International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 24 (2016) pp. 11950-11957

Assessment of Mathematical Modeling to Improve Agricole Irrigation Area Works in Senegal (Kas Kas).

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Abstract

This paper aims to study optimization of Dam Land and Land channels in Kas Kas region Agricola location north of Senegal, Thila Sara Suki (W594771.79; N1816528.59) agricultural area located in order with the aim of improving rice plantations. The proposed of this work is to create irrigation channels and dikes necessary to create the resources for the rice plantation, in this way the agricultural perimeter of Thila Sara Suki counts on 6.400 m^3 of land fillings in irrigation channels and 21.300 m^3 Dam land construction. The required yield is 1.800m^3 daily compacted taking into account the land-swapping loan of about 18% the expected realization time is 17 days. The optimum number of trucks will be studied for the realization of this work according to the queuing theory models.

Keywords: Simulation, Visualization, Excavation, Dam Land, Queuing Theory.

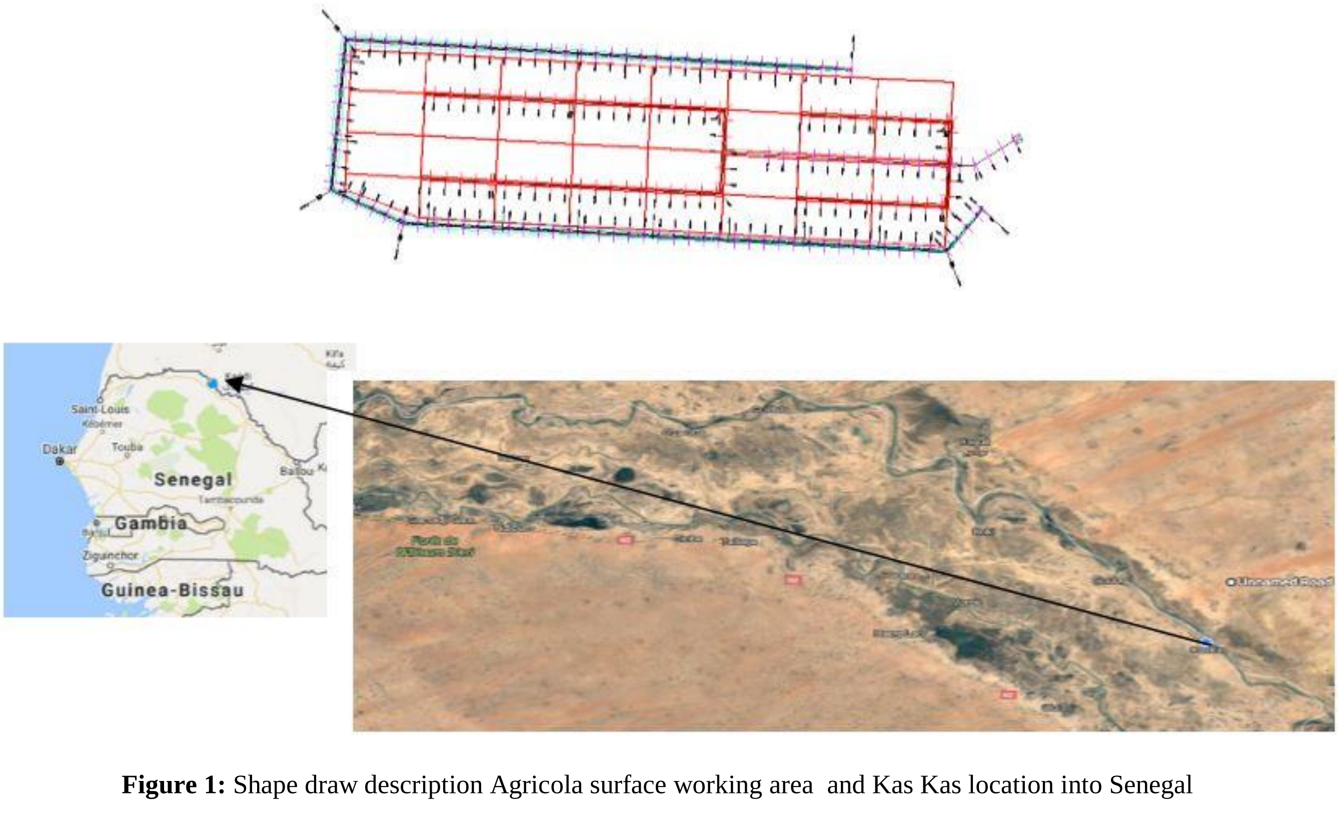

Figure 1: Shape draw description Agricola surface working area and Kas Kas location into Senegal

INTRODUCTION

New irrigation systems in agriculture area to build the rice plantation are order to handle increasing quantity of production. The construction project is expected to make a total of 16 ha of rice cultivation for this reason needle to make previously the previous infrastructure to irrigation system. The first phase of construction is necessary to create a quarry of land exploitation nearby of the perimeter to carry out the trucks the material to make the Layers of land.

To extend the layers land currently the second phase of construction is in progress. To create the land layers is previously extracted by Bulldozer which moves the land to be amazed with water before charge into the trucks.

This sequence of works is very important to permit the land gain necessary plasticity to be a performed material.

To quarry be exploited is necessary machinery equipment composed by Bulldozer, Irrigation truck, Excavator shovel which done 1.800 m^3 per jour,

If one 28 ton truck hauling 10m^3 at once is employed to transport this 3 round trips would be required to transport all of them in one hour. If a truck can make one round trip in 18 minutes, and if the truck is running for 10 hours a day Considering 3 round trips per hour, one needs to hire at least minimum of trucks to get the job done on time.

However, this simple calculation may not predict a reasonably accurate transport because:

As more trucks are running on the mountain roads at the same time, more trucks may end up waiting for their turn at the way stop intersection, which results in the truck's overall speed reduction.

It is not clear how long a truck should wait at a blasting site until it gets loaded.

The time needed for this activity may depend on the number of backhoes to be used. The truck's waiting time at the blasting site can be reduced by increasing number of backhoes. However, too many backhoes may result in having backhoes to wait for trucks, which is not economically advantageous because the backhoe is more expensive to hire.

It is unclear how long a truck would wait at the barge wharf. Obviously it depends on how quickly a truck can on the barge.

If too many trucks are waiting for their turns at the barge wharf, more barges may need to be hired. Then one may ask how many barges should be moored simultaneously to get the trucks moving seamlessly. In order to take care of above-mentioned uncertainties and estimate the soil clay production reasonably, a stochastic method needs to be considered.

METHODOLOGY

A simulation model was created to find out whether or not the given combination of loader and trucks equipments could digest 1.800 m3 of Land fillings journal worked, take into account the swelling rate around 18%.

Assumptions made for creating inputs data simulation model are:

- The speed of a truck is not consistent. It could take less or longer than 18 minutes to make a round trip.
- The daily excavation target is 2.320 m^3.
- The clay soil is taking place 610 meter form agriculture area.
- The loading capacity of a 28 ton truck is 10 m^3.
- Trucks are working for 10 hours a day.
- Time needed to load into a truck is 3.8 minutes.
- Time needed to unload is 5.4 minutes.
- Trucks stop for 1 to 2 minutes at each intersection of on the road network.
- The truck's speed is 25 km/hr.
- Land layers will be 30 cm thickness.

A model of a truck and shovel system for an open pit mine with multiple loaders operating within the pit was constructed using Microsoft Excel. This was done with the goal of providing a middle ground between very simplistic deterministic methods of analyzing haul truck fleet performance and complex, full-blown simulations that incorporate every aspect of mine activity. The rate of new haul truck arrivals and the loading rates of the excavators were both assumed to be exponential. An (M/M/c) queuing model was selected to follow this assumption of exponential service and inter-arrival times and to allow for various numbers of loaders to be selected. An (M/M/c) model is one in which each server has an independent and identically distributed exponential service-time distribution and an exponential arrival process. This model of pit behavior is versatile and can be used to model pit behavior for a variety of different haulage configurations and mine layouts. The service discipline used is first come first served, with the assumption that there are no special classes of trucks.

MATHEMATICAL MODELS

To use this model, the values for the number of loaders operating, the arrival rate of new trucks, and the service rate per loader must be known to be used as inputs to the model. The necessary inputs were defined previously.

The arrival rate, λ, is the average rate at which new trucks arrive at the loader. The service rate, μ, is the service rate of an individual loader. In cases with more than one loader in operation, all loaders are assumed to be equivalent, so μ would be the average service rate of the loaders. The arrival rate, λ, and service rate, μ, should both be input in the form of trucks per hour [3,4,5]. Both the arrival rate and the service rate are independent of queue length. The queue will not have impatient customers, since it would be unrealistic for haul trucks to not join the line to be loaded, regardless of how many trucks are already waiting. There would also be no jockeying for position since trucks form a single line to wait to be loaded, with the first truck going to the next available loader. The model uses this information to calculate a variety of outputs about the truck and shovel system.

Equations :

Based on this queuing system and input variables, the variables r and ρ are defined as,

$$r = \lambda / \mu \quad (1)$$

$$\rho = r/c = \lambda / c\,\mu \quad (2)$$

Where r is the expected number of trucks in service, or the offered workload rate, and ρ is defined as the traffic intensity or the service rate factor. This is a measure of traffic congestion. When $\rho > 1$, or alternately $\lambda > c\,\mu$ where c is the number of loaders, the average number of truck arrivals into the system exceeds the maximum average service rate of the system and traffic will continue back up. For situations when $\rho > 1$ [7], the probability that there are zero trucks in the queuing system is defined as

$$P_O = \sum_{n=0}^{C-1} \frac{r^n}{n!} + \left(\frac{r^c}{c!(1-\rho)}\right) - 1 \quad (3)$$

Where n is the number of trucks available in the haulage system. Even in situations with high loading rates, it is extremely likely that trucks will be delayed by waiting in line to be loaded. The queue length will have no definitive pattern when arrival and service rates are not deterministic, so the probability distribution of queue length is based on both the arrival rate and the loading rate [17]. The expected number of trucks waiting to be loaded can be calculated based on using the following equation.

$$L_q = \left(\frac{r^c}{c!(1-\rho)}\right) P_0 \quad (4)$$

The average number of trucks in the queuing system, L, and the average time a truck spends waiting in line, can be found by applying Little's formula which states that the long term average number of customers in a stable system, L, is equal to the long term average effective arrival rate, λ, multiplied by the average time a customer spends in the system [17].

Algebraically, this is expressed as,

$$L = \lambda\, W \quad (5)$$

and can also be applied in the form

$$Lq = \lambda\; W_q \quad (6)$$

Using these equations, the average time a truck spends waiting to be loaded, can be calculated as follows.

$$W_q = \left(\frac{r^c}{c!(c\mu)(1-\rho)^2}\right) P_{0=} L_{q\,/}\,\lambda \quad (7)$$

The average time a truck spends in the system, W, is defined as

$$W_q = \frac{1}{\mu} + \left(\frac{r^c}{c!(c\mu)(1-\rho)^2}\right) P_0 \quad (8)$$

The model currently supports up to seven loaders operating in parallel, but could easily be adjusted to include more. There is no limit on haul truck fleet size, provided the arrival rate of trucks to the loading system does not increase to the point of overwhelming the loading capacity. This model is only valid for values of ρ, the traffic intensity per server, that are less than one. If ρ were to increase above one, the system would back up indefinitely, as the arrival rate of empty trucks would be greater than the loaders are capable of handling.

Symbols and Abbreviations Po = Probability of system being idle or probability of no customers are being server.

Ws = Expected waiting time for a customer in the system.

Wq = Expected waiting time in queue.

Ls = Expected number of customers in the System or length of the system.

Lq = Expected number of customers in queue.

Uf = Utility factor.

μ = Service Pattern.

C = Number of Servers in the System. = Arrival rate.

Outputs :

When given the appropriate inputs, the model calculates and outputs values for various aspects of pit activity. These include loader utilization the average time a truck spends in the system, the average time a truck spends waiting to be loaded, the average number of trucks waiting in line, the average number of trucks in the system, and the system output in trucks per hour.

Table 2, Queuing Model Outputs Variable Units Description ρ % Loader Utilization W hours Time spent in system Wq hours Time spent in queue L Number of trucks Number of trucks in system Lq Number of trucks Number of trucks in queue θ Trucks per hour System output

Table1: Activities cost Daily

Extraction and loader cost	
Bulldozer	1500
Loader	950
Irrigation Trucks	140
	2590.00 €

Transport and widespread clay soil layers cost	
Trucks	Trucks Number
Compactor	390
Grader	600
Irrigation Trucks	140
	1120,00 €

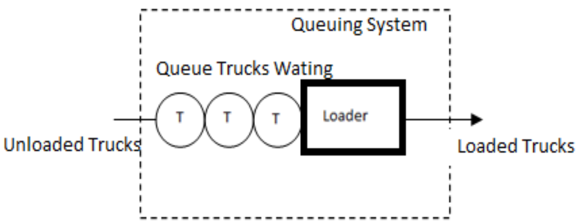

Figure 2, Truck and Loader Queuing System

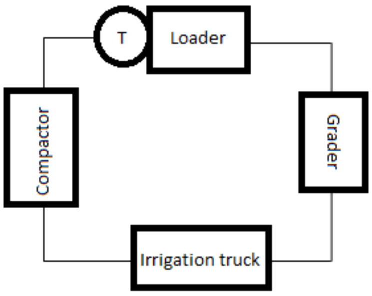

Figure 3: Cyclic Queuing System

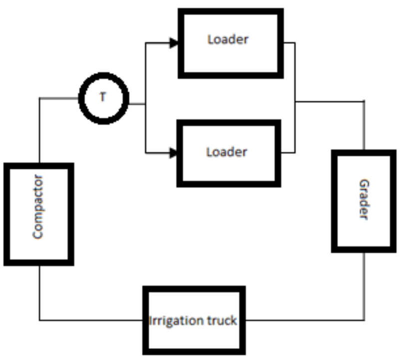

Figure 4: Cyclic Queuing System with Parallel Loaders

RESULTS

Taken into, with the quarry works and the transit mixers which follow the finite capacity single server model (M/M/1). The arrival pattern follows poisons distribution with the arrival rate being 32 loads per truck/day. The loader has a bucket capacity 1.4m^3 which has a rate of 5.5 m^3 cubic meters per minute equals **320** m3/hour. The average load per truck is 10 cubic meter per load and the plant works for 10 hours per day. The total and operating cost for the quarry is 2.590 Euros per day.

For a constant service rate, by increasing the arrival rates the various queue characteristics will vary which is shown in Table 3. It is clear that the number of customers waiting in queue and in the system increases as well as the waiting time in queue and system also increases, thus the ideal number of trucks for this case can be taken 2 elements , the loss in money due to idle trucks, so there are 32 charge per each one hour, 320 m^3 loader equipment production per hour, 10 m^3 charge de one truck.

$$\mu = \frac{320}{10} = 32 \text{ Load /Hour} \quad (9)$$

However it is seen that the extraction and loader land loader is idle for 57 % and transport trucks 43%.

In an attempt to improve the utilization and reduce the idle time and overall cost the same case is considered with varying arrival rates as shown in Table 2.

Table 2: Variation of Various Queue characteristics with Change in Arrival Rate

μ	λ	Po	%	Ls	Lq	N	Ws	Wq	Total
32	1	0,97	3%	0,03	0,00	0,03	0,03	0,00	2,00
32	2	0,94	6%	0,07	0,00	0,07	0,03	0,00	2,13
32	3	0,91	9%	0,10	0,01	0,11	0,03	0,00	2,26
32	4	0,88	13%	0,14	0,02	0,16	0,04	0,00	2,41
32	5	0,84	16%	0,19	0,03	0,21	0,04	0,01	2,57
32	6	0,81	19%	0,23	0,04	0,27	0,04	0,01	2,74
32	7	0,78	22%	0,28	0,06	0,34	0,04	0,01	2,93
32	8	0,75	25%	0,33	0,08	0,42	0,04	0,01	3,13
32	9	0,72	28%	0,39	0,11	0,50	0,04	0,01	3,34
32	10	0,69	31%	0,45	0,14	0,60	0,05	0,01	3,58
32	11	0,66	34%	0,52	0,18	0,70	0,05	0,02	3,84
32	12	0,63	38%	0,60	0,23	0,83	0,05	0,02	4,13
32	13	0,59	41%	0,68	0,28	0,96	0,05	0,02	4,44
32	14	0,56	44%	0,78	0,34	1,12	0,06	0,02	4,79
32	15	0,53	47%	0,88	0,41	1,30	0,06	0,03	5,18
32	16	0,50	50%	1,00	0,50	1,50	0,06	0,03	5,63
32	17	0,47	53%	1,13	0,60	1,74	0,07	0,04	6,13
32	18	0,44	56%	1,29	0,72	2,01	0,07	0,04	6,70
32	19	0,41	59%	1,46	0,87	2,33	0,08	0,05	7,36
32	20	0,38	63%	1,67	1,04	2,71	0,08	0,05	8,13
32	21	0,34	66%	1,91	1,25	3,16	0,09	0,06	9,03
32	22	0,31	69%	2,20	1,51	3,71	0,10	0,07	10,13
32	23	0,28	72%	2,56	1,84	4,39	0,11	0,08	11,46
32	24	0,25	75%	3,00	2,25	5,25	0,13	0,09	13,13
32	25	0,22	78%	3,57	2,79	6,36	0,14	0,11	15,27
32	26	0,19	81%	4,33	3,52	7,85	0,17	0,14	18,13
32	27	0.16	84%	5.40	4.56	9.96	0.20	0.17	22.13
32	28	0.13	88%	7.00	6.13	13.13	0.25	0.22	28.13
32	29	0.09	91%	9.67	8.76	18.43	0.33	0.30	38.13
32	30	0.06	94%	15.00	14.06	29.06	0.50	0.47	58.13
32	31	0.03	97%	31.00	30.03	61.03	1.00	0.97	118.13

Table 3: Loss Incurred due to idle in arrival Rates

λ	Trucks	Server	Total
2	2,36 €	1.865,63 €	1.867,99 €
3	8,78 €	1.803,44 €	1.812,22 €
4	22,96 €	1.741,25 €	1.764,21 €
5	49,56 €	1.679,06 €	1.728,63 €
6	94,86 €	1.616,88 €	1.711,73 €
7	167,21 €	1.554,69 €	1.721,90 €
8	277,78 €	1.492,50 €	1.770,28 €
9	441,41 €	1.430,31 €	1.871,73 €
10	677,94 €	1.368,13 €	2.046,07 €
11	1.013,91 €	1.305,94 €	2.319,84 €
12	1.485,00 €	1.243,75 €	2.728,75 €
13	2.139,56 €	1.181,56 €	3.321,13 €
14	3.043,60 €	1.119,38 €	4.162,97 €
15	4.288,09 €	1.057,19 €	5.345,28 €
16	6.000,00 €	995,00 €	6.995,00 €
17	8.358,92 €	932,81 €	9.291,74 €
18	11.623,09 €	870,63 €	12.493,71 €
19	16.170,90 €	808,44 €	16.979,34 €
20	22.569,44 €	746,25 €	23.315,69 €
21	31.691,18 €	684,06 €	32.375,24 €
22	44.921,25 €	621,88 €	45.543,13 €
23	64.543,31 €	559,69 €	65.102,99 €
24	94.500,00 €	497,50 €	94.997,50 €
25	142.000,16 €	435,31 €	142.435,47 €
26	221.225,69 €	373,13 €	221.598,82 €

As the servers and customers waiting in line, both time and money are lost. Table 3 shows how the cost varies with the arrival rate and for better getting a better understanding about cost variations, graphs are plotted from Fig. 7 it is understood that the overall amount lost due to idleness decreases drastically with increase in service rate. However a higher service rate cannot be chosen since the productivity is gravely affected by the variation. Thus while fixing the arrival rate, servicing rate and the number of customers, they should be such that the equipment utilization percentage is kept high, while at the same time the idle time of both server, waiting time of customer and the total cost must be maintained low. Similarly the various parameters can be calculated for Model (M/M/C) using formulae (3) to (7) and the ideal service and arrival rate and numbers can be determined.

From the table 4 for a constant arrival rate (λ=11) it is clear that by increasing the service rate, the idle time of server increases while the waiting time, number of trucks required and percentage utilization decreases. To understand this a graph is plotted as in Fig. 7 which shows variation of percentage utilization, number of customers and total waiting time with change in service rates for constant arrival rates. It is thus clear that with the increase in service rate, the production rate and the truck requirement keeps decreasing.

Table 4: Variation of Various Queue Characteristics with Change in Service Rate

μ	λ	Po	%	Ls	Lq	N	Ws	Wq	Total
12	11	0,08	92%	11,00	10,08	21,08	1,00	0,92	115,00
15	11	0,27	73%	2,75	2,02	4,77	0,25	0,18	26,00
18	11	0,39	61%	1,57	0,96	2,53	0,14	0,09	13,81
21	11	0,48	52%	1,10	0,58	1,68	0,10	0,05	9,14
24	11	0,54	46%	0,85	0,39	1,23	0,08	0,04	6,73
27	11	0,59	41%	0,69	0,28	0,97	0,06	0,03	5,28
30	11	0,63	37%	0,58	0,21	0,79	0,05	0,02	4,32
33	11	0,67	33%	0,50	0,17	0,67	0,05	0,02	3,64
36	11	0,69	31%	0,44	0,13	0,57	0,04	0,01	3,13
39	11	0,72	28%	0,39	0,11	0,50	0,04	0,01	2,75
42	11	0,74	26%	0,35	0,09	0,45	0,03	0,01	2,44
45	11	0,76	24%	0,32	0,08	0,40	0,03	0,01	2,20
48	11	0,77	23%	0,30	0,07	0,37	0,03	0,01	1,99
51	11	0,78	22%	0,28	0,06	0,33	0,03	0,01	1,82
54	11	0,80	20%	0,26	0,05	0,31	0,02	0,00	1,68
57	11	0,81	19%	0,24	0,05	0,29	0,02	0,00	1,56
60	11	0,82	18%	0,22	0,04	0,27	0,02	0,00	1,45
63	11	0,83	17%	0,21	0,04	0,25	0,02	0,00	1,36
66	11	0,83	17%	0,20	0,03	0,23	0,02	0,00	1,27
69	11	0,84	16%	0,19	0,03	0,22	0,02	0,00	1,20
72	11	0,85	15%	0,18	0,03	0,21	0,02	0,00	1,13
75	11	0,85	15%	0,17	0,03	0,20	0,02	0,00	1,08
78	11	0,86	14%	0,16	0,02	0,19	0,01	0,00	1,02
81	11	0,86	14%	0,16	0,02	0,18	0,01	0,00	0,97
84	11	0,87	13%	0,15	0,02	0,17	0,01	0,00	0,93

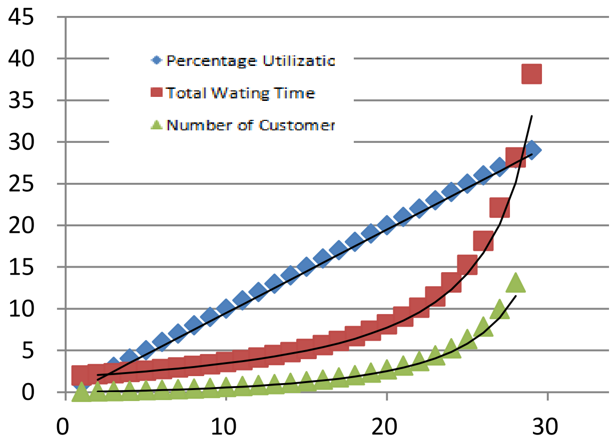

Figure 5: Variation of percentage utilization, number of customers and total waiting time with change in arrival rates.

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 24 (2016) pp. 11950-11957

Table 5: Loss Incurred due to Change in Service Rates.

λ	Trucks	Server	Total
6	76.902,22 €	530,67 €	77.432,89 €
9	19.450,24 €	773,89 €	20.224,13 €
12	7.726,44 €	947,62 €	8.674,06 €
15	3.828,48 €	1.077,92 €	4.906,40 €
18	2.168,12 €	1.179,26 €	3.347,38 €
21	1.343,70 €	1.260,33 €	2.604,03 €
24	888,89 €	1.326,67 €	2.215,56 €
27	617,85 €	1.381,94 €	1.999,79 €
30	446,47 €	1.428,72 €	1.875,19 €
33	332,91 €	1.468,81 €	1.801,72 €
36	254,73 €	1.503,56 €	1.758,28 €
39	199,17 €	1.533,96 €	1.733,13 €
42	158,64 €	1.560,78 €	1.719,42 €
45	128,37 €	1.584,63 €	1.713,00 €
48	105,32 €	1.605,96 €	1.711,29 €
51	87,46 €	1.625,17 €	1.712,63 €
54	73,42 €	1.642,54 €	1.715,96 €
57	62,22 €	1.658,33 €	1.720,56 €
60	53,19 €	1.672,75 €	1.725,94 €
63	45,82 €	1.685,97 €	1.731,79 €
66	39,75 €	1.698,13 €	1.737,88 €
69	34,70 €	1.709,36 €	1.744,06 €
72	30,47 €	1.719,75 €	1.750,22 €
75	26,90 €	1.729,40 €	1.756,31 €

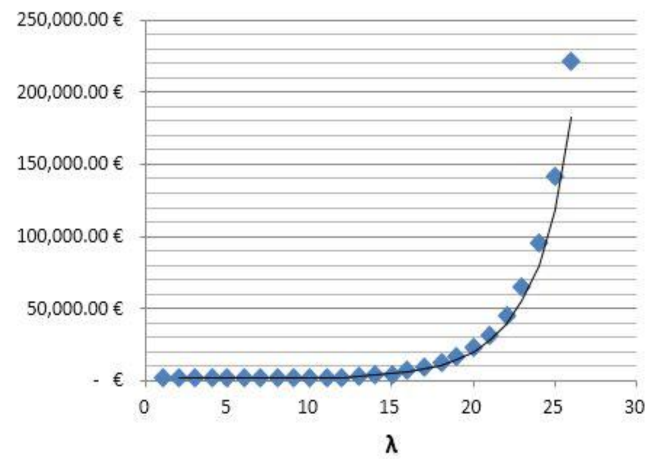

Figure 6: Total amount lost due to idleness with change in arrival rates

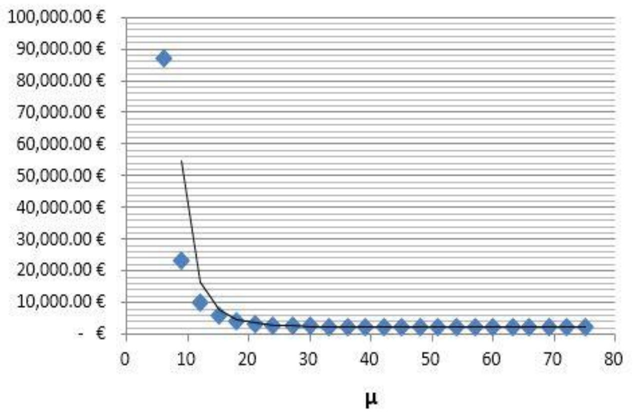

Figure 7: Variation of overall amount lost due to idleness with respect to change in service rate

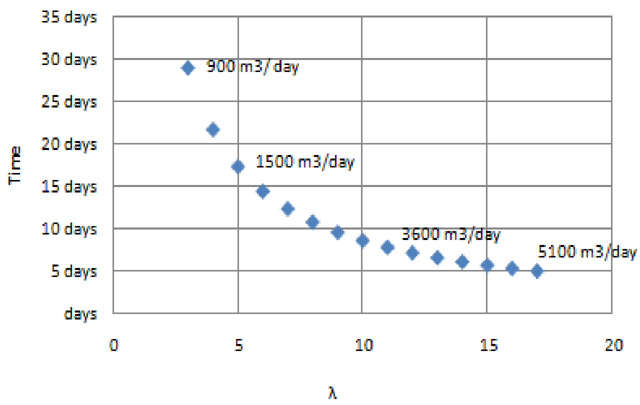

Figure 8: Capacity Performance Vs Trucks numbers.

DISCUSSION AND CONCLUSIONS

The present study is based on a queuing system single server (M/M/1). Load equipment disposes the trucks to move the material to widespread clay soil equipment. Loader performance daily is 2.400 m^3 versus 1.800 m^3 compacted due clay soil swelling rate.

One time defined the loader and widespread soil clay price activity which's allows to arrives to optimal number trucks.

Table 2 permits obtained idleness activities time in table 3, finally Fig 5 shows percentage variation of utilization of number by customers and total waiting time with change in arrival rates.

Table 4, constant arrival rate allows knowing the increases limit in Fig. 6 which determined theoretical trucks numbers.

Discussion Information has been obtained the problems associated with equipment usage and their productivity and how they adversely affect the cost is realized. Major problems relating to equipment usage are found to be: difficulty in management, scheduling and maintenance of the machines, the occurrence of unwanted cost due to accidents, failure and wrong choice of technology (machines and their combinations). Hence methods, techniques and measures to ensure equipment utility [4], lower overall cost and improved productivity is formulated and adopted by means of queuing theory. Two case studies have been taken in account to show the potential use of the queuing theory and application of its formulae. For both cases either single server system or multiple server system can be assumed and the appropriate formulae (2-6) can be applied to calculate the idle time, waiting time, length of queue etc. It is seen clearly from the tables that for a constant service rate, with the increase in arrival rates the utilization of the equipment increases while the idle time of the server and the loss in cost of both the server as well as that of the servers reduces. But, for a constant arrival rate [4], as the service rate increases the productivity and waiting time reduces while the overall cost initially reduces and then increases. It is not possible to completely eliminate idle time of server and waiting time of customer equipment without incurring heavy costs. Thus in order to strike a balance between the various parameters [4], various combinations of arrival rate, service rate and number of equipment must be analyzed and the most suitable combination which ensures that the cost is minimum without compromising with the productivity of the equipment must be chosen. A model can be developed for this purpose. In order to reduce the idle time of the server, the arrival rates have to be increased. This can be achieved by improving the efficiency and capacity of the servers. On the other hand, to reduce the waiting time of customers, the service time is reduced (by using more efficient server or with a server of higher capacity). Any changes in capacity of the server or customer will result in a change in their number. Care must be taken to ensure that the arrival rate does not exceed the servicing rate. If this happens it means that the system is overload and that more number of servers will have to be employed. The aim is to reduce the cost of construction, to avoid unnecessary delays in construction as well as to eliminate unnecessary cost due to wrong choice of technology, mechanism or combination.

As shown in Figure 8, the losses due to the delay of the production system are quantified by the number of loads per hour, till 9 charges per hour the loss idles was reduced 80%.

Finally shows in graphs 7 and 8 the final work cost due to trucks. numbers, noting that from 11 trucks the cost Stabilizes around 2.4 Euros /m^3.

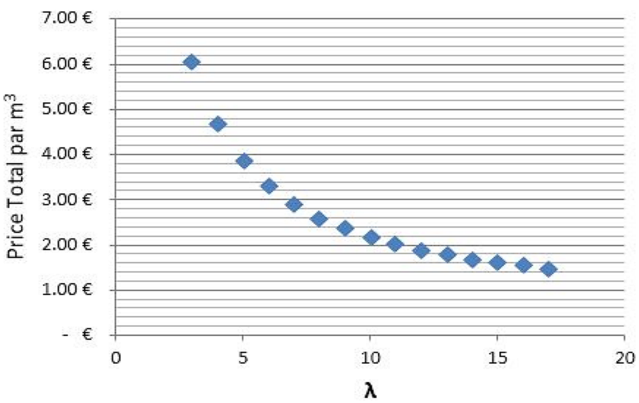

Figure 9: Price par meter cube Vs trucks numbers.

The optimization of the performance in systems of a simple server with a single loader would happen to increase the size of the bucket of the loader avec 2.4 m3 capacity par charge **which** would result in 480 m3/hour reaching a capacity the (λ= 48 Loads/ hour) increasing le performance work system 64% with 14 trucks par day allows compacter 3.600m^3 which permits reduces le execution price under 1.70 Euros /m^3.

REFERENCES

[1] Giffin C. Queuing: Basic Theory and Applications. (Grid Inc,Columbus, Ohi), 1978.

[2] Meredith Augusta May (2012), "Applications of Queuing Theory for Open-Pit Truck/Shovel Haulage Systems", Virginia Polytechnic Institute and State University, 19th December 2012.

[3] Min-Yuan Cheng, Hsing-Chih Tsai, and Yun-Yan Lai, "Construction management process reengineering performance measurements", Automation in Construction 18 p. 183-193, 2009.

[4] A. Sheikh , M. Lakshmipath, , A. Prakash ,Application of Queuing Theory for Effective Equipment Utilization and Maximization of Productivity in Construction Management. International Journal of Applied Engineering Research Volume 11, Number 8 (2016) pp 5664-5672

[5] Kenneth David Strang, "Importance of Verifying Queue Model Assumptions Before Planning with Simulation Software", European Journal of Operational Research 218 (2012) 493-504, November 2011.

[6] WuyiYue, Yataki Takahashi, Hideakil Takagi, Advances in Queuing Theory and Network Applications, Springer - 2009.

[7] VjacheslavUsmanov, CenekJarsky, "Application of queuing theory in construction industry", Journal on Research Gate, June 2012.

[8] Teknomo. K., "Queuing Rule of Thumb based on M/M/s Queuing Theory with Applications in Construction Management", Civil Engineering Dimension, Vol. 14, No. 3, (Special Edition), December 2012.

[9] Au, T., Bostleman R., and Parti E., "Construction Management Game - Deterministic Model", Journal of the Construction Division, ASCE Vol. 95:25-38, 1969.

[10] Halpin, D. W., "CONSTRUCTO-An Interactive Gaming Environment", Journal of the Construction Division, ASCE, 102 No. CO1: 145-156, 1976.

[11] AbouRizk, S. M., Halpin, D. W., and Lutz, J. D., "State of the Art in Construction Simulation", Proceedings of the 24th conference on Winter Simulation, Arlington, Virginia, 1271-1277, 1992.

[12] Halpin, D. W., "An Investigation of the Use of Simulation Networks for Modeling Construction Operations", Ph.D. thesis presented to the University of Illinois at Urbana-Champaign, Illinois, 1973.

[13] Lluch J. F., and Halpin D.W., "Analysis of Construction Operations Using Microcomputers", Journal of the Construction Division, ASCE Vol. 108 No. C01:129-145, 1981.
[14] Paulson, Boyd C., Jr., "Interactive Graphics for Simulating Construction Operations", Journal of the Construction Division, ASCE, 104(1):69-76, 1987.
[15] Chang, D. Y. and Carr, R. I., "RESQUE: A Resource Oriented Simulation System for Multiple Resource Constrained Processes", Proceedings of the PMI Seminar/Symposium, Milwaukee, Wisconsin, 4-19, 1987.
[16] Halpin, D. W. and Martinez, L., "Real World Applications of Construction Process Simulation", Proceedings of the 31st Conference on Winter Simulation, Phoenix, Arizona, 956-962, 1999.
[17] Pegden, C. D. and Davis, D. A., "Arena: A SIMAN/Cinema-based hierarchal modeling system", Proceedings of the 1992 Writer Simulation Conference, 390-399, 1992.
[18] Keilson, J. and L. D. Servi. A Distributed Poisson Approximation for Preempt-Resume Clocked Schedules. Submitted to IEEE Trans.on Comm., 1987.
[19] Gross, D., Harris, C.M. 1998. Fundamentals of Queueing Theory, 3 rd ed., John Wiley and Sons, New York.