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Floor bearing capacity: 2x3=3x2

In high school, the formula mentioned in the title is referred to as the Commutative property of multiplication. This formula is described as one of the important principles of arithmetic. By using this apparently simple looking formula, one of our customers achieved significant cost savings. The usual pallet racking with three pallets next to each other is replaced by more expensive racks (due to more uprights), with a section width of only two pallets. This plan resulted in enormous savings because the floor did not require any additional reinforcement.

Floor Bearing Capacity

In this business case, the customer would like a compact storage area on the ground floor in an existing building. The storage should be in pallet racks with aisles of approximately three meters for material handling trucks. The pallets are heavy and the entire building has a light structure. There are doubts about the bearing capacity of the floor.

After examination with drill cores, the floor appears indeed to be very lightly constructed and only has a light steel fiber reinforcement. In contrast, the floor has been constructed on a good sand layer.

An initial global calculation indicates that the forces from the pallet racks exceed the bearing capacity of the floor. There are three different scenarios that could solve this problem:

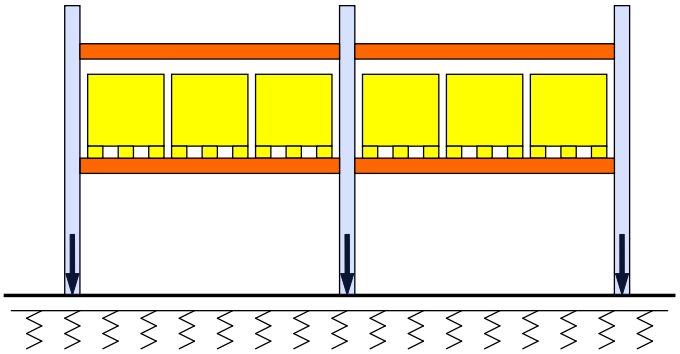
1. install heavy beams between floor and racking
2. overlaying of the floor
3. construct a new floor

Each scenario involves high investment and requires long implementation time.

Calculation of floors

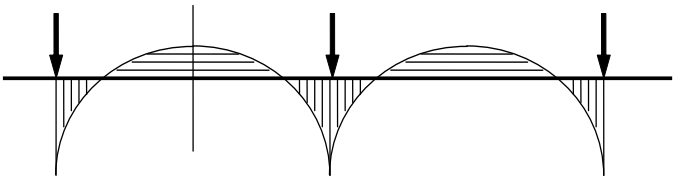
The floors in a warehouse are primarily loaded with forklift trucks and pallet racking. The pallets generate point loads on the floor via the beams, frames and the uprights. In the construction and logistics world, all too often statements are made like: "this floor has a bearing capacity of two tons per square meter". This statement has no meaning at all especially when the floor is directly on the ground. In the calculation of these types of floors the size and distance of the point loads is the important factor, not the equal loading. The calculation of a floor directly on the ground can be seen as a thin sheet on a mattress.

If it is a solid mattress ("good sand layer or compacted gravel"), you can equally spread a lot of weight on the sheet; overall there is an equal compression of the mattress. With high point loads however, the sheet ("the concrete floor) can bend dramatically and the mattress will be unequally loaded. See the attached drawing for the explanation of the forces on such a floor.



Plan Racking

Plan Floor and Subsoil



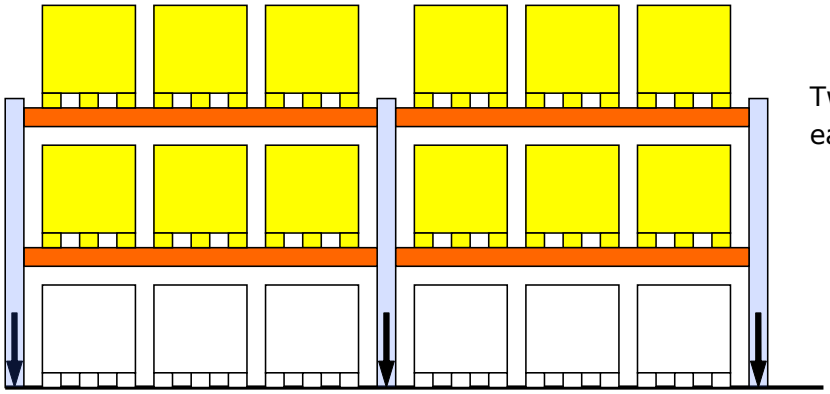
Plan forces

New racking configuration

In this business case, the customer would like to have four levels of pallets; one on the ground and three in the pallet racking. The conclusion after calculation was that this configuration would exceed the bearing capacity of the existing floor. The point loads with traditional racking with three levels and three pallets next to each other are:

Three levels * Three pallets * 4,0 kN (=400kg) = 36 kN, per frame. This is more than 25 kN per frame which is allowable on this floor.

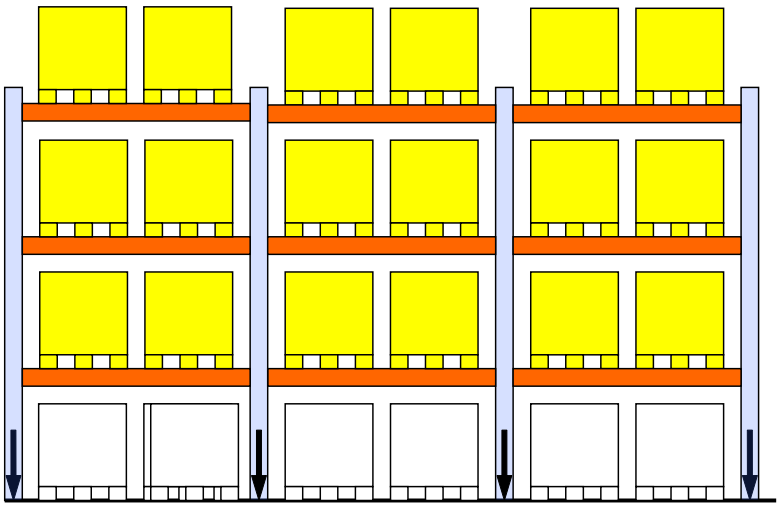
This client specification for the storage would generate much too high of stress on the existing floor. Therefore, only a racking system with two levels and three pallets per beam could be placed on this floor.



Two levels of each 3 pallets

Two levels * three pallets * 4,0 kN(=400kg) = 24 kN per rack frame. That is 12 kN per upright.

However, if you apply racking with a width of 2 pallets per beam, the point load per upright is as equally large as in the above mentioned configuration:



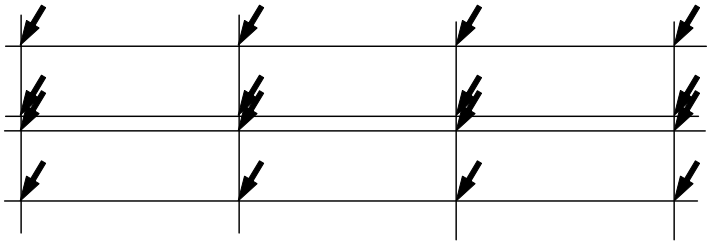
Three levels of two pallets

Three layers * two pallets * 4,0 kN(=400kg) = 24 kN per rack frame. That is 12 kN per upright.

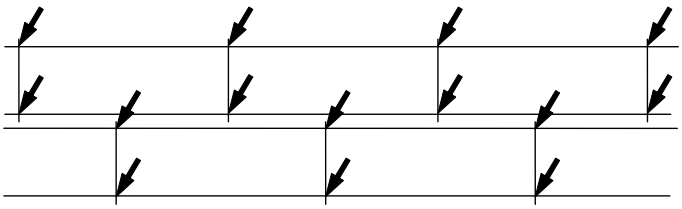
In other words, because of the weak floor in the current warehouse, a traditional racking configuration with only two layers of pallets would be allowed. By choosing a different configuration setting, three layers can be stacked. And thus 50% more storage locations could be realized.

One step further

In this particular business case we went one step further. In a normal racking configuration, the forces in the floor are concentrated where two uprights are positioned back to back. The total floor bearing capacity could increase enormously by shifting the racking a half-width, which means that in the middle the point loads do not come together.



Floor plan of two racks back to back, standard configuration



Floor plan of two racks back to back, shift half-width compartment

All in all, this plan appears to be a "nail bed" approach of the floor: many small, well-distributed point loads create a system that meets the bearing capacity of the existing floor.

More information

If you have questions or if you would like to offer your feedback to this article, you can contact Mari van Kuijk via vankuijk@groenewout.com or +31 76 533 0440.