

CHOOSING A WAREHOUSE EXTERNAL SHAPE WITH THE HELP OF NEW SIMULATION PROGRAMME

M.Murat Erkmen¹, Nurşen Topçubaşı²

¹Master Degree Student of Information Technologies, Okan University, Istanbul, Turkey

²Assistant Professor, Computer Science Department Okan University, Istanbul, Turkey

Abstract - The thesis objectives are delete wrong information about warehouse buildings and teach correct facts with the help of the warehouse simulation software. This software is free. Also, the software does not need extra workforce, statistics and logistics knowledge and programming language. Thus, the software compares warehouses easily.

Over the last 15 years, many logistics warehouses have been built. The majority of these warehouses are rectangular and the doors are on the short side of the rectangle. By looking at each other, the construction of the depot continued in this way. These warehouses are not good warehouses in terms of performance, have been proven by simulation program that we developed. At least from now on, this program will be helpful to make a higher performance warehouses. Thanks to this program you have the possibility to further develop your existing depot by simulating it without breaking walls down. The WarehouseComparison simulation program has been developed to be used in the external warehouse selection of the depot.

Warehouse Comparison software can be requested free of charge from DepoKiyaslama@gmail.com

Key Words: Warehouse Building External Shape, Simulation Program, Warehouse Doors and Performance Relation, Rectangular and Square Warehouse comparison, Warehouse Shape and Performance Relations, Warehouse Layout, Warehouse improvement.

1. INTRODUCTION

When many warehouses are examined in the logistics sector, the interesting thing is; it is observed that hundreds of depots are rectangular with a large number of depots with gates on the short edge. (Google Earth, 2016).

- Is rectangular depot shaped, ideal for usage in all form of depots?
- Is there a better way to use any warehouse?
- How can we improve our existing depot?

Before the construction phase, a simulation program is required to determine which warehouse is the best warehouse for the purpose of use. There are many simulation programs available. But these programs are not

used for a variety of reasons. The warehouse is usually built according to the shape of land. Choosing a rectangular or a square building is a preference.

On the exterior shape of the warehouse; we will design and write a program that compares a few simple forms of warehouses with scientifically utilizing the Information Systems and present it to the use of the logistics sector. This warehouse will be tested by comparing some exterior shapes of warehouses. According to the results obtained from the program, which warehouse will appear to be more advantageous for use. The logistics industry can use this program for their existing depots or new ones to build. It will be possible to simulate real life in a virtual world, before building the depots

DepotsComparison simulation program measures performance during storage use. The result of comparison is reduction in staff, equipment, warehouse investment costs. It also increases the warehouse performance.

DepotsComparison simulation program is; simple, specialized on a specific topic, just as much logistical and statistical information as needed, user friendly, free, attainable, not requiring consultancy and training.

1.1 NEED OF STUDY

Depots horizontal movements are carried out by people, stackers and conveyors. There is a relationship between the horizontal shape of the warehouse and horizontal movements. This relationship is also the main factor in the selection of the ideal warehouse.

When two warehouses of the same square meter are taken into consideration, which warehouse is more efficient?

The comparison of the shortest movements in the path and time between the palette addresses of the rectangular and square stores and the doors will be measured.

1.2 LITERATURE REVIEW

According to Ed Acker "The economics of modern commercial warehouses dictate that goods are processed in minimal turnaround time." (Acker, 2011) warehouse design should be functional and efficient; in order to increase workers productivity and to reduce the operating costs.

According to Rob O'Byrne "Time is money and distance is time.", (O'Byrne,2015). It is aimed to make the shortest distance calculation in warehouse simulation program.

The Travel Distance Calculation is available in the LM Labor Management module in the SAP ERP system which measures employees in the warehouse. Worker performance is measured with this distance. There are two different ways of measuring distance (SAP).

Two methods are used to measure distance:

- Euclidean (direct distance) method
- Manhattan Meter method (Actual movement distance)

Euclidean method; As Figure 1 shows, it measures the shortest distance between two points.

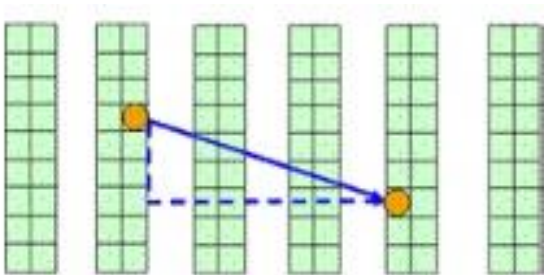


Figure-1 Euclid

The distance method according to Manhattan Meters is the measurement of the actual movement distance according to the layout of the shelves, as shown in Figure 2

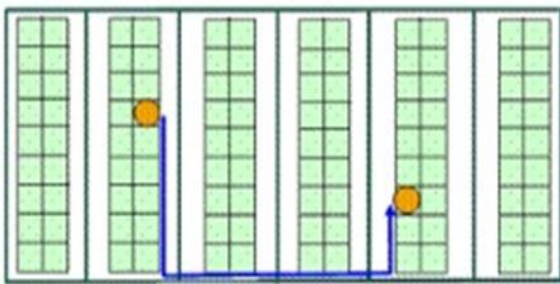


Figure-2 Actual movement distance (help.sap.com)

The warehouse comparison simulation program designed in the thesis should be able to perform both of these methods using the distance measurement parameter.

Logistics warehouses were built in Turkey, mainly in the last 10-15 years (Perşembe Rotası, 2012).

When the current state of the warehouses from the Google Earth program compared to past images, many warehouses built after the year 2000 (Figure 3) (Google Earth, 2016).

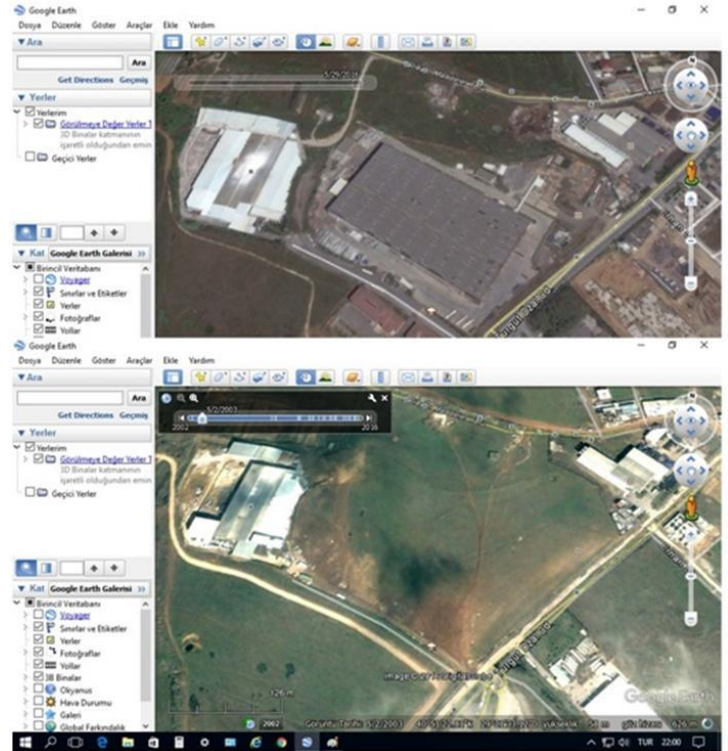


Figure-3 A warehouse in Tuzla Istanbul Google 2016 and 2003 benchmark

There were many simulation programs before the warehouses became widespread. Table 1 lists the simulation program examples.

Table-1: Simulation Programs in 1997

Program Name	Producer	2017	Price	Training Cost	Consultancy	Internet Address
Arena(Simulation)	Systems Modelling Corp.	Yes	Yes	3000\$	Yes	https://www.arenasimulation.com/
AutoMod	AutoSimulations Inc.	Yes	Yes	Yes	Yes	http://www.appliedmaterials.com/global-services/automation-software/automod
AweSim!	Pritsker Corp.	Yes	Yes	Yes	Yes	https://www.awesim.org/en/
Extend	Imagine That	Yes	Yes	Yes	Yes	http://www.extend-sim.com/
FACTOR/AIM	Pritsker Corp.	No				
G2	Gensym Corp	Yes	Yes	Yes	Yes	http://www.gensym.com/platforms/g2-standard/
GPSS/H	Wolverine Software Inc.	No	No	Yes	Yes	http://www.wolverinesoftware.com/yok-artik
GPSS/PC	Minuteman Software	Yes	695\$	Yes	Yes	http://www.minutemansoftware.com/

ithink	High Performance System	Yes	Yes	Yes	Yes	http://www.iseesystems.com/store/products/ithink.aspx
MAST	CMS Research	Yes	Min.5 500\$	Yes	Yes	http://www.cmsres.com/
Micro Saint	Micro Analysis and Design Inc	Yes	Yes	Yes	Yes	http://www.maad.com/index.pl/micro_saint
ProModel	ProModel Corp	Yes	Yes	min.599\$	Yes	http://promodel.com/
Simple++	Aesop Corp	No				
Simprocess	CACI	Yes	Yes	Yes	Yes	http://simprocess.com/
QUEST	Deneb Robotics	Yes	Yes	Yes	Yes	https://www.3ds.com/
Taylor II	F&H Simulations	Yes	Yes	Yes	Yes	https://www.flexsim.com/company/witness-simulation-software.html
WITNESS	Lanner Group	Yes	Yes	Yes	Yes	https://www.lanner.com/technology/witness-simulation-software.html

(Institute for Industrial Engineers, 1997) (Arena (Siman), 2017) (AutoMod, 2017) (AweSim!, 2017) (Extend, 2017) (G2, 2017) (GPSS/H, 2017) (GPSS/PC, 2017) (MAST, 2017) (Micro Saint, 2017) (ProModel, 2017) (QUEST, 2017) (Simprocess, 2017) (Taylor II, 2017) (WITNESS, 2017) (Ithink, 2017)

Table 1, there are many reasons why the 1997 Simulation Programs are not used in warehouse design;

There are many simulation programs in 1997 without any further storage. These programs could be used in the logistics warehouse. To use these programs; license fee required. Programs are available in their own simulation software language. You need to learn this language for each program. You need to be trained to use this program. And tuition fee is required. In general education is given abroad. In addition, an expert person is required to use the program. Or counseling is needed. Counseling service is also chargeable. Logistics warehouse information and statistical information are also required even if all of the requirements for this discrete Simulation program are met. (James A.Tompkins, 1998)

According to Randall R. Gibson, working with an outside consulting firm will be very helpful initially. That's the cost, too. (Gibson, 1998)

Too many prerequisites are required to use these simulation programs. As a result, no warehouse simulation program has been tested with these difficulties in mind. Warehouses were constructed according to the examples which had seen before. A warehouse comparison program is required. This

program is simple, everyone can use without any training, free, logistics and statistical information is not required.

Some of the important simulation programs in 2017 are as follows:

Free Simulation Programs List;

1. Advanced Simulation Library <http://asl.org.il/>
2. ASCEND http://ascend4.org/Main_Page
3. Celestia <http://celestiaproject.net/>
4. DWSIM <http://dwsim.inforinside.com.br/wiki/index.php?title=Downloads>
5. Elmer <http://www.csc.fi/elmer>
6. Facsimile <http://facsim.org/>
7. Freemate <http://freemate.sourceforge.net/>
8. Galatea <http://galatea.sourceforge.net/>
9. GNU Octave <https://gnu.org/software/octave/>
10. Modelica <http://www.modelica.org/>
11. Mobility <https://github.com/agents4its/mobilitytestbed> Testbed
12. NetLogo <http://ccl.northwestern.edu/netlogo/>
13. ns-3 <http://www.nsnam.org/>
14. OpenFOAM <http://openfoam.org/>
15. OpenEagles <http://www.openeagles.org/>
16. Open Source Physics <http://www.compadre.org/osp/>
17. OpenSim <http://simtk.org/home/opensim/>
18. Physics Abstraction Layer <http://www.adrianboeing.com/pal/index.html>
19. Project Chrono <https://github.com/projectchrono/chrono>
20. SageMath <http://www.sagemath.org/>
21. Scilab <http://www.scilab.org/>
22. SimPy <http://simpy.readthedocs.org/>
23. SOFA <https://www.sofa-framework.org/>
24. Stanford University Unstructured <http://su2.stanford.edu/>
25. Step <http://edu.kde.org/step/>
26. Tortuga <http://code.google.com/p/tortugades/>

List of Licensed Simulation Programs;

1. 20-sim – grafik tabanlı, çok kullanıcı simülasyon yazılımı. <http://www.20sim.com/>
2. ARENA <https://www.arenasimulation.com/>
3. Actran – <http://www.fft.be/>
4. ACSL and acslX – <http://www.acslx.com/>
5. AMESim http://www.plm.automation.siemens.com/en_us/products/lms/imagine-lab/amesim/index.shtml
6. AnyLogic – <https://www.anylogic.com/> bkz.
7. APMonitor – <http://www.apmonitor.com/>
8. AutoCAST - <http://www.autocast.co.in/>
9. Automation Studio – <http://automationstudio.com/>
10. Chemical WorkBench <http://www.kintechlab.com/products/chemical-workbench>

11. CircuitLogix -Logic Design Inc. https://www.circuitlogix.com/	49. Simulations Plus http://www.simulations-plus.com/
12. COMSOL Multiphysics (ex-name FEMLAB) - https://www.comsol.com/	50. SimulationX http://www.simulationx.com/
13. DX Studio http://www.dxstudio.com/features.aspx	51. Simulink https://www.mathworks.com/products/simulink.html?s_cid=wiki_simulink_2
14. Dymola - https://www.3ds.com/products-services/catia/products/dymola	52. TRNSYS http://www.trnsys.com/
15. Ecolego http://ecolego.facilia.se/ecolego/show/HomePage	53. Vensim http://www.trnsys.com/
16. EcosimPro - http://www.ecosimpro.com/	54. VisSim http://vensim.com/
17. Enterprise Architect www.sparxsystems.com	55. Vortex (software) http://www.cm-labs.com/
18. Enterprise Dynamics www.incontrols.com	56. Wolfram SystemModeler http://www.wolfram.com/system-modeler
19. ExtendSim https://www.extend3d.com/	57. Working Model http://www.design-simulation.com/WM2D/Index.php
20. Flexsim https://www.flexsim.com	58. VisualSimArchitect http://www.mirabilisdesign.com/new/visualsim/?s_cid=wiki_VisualSim_2
21. Fluent, Inc. www.ansys.com	
22. GoldSim https://www.goldsim.com	
23. HyperWorks www.altairhyperworks.com/	
24. Isaac dynamics www.strutturainformatica.it/	
25. Khimera - https://www.cgl.ucsf.edu/chimera	
26. Lanner WITNESS https://www.lanner.com	
27. Lanner L-SIM Server https://www.lanner.com/insights/news/l-sim-bpmn-2-0-compliant-simulation-capabilities.html	
28. Maple - by Waterloo Maple Inc. www.maplesoft.com	
29. MapleSim - by Waterloo Maple Inc. www.maplesoft.com	
30. MATLAB www.mathworks.com	
31. Mathematica https://www.wolfram.com	
32. ModelCenter www.phoenix-int.com/product/modelcenter-integrate Phoenix Integration.	
33. NEi Nastran http://www.upfronteng.com/nei_nastran.html	
34. NetSim www.tetcos.com	
35. NI Multisim www.ni.com	
36. Plant Simulation-by Siemens PLM Software. https://www.plm.automation.siemens.com/en/products/tecnomatix/manufacturing-simulation/material-flow/index.shtml	
37. PLECS - by Plexim. https://www.plexim.com	
38. PRO/II http://software.schneider-electric.com/products/simsci/design/pro-ii/	
39. Promodel https://www.promodel.com	
40. Project Team Builder https://www.pmi.org/learning/library/project-team-builder-simulation-training-6184	
41. PSF Lab http://onemolecule.chem.uwm.edu/software	
42. RoboLogix http://www.robologix.com/	
43. Ship Simulator https://en.wikipedia.org/wiki/Single-player	
44. Simcad Pro http://www.createasoft.com/	
45. SimEvents http://www.mathworks.com/products/simevents/	
46. Simio http://www.informs-sim.org/wsc07papers/286.pdf	
47. SimScale https://www.simscale.com/	
48. SIMUL8 http://www.simul8.com/	

All programs that can be used today in warehouse design are more advanced and simplified, but the above mentioned obstacles continue. To use these simulation programs even in simple operations; the element, program, training, logistics and statistical knowledge are required. Even consulting is required. These programs are costly for those who build warehouse. Warehouse comparison program was developed in this thesis in order to test and simulate the warehouse. This Warehouse Comparison program is free, easy to use and does not require extra logistical and statistical information. It is a simple user-friendly program. Emshoff and Sisson believe that “*all simulations require certain common functions*;

- Create random numbers
- Create random variates
- Advance time, either by one or to the next event
- Record data output
- Perform statistical analyses on recorded data
- Arrange outputs in specified formats
- Detect and report logical inconsistencies and other error conditions (Emshoff & Sisson, R.L., 1970)”

The Warehouse Comparison Simulation program was developed considering these features above.

2. MATERIALS AND METHODS

2.1. Research Method

Designing an example to promote and demonstrate the Warehouse Comparison Program. We take a hypothesis and test it in Warehouse Comparison Program, Two Rectangle and Square warehouses with the same square meters of space and the same number of doors are examined.

Hypothesis;

H₀ All External Warehouse shapes do not affect warehouse usage in terms of time and time.

H₁ Rectangular warehouse is shorter than square warehouse concerning to time and distance

H₂ Square warehouse is shorter than Rectangular warehouse concerning to time and distance

Method;

An artificial experimental environment will be created with the program of warehouse simulation. Simulation results in two samples. ANOVA analysis of variance calculates hypothesis that the dependent variable in the samples obtained from the same universe or from different universe. Experimental research provides the most accurate results in all scientific methods. With the applications to two or more groups, whether the effects on certain variables are differentiated. (Büyükoztürk, 2014)

Artificial experimental environment is established with the program of warehouse simulation.

2.2. Independent Variables in the experiment;

Independent variables used in the experiment; Input / Output Number of Doors, Number of Pallets Address, Figure 4, Distance between Pallet Address and Input / Output Doors Figure 5,

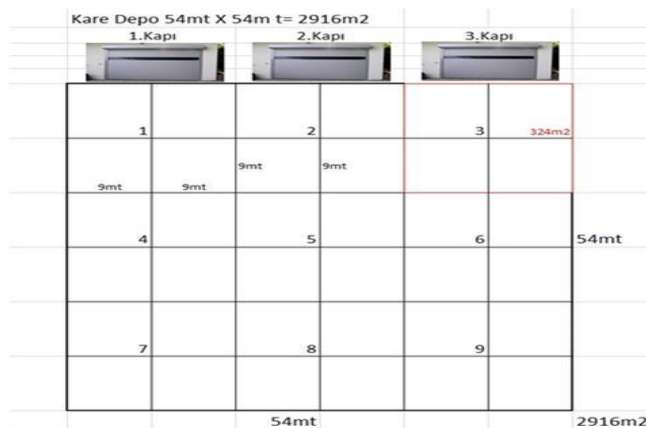
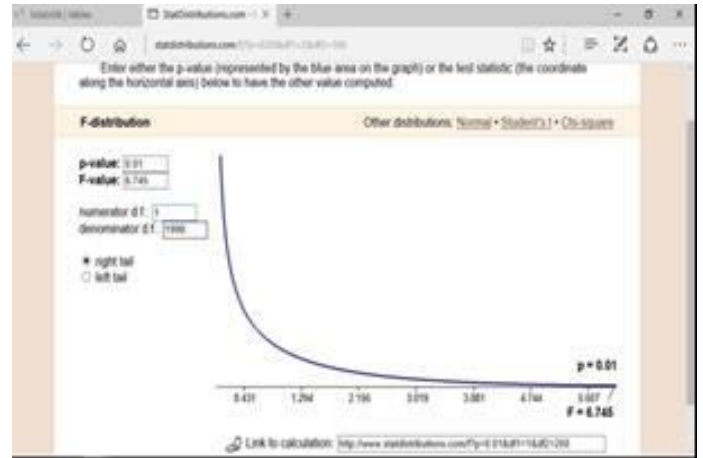


Figure 4 Input / Output Number of Doors = 3, Number of Pallets Address = 9

Adres	Giriş		Çıkış
	Kapı 1	Kapı 2	
1	9	27	45
2	27	9	27
3	45	27	9
4	27	45	63
5	45	27	45
6	63	45	27
7	45	63	81
8	63	45	63
9	81	63	45

Figure 5 Distance between Pallet Address and Input / Output Doors

The number of pallets entering the tested warehouse is fixed variable. 1000 pallets entrance is fixed in each warehouses. As can be seen from the F-distribution in Figure 6, there is very little change after 200 samples (Johston, 2017).



Sum of values of distance from door to pallet address and from pallet address to door are dependent variable.. Here, the distance that a pallet enters from the Entry Door, reaches the Pallet Address, and exits from the same address and reaches the Outlet Door, is measured. A simulation program is designed to give the shortest path and time. “The shortest path means the shortest time” (O’Byrne, 2015).

“Analysis of Variance ANOVA-F Test is; a method using variances to test the equality of two or more averages, and Used to analyze completely random design models” (Kılıç, 2017).

In the following Sample Simulations; 9 pallet addresses which are distributed equally in all warehouses's shapes will be taken. As many addresses as desired may be taken, there is no limitation, this is up to the user’s choose. Equal square meters divide the samples to make sampling operations in a short time. The number of entry and exit doors in here will be 3 doors. These 3 doors divide the edge into 3 equal parts. The person who uses the program can choose as many doors as he wants, there is no limit.

The sample warehouse will be taken 2916 m². 2916 is a number with a square root. 2916 consists of both 2 and 3 layers. Square and rectangular warehouses with the same square meters are divided by both 3 and 2 is taken as an example. It will be convenient for calculations. A warehouse of this size is neither too small nor too large, a medium sized depot. The calculations are not affected whether the warehouses are small or large. The difference will be very small when you get a small warehouse. In order to make clearer figures, this size of square meters of warehouses will be compared.

2.3. Sample: Simulation Test According to Warehouse External Shapes

The warehouse comparison process according to the exterior forms of the warehouse is tested between rectangular and square warehouses with the same square meter. Both of the warehouses are 2916m². The distance from the entry doors to the 9th pallet address for the square warehouse and the distances from the 9th pallet address to the output doors are shown in Figure 5.

The distance from the entry doors to the 9th pallet address for the rectangular warehouse and the distances from the 9th pallet address to the output doors are shown in Figure 6. Entrance and Exit are from the same door. Therefore, the distance between the entrance and exit is the same.

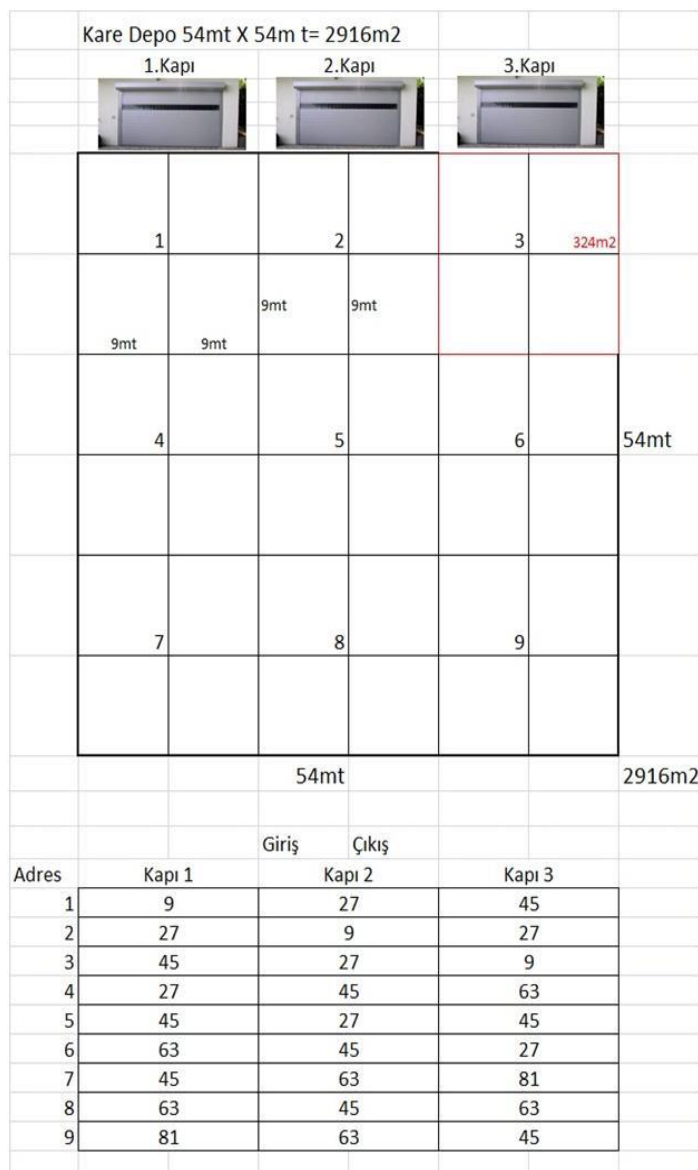


Figure-5 Square Warehouse and doors in one side

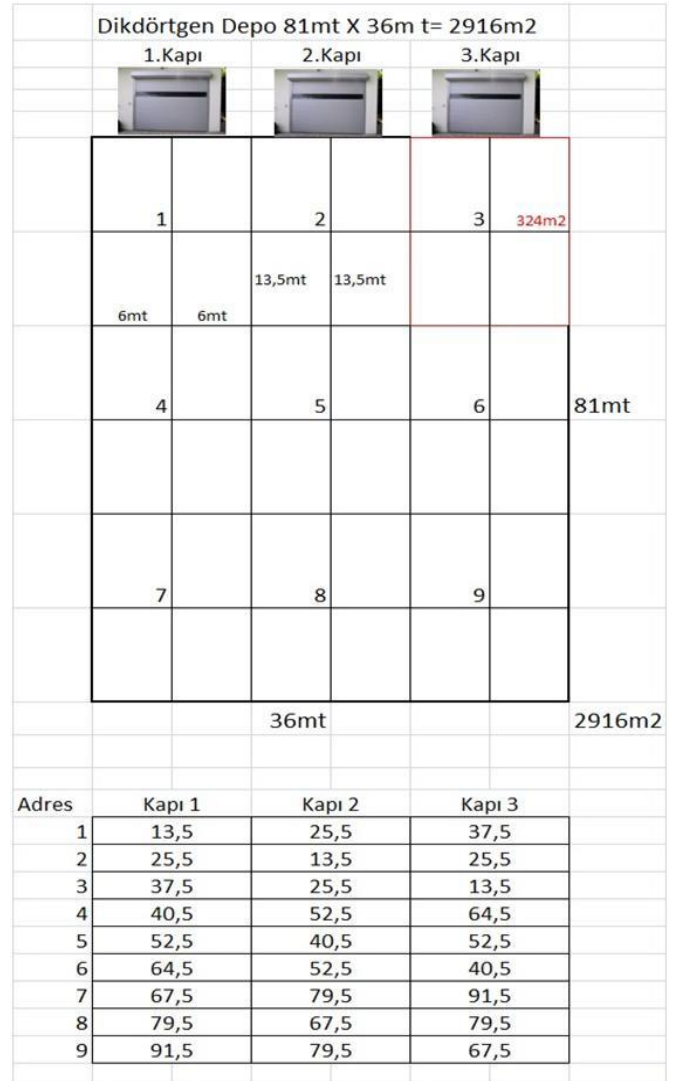


Figure-6 Rectangular Warehouse and doors in one side

2.4. Simulation Program Features

There is no limit on the variable of pallet address. Any number can be taken Equal ratio for two warehouses to be selected and tested, which ensures that the comparison is done correctly. Instead of testing at all addresses, you can simplify the process of dividing the warehouse into equal areas and taking a single address. Otherwise thousands of data have to be entered. 1000 pallets will be tested. 1000 test is fixed. 1000 tests are enough. Even after 200 attempts on the ANOVA table the numbers are almost the same, (Johston, 2017).

There is no limit in number of the door as a variable. Entrance or exit doors can be any number and in any side. It is assumed that the product types in the warehouses to be tested will be the same.

Vehicle docking will take place randomly between 3 doors. Placement from the Entry Gates of the Pallets to the Palette Addresses will also occur randomly.

Movements from the pallet address to the exit doors will also be randomly.

The program will collect all path numbers for each 1000 pallets, from the entrance to the pallet address and from the pallet address to the exit individually.

The Input-Output total distance average is compared with the ANOVA variance analysis at each warehouse. The summary report is shown in Figure 7.

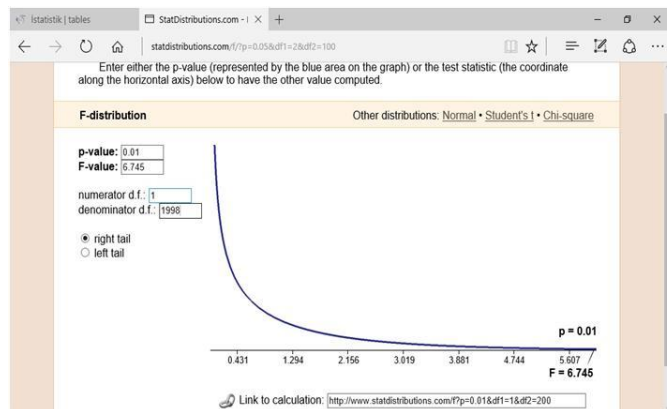


Figure-7 The summary report will receive p-value 0.01, F-Value 6,745 (Johston, 2017).

2.5. Use of Warehouse Comparison Program:

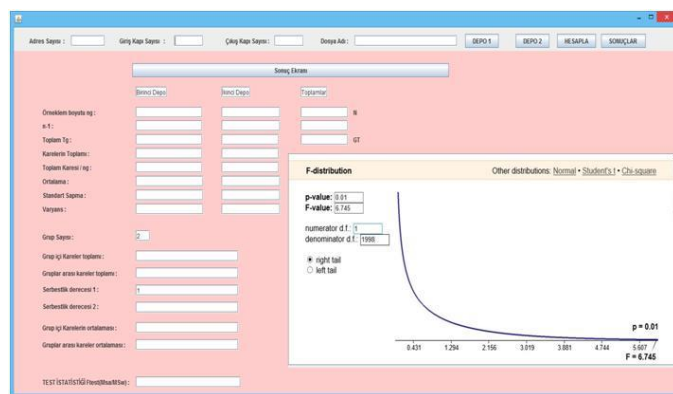


Figure-7 Main Input Screen

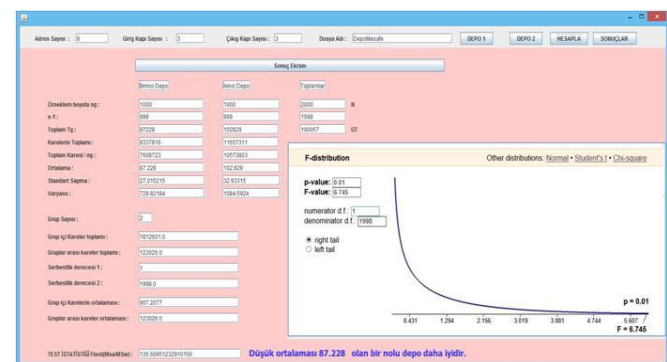


Figure-8 Report Page

Warehouse in Figure 5; The 1000 pallet entry and exit of the same square meter square warehouse is about 87 meters average distance and the standard deviation is about 27 meters. Warehouse in Figure 6; The 1000 pallet entry and exit of the same square meter rectangular warehouse is about 87 meters average distance and the standard deviation is about 27 meters. ANOVA variance analysis revealed an F-test = 135 for one way 1%. Since the F-test 135 is too high from the 1% one-way F-test 6,745, the square warehouse is definitely more suitable for performance Rectangular Warehouse requires 18% more movement than Square Warehouse. More movement means more workforce man, machine and lower performance. It has been reapplied many times to see the results and the consistency of the program. Mean, standard deviation and ANOVA results were very close to each other.

3. CONCLUSIONS

Other warehouse simulation programs can not be used in warehouse exterior design due to various obstacles. Because of these obstacles; economic, human resources, training, logistics warehouse and statistics lack of knowledge, consulting cost, our new DepoKiyaslama program is better to use. This warehouse comparison program may be requested for free from DepoKiyaslama@gmail.com. A new website will be set up for the warehousing program, Link will be provided from internet, and the Android version will also be available for free download from Google Play.

Some examples of deductions have been obtained through the Warehouse Simulation Program;

- Doors in short sided rectangular warehouse made in last 15 years is mistaken..

Users can try a lot of sample simulations using the program. To improve existing warehouses, users can create scenarios that improve performance without breaking down the walls of the warehouses and doors with the Warehouse Comparison program.

This simulation program can compare all types of warehouse types. WarehouseComparison simulation program is a very simple program according to other simulation programs. Access to the WarehouseComparison simulation program is free. One or more staff does not need to leave for this matter. With this program you do not have to have a deep knowledge of logistics, statistics and simulation software. The program uses the necessary amount of logistics, statistics and software knowledge in place of the user himself. The program presents a straightforward summary without showing the complex system and calculations at the back. Warehouse Comparison simulation program can be used for warehouse exterior selection.

Warehousecomparison simulation program reduces and optimizes staff, equipment and warehouse operating costs. Customer service is also increasing by accelerating warehouse performance. The WarehouseComparison

program is open source software. It is possible for anyone to take and develop this program, according to specific needs. WarehouseComparison program; simple, specialized on a specific topic, has just as much logistical and statistical information as needed, user friendly, free, attainable, does not require consulting and training

ACKNOWLEDGEMENT

People who want to use this program may be asked for free from DepoKiyaslama@gmail.com .

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