



Associação Nacional dos Industriais de Prefabricação em Betão

CIRCULAR N.º 050/2015

Assunto: Projeto de Investigação Holcofire: carta de encerramento

Caros Associados,

Como é do vosso conhecimento, a ANIPB participou no Projeto de Investigação **HOLCOFIRE**, o qual teve como finalidade realizar novas pesquisas sobre o comportamento das lajes alveolares pré-fabricadas em betão sujeitas ao fogo. Para este projeto a nossa Associação contribuiu com 5.000,00 € (cinco mil euros). Se Portugal tivesse avançado com este projeto isoladamente, o custo seria superior a € 80.000,00 (oitenta mil euros).

Este Projeto teve a duração de 5 anos e a sua conclusão foi oficialmente anunciada no passado dia 22 de maio. Assim, junto enviamos a carta de encerramento do Projeto.

Com os nossos cumprimentos e os votos de um excelente fim-de-semana,

(Iris Vilela)

Lisboa, 29 de maio de 2015



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Brussels, 22 May 2015

Dear HOLCOFIRE Partners,

Five years after the beginning of the project, the Steering Group is pleased to announce the official closure of the HOLCOFIRE project. This project was initiated with the objective to get full understanding of the behaviour of prestressed concrete hollow core slab floors under fire conditions in order to regain full acceptance for the application of hollow core slabs under fire conditions. 12 partners (see Annex A) under the umbrella of BIBM took part to the project.

Main results

During this period, a thorough global analysis has been carried out that finally demonstrate the safety in use of prestressed hollow core flooring solutions exposed to fire. Meta-analysis, laboratory fire tests, finite element simulations, and calculations conducted by experts in the field of precast hollow core floor construction and fire testing have been performed to prove with enough confidence their structural integrity following the present design rules. The scientific results were supported by a zero death score in Europe in the studied period and several examples of easy repairing (even after very severe fire conditions) showing their resilience.

The study also permitted to generalise the findings to all the support types most commonly used in Europe and to confirm the reliability of the determination by testing of the fire performances of hollow core floors according to EN 1168, Annex G.

Summary of the technical work

Most of the technical work was carried out or managed by the "Project Team". Composed of around 7-9 people (see annex B) and led by Wim Jansze, the team was the real engine of the work, both producing results and managing the technical relationship with service providers.

Besides the Fire laboratory that run all the fire tests (Promethee, CERIB), external consultancy for calculations and simulations as well as external experts from different EU universities (mainly for peer reviewing) has been involved in the realisation of the HOLCOFIRE project.

Technical findings and conclusions have been collected in a book titled "Structural behaviour of prestressed concrete hollow core floors exposed to fire".

A database covering 1966-2010 was set up with 162 fire test results in order to perform a meta-analysis over the fire tests. It is concluded that 94.5% of the database can be fully explained with the design models and requirements stated in the available European standards (EN1992-1-2, EN1168, EN1363-1, EN1365-2). The other 5.5% required additional analysis with the R-series and HOLCOFIRE Frame Model and could also be fully explained.

In the fire tests G-series, the shear formula presented in EN 1168 A3 Annex G was checked with 42 fire test results from the database and the Holcofire fire tests G1 to G7. It is concluded that with this EN1168 Annex G formula for shear and anchorage resistance under fire, the designed hollow core floor



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is safe for the ultimate limit state in 6 accidental situation. In the subsequent desk-study it is concluded that the EN1168 Annex G formula can also be used for determining the shear and anchorage resistance under fire for hollow core floors on flexible supports.

The Rotterdam fire case has been analysed in retrospective view and in-depth analyses gained new insights. In a finite element simulation of the real fire of Rotterdam with FDS5 software it was concluded that the fire was more severe than an ISO fire due to the travelling characteristics of the fire, at 20 minutes leading to 33% higher temperature above "car n. 1" and three times higher temperature increase rate. A clear explanation of the successive phases of delamination of underflanges is given.

In the fire tests R-series, the capacity of hollow core slabs under restrained conditions was investigated in fire tests R1 to R4. Overall it is concluded that high floor restraints due to thick topping and blocking can lead to buckling spalling and horizontal cracking. But these are not failure mechanisms. Under moderate loads and well anchored strands, the fire resistance time can still be met by virtue of structural redundancy and alternative load paths in the hollow core slab floor.

It is shown with the Holcofire Frame Model that the initiation of horizontal web cracks and buckling spalling at the soffit can clearly be simulated with the defined parameters. It is concluded that both the thickness of the structural topping and the magnitude of transversal restraint are the main influencing parameter for both phenomena. But it turns out that shrinkage cracks and dilatations in hollow core floors used in practice are enough to hold these transversal blocking effects at such a low level that horizontal web cracking respectively buckling spalling of the under flange is unlikely to occur. This explains why these local damages are only seldom observed in practice. But when observed, are an incident, like the Rotterdam fire case where the fire was more severe than an ISO fire.

In The Netherlands, an additional review of the HOLCOFIRE study by some professors and additional analyses on the behaviour of hollow core floors with thick topping was carried out with positive result. This reconfirmed the outcome of HOLCOFIRE and in addition demonstrated that the thickness of the structural topping should be limited to 25% - 30% of the depth of the slab in buildings categorized with a medium (upper risk group) or high consequence of failure. If in this category the structural topping is thicker, a risk analysis has to be carried out. With this regulation, the specific solutions of hollowcores with topping in The Netherlands in relation to fire was solved. This has been very well accepted by the market: fire and hollowcores, in general and in combination with thick toppings, is not an issue anymore.

In Germany, the situation has also normalized as the DIBt (Deutsches Institut für Bautechnik) renewed the HC floor Zulassung (Approval) for the next 5 years after intensive legal and technical discussions. However the DIBt is still proceeding with further studies on the boundary conditions of the HC floor. A fire test will be carried out under the control of DIBt in the BAM institute in Berlin, for which discussions on the details are still taking place. A more general discussion on the legal status of the Zulassung is also taking place, linked with the results of the court case against the Zulassung in general in the European Court and outside the scope of HC. As a result of the whole discussions in Germany, the general trust in HC is decreased, even if the market is secured for the next 5 years.



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The main conclusions of the HOLCOFIRE project have been put forward to the working group of EN1168 that is currently discussing a new revision of the product standard.

To perform this work, the equivalent of 5 men years were necessary from resources within the industry, to which adds up the time for approximately 30 meetings (representing another 1,5 men years).

Summary of the management work

The project was managed by the "Steering Group", composed of 5-6 people (Annex C) with managerial positions, led by Stef Maas (until September 2012) first and Axel Baumann later.

The main objective of this group was the validation of the conformity of the technical work with the agreed project targets. It also have been regularly monitoring the changing political and market situation in the partner countries and maintaining relationship with third parties (suppliers, authorities etc...).

This group was also in charge of managing both the internal and external communication throughout the project. Besides the publication of the book as explained above, a regular but limited information was provided to the partners in order to avoid the leakage of unexplained material. Some intermediate papers on main findings for external circulation were also provided. In terms of direct communication to the outside world, presentations of the project findings were given both at the BIBM Congress (Istanbul, May 2014) and at two sessions of the "Structures in Fire" conference. Finally, the IPHA technical seminar of October 2013 (co-organised with the HOLCOFIRE project) was fully dedicated to this project and open to partners.

As summarised below, the Steering Group was also responsible for the management of the financial aspects of the project (see below).

In total, the Steering Group met around 20 times, representing an additional charge for the industry of 1 men year.

Financial report

The initially foreseen budget for the project was 660.000 €. More than two thirds (460.000 €) were allocated to fire tests (including slabs and beams), 125.000 to external expertise, 60.000 € for communication and the remaining 13.000 for overheads and unexpected.

Savings were achieved in all budget lines. The number of test was reduced (from 9 to 7) and most of the testing elements have been provided for free or at production cost by hollowcore companies. A more extensive use of internal human resources from the industry allowed to reduce the need for external expertise, whereas communication has been limited to the production of common material and messages. Overheads have been controlled and no relevant unbudgeted cost was incurred.

443.115 € have finally be spent divided as follows (rounded-up figures; for the details, see Annex D): 365.000 € for the tests (including slabs and beams), 52.000 € for external expertise, 20.000 € for communication and 6.800 € for overheads and unbudgeted.



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Out of the total collected money (660.000 €), 220.000 € are being reimbursed to the partners. At the end of 2013, a first portion of 100.000 € was already returned to the partners, whereas the remaining (120.000 €) will soon be reimbursed in the form of a credit note following the same percentage as the initial contribution. The detailed table of final reimbursement is enclosed in Annex E.

Conclusion

It is concluded that there is no need for further tests, analyses or modelling in this field.

The Holcofire study concludes that the proven track record of more than 1000 million m² of hollow core floors in Europe, together with the extensive testing of hollow core slabs in laboratories and the analysis of the real fire in the Rotterdam incident, reconfirm that hollow core floor systems meet all regulatory, quality and safety requirements. The HOLCOFIRE "Lessons Learned" are:

- the product meets regulations and requirements;
- the product performs well exposed to fire;
- the scale of real fires in parking garages in specific cases is more severe than the standard fire.

Based on the knowledge and experiences gained in this European project run by experts and reported on in this book, it is asserted that there is no more need for further fire testing and modelling. Society can continue to fully rely on the structural solid performance of floors consisting of hollow core slabs.

The details of all test results remains available for consultation by all the partners in the BIBM premises.

Although the HOLCOFIRE project has now come to an end, both IPHA and BIBM will continue monitoring the situation and be ready to answer questions arising from the society or policy makers on topics related to hollow core exposed to fire. The gathered intelligence is deemed to answer not only present but also many of the future questions. Should you have any issue that could be of European or international impact, you can address your queries to the BIBM or IPHA secretariat.

We would like to close this letter with a final thank to the partners, the project team experts, as well as all those who have contributed to the achievement of the targets of this project.

On behalf of the Steering Group

Alessio RIMOLDI
BIBM Secretary General

Axel Baumann
HOLCOFIRE chairman



HOLCOFIRE - Official closure of the project

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Annex A - Partners list

- VERBAND ÖSTERREICHISCHER BETON - UND FERTIGTEILWERKE – VÖB
Gablenzgasse 3/5 OG, AT-1150 WIEN
- FEDERATION DE L'INDUSTRIE DU BETON – FEBE Bd du Souverain, 68 B – 1170
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- BVSF (BUNDESVERBAND SPANNBETON-FERTIGDECKEN e.V.) Schlossallee 10
D-53179 BONN
- BETONELEMENT-FORENINGEN Kejsergade 2 – Postboks 2125 DK-1015
KØBENHAVN K
- FINNISH CONCRETE INDUSTRY ASSOCIATION P0 Box 381 - Unioninkatu 14, 2nd
Floor FI-00131 HELSINKI
- FEDERATION FRANCAISE DE L'INDUSTRIE DU BETON – FIB 23, Rue de la Vanne
FR-92126 MONTROUGE CEDEX
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