POSSIBILITIES TO INCREASE THE WAREHOUSE CAPACITY: CASE STUDY

Daniela MARASOVÁ, Janka ŠADEROVÁ

Technical University of Košice, Faculty of BERG, Košice, Slovak Republic, EU
daniela.marasova@tuke.sk, janka.saderova@tuke.sk

Abstract

Storage of goods is one of the most important subsystems of the logistics system in a company. The paper deals with the problem of increasing warehouse static capacity of a selected warehouse. In the paper, the three variants of increase will proposed: Installation of a new rack (3.5 % capacity increase), Installation of transitional rack fields (9 % capacity increase) and Change of the support system for storage on beams (11 % capacity increase).

Keywords: Warehouse, capacity, rack field, support system

1. INTRODUCTION

Storage of goods is one of the most important subsystems of the logistics system in a company. It covers the storage of goods of various types and properties for various periods of time. A warehouse is a place where multiple activities are carried out, depending on the warehouse function and position within the logistics system of a company or in its supply system. Several authors have presented the characteristics of storage and storage systems in their publications, or they deal with issues regarding solutions of specific problems related to the storage of goods. The technical literature deals with issues concerning the warehouse design [1, 2], warehouse and rack systems [3], warehouse space [4], warehouse layout [5, 6, 7], costs, performance [8], etc. An important parameter of a warehouse is the Warehouse Capacity. The Warehouse Capacity depends on several parameters, primarily on the properties of goods (products), the storage unit size, the type of the storage facility and the handling (manipulation) technology, the storage method, and the warehouse layout. The Warehouse Capacity is a parameter that may be expressed in various forms [9]. We distinguish between the warehouse static capacity and the warehouse dynamic capacity. The Warehouse Static Capacity relates to the number of storage places for goods at a standstill that are available for removal and subsequent shipment. The main purpose of the present article is to propose the method of increasing the current static capacity of a selected warehouse. The proposal is conditioned by preserving the existing storage system (the rack system and the handling technology).

2. METHODOLOGY

The Warehouse Static Capacity (WSC) represents the number of storage units that may be stored in a warehouse at the same time. For the existing warehouses, such capacity is calculated on the basis of the rack system parameters, using a simple formula (1):

$$SWC = \sum_{i=1}^{m} \left(R_i \cdot N_{RF_i} \cdot N_{L_i} \cdot N_{URC_i} \right) \quad (1)$$

where:

m is the number of rack types (depending on the number of rack fields),
R_i is the number of racks at the given number of rack fields,
N_{RF_i} is the number of rack fields, in pieces,
N_{L_i} is the number of levels in the rack field, the number of rack cells, in pieces,
N_{URC_i} is the number of storage units (places) in the rack cell, in pieces.

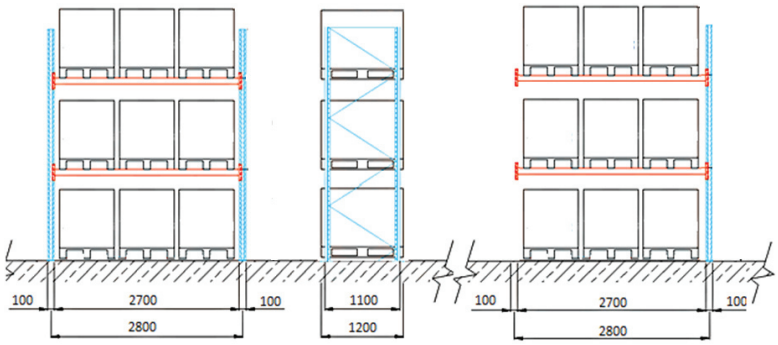
The R_i parameter indicates the number of racks in the warehouse. The racks consist of rack fields N_{RF_i} that may comprise several levels. Each level corresponds to a single rack cell. In the rack cell, storage units N_{URC_i} are placed. Their number (storage places) depends on the dimensions of a storage unit and on their number. **Figure 1** presents an example of a rack field consisting of 3 levels, and in each rack cell there are 3 storage units, including the parameters of the main rack field and the additional rack field.

Another important parameter is also the area of the rack assembly (rack system) A_R that is calculated using the formula (2) [5].

$$A_R = \sum_{i=1}^{m}[R_i \cdot (A_F + n \cdot A_A)] \quad (2)$$

where:

A_F is the area of the basic rack field in m^2,
A_A is the area of the additional rack field in m^2,
n is the number of additional rack fields,
R_i is the number of racks at the given number of rack fields,
m is the number of rack types (depending on the number of rack fields).



a) Basic rack field b) Additional rack field

Figure 1 Rack field scheme

In order to achieve the objective defined in the introductory part (increasing the current static capacity), the first step is to calculate the WSC parameter using the formula (1), on the basis of the analysis of the current situation - the analysis of the parameters of storage units and the analysis of the parameters of the installed rack system: the rack cell size (number of storage units in one rack cell), number of levels in a rack field, number of rack fields, and arrangement of racks in the warehouse premises.

The second step is to determine the conditions under which it is necessary to propose increasing the capacity. The third step is to propose several possibilities how to increase the existing capacity and produce the underlying calculations. The last step is to make a decision, while considering the selected parameters (for example, investment costs, execution time, etc.), on which of the provided possibilities is acceptable in the given conditions. Such decision should be made applying the multi-criteria evaluation.

3. RESULTS

Increasing the Warehouse Static Capacity, hereinafter referred to as Capacity, was carried out in the warehouse of the Registry Centre that is used as an archive of documents pursuant to the registry code (long-term document storage). The warehouse dimensions are 14 x 41 m, its area is 574 m^2, and the Centre also comprises other premises that are necessary for the warehouse operations. Following activities are carried out in the Centre:

- acceptance of material (archive boxes from suppliers, documents to be archived),

- sorting and making entries in the information system,
- packing the documents in the archive boxes,
- placing the full archive boxes in the racks,
- picking documents upon a customer's request and shredding documents with expired storage period.

3.1. Determination of the current Static Warehouse Capacity

The warehouse is used for the storage of archive boxes. One archive box represents a single storage unit. The archive box dimensions are 300 mm × 360 mm × 300 mm. The boxes are used for the storage of documents of the A4 size. The weight of a full archive box ranges from 5 to 15 kg.

Wooden pallets that are used in the warehouse custom-made and their dimensions are as follows 900 mm × 1,100 mm × 144 mm. The pallets are placed on the floor and on the rack beams.

In the storage area, there is a rack system with the racks arranged in one row and two rows. The warehouse contains 7 racks - 6 racks consist of 12 rack fields and a 1 rack consists of 13 fields. The rack field comprises 6 levels, i.e., 6 rack cells. The rack cell is 2,700 mm long and 1,080 mm high. The rack depth is 1,100 mm and its loading capacity is 1,500 kg. The parameters of the main and additional rack fields are the same as presented in **Figure 1**. In a single rack cell, there are 3 pallets that function as a supporting system for placement on beams. These pallets are used to place the archive boxes on, as shown in **Figure 2**. A single rack cell contains 72 archive boxes.

Figure 2 Boxes in a rack cell

The current capacity of the rack system, calculated using the formula (1), is **36,720 pieces of archive boxes**. The area of the racks system, calculated using the formula (2), is 286.44 m^2, representing 49.9 % of the total warehouse area. A simple diagram of the rack arrangement (green colour) in the warehouse is shown in **Figure 3**.

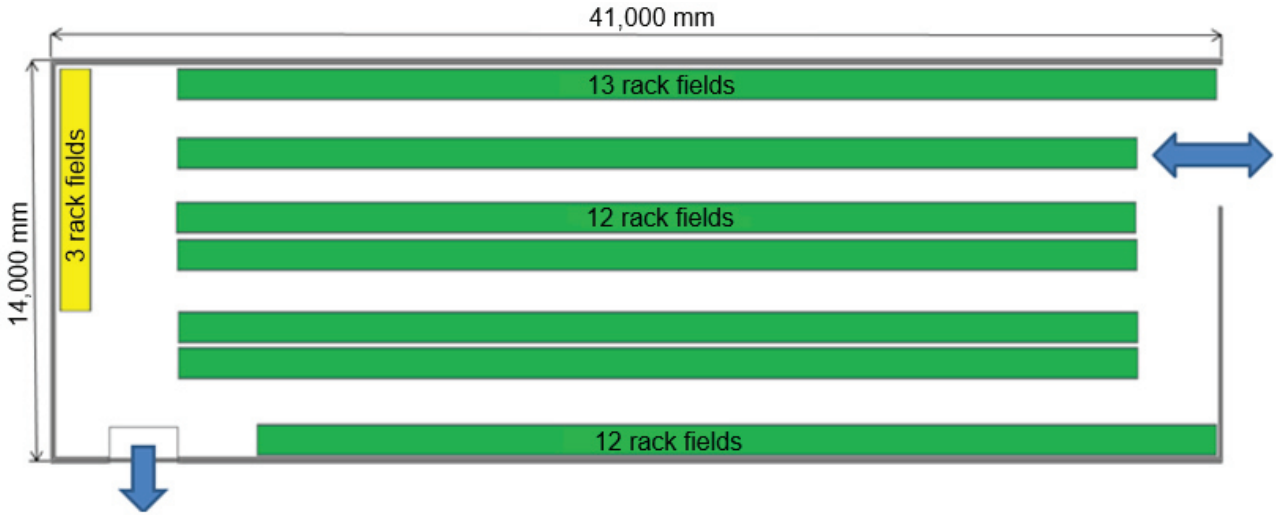


Figure 3 Rack arrangement - the original arrangement and a newly proposed rack (yellow colour)

To a determined date, 35,571 archive boxes were stored in the warehouse and the current capacity facilitates the storage of additional 1,149 archive boxes. The racks system is currently used in 97 %. On the basis of the statistical data, 368 new archive boxes, on average, are stored in the warehouse per month. The documents with a pending expiry of their storage period are removed from the warehouse and relocated for shredding; this creates vacant capacities. However, when comparing the boxes to be shredded and the boxes to be stored, the amount of boxes to be stored is several-fold higher. On the basis of the observed facts we may state that the warehouse does not have a sufficient capacity that is required for the upcoming period. On the other hand, the warehouse comprises the areas and premises where more rack fields may be installed.

3.2. Proposed possibilities of increasing the current capacity in the determined conditions

The proposed measures must be feasible while maintaining the existing arrangement of racks and using the existing handling technology, with acceptable investment costs. In order to increase the capacity, three options were proposed:

A. installation of a new rack with the same rack field parameters as in the existing rack system,

B. installation of transitional rack fields,

C. change of the support system for storage on beams.

A: Installation of a new rack

Figure 2 shows the existing arrangement of 7 racks, highlighted in green. In the rear section of the warehouse, there is a vacant area that may be used for the installation of a rack with the same rack field parameters as in the existing rack system. The position of the rack is highlighted in yellow in **Figure 2**. The rack length is affected by the space near the back gate that should be available for the preparation and release of documents to be shredded. The proposed rack consists of 3 rack fields. The rack capacity is 1,296 archive boxes, representing a 3.5 % capacity increase; this corresponds to the average capacity required for the period of 3.5 months. The above specified proposal does not provide a long-term solution of the capacity problem. In this particular case, the area of the rack system would represent 296.4 m^2 that is 51.68 %.

B: Installation of transitional rack fields

This option represents the installation of transitional rack fields, highlighted in light yellow in **Figure 4**. The rack fields would be installed in the front and rear sections, at level 4 and higher, in order to preserve the space for handling using the existing handling technology; this means that the transient rack field would comprise 3 levels. The parameters of the rack cell in the transitional rack field in the front and rear sections of the warehouse are listed in **Table 1**. In both cases, it is necessary to manufacture custom-made pallets that would fit the rack field. In the rear section, 6 rack fields would be installed, representing the capacity of 2,268 archive boxes. In the front section, 4 rack fields would be installed, representing the capacity of 972 archive boxes. The above described option of installing transitional fields would result in increasing the capacity in 3,240 archive boxes, representing an 8.8 % capacity increase, which would cover the capacity requirement for 9 months. The area of the racks system would remain unchanged as the additional fields are not located on the warehouse floor. However, this would increase the storage volume in the volume of transitional fields.

C: Change of the support system for storage on beams

Another solution is replacing the currently used pallets with the base of a different type to be placed under the archive boxes. A suitable type is, for example, a steel wire mesh shown in **Figure 5**; the mesh dimensions are as follows 880 mm × 1,100 mm × 10 mm, and the loading capacity of 800 kg. The mesh height is only 10 mm while the height of a pallet is 144 mm. Replacing pellets with steel wire meshes would save 134 mm at each level; with six levels, this would save 804 mm. Replacing pellets with wire meshes will result in the reduction of the rack cell height from 1,080 mm to 950 mm. Adjustment of rack cells to the required height will facilitate

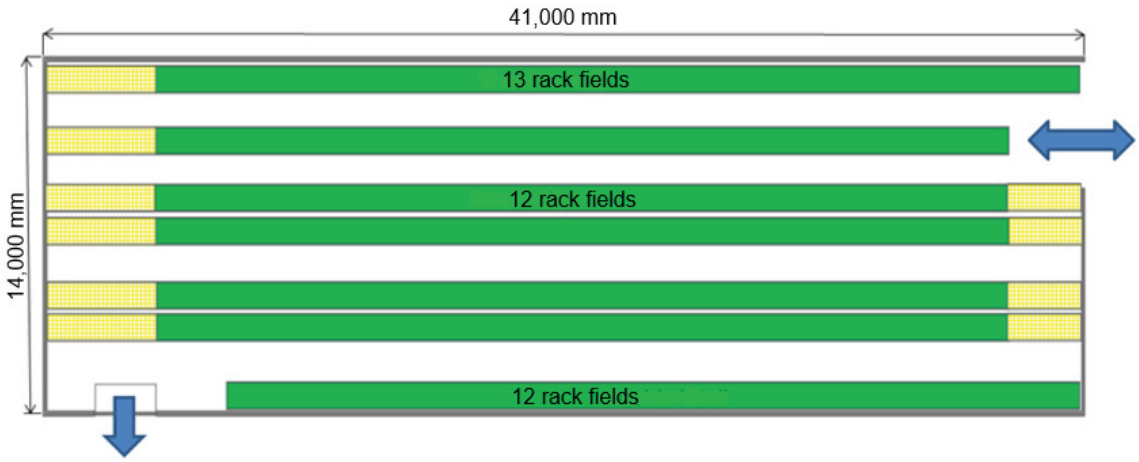


Figure 4 Proposed transitional rack fields

Table 1 Parameters of the rack cells in the transitional rack field

Rack cell parameters	Rear section of the warehouse	Front section of the warehouse
Beam length (mm)	4,200	2,900
Height (mm)	1,080	1,080
Depth (mm)	1,100	1,100
Assumed loading capacity of a cell* (kg)	2,000	1,500
Number of parallel rows of archive boxes	14	9
Number of archive boxes in a single rack cell	126	81
Number of archive boxes in the transitional rack field (3 levels)	378	243
Number of installed rack fields	6	4
Number of archive boxes in the rack fields	2,268	972

** depending on the weight of the custom-made pallets*

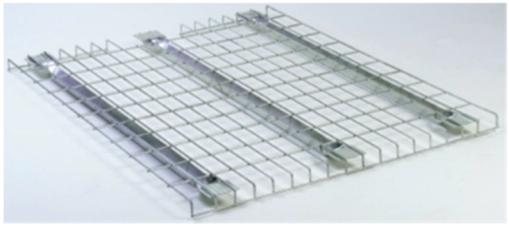


Figure 5 Steel wire mesh

additional installation of level 7 in the rack field. The boxes would only be placed on the new 7th level in two layers that is 48 archive boxes (the height limit). The adjusted rack field would facilitate the storage of 480 archive boxes (originally 432 boxes). In this particular case, an increase in the capacity represents 4,080 archive boxes, an 11 % increase, covering the capacity requirement for approximately 1 year.

4. DISCUSSION

We will only reach an 11 % increase by replacing pellets with steel wire meshes. However, this solution requires the relocation of all archive boxes which is time consuming and physically demanding. Disadvantages of the above mentioned solution include production of waste - pellets, financial costs of the purchase of wire meshes (1,785 pc), financial costs of the storage system adjustment, and the time required for such adjustment.

The capacity may be increased in 9 % by installing transitional racks. This would require financial costs of the purchase of a new storage system with the necessary parameters. The installation of the storage system is not time consuming or physically demanding, as it is in the previous case.

A 3.5 % capacity increase may be achieved by installing a rack in the rear section of the warehouse. In such case, again, it is necessary to invest in the purchase and installation of a new system. On the basis of the above listed facts we may state that none of the presented options solves the problem with the capacity in the long term. It is therefore necessary to consider an option of establishing a new warehouse.

5. CONCLUSION

The present article deals with the issues regarding increasing the static warehouse capacity. The analysis of the existing storage method and of the description of storage units and the rack system facilitated the calculation of the static capacity - the number of archive boxes (in pieces) that may be stored in the installed racks. On the basis of the obtained results, three options were proposed. They were aimed at increasing such capacity while meeting the limiting requirements.

On the basis of the results obtained from the proposed solutions we may state that the company in question should consider establishing a new warehouse. This solution is associated with the issues regarding the warehouse allocation and procurement of a storage system to be used in the warehouse because the one that is currently used in the existing warehouse is not particularly appropriate.

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