound insulation. The individual layers and overall structure form a spring-mass system. Here, the footfall sound insulation acts like a spring between screed and structure.

Additional, massive layers further and significantly improve noise protection properties of wood floors. Even so, sufficiently ballasted floors made of wooden beams or massive wood are still considerably lighter than floors made of reinforced concrete. Together with footfall sound insulation, featuring a low dynamic stiffness, added ballast leads to better floor properties with frequencies above the resonant frequency. These measures do not have any impacts with low frequencies. Bonding ballast and wooden floor does lead to greater stiffness and but that also entails poorer sound insulation properties than screwed systems.

Greater rigidity and load-bearing capacity

Unlike ballasting or weighting, concrete slabs are more than just an additional layer to increase the mass. The bond between the concrete slab and the substructure by means of bolts is sufficiently rigid to significantly increase the overall rigidity of the structure. At the same time, this connection is sufficiently ductile to cushion the vibrations somewhat.

High resistance to fire

Amendments to local construction regulations allow for the construction of buildings of up to eight floors made entirely of wood. This entails tougher requirements with regard to fire resistance of the individual components.

Unless the floors are protected by corresponding fire protection cladding, proof that the components comply with the required fire resistance time can be provided in accordance with EN 1992-1-2 and EN 195-1-2. Fire resistance durations of up to R60 (beam constructions) and R90 (solid wood ceilings) can be verified.
The criterion of sustainability is becoming increasingly important in the planning of new buildings. Thanks to its properties and the use of renewable raw materials, the focus is increasingly on this hybrid construction method.

**Larger spans**

Thanks to the composite effect of wood and concrete, very large spans can be realized with this construction method – even without supports or partition walls.

**More lightweight constructions**

Compared with the pure steel-concrete ceiling, ceilings in timber-concrete composite construction have a significantly lower own weight but the same load-bearing capacity. The weight of these structures is only about two thirds of the weight of a steel-concrete ceiling. This is largely due to the smaller concrete slab thickness. This is because the concrete slab’s tension zone is replaced by a much lighter wooden structure.

**Sustainability**

The criterion of sustainability is becoming increasingly important in the planning of new buildings. Thanks to its properties and the use of renewable raw materials, the focus is increasingly on this hybrid construction method.

**Time saving**

The timber-concrete composite design version using FT connectors (prefabricated connectors) allows a very high degree of prefabrication. So far, the WÜRTH fastener system is the only one known that allows separate prefabrication of the timber and concrete construction and does not introduce any moisture into the structure.
# Manufacture of Timber-Concrete Composite

## Two Variants in Comparison

<table>
<thead>
<tr>
<th>In-situ Concrete</th>
<th>Prefabricated Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sequence</strong></td>
<td></td>
</tr>
<tr>
<td>1. Manufacturing</td>
<td>1. Timber production</td>
</tr>
<tr>
<td>2. Screw in the screws</td>
<td>2. Screw in the screws</td>
</tr>
<tr>
<td>3. Concreting</td>
<td>1. Concrete production</td>
</tr>
<tr>
<td>Factory</td>
<td>Factory</td>
</tr>
<tr>
<td>Construction site</td>
<td>Construction site</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Fasteners</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSY® plus VG 4 CH Ø 8 mm</td>
<td></td>
</tr>
<tr>
<td>Art. No. 0150 008 ...</td>
<td></td>
</tr>
<tr>
<td>The screw-in angle between the screw axis and the wood fiber is $30^\circ / 45^\circ$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pre-assembly</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefabrication of timber elements</td>
<td>Prefabrication of concrete elements in the concrete plant</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>FASTENERS</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ASSY® plus VG 4 CS Ø 10 mm</td>
<td></td>
</tr>
<tr>
<td>Art. No. 0150 110 ...</td>
<td></td>
</tr>
<tr>
<td>FT connectors</td>
<td></td>
</tr>
<tr>
<td>Art. No. 0165 300 10</td>
<td></td>
</tr>
<tr>
<td>The screw-in angle between the screw axis and the wood fiber is $30^\circ$</td>
<td></td>
</tr>
</tbody>
</table>
IN-SITU CONCRETE

<table>
<thead>
<tr>
<th>ACTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install wooden beam or solid wood ceiling</td>
<td>Transport concrete elements to construction site</td>
</tr>
<tr>
<td>Support ceiling</td>
<td>✗</td>
</tr>
<tr>
<td>Align &quot;lost&quot; formwork [on wooden beam ceiling]</td>
<td>✗</td>
</tr>
<tr>
<td>Film as wood protection</td>
<td>✗</td>
</tr>
<tr>
<td>Install screws</td>
<td>✗</td>
</tr>
<tr>
<td>Place concrete</td>
<td>✗</td>
</tr>
<tr>
<td>Wait for drying time (28 days), rework if necessary</td>
<td>✗</td>
</tr>
<tr>
<td>Knock out / remove support after hardening</td>
<td>✗</td>
</tr>
</tbody>
</table>

PREFABRICATED PARTS

<table>
<thead>
<tr>
<th>ACTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install screws</td>
<td>✓</td>
</tr>
</tbody>
</table>

Install screws

- immediate composite effect
- The following trades can start immediately!

ADVANTAGES OF PREFABRICATION

- Shorter construction times
- Transport and installation costs can be drastically reduced
- Light individual elements
- Favorable geometries
- Moisture doesn’t enter the structure
- No soiling of the wooden components during the concreting process
- No separating layer required to protect the wood
- The bottom side of the concrete slabs may remain visible if their quality allows
- No hardening and drying times on the construction site

ADVANTAGES OF WOOD SCREWS

- Simple to apply
- No special demands placed on personnel
- Approved system [ETA-13/0029]
- Use standard screws (WÜRTH ASSY® plus VG 4)
- Variable screw length
- Small axial and edge spacings due to the drill point

Large-span floors featuring visually appealing exposed wood beams can be built in a short installation time using wood-concrete composite floors with prefabricated concrete slabs.
### CONCLUSION

<table>
<thead>
<tr>
<th>Timber-concrete composite construction method (prefabricated part)</th>
<th>Timber construction method</th>
<th>Concrete construction method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load-bearing capacity</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Sound insulation</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Fire protection</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Spans</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Own weight</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Cradle to Cradle®</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Pre-assembly</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Ceiling thickness</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Installation time</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Moisture ingress</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>CO₂ emission</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Economic efficiency*</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Durability</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Transportability</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

**Approval**

- 3 • very good
- 2 • good
- 1 • moderate

We provide individual and targeted advice.

To contact us, please get in touch with the Engineers, Planners, Architects (IPA) department at Würth: ingenieure@wuerth.com

Consultation on site:
One appointment, many topics
- Fire protection in buildings
- Sound insulation
- ...

*Taking into account the building life cycle*

For easier processing of your project inquiry, use our timber-concrete composite data sheet on page 63.
DIMENSIONING FUNDAMENTALS

EFFECTIVE BENDING RIGIDITY

The γ method regulated in DIN EN 1995-1-1 is used to determine the internal forces. In this method, the stress curves are determined over the beam height as a function of the fastener rigidity via an effective bending rigidity $EI_{ef}$ of the composite cross-section. The γ value takes into account, among other things, the rigidity parameters $k_{ser}$ and the spacing s of the fasteners. It is between $0 \leq \gamma \leq 1$ and is used for interpolation of the bending rigidity between loosely ($\gamma = 0$) and rigidly connected supports ($\gamma = 1$). The axial rigidities of the individual composite components have an additional influence on the stress curves. By cleverly configuring the individual parameters, composite cross-sections can be achieved in which the concrete part largely experiences compressive stresses and the timber part largely experiences tensile stresses.

![Composite cross section with stress curve](image)

The effective total bending rigidity of the composite cross-section can be determined as follows:

$$ (EI)_{ef} = \sum_{i=1}^{3} (E_i I_i + \gamma_i E_i A_i a_i^2) \quad [1] $$

with:

$$ \gamma_1 = \frac{1}{1 + \pi^2 \cdot \frac{E_1 \cdot A_1}{k_{ser} \cdot l^2}} $$

The spacings of the centers of gravity of the individual cross-sections to the stress zero plane are then determined as follows:

$$ a_2 = \frac{1}{2} \frac{\gamma_1 E_1 A_1 (h_1 + h_2 + 2h_3)}{\gamma_1 E_1 A_1 + \gamma_2 E_2 A_2} \quad [1] $$

$$ a_1 = \frac{h_{1,ef} + h_2}{2} + h_2 + h_{cr} - a_2 $$

The bending rigidity of the individual cross-sections can be determined as follows:

$$ (EI)_{ef,1} = E_1 I_1 + \gamma_1 E_1 A_1 a_1^2 \quad [1] $$

$$ (EI)_{ef,2} = E_2 I_2 + \gamma_2 E_2 A_2 a_2^2 $$

The total bending rigidity is then:

$$ (EI)_{ef} = (EI)_{ef,1} + (EI)_{ef,2} \quad [1] $$

The bending and normal force stresses can then be determined, taking into account the effective bending rigidity:

$$ \sigma_{c,\beta,d} = \frac{\gamma_1 E_1 A_1 M_d}{(EI)_{ef}} \quad [1] $$

$$ \sigma_{m,1,d} = \frac{0.5E_1 h_{1,ef} M_d}{(EI)_{ef}} $$
STATIC SYSTEM

As static systems, the γ method exclusively makes provision for single-span beams. In exceptional cases, two-span beams or cantilever beam systems can also be considered. However, these are not recommended due to additional design difficulties in the area of the intermediate support.

EFFECTS

Due to the mathematical derivation of the dimensioning formulae, the γ method can only take into account uniformly distributed loads. Individual loads that cause a jump in the shear force curve are not permissible.
FASTENERS

The number of fasteners has a decisive influence on the composite rigidity. The spacing of the fasteners can be adjusted according to the shear force curve. However, the maximum spacing must not be greater than 4 times the minimum spacing.

If screws are chosen as the fasteners, they should be inserted at an angle of $\alpha \leq 45^\circ$ in order to activate the high axial strengths and rigidities. For the in-situ concrete construction method, ASSY®plus VG 4 CH screws with $d = 8$ mm are inserted at less than $45^\circ$ or ASSY®plus VG 4 CS $d = 10$ mm are inserted at less than $30^\circ$ together with the FT connector. For prefabricated elements, FT connectors are always used in combination with ASSY®plus VG 4 CS.

RIGIDITIES

The effective bending rigidity $E l_f$ of the composite support depends on the number $n$ and the rigidity $k_{ser}$ of the fasteners. The $k_{ser}$ values of the connectors can be found in [4]. They depend on the diameter $d$ of the fastener, the screw-in angle $\alpha$ and the effective embedment length $l_{ef}$ of the fastener into the wooden beam.

When manufacturing prefabricated elements with $70 \, \text{mm} < t \leq 120 \, \text{mm}$, a wooden strip with the corresponding thickness $t_{ib}$ can be placed under the FT connector. When determining the $k_{ser}$ value, allowance must be made for the wooden strip by subtracting $2 \cdot t_{ib}$ from $l_{ef}$.

**Alignment**

<table>
<thead>
<tr>
<th>ASSY®plus VG 4 screws</th>
<th>$k_{ser}$ in N/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With intermediate layer</td>
</tr>
<tr>
<td>$d = 8$ mm</td>
<td>$d = 10$ mm</td>
</tr>
<tr>
<td>90°</td>
<td>700</td>
</tr>
<tr>
<td>45°</td>
<td>100 $l_{ef}$</td>
</tr>
<tr>
<td>30°</td>
<td>–</td>
</tr>
</tbody>
</table>

[4]

The load-bearing capacity of the fasteners at an angle of $30^\circ$ or $45^\circ$ is determined as follows:

$$ F_{ax,\alpha,Trk} = \frac{f_{ax,k} \cdot d \cdot l_{ef}}{1.2 \cdot \cos^2 \alpha + \sin^2 \alpha} \cdot \left( \frac{\rho_k}{350} \right)^{0.8} $$

[4]

When there is direct contact between concrete and timber (prefabricated part with FT connector), a factor $\mu$ can be applied to the load-bearing capacity, taking friction into account.

$$ (\cos \alpha + \mu \cdot \sin \alpha) \cdot \min \{F_{ax,\alpha,Trk}, f_{tens,k}\} $$

[4]

Friction coefficient for direct contact between timber and concrete: $\mu = 0.25$
In timber-concrete composite systems, building materials with different time-dependent deformation behaviour are joined together to form an overall structure. This state of affairs has a decisive influence on the stress curve and the deformation behaviour on the overall beam. [1] prescribes a verification in the initial state \( t = 0 \) and in the final state \( t = \infty \) for this eventuality. The different creep behaviour and the swelling or shrinkage behaviour of the timber can be taken into account by reducing the rigidities, taking into account the corresponding \( k_{d\text{f}} \) values in the final state.

### Rigidities at the point in time

<table>
<thead>
<tr>
<th></th>
<th>( t = 0 )</th>
<th>( t = \infty )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>( E_1 = \frac{E_{cm}}{\gamma_C} )</td>
<td>( E_1 = \frac{E_{cm}}{1 + k_{d\text{f,1}}} )</td>
</tr>
<tr>
<td>Timber</td>
<td>( E_2 = \frac{E_{0,\text{mean}}}{\gamma_M} )</td>
<td>( E_2 = \frac{E_{0,\text{mean}}}{1 + \psi_2 \cdot k_{d\text{f,2}}} )</td>
</tr>
<tr>
<td>Fasteners</td>
<td>( k_u = \frac{2}{3} \cdot k_{ser} )</td>
<td>( k_u = \frac{k_d}{1 + \psi_2 \cdot k_{d\text{f,k}}} ) with ( k_d = \frac{k_u}{\gamma_M} )</td>
</tr>
</tbody>
</table>

The \( k_{d\text{f}} \) values can be found in [4]:

Table 2.1 - Values for \( k_{d\text{f}} \) of timber, concrete and ASSY® plus VG screws

<table>
<thead>
<tr>
<th>Material</th>
<th>Utilization class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid wood, EN 14081-1</td>
<td>0.6</td>
</tr>
<tr>
<td>Glued laminated timber, EN 14080</td>
<td>0.6</td>
</tr>
<tr>
<td>LVL, EN 14374</td>
<td>0.6</td>
</tr>
<tr>
<td>Cross-laminated timber, ETA</td>
<td>0.8</td>
</tr>
<tr>
<td>Concrete, EN 206-1</td>
<td>2.5</td>
</tr>
<tr>
<td>ASSY® plus VG screw connection</td>
<td>0.6</td>
</tr>
</tbody>
</table>

[4]
CONCRETE SHRINKAGE

In addition, according to [5] the plastic shrinkage of the concrete should be taken into account immediately after installation of the in-situ concrete by a substitute load $p_{s,ls}$. This is determined as follows, taking into account the rigidities of the individual cross-sections, the flexibility of the composite, the effective lever arm $z$ and the effective elasticity between timber and concrete.

$$C_{p,ls} = \frac{\pi^2}{l^2} \cdot \frac{E_1 \cdot A_1 \cdot E_2 \cdot A_2 \cdot z \cdot \gamma_1}{E_1 \cdot A_1 + E_2 \cdot A_2} \quad z = \frac{h_{1,ef} + h_2}{2} + h_s + h_{cr} \quad [5]$$

$$\Delta \varepsilon_{ls} = \varepsilon_{t,wo} - \varepsilon_{c,wo}$$

$$P_{s,ls} = C_{p,ls} \cdot \Delta \varepsilon_{ls} = 0.55 \frac{kN}{m}$$

When determining the internal forces in the final state, 80% of this substitute load is superimposed on the external internal forces.

$$\Delta M_a = 0.8 \cdot P_{s,ls} \cdot \frac{l^2}{8} \quad [5]$$

This substitute load is not taken into account when using precast elements with FT connectors.

When concrete shrinks, this results in increased stress on the overall structure. This effect is taken into account with the uniformly distributed loads approach.

SPACING OF THE FASTENERS

The distribution of the fasteners is constant over the entire support length. According to the shear force curve, the spacing can be varied within the limits $S_{min} \leq S \leq 4 \cdot S_{max}$ and is usually distributed over 4 ranges. The spacing of the fasteners is determined according to the maximum shear force in these areas.

EVIDENCE OF REINFORCEMENT

When verifying the reinforcement, both longitudinal and transverse reinforcement must be taken into account. Verifications are carried out to limit the crack widths, the minimum reinforcement and, in the case of construction with ceiling beams, the statically necessary reinforcement transverse to the load-bearing direction. According to [4] and [5], the tensile stress of the concrete is limited to 2 times the tension resistance of the concrete in order to account for the compatibility conditions. Both mesh reinforcement (for in-situ concrete construction) and bar reinforcement (for prefabricated elements) can be considered. All verifications are carried out according to the regulations of DIN EN 1993-1-1.

According to [4], the height of the concrete part must not exceed 70% of the height of the wooden part. The concrete cover must be determined by the planner in accordance with the exposure classes according to DIN EN 1992.

The thickness of the concrete slab is limited to a minimum of 70 mm, depending on the necessary reinforcement and concrete covering. In the case of in-situ concrete, the maximum thickness is not limited, taking into account the thickness of the timber component. For precast elements, the maximum thickness is limited to 120 mm with the use of additional measures.
VIBRATION ANALYSIS

The verifications for limiting the vibration behaviour of the ceiling are furnished according to [7]. Two criteria must be met here.

1. The natural frequency, for ceilings hinged at all edges, is determined taking into account the effective bending rigidity, mass and span of the system.

\[ f_T = \frac{\pi}{2 \cdot l^2} \sqrt{\frac{(EI)_1}{m}} \]

The limit value of the natural frequency is

- Class 1 (different usage units): \( f_T \geq 8 \text{ Hz} \)
- Class 2 (same usage units): \( f_T \geq 6 \text{ Hz} \).

Both criteria must be met. Additional evidence is provided if this is not the case.

Minimum frequency: .........................The minimum frequency must be \( f_{min} \geq 4.5 \text{ Hz} \)

Unit pulse acceleration: .....................The acceleration \( a \) takes into account the vibrations caused when a person walks.

It is determined in detail and must not be greater than:

\[ a \approx 0.4 \cdot \frac{P_0 \cdot \alpha_2}{M_{gen}} \cdot \frac{1}{\sqrt{\left[ \left( \frac{f_1}{f_F} \right)^2 - 1 \right]^2 + \left( 2 \cdot \zeta \cdot \frac{f_1}{f_F} \right)^2}} \leq 0.1 \times \frac{m}{s^2} \]

- \( P_0 = 700 \text{ N} \) (usual personal load value)
- \( \zeta = 0.01 \) to \( 0.03 \)
- \( \alpha_2 = \text{Fourier coefficient from Tab. 8 [6]} \)
- \( f_F = \text{Excitation frequency from Tab. 8 [6]} \)
- \( M_{gen} = \text{generalized mass} \)

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Fourier coefficient ( \alpha_2 )</th>
<th>Excitation frequency ( f_F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 3.4 &lt; f_T \leq 5.1 \text{ Hz} )</td>
<td>0.2</td>
<td>( f_F = f_T )</td>
</tr>
<tr>
<td>( 5.1 &lt; f_T \leq 6.9 \text{ Hz} )</td>
<td>0.06</td>
<td>( f_F = f_T )</td>
</tr>
<tr>
<td>( f_T &gt; 6.9 \text{ Hz} )</td>
<td>0.06</td>
<td>( f_F = 6.9 \text{ Hz} )</td>
</tr>
</tbody>
</table>

DIMENSIONING IN CASE OF FIRE

Evidence for fire protection can be provided for fire resistance durations of R30-R60 for timber-concrete composite systems with individual ceiling beams, and R30-R90 for structures with stacked board elements. The verification method according to [2] with reduced cross-sections is applied. Alternatively, it is possible to apply the Frangi and Fontana method according to [6]. This method offers advantages particularly for structures subjected to high loads and wide-span structures.
EVIDENCE WITH REDUCED CROSS SECTIONS

Taking into account a burn-up rate defined in [2] a remaining cross-section can be determined depending on the required fire resistance duration.

With multi-dimensional burn-up:

\[ d_{ef} = d_{char} + k_0 \cdot d_0 \]

whereby: \( d_0 = 7 \text{ mm} \)

\( d_{char} = \beta \cdot t \)

\[ k_0 = \begin{cases} \frac{t}{20} & \text{if } t < 20 \text{ minutes} \\ 1.0 & \text{if } t \leq 20 \text{ minutes} \end{cases} \]

The values apply to a characteristic raw density of 450 kg/m³ and a material thickness of 20 mm, for other material thicknesses and densities, see 3.4.2 (9)

The material safety coefficient \( \gamma_M \) and the modification coefficient \( k_{mod,fi} \) may be set to 1.0 in the method with reduced cross sections.

<table>
<thead>
<tr>
<th>Material</th>
<th>( \beta_0 ) mm/min</th>
<th>( \beta_0 ) mm/min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softwood and beech</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glued laminated timber</td>
<td>0.65</td>
<td>0.7</td>
</tr>
<tr>
<td>Solid timber</td>
<td>0.65</td>
<td>0.8</td>
</tr>
<tr>
<td>Deciduous wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid timber</td>
<td>0.65</td>
<td>0.7</td>
</tr>
<tr>
<td>Glued laminated timber</td>
<td>0.50</td>
<td>0.55</td>
</tr>
<tr>
<td>Veneer layer wood</td>
<td>0.65</td>
<td>0.7</td>
</tr>
<tr>
<td>Panels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood panels</td>
<td>0.9*</td>
<td>–</td>
</tr>
<tr>
<td>Plywood</td>
<td>1.0*</td>
<td>–</td>
</tr>
<tr>
<td>Wooden composite boards</td>
<td>0.9*</td>
<td>–</td>
</tr>
</tbody>
</table>

*The values apply to a characteristic raw density of 450 kg/m³ and a material thickness of 20 mm, for other material thicknesses and densities, see 3.4.2 (9)

The material safety coefficient \( \gamma_M \) and the modification coefficient \( k_{mod,fi} \) may be set to 1.0 in the method with reduced cross sections.
RIGIDITIES, STRENGTHS, DISPLACEMENTS

The 20 % quantile values can be used for the evidence with reduced cross-sections. These are determined from the 5 % quantile values, taking into account a $k_f$ value.

\[ f_{20} = k_f \cdot f_k \]
\[ S_{20} = k_f \cdot S_{05} \]

For mechanically connected components, the displacement modulus of the fasteners in the event of fire must be reduced by taking into account a $\eta_f$ value.

\[ k_{fi} = k_u \cdot \eta_f \]

For beam constructions with a fire resistance duration up to R60, the load-bearing capacity of the fasteners is reduced by a factor of $\eta$.

This is determined as a function of the required fire resistance duration and the minimum spacings of the fasteners $a_1$, $a_2$, and $a_3$ to the edge.

\[ \eta = \begin{cases} 
0 & \text{for } a_1 \leq 0.6 \cdot t_{d,fi} \\
0.44 \cdot a_1 - 0.264 \cdot t_{d,fi} & \text{for } 0.6 \cdot t_{d,fi} \leq a_1 \leq 0.8 \cdot t_{d,fi} + 5 \\
0.56 \cdot a_1 - 0.36 \cdot t_{d,fi} + 7.32 & \text{for } 0.8 \cdot t_{d,fi} + 5 \leq a_1 \leq t_{d,fi} + 23 \\
0.2 \cdot t_{d,fi} + 23 & \text{for } a_1 \geq t_{d,fi} + 28 
\end{cases} \]

According to current regulations, fire resistance durations with $R > 60$ minutes can only be achieved with wood-concrete composite systems in combination with solid wood ceilings.

DIMENSIONING REGULATIONS


Sources:
AIF Plan No.: 15283 N
[8] BDF Merkblatt 02-04 Gebrauchstauglichkeit von Holzbalkendecken
WÜRTH
TECHNICAL SOFTWARE:
TIMBER-CONCRETE COMPOSITE MODULE

Würth provides you with a completely new dimensioning programme for dimensioning timber-concrete composite structures. You quickly reach your objective thanks to automated solution offers and active plausibility checks.
CALCULATION BASIS AND SYSTEM
The basis for the determination of the rigidity parameters and the internal forces is DIN-EN-1995-1-1 Annex B ("ϒ-method"). Single-span beams with uniform loads can be calculated. Timber components can be selected as beams or solid wood panels. The concrete slab can be constructed using the in-situ concrete method or as a prefabricated element.

CLEAR USER INTERFACE
The Würth Technical Software is easy to understand and has an appealing interface. Any change to the input results in immediate result feedback. Possible alternatives in the screw selection are directly translated into required quantity and load factor. Accordingly, the software actively and quickly guides the user to an economical detailed connection without raising unnecessary questions.

In the fastener selection, the possible screw types and dimensions can be selected with the required number. The load factors and fasteners are displayed. If desired, implausible or overloaded fasteners (red bar!) can also be displayed.

Tabs at the top of the screen allow quick entry of all parameters, such as component data, support situation, load effect and the required verifications. It is possible to quickly and interactively switch between the tabs as desired.

Important information on plausibilities, further evidence or possible overruns is provided in the note field.

In the result display, an economical screw selection is suggested or the selected screw selection is shown. The load factors of the individual verifications are shown as a percentage.

= Verification complied with
= Verification exceeded

Important information and notes can be found by moving the mouse over the input field.

The interactive graphic in the center of the screen provides a visual overview of the selected structure. All changes are calculated and displayed in real time.
SUPPORT TYPE

Various support types are available for selection. The support type can be selected independently for the left and right supports. The design of the support influences the span width and the screw arrangement.

**Direct support**

Type 1  Wooden beam lying on wall (support),
         Concrete slab not routed over support (e.g. in existing building)

Type 2  Concrete slab routed over the support (e.g. new construction)

Type 3  Wooden beam led to ring beam, if necessary with notch;
         Concrete slab ties into ring beam (e.g. in new construction)

**Indirect support**

Type 5  Wooden beam suspended from overlay (edge beam),
         Concrete slab stops before suspender beam

Type 6  Concrete slab runs through below suspender beam

**Cutting support**

Provided that the support design is still open or the system is taken from a static calculation, an ordinary cutting support can be selected.

**Installation dimension**

In the case of rising components (e.g. in existing buildings), a spacing dimension can be entered so that the screws can be installed close to the support. In this case, the screw-in direction is changed for the screws close to the bearing and an additional lag screw is arranged. Verifications for the pressure screw and the lag screw are provided.
LOAD EFFECT

Intrinsic weight. The structure’s intrinsic weight is automatically taken into account as standard. The entry can be edited.

Extra load. The extra load refers to the further structure, e.g. floor, filling, intermediate insulation or ceiling cladding on the underside. If a screed is used for the vibration analysis, the intrinsic weight of the screed must also be entered here.

Construction load. When timber-composite structures are used as roof surfaces, a construction load (man-load) can be taken into account in accordance with the recommendations of BG Bau or EN 1991-1-1/NA (live loads on roof surfaces).

Snow load. A snow load can be applied to timber-composite structures used as a roof surface. The snow load to be applied is determined automatically when a postal code is entered.

Live load. The characteristic values of the perpendicular live loads according to DIN-EN 1991-1-1 must be entered. A selection option of the load duration class is offered on the basis of the categories A-G and Z.

VERIFICATIONS

Deflection. For the serviceability verification, the recommended limit values for deflections are preset according to the EC 5, NA A1. The various deflections are listed for the load combinations stated in the A1 paper. The limit values can be edited accordingly by the responsible structural engineer, if necessary in consultation with the building owner. (For details see DIN EN 1995-1-1/NA; NCI to 7.3.1)

Camber. A camber of up to 50 mm can be specified. The camber can have a favorable influence on the serviceability verification or make it possible in the first place. In the case of the in-situ concrete method, a camber can easily be produced by the required support in the installation state.

Vibration verification. (see also the Dimensioning basis chapter). The verifications can be carried out for class 1 ceilings between different usage units and class 2 ceilings within one usage unit. The Lehr damping coefficient is preset to 0.01 (1 %) and can be edited. This corresponds to a wooden ceiling without floating screed. The damping value is included in the determining the acceleration. For example, a value of 3 % or 0.03 can be assumed for wooden beam ceilings and mechanically connected stacked board ceilings. For details, see the publication by Winter, Hamm, Richter: “Schwingungstechnische Optimierung von Holz-Beton-Verbunddecken” AIF project No.: 15283N]

The ceiling width or ceiling bay width in the transverse direction influences the transverse rigidity and thus affects the vibration verification. The larger the ceiling width, the more unfavourable it is. A screed can be entered in the planned thickness to advantageous effect. The dead weight of the screed must also be taken into account for the load effect in the Extra load box.

Fire protection verification. Verifications for fire protection classes R30, R60 and R90 can be provided. DIN EN 1995-1-2 or the [extended] verifications according to A. Frangi and M. Fontana can be selected as the dimensioning basis. A conversion factor η for the screws is determined in the notes by Frangi and Fontana. The investigations according to Frangi and Fontana can be considered state of the art. Fire protection class R90 can be verified when solid wood panels are used.
**FASTENERS**

These choices are available:

### Straight individual screws
ASSY®plus VG 4 CH cylinder-head screws
ø 8 mm

**Art. No. 0150 008...**

### Inclined individual screws
ASSY®plus VG 4 CH cylinder-head screws
ø 8 mm

**Art. No. 0150 008...**

### Inclined screws + FT connectors
ASSY®plus VG 4 CS countersunk head screws ø 10 mm

**Art. No. 0150 110...**

### Prefabricated part connector (FT connector)
For prefabricated concrete parts > 70 mm thick, the required installation strip is displayed automatically.

**Art. No. 0165 300 10**

### Classification of the ranges
According to EC 5, Annex B, the spacing s of the fasteners may be either constant or graduated according to the shear force line between s_{min} and s_{max}, whereby s_{max} ≤ 4 s_{min}. In the Fasteners tab, you can select between 1 and 4 ranges. If no selection is made, the programme suggests a favorable gradation.
**DIMENSIONING**

**Measurement method**

Depending on the country, the corresponding Euro codes with the national annexes can be selected as the dimensioning basis.

- Eurocode Deutschland
- Eurocode España
- Eurocode France
- Eurocode Hrvatska
- Eurocode Italia
- Eurocode Italia (NTC 2018 4.4.11 - A)
- Eurocode Italia (NTC 2018 4.4.11 - B)

**Multiple dimensioning**

Once again, the multiple dimensioning offers the possibility to clearly compare all screw dimensions and quantities. The filter function can also be used to display overloaded and implausible results.

**Print preview**

Compact print-out........... Clear PDF with all data relevant for the construction site and the fitter
Detailed........................ List of the standards and technical literature used as a basis
Output of the load combinations and comprehensible presentation of the individual verifications, indicating the assessment basis
User-defined ................. With additional options such as specifying the page number, date, own logo, etc.

**Example extract of detailed print-out**

**Shrinkage**

The elongation rigidity at time $t = \infty$ is used to determine the substitute load and the modified effective bending rigidity.

**Substitute line load**

$\eta_{\text{eff},1} = 2.5$

$E_1 = \frac{E_\text{con}}{1 + \psi_1 \cdot k_{\text{eff},1}} = 8571 \frac{N}{\text{mm}^2}$

$\psi_1 = 1.0$

$k_{\text{eff},1} = 0.6$

$E_2 = \frac{E_\text{con}}{1 + \psi_2 \cdot k_{\text{eff},2}} = 6875 \frac{N}{\text{mm}^2}$

$k_{\text{eff},2} = 0.6$

$K_\alpha = \frac{K_\alpha}{1 + \psi_1 \cdot k_{\text{eff},1}} = 6731 \frac{N}{\text{mm}}$

$\psi_1 = \frac{1}{1 + \psi_1 \cdot k_{\text{eff},1}} = 0.4261$

$\eta_{\text{eff},2} = \frac{h_\text{eff} + h_\eta + K_\alpha}{\eta_{\text{eff},1}} = 203 \text{ mm}$

$c_{\text{eff},0} = \frac{\alpha}{2} \cdot \frac{c_{\text{eff},0} \cdot c_{\text{eff},1} \cdot c_{\text{eff},2}}{c_{\text{eff},1} \cdot c_{\text{eff},2} \cdot c_{\text{eff},3}} = 3812 \frac{\text{cm}}{\text{m}}$

$e_{\text{eff},1} = 0$

$e_{\text{eff},2} = -0.00068$

$\Delta e_{\text{eff}} = e_{\text{eff},1} - e_{\text{eff},2} = 0.00068$

Reference to EC 5, Section 2.3.2.2, Paragraph [2]
Formula (2.12)

Reference to specialist publication used.
Number according to literature reference.

Reference to the ETA

**Bearing forces**

$g_0 = g_1 \cdot \frac{L}{2} = 8.63 \frac{\text{kN}}{\text{m}}$

$g_{12} = g_{02} \cdot \frac{L}{2} = 5.60 \frac{\text{kN}}{\text{m}}$

**Intermediate support (construction state)**

- for intermediate support in the thirds points
- Structural own weight (timber cross section and concrete slab)
- Weight of on-site formwork not taken into account

$g_0 = 1.95 \frac{\text{kN}}{\text{m}}$

$G_0 = 1.25 \cdot g_0 \cdot \frac{L}{3} = 4.97 \frac{\text{kN}}{\text{m}}$

$g_0 = 1.00 \frac{\text{kN}}{\text{m}}$

$Q_0 = 1.25 \cdot q_0 \cdot \frac{L}{3} = 2.08 \frac{\text{kN}}{\text{m}}$

The bearing forces for forwarding are output. The loads for the intermediate support in the construction state are also obtained.
Documents

The product data sheets of the screws and FT-connectors with available dimensions, articles, numbers, packaging units etc. can be viewed or downloaded.

<table>
<thead>
<tr>
<th>Nenndurchmesser (d)</th>
<th>Kopfdurchmesser (d&lt;sub&gt;h&lt;/sub&gt;)</th>
<th>Kopfhöhe (k)</th>
<th>Innenantrieb</th>
<th>Werkstoff</th>
<th>Oberfläche</th>
<th>RoHS-konform</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm</td>
<td>20 mm</td>
<td>6,5 mm</td>
<td>RW50</td>
<td>Stahl gehärtet</td>
<td>Verzinkt</td>
<td>Ja</td>
</tr>
</tbody>
</table>

Product information

Approvals / ratings

The approvals and ratings used can be displayed or downloaded. Various national versions are available.

Documents

In addition to the timber-concrete composite module, you will find many other timber construction dimensioning modules such as general screw connection, notched or transverse pressure reinforcement, etc.

Other applications such as anchor systems, solar fastening, window mounting or fire protection are also integrated.

DOWNLOAD SOFTWARE

www.wuerth.de/services
www.wuerth.de/assy

In addition to the timber-concrete composite module, you will find many other timber construction dimensioning modules such as general screw connection, notched or transverse pressure reinforcement, etc.

Other applications such as anchor systems, solar fastening, window mounting or fire protection are also integrated.

DIMENSIONING SERVICE

If you have any questions or require assistance on any aspect of timber-concrete composites, please contact

bpm-holzbau@wuerth.com

For easier processing of your project inquiry, use our timber-concrete composite data sheet on page 63.
NOTES FOR PROCESSORS
A – IN-SITU CONCRETE WITH ASSY® SCREWS

A1 Construction site installation
The screws are screwed into the existing wood structure. This can be designed as a beam ceiling or a solid wood ceiling. The use of a screw gage is recommended for screwing in. The in-situ concrete is usually held in place by a "lost" formwork. A suitable foil must be installed to protect the wood from moisture coming from the wet concrete. The structure must be supported until the concrete has fully cured (28 days) – generally at the thirds points.

A2 Prefabrication
In new buildings, the ceilings can be prefabricated element by element. The screws are screwed into the wooden beams/panels in the first step. In the second step, these can be immersed upside down in the formwork bed and fixed in place for the duration of the concrete curing time. The finished elements can be installed in one piece at the construction site.
**B – FT CONNECTOR, IN-SITU CONCRETE (FORMWORK AS FILIGREE CEILING)**

FT connectors, in-situ concrete
Alternatively, FT connectors can also be used for “standard” casting of wet concrete right on the construction site. By combining the right component cross-sections, material qualities and high load-bearing capacity of FT connectors, both approaches can lead to composites featuring high load-bearing capacities, despite a reduced number of shear connectors being required.

**C – PREFABRICATED PART WITH FT CONNECTOR**

Prefabricated part with FT connector
While “traditional” systems always require the wet concrete to be added to the wood structure, this system offers the option to prefabricate the concrete slab separately from the timber construction. Like with solid structures, the prefabricated concrete slabs are delivered to the construction site, laid and screwed to the wood structure. With the positioning of the screws, the concrete and wood substructure bond immediately. Note that the concrete elements may also be screwed to the substructure at a later point in time. Depending of the requirements, elaborate propping of the floor structure until the concrete is dry can be completely done without. Additional vertical ASSY® 4 WH partial-thread screws $d = 10 \text{ mm}$ (e.g. in the quarter points) should be arranged in order to ensure contact between the concrete slab and the timber.

Installation of the remaining structure can continue immediately. There are no curing or drying periods. As the parts are prefabricated, there is no ingress of moisture nor contamination of the wood components by moisture separations of the concrete.

No separating layer is necessary to protect the wood. The high degree of prefabrication leads to a massive reduction of delivery and assembly costs as well as construction time. The bottom side of the concrete slabs may remain visible if their quality allows for it. Large-span floors featuring visually appealing exposed wood beams can be built in a short installation time using wood-concrete composite floors with prefabricated concrete slabs.
## Installation Sequence

### In-situ Concrete

1. **Install timber beams or CLT floors**
2. **Support floor**
3. **Mount the "lost" formwork**
4. **Protect floor against moisture using foil**
5. **Set screws**
6. **Apply concrete**
7. **Drying time**
8. **Remove formwork and supports**

### Prefabricated Parts

1. **Prefabrication of concrete components**
2. **Transport to construction site**
3. **Install concrete components**
4. **Screw in screws > Immediate composite effect**

**Time and cost saving**
PRODUCTS FOR SCREWING IN/AIDS

- **Hand drill EHB 32/2.2 R R/L**
  - Art. No. 0997 676 867

- **Driver Drill BS 13-SEC POWER**
  - Art. No. 0702 315 2

- **Adapter MK3**
  - Art. No. 0997 676 881

- **Battery-Operated Driver Drill ABS 18 POWER M-CUBE**
  - Art. No. 5701 404 005

- **Screw-in angle 45/60 degrees**
  - Art. No. 0165 300 20

- **Bit RW 50**
  - Art. No. 061472 50

- **Bit RW 40**
  - Art. No. 0614 70 40

- **Roof protection film WÜTOP®**
  - Full Protection SK
  - Art. No. 0681 001 103
SCREW ARRANGEMENTS AND SPACINGS

Principle arrangement on the beam
ASSY® 8 mm 45°

Principle arrangement on the beam
ASSY® 10 mm 30°

Possible screw-in variants in detail

Fig. 1.1d: Arrangement of ASSY® plus VG 4 CH screws in a composite component
Minimum and edge spacings after approval

<table>
<thead>
<tr>
<th>ASSY® plus VG 4 CH screws</th>
<th>8·d -30° to 45°</th>
<th>8·d -90°</th>
<th>10·d -30° to 45°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center distance parallel to fiber $a_1$</td>
<td>80</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>Center distance perpendicular to fiber $a_2$</td>
<td>24</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>Spacing to the stressed end grain $a_{3,t}$</td>
<td>–</td>
<td>96</td>
<td>–</td>
</tr>
<tr>
<td>Spacing to the unstressed end grain $a_{3,u}$</td>
<td>40</td>
<td>56</td>
<td>50</td>
</tr>
<tr>
<td>Spacing to edge $a_{4,c}$</td>
<td>24</td>
<td>24</td>
<td>30</td>
</tr>
</tbody>
</table>

The center distance $a_1$ in a plane parallel to the fiber can be reduced to $5·d/sin \alpha$ if the condition $a_1·a_2·sin \alpha ≤ 25·d_2$ is fulfilled.

Fig. 1.1a: Longitudinal section (left) and cross-section (right) through a composite element with ASSY® plus VG 4 CH screws

Fig. 1.1b: Front view (left) and side view (right) of a FT connector
Arrangement example ASSY® 8 mm 45°

Concrete C30/37

"lost" formwork

Wooden beam 26/32 GL24h

Arrangement example ASSY® 10 mm 30°

Concrete C30/37

Extra layer

Wooden beam 26/32 GL24h
The timber-concrete composite construction method requires a careful structural calculation and implementation planning showing the exact arrangement of the shear connectors. In the case of construction projects subject to mandatory structural inspections, the implementation documents (static calculation and implementation plans) approved by the inspection engineer must also be available before the start of construction.
In the case of in-situ concrete, the structure is usually supported at the third points. The corresponding support loads for the design of the temporary supports are output in the Würth Technical Software at the end of the printout. With prefabricated parts, the support can usually be omitted.
CONFIGURATION EXAMPLES

Prefabricated part: Stack formations, stacked board ceilings
- Coupling the prefabricated elements by offsetting the stack

Prefabricated part: Stack formation details
beam ceiling prefabricated part
- Coupling of prefabricated elements via stack on wider ceiling beam
- Introduction of concrete slab stiffening loads into the end beams

In-situ concrete: Detail of rising walls during renovation

In-situ concrete: “lost” formwork milled in

Expert opinion in preparation!
In-situ concrete:
"lost" formwork laid on

In-situ concrete: Semi-finished concrete part laid on as formwork

Prefabricated part: Battening for concrete slab thicknesses of $7 \text{ cm} \leq h \leq 12 \text{ cm}$

In-situ concrete for concrete slab thickness $> 7\text{ cm}$
- FT connector requires no battening for in-situ concrete
CONCRETE CLASSES, QUALITY INSPECTION FOR E.G. C35/45

Depending on the construction project, different levels of monitoring are required to ensure the quality of the concrete. DIN EN 13670/DIN 1045-3 [4,3] formulates a multi-stage monitoring system with monitoring classes 1, 2 and 3. The requirements for inspection of the crucial fresh concrete and hardened concrete properties increase with ascending monitoring class. Monitoring classes 1 and 2 regulate the monitoring of concrete of compressive strength classes up to and including C50/60.

In addition to the strength class, the monitoring effort and the classification are primarily based on the required exposure classes (according to DIN EN 1992), whereby the highest applicable monitoring class is decisive for the assignment. Monitoring Class 3 relates to high compressive strength classes for what are known as high-strength concretes.

Monitoring classes for concrete

<table>
<thead>
<tr>
<th>Subject matter</th>
<th>Monitoring class 1</th>
<th>Monitoring class 2(^1)</th>
<th>Monitoring class 3(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength class for normal and heavy concrete</td>
<td>≤ C25/30 (^2)</td>
<td>≥ C30/37 and ≤ C50/60</td>
<td>≥ C55/67</td>
</tr>
</tbody>
</table>

\(^1\) The construction company must have a permanent concrete testing station as one element of its self-monitoring.

\(^2\) Prestressed concrete C25/30 is always to be assigned to Monitoring Class 2.

---

Monitoring class 11

- Supervision by the construction company (self-monitoring)
- Site staff
- Site Manager
- Permanent concrete testing laboratory (management by concrete specialist with proven knowledge)

Monitoring class 12 and 3

- Supervision by the construction company (self-monitoring)
- Monitoring by monitoring institution (external monitoring)
- Approved monitoring agency
PRODUCTION OF PREFABRICATED PARTS IN THE FACTORY – WITHOUT BATTENING

Formwork table

Division of FT connectors in element width e.g.: with marking cord

Batten gage for dividing the FT connectors in the element longitudinal direction

FT connectors on formwork table with hot glue
Positioned FT connectors on formwork table

Inserting spacers

Inserting lifting loops

Inserting and fixing reinforcement bar
Concreting

READY FOR TRANSPORT AND INSTALLATION AFTER CURING
A 4-point attachment including a load-distributing crossbeam is recommended for transporting the prefabricated concrete slabs. The lifting loops anchored in the reinforcement can be removed as soon as the slabs have been laid. If recesses are provided in the slab for hook fastening to the reinforcement, these must be closed after installation.
PRODUCTION OF PREFABRICATED PARTS IN THE FACTORY – WITH BATTENING

Battening preassembly – battening laid out, FT connector spacings applied

Battening preassembly – FT connectors secured with e.g.: Pias 2.9 x 19 Art. No. 02062919

Formwork table

Division of FT connectors in element width e.g.: with marking cord
Preassembled battening incl.
FT connectors fixed to formwork
table with hot glue

Inserting spacers

Inserting and fixing reinforcement bar
Concreting

READY FOR TRANSPORT AND INSTALLATION AFTER CURING

Construction tips
- Recommended individual batten length: < 3 m (handling / deformation when screwing on and inserting into the formwork table)
- Recommended minimum batten thickness 30 mm
- Graduation of concrete slab thicknesses d
  - FT connector without battening ............... d = 70 mm
  - FT connector with battening ................. 30 mm d = 100 mm
  - FT connector with battening ............... 40 mm d = 110 mm
  - FT connector with battening ............... 50 mm d = 120 mm
- Secure the FT connectors to battening: Pias screw 2.9 x 19 Art. No. 0206 29 19; Stapling or using a nail gun is not recommended, as it may tear out the plastic of the base plate
- Battening must be secured on the formwork table to prevent lateral slipping and floating, e.g. due to hot glue
- Take care when working with FT connectors
  - if the small plastic tubes are damaged, concrete runs into the connector and screws can no longer be screwed in during assembly.
ASSY® PLUS VG 4 CS
CONSTRUCTION SCREW
GALVANISED STEEL FULLY-THREADED COUNTERSUNK HEAD

Ideal force transfer thanks to RW drive
• Larger bit contact surfaces for more power
• Greater stability, one-handed working, precise application thanks to the plug-in effect and perfect fit of the bit
• Fewer bit changes, 1 bit for many screw diameters
• Compatible with existing AW drive

Positive connection on metal fittings or in wood products with high bulk density
• For fitting connection with fully-threaded steel screws
• Perfect fit of the 90° head in fittings with metal countersinks
• Pull together without head milling thanks to lack of milling elements below the head
• The head is drawn in by pressing

Maximum force transfer in the tension and compression direction
• Symmetrical high-performance thread matched to the pre-drilling performance of the drill tip
• For high load-bearing wood-to-wood connections irrespective of the load direction

Compact screw connections and small material cross-sections thanks to effectively acting drill tip
• Very small, permissible edge spacings e.g. 3 x d, whereby ASSY screws Ø 8 mm can be used for beam widths of 60 mm
• No pre-drilling required
• The wood does not split and break open
• Small run-out for long screw dimensions, high strength values and ductility
• Tailored heat treatment guarantees high strength values and at the same time ensures high ductility

Extensive services are available to you on the ASSY® service page www.wuerth.de/assy

Assessment in accordance with ETA-11/0190, for timber-concrete composite ceilings ETA-13/0029
Clear material storage due to storage capability in ORSY shelves or in ORSYMAT self-picking machines.

<table>
<thead>
<tr>
<th>Length (l)</th>
<th>Thread length (lg)</th>
<th>Thread length with drill tip (b)</th>
<th>Art. No.</th>
<th>VE</th>
</tr>
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<tbody>
<tr>
<td>160 mm</td>
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Nominal diameter (d) 10 mm
Head diameter (dh) 20 mm
Head height (k) 6.5 mm
Internal drive RW50
Material Hardened steel
Surface Galvanized
Compliant with RoHS Yes

For more information, go to www.wuerth.de
ASSY® PLUS VG 4 CH
CONSTRUCTION SCREW
GALVANISED STEEL FULLY-THREADED CYLINDER HEAD

Special fully-threaded screw with small cylinder head for high load-bearing wood-to-wood connections or reinforcements in structural timber construction where small edge and screw spacings are required at the same time, in dry interior or damp areas.

Ideal force transfer thanks to RW drive
- Larger bit contact surfaces for more power
- Greater stability, one-handed working, precise application thanks to the plug-in effect and perfect fit of the bit
- Fewer bit changes, 1 bit for many screw diameters
- Compatible with existing AW drive

Inconspicuous attachment of wooden components
- Small head diameter for inconspicuous attachment
- Low splitting effect when countersinking the screw head

Maximum force transfer in the tension and compression direction
- Symmetrical high-performance thread matched to the pre-drilling performance of the drill tip
- For high load-bearing wood-wood connections regardless of the load direction

Compact screw connections and small material cross-sections thanks to effectively acting drill tip
- Very small, permissible edge spacings e.g. 3 x d, whereby ASSY screws Ø 8 mm can be used for 60 mm beam widths
- No pre-drilling required
- The wood does not split and break open
- Small run-out for long screw dimensions

High strength values and ductility
- Tailored heat treatment guarantees high strength values and at the same time ensures high ductility

Extensive services are available to you on the ASSY® service page www.wuerth.de/assy

Approval in accordance with ETA-11/0190, for timber-concrete composite ceilings ETA-13/0029
Nominal diameter (d) 8 mm
Head diameter (dh) 10 mm
Head height (k) 7.5 mm
Internal drive RW40
Material Hardened steel
Surface Galvanized
Compliant with RoHS Yes

<table>
<thead>
<tr>
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</tr>
</tbody>
</table>

Clear material storage due to storage capability in ORSY shelves or in ORSYMAT self-picking machines

For more information, go to www.wuerth.de
Advantages:
- Approx. 4 times the load-bearing capacity of conventional timber-concrete composite types with screws, thereby reducing the installation time
- Predetermined insertion angle
- High overall rigidity of the ceiling structure
- Helps to create joist and solid timber ceilings with longer clear spans or higher load-bearing capacities
- No licensing, high value added in the case of in-house productions
- Flexible use in several systems

Especially for installing dry, prefabricated concrete elements with integrated FT connectors:
- Very quick installation
- Full load-bearing capacity of the composite structure directly after fastening (immediate composite action)
- No waiting time while concrete is curing; construction work can continue immediately
- No separating layer that needs to be masked
- Minimizes the entry of moisture into the building as well as the swelling or shrinkage of timber parts

For more information on load values, visit www.wuerth.de/assy

Details/application
Suitable for on-site installations of timber-concrete ceilings in wet concrete as well as for fastening factory prefabricated elements with cast-in FT connectors to a corresponding wood ceiling structure. Suitable for use in joist and solid timber ceilings. Approval for use in service class 1 and 2 (with sufficient concrete covering) Concrete thicknesses of 7 cm (standard) to a maximum of 12 cm (timber lining) are possible.

Proof of performance
ETA-13/0029
Expert opinion (KIT) for concrete thickness increase (up to 120 mm)
DATA SHEET
TIMBER-CONCRETE COMPOSITE

Company

Contact partner

Phone

Customer number

E-mail

Project name

Ceiling properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Beam ceiling</th>
<th>Stacked board ceiling</th>
<th>Cross-laminated timber ceiling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>GL</td>
<td>GL</td>
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<tr>
<td>Beam spacing</td>
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<td></td>
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</tbody>
</table>

Dimensions

<table>
<thead>
<tr>
<th>Span</th>
<th>Wood component height</th>
<th>Concrete height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
</tr>
</tbody>
</table>

Design version

☑ in-situ concrete
☑ prefabricated part

Load effect

<table>
<thead>
<tr>
<th>Own weight</th>
<th>Extra load</th>
<th>Live load</th>
<th>Utilization class</th>
</tr>
</thead>
<tbody>
<tr>
<td>kN/m²</td>
<td>kN/m²</td>
<td>kN/m²</td>
<td></td>
</tr>
</tbody>
</table>

Verify

vibration
Class I
Class II

Fire protection
R30
R60
R90

Comments

Please return the data sheet to bpm-holzbau@wuerth.com
TIMBER-CONCRETE COMPOSITE
Design variants and application recommendations

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