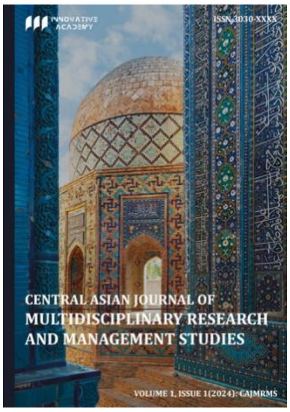
CENTRAL ASIAN JOURNAL OF MULTIDISCIPLINARY RESEARCH AND MANAGEMENT STUDIES
www.in-academy.uz



FREIGHT VILLAGES: MODERN WAREHOUSE DESIGN AND RAIL LINK ASPECTS

Nazirov Nozimjon Nodirjon ugli

nozimjon.naziov.99@mail.ru

Masters degree student of Tashkent State Transport University

Tashmurodov Umidjon Baydulla ugli

umidbaydullaev00@gmail.com

Masters degree student of Tashkent State Transport University

https://doi.org/10.5281/zenodo.13928721

ARTICLE INFO

Received: 7th October 2024
Accepted: 9th October 2024
Published:14th October 2024

KEYWORDS

freight villages, warehouse design, scientific papers, logistics, global methodological design framework.

ABSTRACT

Freight villages reflect a modern way of organizing logistics, transport and goods distribution activities. Warehouses are a basic element in such building complexes and their efficient planning and operation is essential for the viability of the system. Warehouse design requires a mixture of analytical skills and creativity. Although effort has been dedicated to define a global methodological design framework, the overwhelming majority of scientific papers on the subject address well-defined isolated problems. On the other hand, a practitioner may notice that a great number of warehouses offering efficient, cost-effective services are in operation nowadays and that a number of warehouse design manuals, tackling actual design and operation aspects exist.

INTRODUCTION

The term "freight village" generally denotes those sites specially organized for carrying out logistics activities. Various terms are used for such facilities, namely logistics centers, centres logistiques de fret (France), Logistics park, Interporto (Italy) etc. A freight village is the hub of a specific area where all the activities relating to transport, logistics and goods distribution - both for national and international transit - are carried out, on a commercial basis, by various operators. The operators may be either owners or tenants of the buildings or facilities (warehouses, distribution centers, storage areas, offices, truck services, etc.) built there. In addition, bank, postal, insurance services and in certain cases Customs infrastructures may also be accommodated (1). Freight villages evolve alliances among the entities responsible for the transport, storage and distribution services, which can generate significant reduction in the number of trucks vehicle-kilometers. In addition, a freight village located in the vicinity of a large city may provide an efficient solution to urban freight transport problems including traffic congestion, regional competitiveness, and quality of life (2).

The first freight villages were created in France, notably Garonor and Sogaris in the wider Paris region. They responded to urban policy criteria. In the late 1960's and 70's, freight villages appeared also in Italy and Germany, this time following the concept of extended inland rail/road intermodal terminals. In the 1980s and 1990s, the number of freight villages multiplied in France, Germany, Italy, Netherlands, Belgium and the United Kingdom (3).

Freight villages have been developed and operate in the United States (the term "Inland Ports" stands for Freight Villages) in Alliance Texas, a green field rail-air-highway multi-modal facility, in the Port of Huntsville (formed by the Huntsville International Airport, the International Intermodal Center, and the Jetplex Industrial Park), the Global TransPark in North Carolina etc while many sites (in Texas, Ohio, Missouri, California, Alabama, Michigan, New York/New Jersey, Virginia) have been studied as potential inland ports(4).

The freight village concept is still evolving in Europe and is continuing to emerge in the United States (5).

2. LITERATURE REVIEW ON FACILITY AND WAREHOUSE DESIGN

The high costs associated with land acquisition and freight village constructions as well as with the operations of storage and distribution systems, impose the systematic investigation of all related aspects that include site location selection, site-level layout planning and warehouse design aspects.

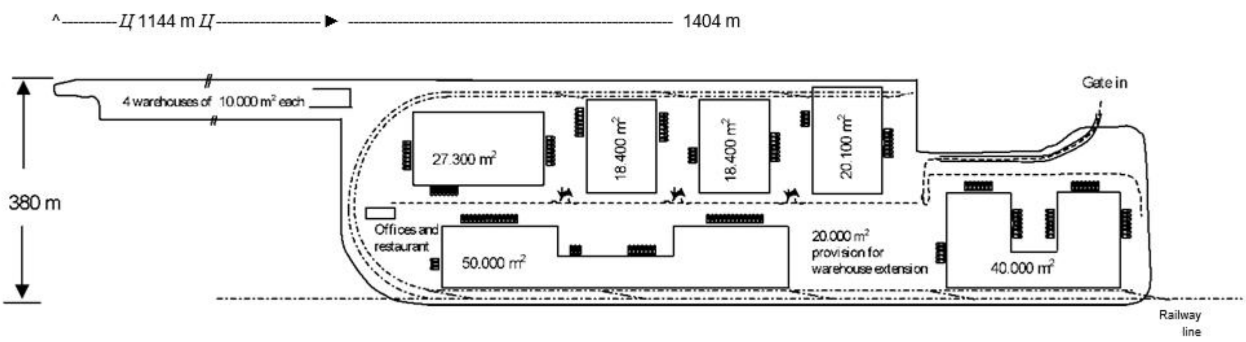
Decision making for freight village location should take into account the current market status and trends. The identification of the appropriate location is a difficult task, as uncertain future conditions should be taken into account. From the scientific point of view, the freight village location issues can be talked within the framework of the facility location problem. Most of the research dedicated to these issues concerns simplified static and deterministic models, although a number of researchers have developed solutions where stochastic and dynamic aspects were considered (6). The single facility location problem concerns the identification of the optimal location of a single facility, subject to a given number of existing supply/demand locations The many facilities location problem focuses on the identification of the required number and spatial distribution of many facilities in order to satisfy certain objectives' namely, cost objectives (or some surrogate for it, such as minimization of travel distance), or demand-oriented objectives (proximity, accessibility), profit objectives (maximize the return on investment, maximize market share etc), or even environmental objectives (minimize degradation of air quality, minimize population at risk etc) (11).

Typical warehouse size and type

Warehousing constitutes a significant component of many so-called supply chains. These systems are global, and must be adaptive, due to the ever changing customer preferences [29]. From this point of view, there are many ways to classify warehouses: According to the proper environment for storing goods and materials, warehouses can be classified as heated/unheated general warehouses, refrigerated warehouses, controlled humidity warehouses or special- designed warehouses (e.g for liquid, hazardous chemical, ammunition storage)[J0]. According to their role in the production/distribution chain we may distinguish the production warehouses, storing raw materials, work-in-process and finished products associated with a manufacturing and/or assembly process and the distribution warehouses, storing finished products and fulfilling external customer order-picking orders [31]. According to the degree of automation, warehouses can be classified as mechanized (conventional) or automated [32].

Most probably, the majority of the Thriasio warehouses will belong to general, distribution, mechanized classes, while a number of refrigerated warehouses is expected as well. Nevertheless, the sizing of these warehouses is not an easy task as no relevant rules of thumb exist: Verona freight village promotes small (2.000 to 8.000 m^2) warehouses as advantageous while on the other side, in the under development freight villages of Moissy-Cramayer in the Paris region, no warehouse is smaller than 20.000 m^2.

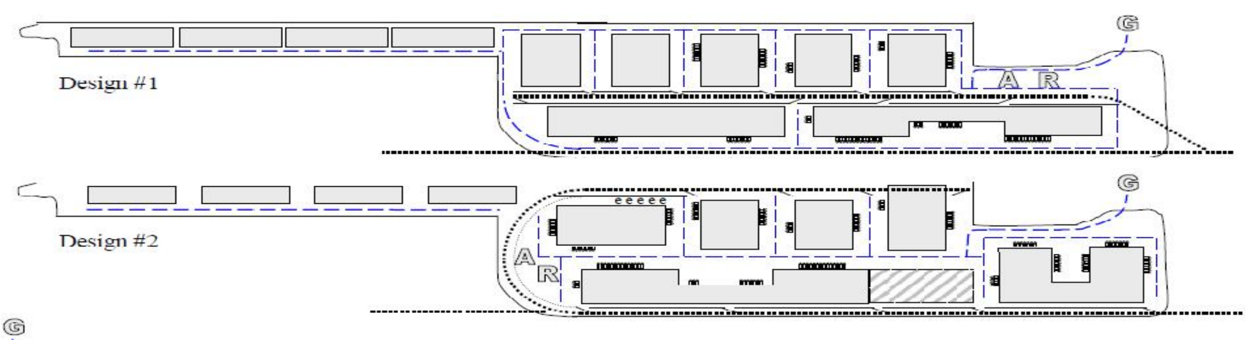
In order to identify the appropriate typical warehouse size for Thriasio/Athens, a combination of mathematical calculations with expert views, extracted from interview-based surveys with potential building owners and operators, was used. The scope of these
surveys was to identify the willingness of freight forwarders/transporters to shift their activities to



Thriasio area, the desirable warehouse size and commodity profiles, the potentiality of rail transport usage etc.

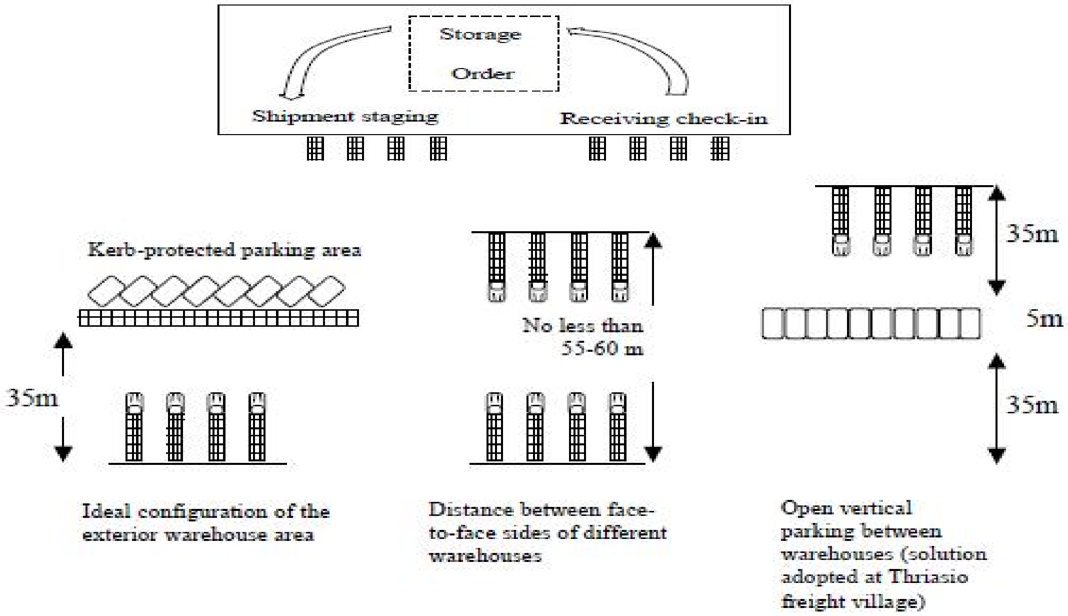
Internal road, parking areas and remaining installations

Having defined the critical elements of the design, the rest elements were harmonically " assembled" as follows: A 35 m zone in front of each warehouse side allows for truck maneuvers and circulation road lanes. For face-to-face sides of different warehouses the distance may be less than 2 X 35m but not less than 55-60 m. Ideally, the parking for the warehouse customers/visitors and employees is located alongside the warehouse, protected by a kerb (see Figure 3, lower part). This way, cars are not interfering with trucks. In addition, the visitors/ employees may park close to the required dock. If no sufficient space is provided (as in the case of example) an open vertical parking solution (see Figure 3) may be implemented.
Using the above elements, a number of alternative designs were produced (see Figure 2) and evaluated by a group of experienced engineers according to the following criteria:
Utilization of the maximum space allocated for building construction (building factor). This maximum value is defined as a percentage of the ground area of the freight vi 11 age. A maximum of about 240.000 m2 has been calculated for the example, but many designs cannot



make use of all permissible space due to limitations imposed by the existence of road/rail networks, parking areas etc. o Conformity of warehouses sizes with preferred values. Based on the results of market analysis, a 20.000 m2 preferable value was set as for the warehouses of module 1 and a preferable value 60.000 m2 was set for the warehouses of module 2. Figure 2 Alternative freight village designs for the example region

Figure 3 Cyclic and straight line flow patterns (upper part) and exterior warehouse area configurations (lower part)



Modern railroad warehouses have an important place in supply chains, their task is to transform incoming cargo flows with large consignments into outgoing flows [1-9]. Railway warehouses, like any material object, which is a collection of elements that are interconnected and have a clear structure and are united by a common goal, which can be considered as a system. Figure 1 shows the structure of a railway warehouse as a technical system, which is a set of technological sections.

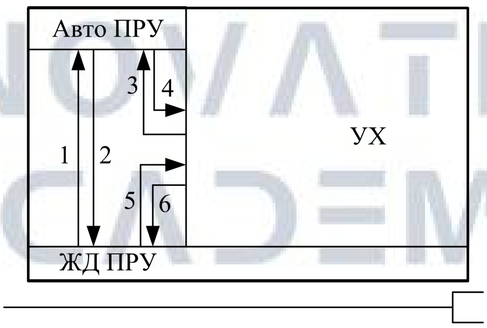


Figure 1 - The structure of a modern trade warehouse

Figure 1: Railroad PRU - railway loading and unloading area; Auto PRU - automobile loading and unloading area; UX - area of the main storage of goods; 1-6 - freight traffic inside the warehouse.

The main options for the location of technological areas (see Figure 2) are selected when determining the general layout of the warehouse, depending on the traffic flow. Like any system, the functioning of a railway warehouse must be well-coordinated, and therefore this study is aimed at finding a rational location of technological sections.

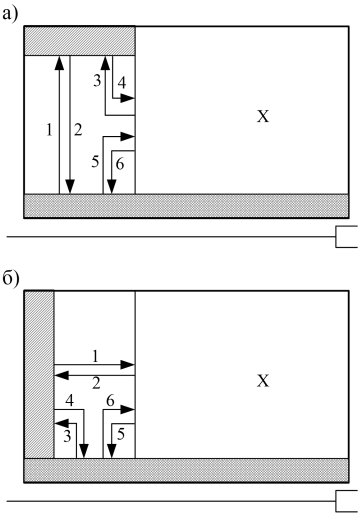


Figure 2 - Options for the location of technological areas

V.P. Sityaev proposed an original method for choosing the optimal layout solution for a timber warehouse, which can be successfully used in the design of trade warehouses. Research [10] carried out by V.P. Sityaev for the design conditions of a timber warehouse, showed that the application of the described methodology can save transport costs up to 40% compared to projects developed using traditional methods.

The method is based on the principle of "covering" the allocated territory for the placement of technological elements of a railway warehouse with standard shapes: squares, circles, rectangles (see Figure 3). A rational planning option is selected according to the cost criterion, representing the amount of logistics costs associated with the construction of communications [11].

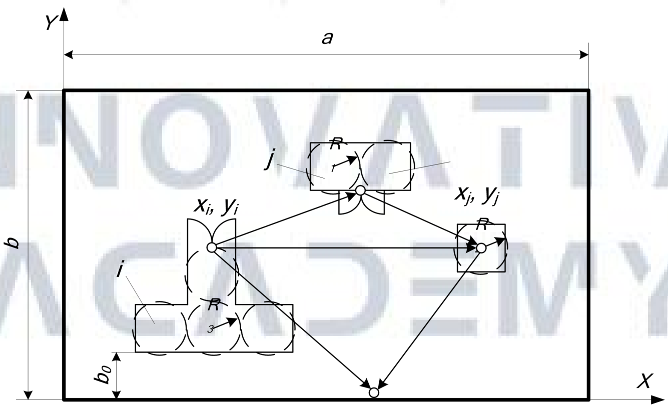


Figure 3 - "Coating" method

Let i and j be the technological areas to be placed on the plan of the railway warehouse;

xi, yi, xj, yj - coordinates of points of technological sections, representing points of entry and exit of cargo flows;

a and b is the specified dimensions of the railway warehouse;

cij - unit cost of moving 1 ton of cargo from point i to point j;

Qij - the annual volume of traffic between technological sections i and j;

ri and rj are the minimum distances between sections of the railway warehouse when covered with circles (see Fig. 3).

Then we form the problem of choosing the optimal planning option as follows:

$$R^* = \min_{x_i, x_j} \quad {}_{ij} \; C_{ij} Q_{ij} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$, (one)

if:

$$r_i \quad x_i \quad a - r_i ,$$ (2)

$$r_i \quad y_i \quad b - r_i , \qquad (3)$$

$$\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2 \quad \left(r_i + r_j\right)^2 , \qquad (4)$$

$$\left(x_{ij} , y_{ij}\right) \quad 0 , \qquad (5)$$

Constraints (1) - (5) determine the conditions for the placement of technological sections of a railway warehouse in the designated area. Depending on local conditions, restrictions may be given, determined by the minimum approximation of the object, for example, b0 to the railway tracks, etc.

For the selected option, the problem of mathematical programming (1) - (5) is solved, a conditionally rational variant of the planning from the point of view of minimizing the objective function is determined. If, according to the conditions of the technology, a different composition of technological sections of the warehouse is possible on its territory, then similar calculations are performed for them. As a result, a rational warehouse planning solution is found.

Discussion of the results. We implement a mathematical model of a rational search for the location of technological sections corresponding to the number of tests Nk. For this purpose, in Figure 4, in a sequential order, we will depict the location of the doors of the sections, as a result, for the adopted options, we will determine a rational option.

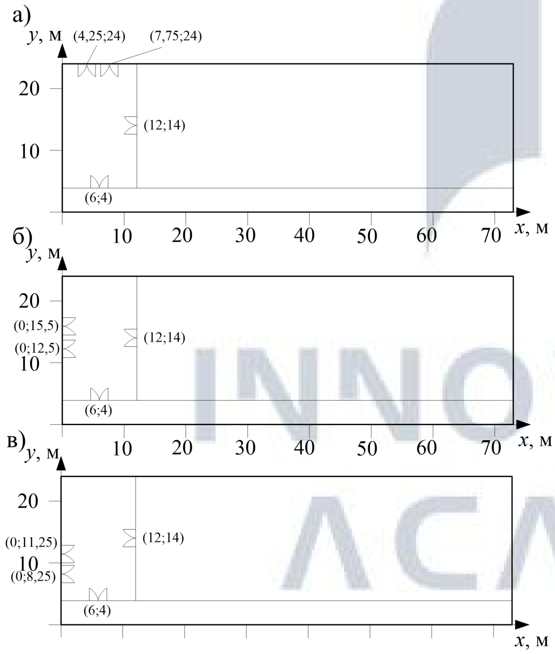


Figure 4 - Options for the location of technological areas

For option I of the location of technological areas (see Figure 4, a):

$$R_{\mathrm{I}} = 100 \ \ 10^3 \ \ 5 \quad \sqrt{(6-12)^2 + (4-14)^2} + \sqrt{(12-7{,}75)^2 + (14-24)^2} + \sqrt{(6-7{,}75)^2 + (4-24)^2} +$$

$$+ \sqrt{(6-12)^2 + (4-14)^2} + \sqrt{(12-4{,}75)^2 + (14-24)^2} \sqrt{(6-4{,}75)^2 + (4-24)^2} \quad = 43496939$$

For option II (see Figure 4, b):

$$R_{\mathrm{II}} = 100 \ \ 10^3 \ \ 5 \quad \sqrt{(6-12)^2 + (4-14)^2} + \sqrt{(12-7{,}75)^2 + (14-24)^2} + \sqrt{(6-7{,}75)^2 + (4-24)^2} +$$

$$+ \sqrt{(6-12)^2 + (4-14)^2} + \sqrt{(12-4{,}75)^2 + (14-24)^2} \sqrt{(6-4{,}75)^2 + (4-24)^2} \quad = 35443014$$

For option III (see Figure 4, c):

$$R_{\text{III}} = 100\ 10^3\ 5\ \ \sqrt{(6-12)^2+(4-14)^2}+\sqrt{(12-7{,}75)^2+(14-24)^2}+\sqrt{(6-7{,}75)^2+(4-24)^2}+$$

$$+\sqrt{(6-12)^2+(4-14)^2}+\sqrt{(12-4{,}75)^2+(14-24)^2}\sqrt{(6-4{,}75)^2+(4-24)^2}\ \ =32852424$$

Thus, the rational arrangement of technological sections of the railway warehouse, corresponding to the minimum costs, is equal to the third option.

Conclusions. Based on the results of modeling in the search for the most rational planning of technological areas, three options for non-traditional planning schemes for these types of warehouses were obtained and recommended (see Figure 5).

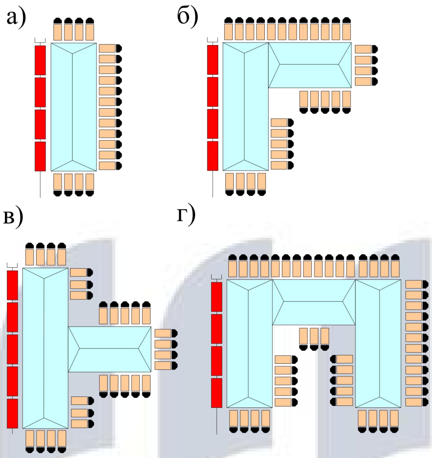


Figure 5 - Various forms of planning railway warehouses for organizing cross-docking technology in them

Figure 5: a - traditional planning of a railway warehouse; b - L-shaped warehouse planning; c - T-shaped warehouse planning; d - U-shaped warehouse planning.

In the general case, when constructing a mathematical model for the rational planning of warehouse sections, the norms of technological design of general-purpose warehouses should be taken into account.

Conclusion

Freight villages reflect a modern way of organizing logistics, transport and goods distribution activities. Warehouses are a basic element in such a system offering the space, equipment and the operating environment where receiving, storage, order-picking, packaging and shipping processes are taking place. The general warehouse design runs from a functional description, through a technical specification, to equipment selection and determination of a layout. Warehouse design requires a mixture of analytical skills and creativity. A great number of scientific works covering the various aspects of warehouse design and control exist, addressing mainly well-defined isolated problems and are typically of an analytical nature. In addition, a number of warehouse design manuals provide background and information for actual design and operation aspects. The current research work of our scientists at the Tashkent State Transport University will be proved in the future. The development of the railway and other transport sectors in the territory of Uzbekistan will certainly contribute to the further development of the logistics sector and the attraction of our foreign partners in the future.

REFERENCES:

1.Europlatforms EEIG. Logistics Centres Directions for Use, 2004. In site: www.unece.org/trans/main/eatl/docs/ENREVWhat_is_a_Freight_VillageFinalcorretto

2. Zografos K., and Regan C., Current challenges for intermodal freight transport and logistics in Europe and the US. CD-ROM. Proceedings of the 83rd TRB Annual Meeting, Washington, D.C. 2004.

3. Kapros, S., K. Panou, and D.A. Tsamboulas. Evaluation of intermodal freight villages using a multi-criteria approach. CD-ROM. Proceedings of the 84th TRB Annual Meeting, Washington, D.C. 2005.

4. Leitner, S., and R. Harrison. The Identification and Classification of Inland Ports, Research Report 4083-1, Center for Transportation Research, Texas Department of Transportation, Austin, Texas, August 2001

5. Weisbrod, E.R., E. Swiger, G. Muller, F.M. Rugg, and M.K. Murphy. Global freight villages: A solution to the urban freight dilemma. CD-ROM. Proceedings of the 81st TRB Annual Meeting, Washington, D.C. 2002.

6. Owen, H.S., and M.S. Daskin. Strategic facility location: A review. European Journal of Operational Research, Vol. 111, 1998, pp: 423-447.

7. Ilesaliev D.I. Influence of the location of the passages between the racks on the performance of the water transport warehouse / D.I. Ilesaliev, E.K. Korovyakovsky // Bulletin of the State University of Maritime and River Fleet named after Admiral S.O. Makarov. - 2015. - Issue. 6. - No. 34. - S. 52-59.

8. Ilesaliev D.I. The use of different layouts of the aisles of the container-piece cargo warehouse / D.I. Ilesaliev // Logistics: modern development trends: materials of the XIV Intern. scientific-practical conf. April 9, 2015: mat. report / resp. ed. V.S.Lukinsky. - SPb .: FGBOU VO GUMRF named after Admiral S.O. Makarova, 2015 .-- S. 174-176.

9. Ilesaliev D.I. On the issue of the capacity of warehouses for packaged goods / D.I. Ilesaliev // Scientific and technical bulletin of the Bryansk State University. - 2017. - Issue. 2. - S. 154-162.