SHALLOW STEEL-CONCRETE FLOOR AND DELTABEAM CONNECTIONS IN NORMAL AND EXTREME CONDITIONS

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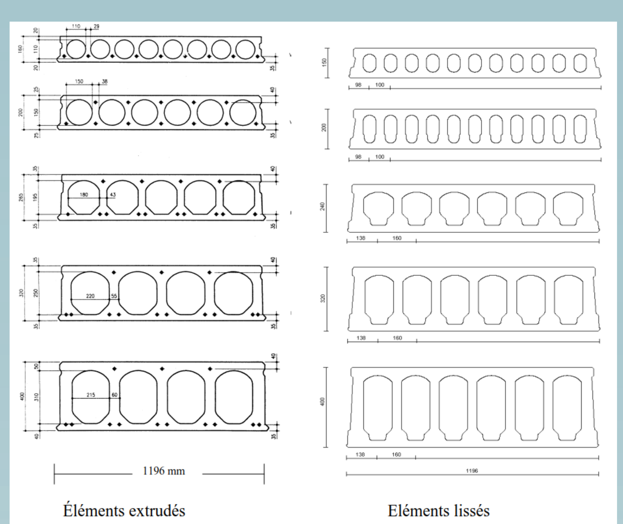
Introduction

A new type of floor, called Shallow-Floor, have been developed in the 1990s, using the advantages of composite construction and offering flexible spaces without dropdown beam with reduced floor thicknesses. This type of floor is made possible thanks to the use of slabs embedded in the height of a metallic beam, as Deltabeam. The most common is the use of Hollow Core slabs with Deltabeam that can more than 12 meters of span.
However, initially Hollow Core slabs were used and designed for rigid bearings, such as walls. With the introduction of column-beam structure and also the Shallow-Floor, the Hollow Core slabs are now being used on supports qualified as flexible.

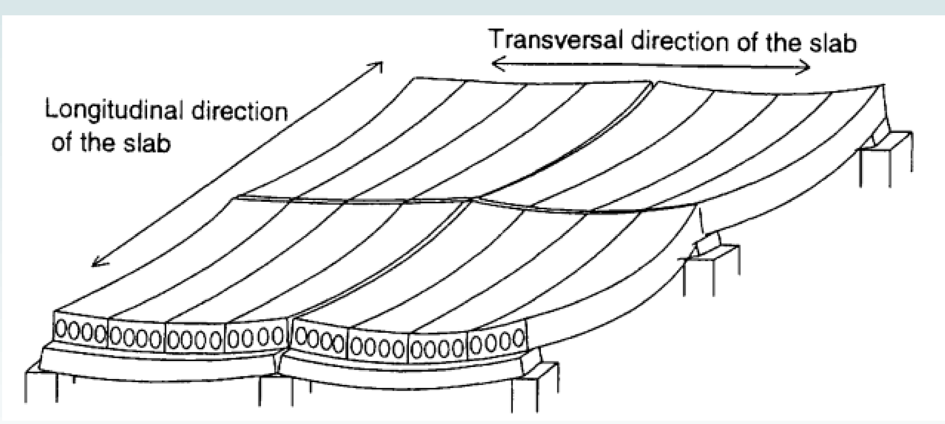
At current, the behavior and design of theses slabs on flexible bearings aren't very popular in some countries, particularly in France, and aren't included in the European regulations [3&4]. Furthermore, the application of Shallow-Floor is currently not very widespread in the French construction.

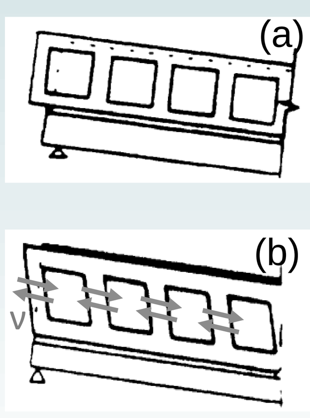
State-of-the-art

The Hollow Core slabs are traditional products for the construction of prefabricated floor. They are generally made of prestressed concrete with longitudinal strands and haves holes in their direction of span. The characteristics of the Hollow Core slabs allow to obtain lighter slabs with a high degree of mechanical performance.



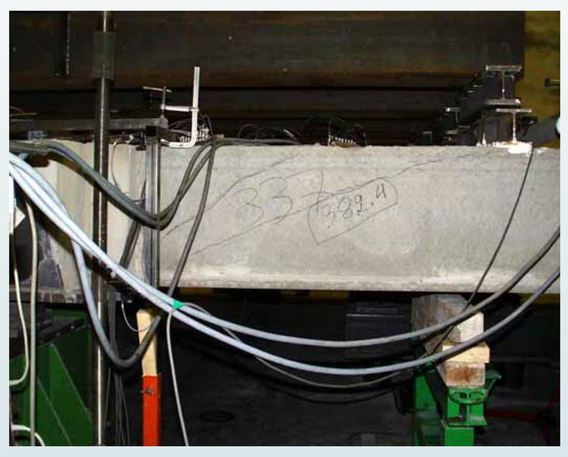
Originally designed for rigid supports, the emergence of column-beam structure has led to the use of Hollow Core slabs on flexible bearings and it was in 1990 that the first research on the behavior of Hollow Core slabs on flexible supports began in the Finnish Technical Center VTT, by Pajari. Then, they continued throughout Scandinavia and Germany. All in all, 20 large-scale tests were made public by Pajari in his publication VTT n°148 [6] in 2005.
In all experimental tests, a reduction of up to 60 % in the shear resistance of Hollow Core slabs on flexible supports is observed compared with rigid bearings. This decrease is caused by a failure of the webs in the Hollow Core slabs due to the formation of a transverse shear flow in the slabs, noted ν. Specifically, this flow is due to a double curvature of the prefabricated slabs induced by the deformation of the beam when the floor is subjected to a uniformly distributed load. But also due to a composite action between the elements that avoids the progressive displacement of the Hollow Core slabs towards the outside of the beam during the bending of the beam (See (a) without composite action and (b) with composite action).





Examples of the webs failures by transverse shear in VTT n°148 [6]:

Test VTT PC INT.500. 2006



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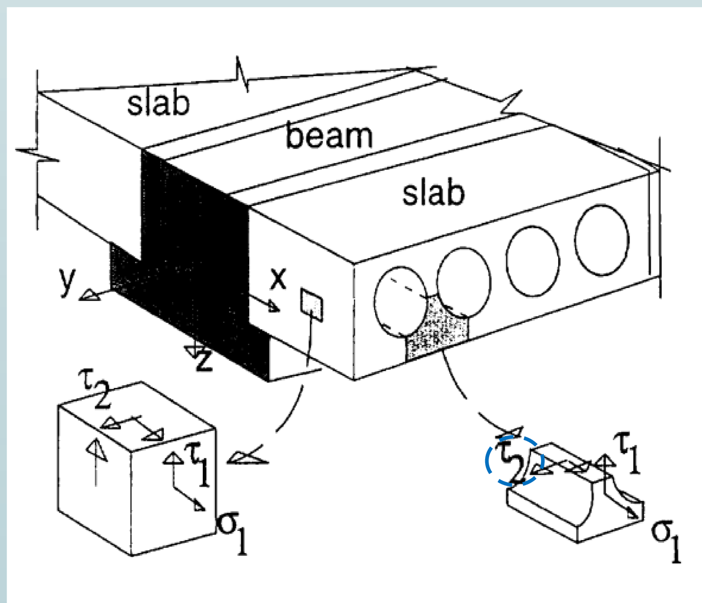
Then, based on the many available researches, different design models have been developed to take into account this transverse shear flow occurring in the webs of Hollow Core slabs on flexible supports. An example is the Pajari's design model, which has been used in many scientific publications, such as the Fib Bulletin n°6 [5].



$$\sigma_{ps} = \frac{\sigma_1}{2} + \sqrt{\left(\frac{\sigma_1}{2}\right)^2 + \tau_1^2 + \tau_2^2}$$

σ_1 : Normal stress due to prestressing force, is determined in analogy with the formula for prestressed concrete beam (as in rigid supports)

τ_1 : Vertical shear stress due to the vertical shear force determined according to the beam theory (as in rigid supports)

τ_2 : Transverse shear stress, due to shear flow in the transverse direction, is determined from the beam theory applied to a section including the support beam, the composite section, the slab section and the top concrete slab if present

The different methods proposed for the behavior of the Hollow Core slabs on flexible supports are still being discussed. One of the reasons is that the reduction in the shear capacity of the slabs isn't caused only by the deformation of the beam. But also according to other important parameters, such as the composite properties between slabs and beam and the slab cross section (shape of the voids, webs thickness, prestressed, etc.).
Moreover so far, no general, standardized and precise design model allows the design of Hollow Core slabs on flexible bearings in Europe. And the distinction between rigid and flexible supports is often not clear.

However, in some countries, there are codifications for this design to better avoid transverse shear in Hollow Core slabs. Especially in Finland, with the Code Card [1], which is based on the Pajary's Model. Also, in Germany regulation, Dibt Z-15.10-279 [2], with 4 requirements to limit damage in these prefabricated slabs on flexible floors (Reduction of 50% for the shear strength calculated on rigid supports, cambering limited to L/300, concrete in the void in the slabs near the support beam, support on elastomer tape).

Contributions envisaged

We plan to investigate in more details the behavior of Hollow Core slabs with transverse shear, in particular with Deltabeam, in accordance with the European regulations [3&4] and also following the good practice in France.
In addition, we plan to study the complete functioning of traditional floors (concrete beam + Hollow Core slabs) into the transmission of the forces until the vertical elements, thanks in particular to the connection and diaphragm effect in normal and seismic situations. In order to offer similar effective and durable solutions for complete composite floors (Deltabeam + Hollow Core slabs).
So, the overall objective is to show the good cooperation and functioning of Hollow Core slabs with shallow and mixed beam (such as Deltabeam).

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