WAREHOUSE LOADING FRONT SHAPING IN TERMS OF VARIOUS TECHNOLOGICAL SOLUTIONS OF THE EXTERNAL TRANSPORT

PYZA Dariusz[1], JACHIMOWSKI Roland, JACYNA-GOŁDA Ilona, IZDEBSKI Mariusz

Warsaw University of Technology, Faculty of Transport, Warsaw, Poland, EU
dpz@wt.pw.edu.pl

Abstract

The choice of the proper loading area technology influences the warehouse process efficiency. That is why the efficient loading / unloading needs the optimal parameters of this area. Thus, the choice of the front load technological solution is one of the important stages of the cargo flow in the warehouse. It has a decisive influence on the quality of work carried out in the warehouse and the costs associated with the use of a particular type of technological solution of the loading / unloading area. The article presents the problem of the warehouse front load shaping. Authors examine 2 variants of technological solutions of the cargo front load. For the variant selection, the expenditures for the front load implementation were calculated.

Keywords: Warehouse, front load, SIMMAG3D

1. INTRODUCTION

The warehouse is one of the basic elements of the logistics infrastructure. In the logistics system, warehouse acts as a node where the goods are temporarily stored. The purpose of the warehouse is to ensure rapid and smooth flow of inventory, as well as the protection and maintenance of their value in use. More over the warehouse task is also to ensure prompt and comprehensive flow of information [1, 2].

The basic function of warehouses, which are the main nodes in the logistics chain, is to receive, storage and then transfer materials another nodes of a supply chain. Each warehouse has to be characterized by the optimal size and capacity. Capacity depends on the level of the warehouse mechanization, loading tasks, handling, storage and shipment. Providing adequate capacity is always associated with ensuring the optimum flow of goods through the warehouse [3].

Storage process is a set of activities performed during the flow of goods through the warehouse, from the unloading of external transport, by receiving, storage, completing, shipping and loading on the external transport. Carrying out the storage process provide technical and organizational conditions, which are: storage space, adequate facilities and qualified personnel [1, 4]. In the warehouse all the operations are carried out in separate areas, which are:

- Receiving area - external transport unloading, control, acceptance,
- Storage area - goods storage,
- Order picking area,
- Shipping area - shipping, control and external vehicles loading.

The speed of the warehouse process is influenced by the loading and unloading of external transport vehicles [5]. The loading front is one of the most important elements of the warehouse infrastructure. This is an area (loading docks or loading ramp) intended to carry the load work such as: loading, unloading, reloading [6]. Imprecise estimation of the size of loading front can lead to the reduction of system performance caused by too small loading front surface. On the other hand, the too large surface of the loading front will involve additional costs associated with the necessity of the fixed element maintenance.

2. TECHNOLOGICAL SOLUTION FOR WAREHOUSE LOADING FRONT

Technological solution of the loading front depends on the type of means of transport and handling, as well as the technology of loading work. The choice of technological solution of the loading front has a big influence on the storage process. In order to efficiently load or unload the cargo it is also necessary to determine the parameters of the loading front.

There are two alternative technological solutions of the loading front, which are the loading docks and the loading ramp. In the non-ramp warehouse, the warehouse floor level is at the level of loading platforms of external transport means. Docking system is fitted with mechanical or automatic gate suitable both for loading and unloading cargo units from the external means of transport. Standard loading dock consists of: gates; loading bridge and seals that protect the inner space of the dock and loading units against external influences. The number of loading docks specifies the number of the external transport means which can be operated simultaneously.

The ramp is a part of the construction of a warehouse building, which is an extension of the floor outside the building wall with a higher floor level. The height of the ramp should be equal to external transport means' floor. More over ramps should have a smooth surface, indelible and adapted to the working pressure of handling equipment [3]. Examples of solutions of loading fronts are shown in **Figure 1**

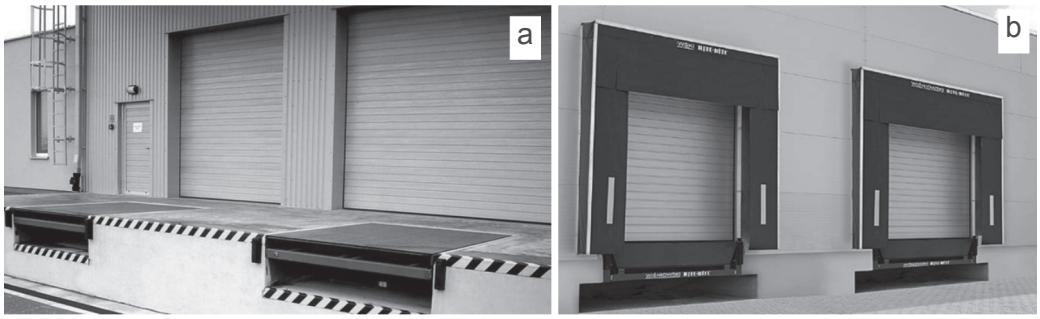

Figure 1 Loading fronts examples a) ramp, b) dock

Modern ramp as well as the docks are also equipped with loading bridges. The main task of loading bridge is to bridge the difference in height between the warehouse floor surface with the floor of an external transport vehicle. In warehouses serving vehicles of a fairly uniform machine park, where the height difference between warehouse floor storage / ramp and the floor of the vehicle is very small can, mechanical (manual) loading bridges can be successfully applied. On the other hand, in warehouses serving vehicles of varying floor heights, it is necessary to use hydraulic bridges. Examples of loading bridge solutions are shown in **Figure 2**.

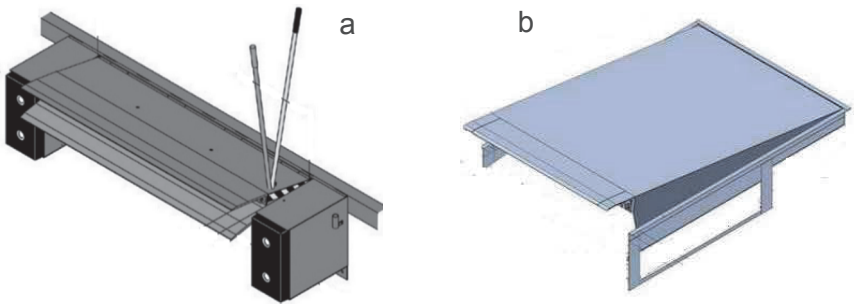

Figure 2 Loading bridges examples a) manual, b) hydraulic

The use of loading docks is dictated by preventing heat loss inside the building as well as the securing of loads and the inner transportation against adverse weather conditions. In addition, depending on the organization of warehouse operation, individual loading docks can assign maintenance tasks to only certain types of vehicles or certain transport relations. Dependent on the dock, it is possible to use a dock as a "night delivery chambers", where it is possible to unload the consignment just by a vehicle driver without any participation of the warehouse personnel after warehouse regular working hours [7].

The loading ramp in opposite to loading docks does not protect the load and the inner transportation from atmospheric conditions (particularly temperature for covered ramps). However, given the dimensions of the cargo docks and the recommended distance between them, it is clear that the loading ramp is capable of handling a larger number of vehicles at the same time on the same length of the magazine. Thus, to use the same amount of vehicle ramp will occupy less space, more versatile than the docks and also ensure a better use of space. Furthermore, in the case of the ramp it is also possible to unload the side of the vehicle [8].

3. CASE STUDY

In order to show the advantages of a given solution for the loading front, the expenditures connected with the setup of a loading ramp as well as the setup of the loading docks were calculated. The analyzed case is shown in **Figure 3**.

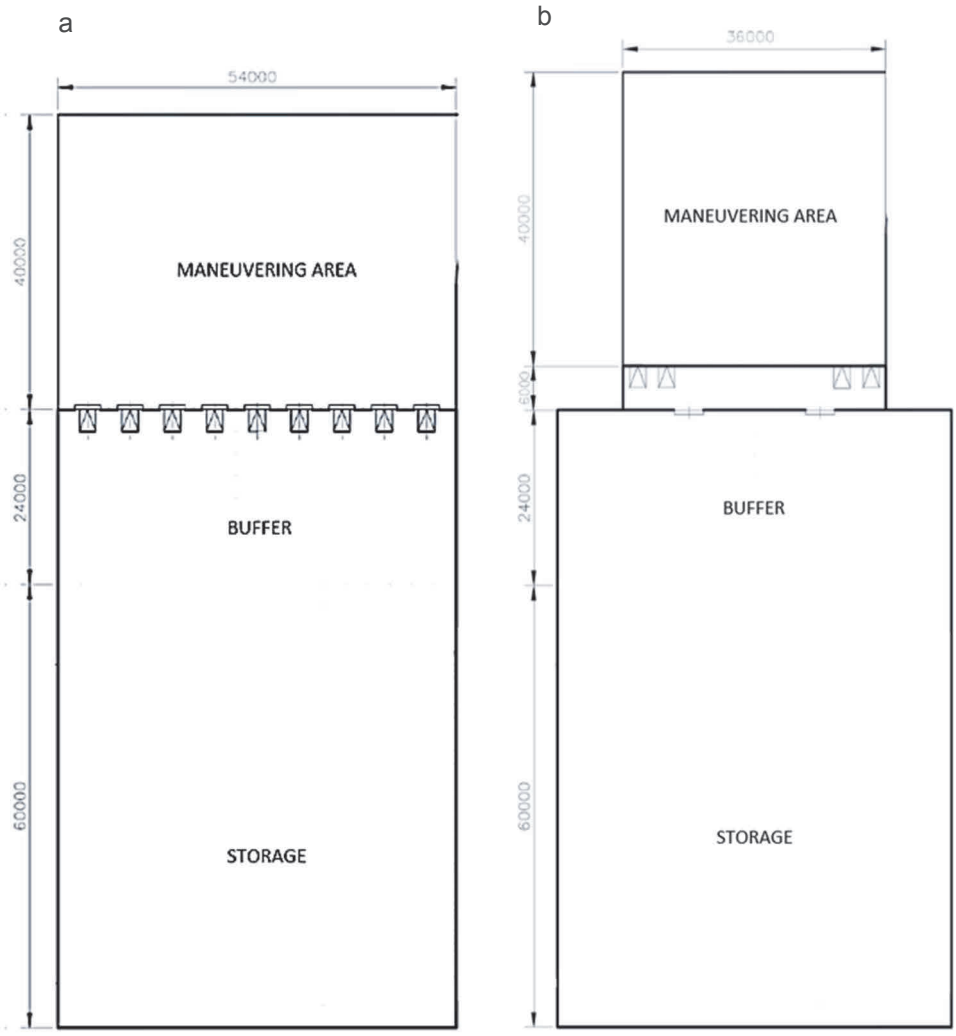

Figure 3 Loading front variants a) loading docks, b) loading ramp

The expenditures D_C connected with the use of a variant with the loading docks were obtained through the equation 1 [7]:

$$D_C = \left(B_W \cdot W_H \cdot W_W \cdot C_W\right) + d\left(C_G + C_{LB}\right) + \left(MA_W \cdot D_L \cdot C_{MA}\right) \quad (1)$$

Moreover, the expenditures R_C connected with the use of a variant with the loading ramp were obtained through the equation 2 [6]:

$$R_C = \left(B_W \cdot W_H \cdot W_W \cdot C_W\right) + \left(R_W \cdot R_L \cdot C_R\right) + \left(b \cdot C_G\right) + \left(LB_N \cdot C_{LB}\right) + \left(MA_W \cdot R_L \cdot C_{MA}\right) \quad (2)$$

The data necessary for the calculations are presented in **Table 1**.

The ramp length was calculated based on the number of operation places. In the article it is assumed that there is 9 operation places, and the single operation place width is 4 m.

On the basis of equation 1 and parameters for the **Table 1**, the expenditures D_C connected with the use of the loading docks are:

D_C= 2613600 PLN

On the basis of equation 2 and parameters for the **Table 1**, the expenditures R_C connected with the use of the loading ramp are:

R_C= 2386400 PLN

Table 1 Calculation data

Parameter	Value
B_W - buffer zone width, [m]	24
W_H - warehouse height, [m]	10
W_W - warehouse width, [m]	54
C_W - expenditures for the 1 m^3 of the warehouse [PLN / m^3]	160
d - loading dock number	9
R_W - loading ramp width, [m]	6
R_L - length of the loading front for the ramp, [m]	36
C_R - expenditures for the 1 m^2 of the loading ramp area [PLN / m^2]	300
D_L - length of the loading front for the docks, [m]	54
b - number of loading ramp gate	2
C_G - expenditures for a single gate, [PLN]	20000
LB_N - number of the loading bridges for the ramp	4
C_{LB} - expenditures for a single loading bridge [PLN]	16000
MA_W - maneuvering area width, [m];	40
C_{MA} - expenditures for the 1 m^2 of the maneuvering area, [PLN / m^2]	100

4. CONCLUSION

Analyzing the calculations presented in the case study it is worth to notice that the choice of a solution of a loading front resolve the costs of its implementation. In the calculation example, the expenditures connected with the loading ramp implementation are 9.5% lower than the expenditures connected with the loading docks.

Both solutions have advantages and disadvantages specified in chapter 2. Taking into account the warehouse process time, the loading front is one of the most important elements of the warehouse.

ACKNOWLEDGEMENTS

The scientific work carried out in the frame of PBS 3 project* "System for modeling and 3D visualization of storage facilities" (SIMMAG3D) *financed by the National Center for Research and Development.

REFERENCES

[1] DUDZIŃSKI Z., KIZYŃ M.: Poradnik magazyniera; Polskie Wydawnictwo Ekonomiczne, Warszawa 2000.

[2] JACYNA M., LEWCZUK K., KŁODAWSKI M. Technical and organizational conditions of designing warehouses with different functional structures. Journal of KONES, Institute of Aviation, Vol. 22, No. 3, 2015, pp. 49-59.

[3] DUDZIŃSKI Z., KIZYŃ M.: Vadamecum Gospodarki Magazynowej; Ośrodek Doradztwa i Doskonalenia Kadr Sp. z o.o., Gdańsk 2002.

[4] ŻAK J., JACHIMOWSKI R., GOŁĘBIOWSKI P. Modelling of storage facilities using databases. In: Proceedings of 20th International Scientific Conference Transport Means. Kaunas, Lithuania: Publishing House “Technologija”, 2016, pp. 772 - 777.

[5] LEWCZUK K. The concept of genetic programming in organizing internal transport processes. Archives of Transport, Vol. 34, Iss. 2, 2015, pp. 61-74.

[6] BASIEWICZ T., GOŁASZEWSKI A., RUDZIŃSKI L.: Infrastruktura transportu; Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 1998.

[7] RATKIEWICZ A., PYZA D.: Wybrane aspekty wyboru rozwiązania technologicznego frontu ładunkowego w magazynie dystrybucyjnym. Prace Naukowe Politechniki Radomskiej, seria TRANSPORT nr 1(21)/ 2005

[8] RATKIEWICZ A., Projektowanie podsystemu przeładunkowego w obiekcie logistycznym.