

Expert opinion

Distance tubes (fibre concrete)

Fire behavior of reinforced concrete walls with formfork spreaders made of fiber cement

GA-2021/119-YN | 16.12.2021

issued by: IBB GmbH, D-Groß Schwülper

Expert opinion No. GA-2021/119 -YN of december 16, 2021

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Date of order: October 13, 2021

Reference no.: Mr. Lindner

Order intake: October 13, 2021

Order intake: Expert opinion on the fire behavior of reinforced concrete walls with formwork spreaders made of fiber cement

This expert opinion consists of 8 pages.



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1 Mission and occasion

In a letter dated October 13, 2021, IBB GmbH, Groß Schwülper, Germany, was commissioned by Max Frank GmbH & Co. KG, Leiblfing, Germany, to prepare an expert opinion on the fire behavior of reinforced concrete walls in connection with wall thicknesses made of fiber-reinforced concrete with regard to a classification of the wall constructions into the fire resistance class "F 30" - "F 120" according to DIN 4102-02 or for the assessment of a fire wall quality ("F 30-M" - "F 90-M") according to DIN 4102-03 with one-sided fire exposure according to the ETK according to DIN 4102-02.

The expert opinion is necessary because there are no technical building regulations or general building authority proofs of usability (e.g. a general building authority test certificate or a general type approval) for the installation of the formwork spreaders within the reinforced concrete wall structures.

2 Fire protection requirements

With the use of fiber-reinforced concrete wall thicknesses, solid wall constructions must ensure that the load-bearing capacity is maintained, that no impermissible temperature increases above the initial temperature occur on the side away from the fire (insulation criterion) and that the room closure is maintained over a one-sided fire exposure of at least 90 minutes.

3 Basis and document of the expert opinion

The expert opinion for the installation of the wall thicknesses in reinforced concrete wall structures is based on

- [1] the test report No. 10121411 of IBS - Institut für Brandschutztechnisch und Sicherheit (Institute for Fire Protection Technology and Safety) of June 7, 2011 on the fire test of wall thicknesses made of fiber-reinforced concrete of Max Frank GmbH & Co. KG, Leiblfing,
- [2] the Classification Report No. 13051304, Rev1 of IBS - Institut für Brandschutztechnisch und Sicherheit dated october 8, 2013 on the classification of the fire resistance of wall thicknesses made of fiber-reinforced concrete ($\varnothing = 22 \text{ mm} / 27 \text{ mm}$) on the basis of the above-mentioned test report [1], issued to Max Frank GmbH & Co. KG, Leiblfing,
- [3] the technical data sheet on the properties of the fiber concrete to be used, prepared by Max Frank GmbH & Co, KG, Leiblfing,
- [4] the technical data sheet on the properties of the REPOXAL adhesive to be used, prepared by Max Frank GmbH & Co, KG, Leiblfing
- DIN 4102-01,
- DIN 4102-02,
- DIN 4102-03,
- DIN 4102-4: 2016-05,
- DIN EN 1991-1-2



- the concrete fire protection manual, Kordina - Meyer-Ottens, Beton-Verlag as well as
- the compilation of possible closure types of FRANK fiber-reinforced concrete wall thicknesses in connection with the fire resistance class to be achieved in each case (see Table 1 to this statement).

In addition to these documents, extensive fire protection testing experience of the IBB GmbH engineers on reinforced concrete wall constructions is included in the fire protection assessment.

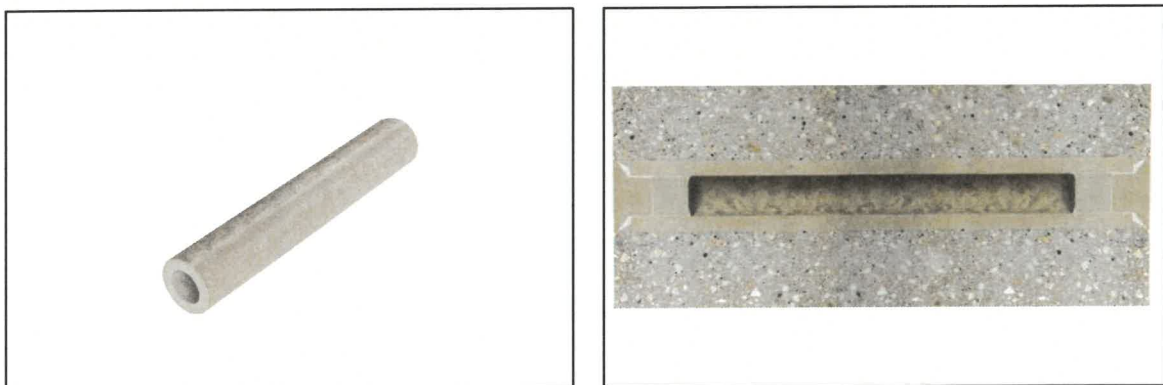
4 Description of the construction

In the following, only the details relevant to fire protection for the construction of the wall structures are discussed.

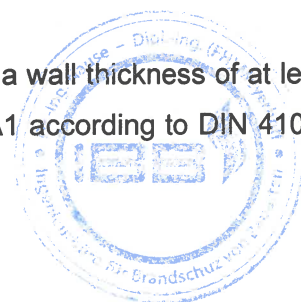
Reinforced concrete walls shall basically be designed in accordance with the boundary conditions for classification into the fire resistance classes according to DIN 4102-4:2016-05 or DIN EN 1992-1-2, so that a further description of the reinforced concrete walls themselves can be dispensed with.

In the following, the wall reinforcements are explicitly described as a component of the structural wall construction and evaluated in terms of fire protection. The wall thicknesses are used as spacers to secure the planned component cross-section or the concrete cover by preventing the formwork spreaders from pressing into the formwork. The formwork spacers remain in the wall cross-section after concreting (see also exemplary Figure 1).

Abb. 1: View of a wall thickness (left) / section through the wall in the area of a wall thickness (right)



The formwork spreaders with an inner diameter of $\varnothing \leq 40$ mm, with a wall thickness of at least 9 mm, are made of fiber cement and comply with building material class A1 according to DIN 4102-01. The fibers added to the concrete are made of polypropylene (PP).



The concreting process with the formwork in conjunction with the formwork spreaders results in remaining openings in the concrete wall, which must finally be closed after stripping the formwork with at least one or two accurately fitting plugs or closure cones in accordance with the specifications in Table 1, depending on the fire resistance class and the building physics requirements. In the case of fire walls in particular, a plug or a sealing cone is incorporated on both sides of the wall and the remaining cavity is completely filled with special swelling mortar to ensure additional impact resistance. The sealing plugs or sealing cones are glued into the anchor opening using "Repoxal" two-component adhesive.

Abb. 2: Illustration of a fiber-reinforced concrete plug for closing the anchor opening

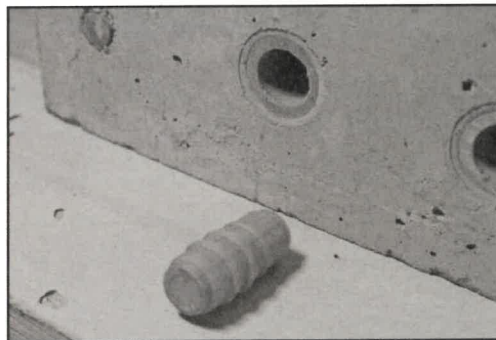
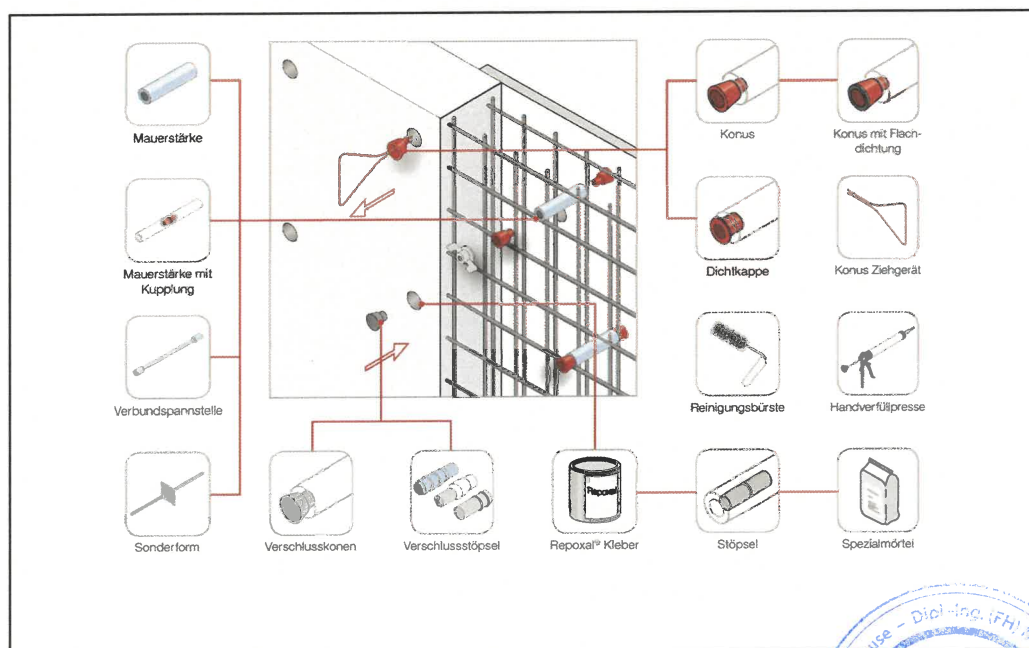
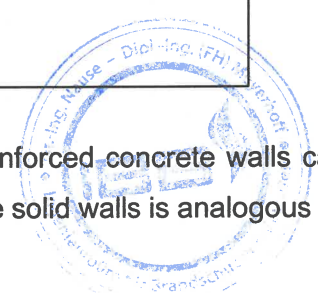


Abb. 3: Overall view of the system solution



Further details on the installation of the formwork spreaders in the reinforced concrete walls can be found in Table 1 to this statement. The use of the wall thicknesses in the solid walls is analogous to the installation shown or described in the table.



5 Fire safety classification of the construction

Based on DIN 4102-04:2016-05, DIN EN 1992-1-2 and the positive test results obtained from documents [1] - [2] and further test experience with reinforced concrete and fiber-reinforced concrete components, the fire protection performance for classification in the above-mentioned fire resistance classes remains unchanged. Fire resistance classes of reinforced concrete walls in conjunction with the formwork spreaders made of fiber cement described in Section 4 and shown in Table 1, taking into account the opening closures under one-sided fire exposure according to the unit temperature-time curve (ETK) in accordance with DIN 4102-02.

Over a fire exposure period of at least 30 - 180 minutes (ETK), it is ensured that, in the case of fire exposure on one side of the wall structure, the following conditions are met

- the load-bearing capacity of the structure is maintained,
- no impermissible temperature increases above the initial temperature occur on the side facing away from the fire ($\Delta 140$ K on average or $\Delta 180$ K maximum) and that
- the room closure is maintained.

In addition, with regard to the fire wall requirement, it can be stated that in the case of one-sided fire exposure over 90 minutes plus the aforementioned performance criteria of a load-bearing, room-enclosing wall construction, due to the complete cavity filling of the spreaders with FRANK special mortar, which supplements the plug arrangement on both sides, also

- the stability is maintained with regard to mechanical impact resistance as defined in DIN 4102-03 (3 x 3000 Nm impact energy).

6 Summary and conclusion

From a fire protection point of view, IBB GmbH, Groß Schwülper, recommends to classify the reinforced concrete walls in connection with the formwork spreaders and the opening closures made of fiber-reinforced concrete into the fire resistance class

„F 30“ – „F 180“ to DIN 4102-2

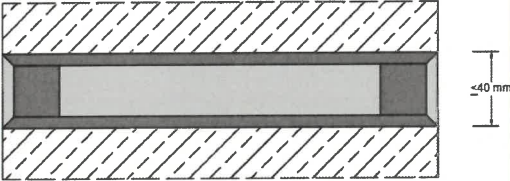
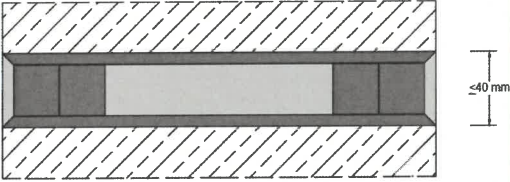
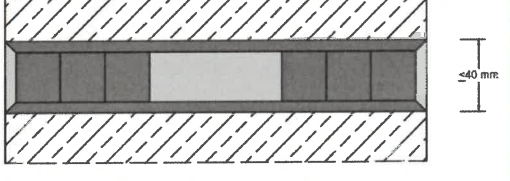
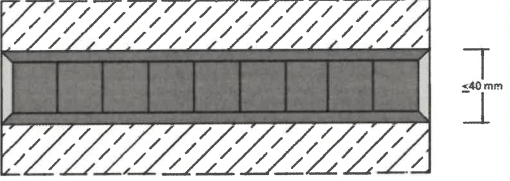
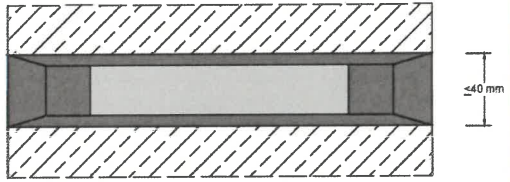
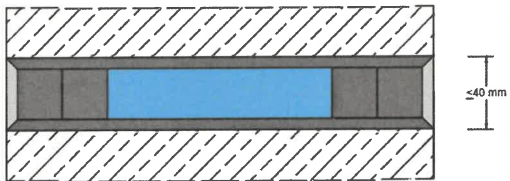
respectively

„F 90-M“ to DIN 4102-03

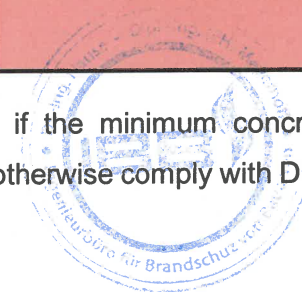
To be classified in compliance with the provisions of the following table.



Table 1: Requirement for wall construction with wall thicknesses / plugs for fire resistance rating

Closure type		Fire resistance class according to DIN 4102-02 or DIN 4102-03
Description	Schematic drawing	
Normal closure with one stopper from each side		F 30
Waterproof closure With two plugs from each side		F 30 – F 180
Soundproof closure with several plugs (total minimum depth at least 4/5 of the wall thickness)		F 30 – F 180
Gas-tight closure with several plugs which close the total cavity		F 30 – F 180
Closure of cone holes With one FB closure cone and one plug per side		F 30 – F 180
Closure of fire walls With two plugs from each side, additionally fill the remaining cavity completely with FRANK special mortar 3/25		F 90-M (fire walls)

The evaluation or classification according to Table 1 only applies if the minimum concrete wall thicknesses and the minimum axial spacing of the steel reinforcement otherwise comply with DIN 4102-04 or DIN EN 1992-1-2 depending on the fire protection requirement.



7 Special notes

Accordingly, the present design does not deviate significantly from the design principles according to DIN 4102-04 or DIN EN 1992-1-2 for the classification of reinforced concrete walls.

The prerequisite for the above fire protection evaluation and classification is that the other parameters for the classification of reinforced concrete structures with regard to the required minimum component dimensions and axial distances with regard to the reinforcement on the basis of the technical building regulations (DIN 4102-04; DIN EN 1992-1-2) are otherwise complied with.

This expert opinion is not a general proof of usability by the building authorities in the building supervisory procedure in the federal states of the Federal Republic of Germany, but serves as a basis for technical advice from Max Frank GmbH & Co. KG, Leiblfing, for corresponding construction projects with regard to the issuance of the declaration of conformity by the builder in connection with "non-substantial deviations" from the applicable technical building regulations.

This expert opinion is only valid from a fire protection point of view. The above fire protection assessment is only valid if the load-bearing (load-dissipating and bracing) components have at least the same fire resistance duration as the installation shafts.

Changes and additions to design details (derived from this expert opinion) are only possible after consultation with IBB GmbH, Groß Schwülper. Proper execution is the sole responsibility of the executing companies.

The validity of the expert opinion ends on December 16, 2026. The validity period can be extended upon request and depending on the state of the art.

Yours truly,

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