

Flooring solutions with a new generation of hollow core floors

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Summary

Trends in buildings and further industrialisation of production and building processes gives possibilities of new products in the market. The invention of the pipe floor gives a breakthrough in the developments of hollow core floors in the building industry. Pipes for sewage and ventilation can be added in the depth of the hollow core floor. It gives also an answer to a trend, that buildings must be flexible in designing an individual floor plan now and during a renovation.

Keywords: hollow core ; pipe floor ; apartment floor ; concrete ; mass customized production ; floor ; floor plan ; precast ; prestressing.

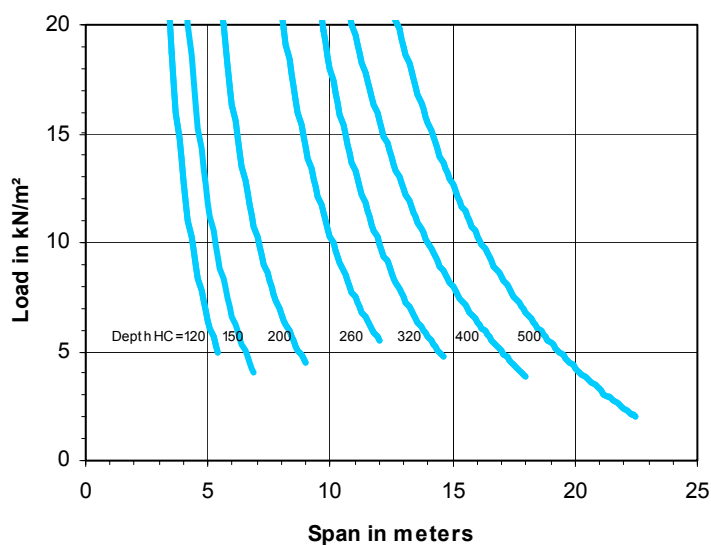
1. Developments of hollow cores in the past

The invention of the hollow-core floor slab took place in the late thirties of last century. Bring the material where it is needed and create holes in the slab. But the real development started in the late sixties. That is when the standard was set that the width of a hollow-core element was to be 1200 mm with pre-stressed tendons only in the longitudinal direction. There was and is no transverse reinforcement.

Due to a high extent of industrialization of the production of hollow-core floor slabs this was a cheap solution in respect to massive floor solutions. It started in the sixties with depths of 100 mm and it went up to 200 or 250 mm in the eighties. And with the experience of the last 20 years new types of hollow-cores went up to 500 mm in the nineties.

All with the same idea to make a floor with less weight and high pre-stressed reinforcement; so it was possible to make a competitive floor system with bigger spans. The hollow-core floors are slender and stiff. To build with hollow-core slabs

fast erection without a lot of concreting on site have a lot of advantages over the cast in situ floors.



2. Building trends

2.1. Trends

The most important social trends in European countries, which influence demands on buildings, are:

- Quality:
 - demand of higher quality houses
 - better indoor climate
- Energy:
 - low energy-houses: more installations in the houses
 - more pipes because of balanced ventilation
- Flexibility
 - more individual influence of the buyer
 - freedom of design of the floor plan
- Less labour on the building site
 - 3D: work on the building site is 3D: dirty, difficult and dangerous
 - more industrialized products

In the Netherlands we translated those trends to Industrial Flexible Demountable buildings. Changeable building is a keyword for the future. It is about the development of building processes and the use of building materials or building parts which use flexibility to an extreme extent and focus on directing the customer/user/buyer. The building as far as lay-out and functionality go, should be able to adapt so easily and quickly at such low cost that the same or future inhabitants are still able to manage with the building.

2.2. Building consumer-friendly

Many building companies go into the problem of how to interpret the wishes of the future inhabitants. More space, more freedom of arranging the apartments and anticipate the individual buyers' wishes at the latest possible time in the building stage, that is the point.

2.3. Flexibility

Flexibility is a keyword for houses and apartments of the future. Where people used to, partly for financial reasons, settle for limited square meters, nowadays the living room and kitchen can not be large enough. And luxury is increasingly within reach of a larger group of people. Besides, there is an obvious trend to adapt the wishes for housing to all stages of life.

3. Industrialisation of the production process

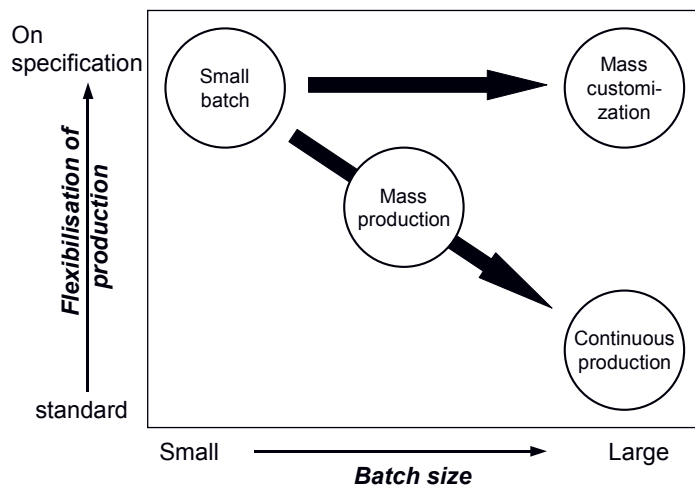


In earlier times the production facilities were poor and a lot of manual labour had to be done. On all parts a lot of improvements have been made and nearly all actions are power-driven. For example the computer-controlled drawing device, the concrete sucking device. Also the labour circumstances have improved tremendously. The noise level of especially the sawing machine has been reduced from 120 dB to less than 85 dB. The labour area in the factories has been

enlarged and labour has been mechanized to its maximum. This creates the possibilities to further develop the hollow-core floors in a industrialised manner.

4. Industrialisation of the building process

In real terms it comes down to it that consumer friendliness mainly manifests itself in a process or production-related approach. Historically there are three ways of production: by piece, series and continuous production (such as in the petrochemical industry). The serial size increases in this set of three, the product flexibility decreases. From the past, the production of hollow-core floors is



usually a series product, like all prefab products. Because of recent ICT-developments and process control, more flexible production methods have become possible maintaining scale effects: flexible production (building in series with added flexibility). Therefore, mass customisation (industrially clustered standards based on thorough market investigations) is not the same as piece production of serial production. In construction continuous production does not occur at this moment. Current house building is somewhere between piece production and serial production, the industrial production of prefab concrete

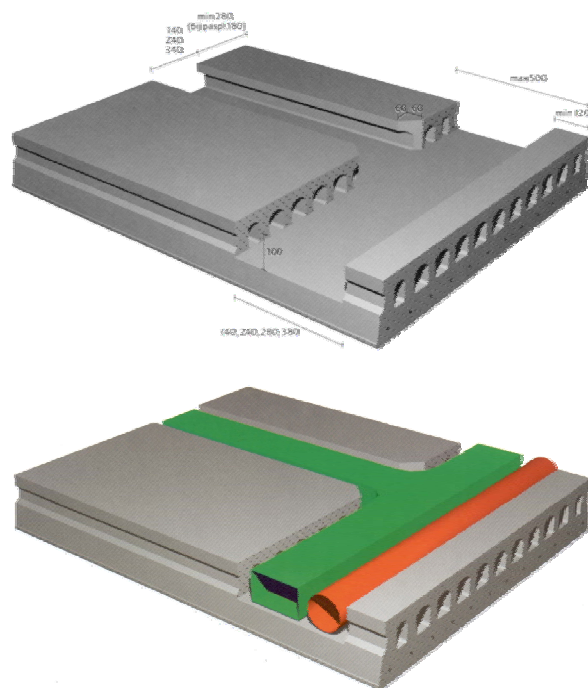
products have all the characteristics of serial production. The latest development of the hollow-core complies with mass customisation.

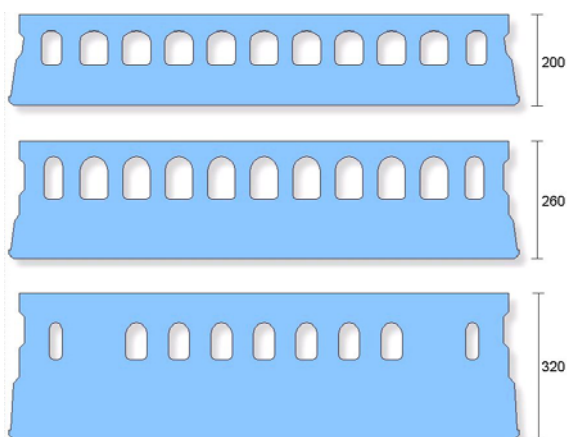
5. New invention: Pipe floor for (detached) houses and apartments

Something new was invented in The Netherlands. A new generation of hollow-core slabs came to life at the end of the nineties of the last century. It was now possible to put pipes in the depth of the hollow core by making recesses in the hollow core slabs. Already it was sometimes possible to make recesses in the longitudinal direction, but now it was also possible to make recesses in the transverse direction near the support of the floor elements. The basic idea is to make a hollow core slab with a thicker under flange. The patented Pipe floor is the result.

Near the support it is possible to take the upper part away, such that the massive part that is left, is strong enough for the bending and shear forces near the support.

A new generation of floor solutions has been made.

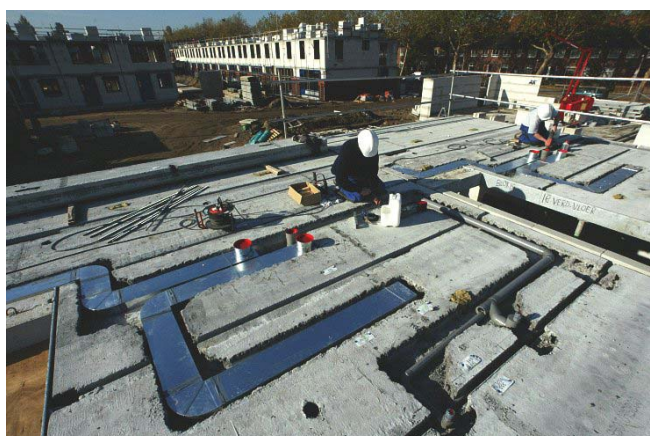




For a good sound insulation the floors need to have a certain weight in relation with the finishing on top such as carpets, floating floors. Also a solution without top-finishing is possible in The Netherlands. In this case a 320 mm Pipe floor is needed with a top-finishing of 50 mm sand/cement screed to fulfill the sound insulation requirement.



The production of the Pipe floor is the same as any hollow-core floor. However, a patented special milling cutter has been developed in order to be able to make the recesses in an industrial way.



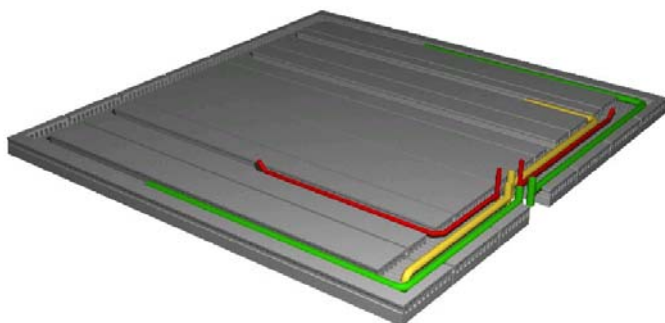
More and more installation will be put into houses, residential buildings and offices. Especially in houses the insertion of horizontal pipes in the height of the floor offers big advantages. Using the Pipe floor this is possible.

In a floor with depths of 200, 260 or 320 mm, recesses of 100, 120 or 135 mm can be made without filling the recesses with constructive mortar. The hollow core with the recesses has been structurally calculated, so there is no need

to fill the recesses with constructive concrete. Like all hollow core slabs there is no need to apply props during assembly. There is no obligation to put pipes in the floor during the stage of putting together the shell of a building.

It is possible to fill the recesses with a non-constructive material. So it is possible to bring in the pipes in a later stage of the work than before.

6. Pipe floor gives maximum freedom in designing the floor plan



This solution offers a lot of possibilities in one-family houses or apartments with spans up to 12 meters! No intermediate supports (walls or columns) are necessary. So all of the space can be divided without limits. Every house can be designed separately. The investors can offer potential buyers or tenants several options, or full freedom. The moment to take a final decision can be postponed until the house is wind and watertight and the interior

finishing begins. By means of putting in a recess for perimeter piping and a number of longitudinal recesses it is possible to choose between all possible plans of a house. This is also valid in renovations. Pipes can be dug up and the recess pattern can be used again to equip the building with new contemporary floor plans.

7. High efficiency

7.1. What is in it for the real estate developer, architect and structural engineer?

To build with Pipe floors it gives them complete freedom in designing a house. There is no need to make all houses or apartments with the same plan. And this freedom can be increased by using larger spans of the floor. With pre-stressed Pipe floors spans up to 12 meters are easy to reach without intermediate supporting walls or columns. Only the vertical shaft must be positioned on the same place. Every individual floor plan can be made. It is even possible for the final buyers to make their decisions after erection of the total skeleton, when it is wind and water-tight. And the floor solution offers the possibility that houses are adaptable afterwards.

The quality of the ceilings of the Pipe floor is good, because the slenderness (span/depth of Pipe floor) of the chosen Pipe floor is always more than or equal to 38. The stiffness of the hollow core is then OK. The (additional) deflection is limited to a maximum 1/1000 of the span. This also goes for the span of 12 meters. The recesses have no influence on this. The recesses do not need to be filled with a constructive mortar. Filling them with a stabilized sand/cement screed is sufficient.

Maximum flexibility can be reached by applying circular pipes. This means that alongside the boundary wall a recess is designed as well as a number of longitudinal recesses. All these recesses mean that the installation work does not have to be done outside. The fitter can go to work when the roof of the house is on and the house is fully glazed. The building process becomes less dependent on weather which is good for the increase of efficiency.

7.2. What is in it for the contractor?



A good preparation and working with prefabricated products offers a building process which is easier to control. The building process is clearly less weather dependent. And the quality of the prefabricated Pipe floor elements is OK, because they were made under good conditions in the factory. For every floor plan the Pipe floor elements are made according to the specifications of the apartment.

8. Conclusion

The success is that in The Netherlands already 10 to 15% of all new houses or apartments are made with Pipe floors and the number is still growing. In Finland and Norway the possibilities with Pipe floors are further developed. The Pipe floor is a breakthrough in the Dutch market.