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Hybrid Model for Predicting the Productivity of Concrete Batching Plants

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Abstract: ***Concrete Batch Plants are the construction projects intensive industry. As poor productivity of concrete batch plants is one of the reasons for cost and time overwhelms in construction projects, it is of basic significance to the profitability and productivity of construction projects and the general economy of any country. This paper meant to distinguish and rank factors influencing construction productivity in Egypt. A study poll was organized and spread to experts who were dealing with concrete batch plants and construction projects. The poll included 19 predefined factors, which were arranged into four essential gatherings: human/labor, management, material, health and safety, and equipment. The overall significance record still was determined and the factors were positioned. The discoveries of this study will give mindfulness what's more a superior comprehension of factors influencing productivity in construction projects in Egypt.***

Keywords: Productivity; factors; concrete; batch; plant; construction; model; Egypt; ANN; SPSS

1. Introduction

Construction industry assumes a significant part in the economy of any country. One of the fundamental factors influencing the construction industry development is the concrete batch plants furthermore it is primarily connected with the productivity.

Productivity is the overwhelming view point in the construction industry as it supports cost investment funds furthermore powerful usage of resources. It is the most significant concern in both developed and underdeveloped nations.

It's noticed that construction is a vital area of the public economy for nations from one side of the planet to the other, as traditionally it takes up a major piece in the country's total employment and its critical commitment to a country's income in general.

Likewise, productivity is one of the significant viewpoints for concrete batch plants, which helps its survival and development. Hence, working on the productivity of concrete batch plants is of basic significance considering its critical commitment to the project's income.

Productivity assumes a vital part in deciding the achievement of a project. Nonetheless, it might be impacted by numerous unexpected factors. These factors might include factors connected with labor, materials, equipment, health and safety, and management. [1]

Low productivity is one of the fundamental driver of cost and time invades in construction projects. Therefore, high consideration should be given to this factor in construction industry. Further developing productivity is a central issue for any benefit situated company, as it addresses the effective and productive change of resources into marketable items and it determines business benefit.

With regards to construction, productivity has turned into a major issue in the constructionindustry. In many nations, labor cost includes 30% - half of the general undertaking's expense (Guhathakurta andYates 1993; McTague and Jergeas 2002). [2], [3]

Like many creating and immature nations, the construction industry in Egypt goes up againstnumerous improvement imperatives, for example, the lacking execution of proper structure material andlabor construction innovations. These requirements have become testing conditions in Egypt.

2. Literature Review

A concrete batch plant is a sophisticated, industrialised facility where concrete is mixed and then transported to the job site in a transit mixer, ready for placement.

The first Ready Mix Concrete (RMC) facility was built in the 1930s, but the industry did not become popular until the 1960s, at which point it began to slowly grow.

Since there are many unknowns when determining how long each process should take, evaluating the productivity of a batch plant for ready mix concrete (RMC) is not simple or straightforward.

Many things contribute to these uncertainties, including operations management, equipment quality, operator skill, weather, and others. [4]

Abdel - Samad (2006) created an artificial neural network model to forecast pouring productivity the most potent influencing factors for ready mix concrete the pouring process's productivity was determined, and as potential input elements for neural network construction model. [5]

Twenty - seven factors were grouped into five categories: among them are project - related and management - related

groupings, industry - related variables, labor - related factors, and additional factors.

An investigation into the productivity of concrete at several sites was done in 2005 by (Polat, G., and Arditi, P) [6]. In this study, data on concrete laying speed, time, volume, and rate are collected, and their relationships to height and the different types of structural members are analysed. (A. W. Dhawale and K. R. Nizamuddin) [7]

The goal of this study is to better understand how site productivity parameters affect the most common robotic concrete installation technique. In order to accomplish this goal, data from 26 concrete pours that were taken from an observation of 167 concrete pours on the construction sites were examined using the multiple regression method.

The distance travelled between the RMC batching plant and various building sites, the length of the casting process, the number of RMC truckmixers owned and operated by the RMC plant owners, and the traffic conditions along the transit route are all factors that affect the RMC delivery process.

The time it takes to mix RMC and load concrete onto the RMC truck may also have an impact on how quickly RMC truck - mixers are sent out. The sole parameter that is taken into consideration and can be characterised as a constant is the time it takes to mix and load concrete into the RMC truck - mixers.

The permitted buffer period is also taken into account in this approach to give the dispatching schedule some flexibility. The construction site's maximum waiting period for RMC truck - mixers is shown by the permissible buffer duration. In order to dispatch RMC truck - mixers as efficiently as possible, the study's goal is to adopt a systematic strategy. Though variables like journey time and casting time are typically unclear, they are believed to be deterministic and recognisable for the sake of creating a systematic model.

The main goal is to arrange the RMC supply schedule from the batching plant in such a way that the truck - mixers' waiting time is kept to a minimum. The sequence with the least amount of waiting time is therefore highly preferred. This lays the groundwork for the development of the decision variables. [8]

Questionnaire Survey

A carefully constructed a questionnaire was created in accordance with the literature review. The survey looking at the important factors influencing the productivity of concrete batch plants.

The questionnaire was created with the idea that they should be easy for respondents to complete while also being straightforward and easy for the researcher to analyze.

In the questionnaire, the responder is prompted to select one of the available answers to a question. The questionnaire sets were distributed both by hard copy and soft copy.

The questionnaire topic was (Questionnaire to analyze the most affecting factors on the productivity of concrete batch plant). Nineteen factors impacting the productivity were chosen as shown in figure (1).

	Factors		Expert 1
1	Temperature	درجة الحرارة	3
2	Deficiency of spare parts	نقص قطع الغيار	3
3	Availability of water sources (through Public pipe lines/ transportation/ well with treatment plant)	توافر مصادر المياه (من خلال خطوط الأنابيب العامة / النقل / بئر مع محطة معالجة)	3
4	Emergency (Ingress/Egress)	الطوارئ (دخول/خروج)	2
5	Security (by police/ by CBD personnel)	الأمن (من قبل الشرطة / من قبل موظفي CBD)	2
6	Proximity to Medical Centre	القرب من المركز الطبي	2
7	The impact of the laborer's wages	تأثير أجور العمال	3
8	Drivers' proficiency	كفاءة السائقين	3
9	Labor Vacations	اجازات العاملين	3
10	Quantity of truck blenders with capacity (10)	كمية شاحنات الخلاطات	3
11	number of working pumps	عدد المضخات التي تعمل	3
12	Presence of programmed control blending	وجود نظام مزج مبرمج	3
13	Availability of waste/undesired concrete removal framework	توافر إطار لإزالة النفايات/ الخرسانة غير المرغوب فيه	2
14	Inappropriate maintenance / slow equipment fixes	صيانة غير مناسبة / إصلاحات بطيئة للمعدات	2
15	Quantity of locales zone which needs RMC	كمية المناطق المحلية التي تحتاج إلى الخرسانة الجاهوة	2
16	Existence of the site lighting around evening time	وجود اضاءة بالموقع عند المساء	3
17	Quantity of truck blenders with capacity (12)	كمية شاحنات الخلاطات	3
18	Efficiency of the batch director &his capacity to convey errands and efficiency of the batch plant administrator	كفاءة مدير محطة خلط الخرسانة و قدرته على نقل المهمات وكفاءة نائب مدير محطة الخلط	3
19	System of material supply	نظام توريد المواد	3

Figure 1: Questionnaire to analyze the most affecting factors on the productivity of concrete batch plant

Each expert had to give a rate from (1 to 5) for every factor where number (1) shows that this factor has a very low impact on the productivity of concrete batch plant, while number (5) shows that this factor has a very high impact on the productivity of concrete batch plant. A sample size was determined by 200 experts. After collecting data from the questionnaires and analyzing them, it is observed that there are four main factors having a great effect on the concrete batch plant productivity.

A sample size of data for 1000 days was collected from the daily records of a real concrete batch plant to observe the variance of the productivity according to the change of the four factors to be stored andanalyzed using the Artificial Neural Network (ANN) using Statistical Package for Social Sciences (SPSS) software programto determine which factors have strong impact on the productivity and which ones are not impactful.

As shown in figure (2), this is a part of the data collected from the concrete batch plant daily reports:

Day	Number of working pumps	number of working trucks (capacity 10)	number of working trucks (capacity 12)	Temperature (◦C)	Productivity per hour	
1	10	33	18	27	**115**	m3
2	10	31	19	25	**114**	m3
3	11	31	18	21	**119**	m3
4	10	30	16	25	**109**	m3
5	11	32	19	28	**121**	m3
6	10	29	20	36	**113**	m3
7	11	29	19	24	**118**	m3
8	11	35	16	31	**120**	m3
9	12	36	19	21	**131**	m3
10	10	30	19	29	**113**	m3
11	12	32	19	28	**127**	m3
12	10	29	16	20	**108**	m3
13	10	34	16	27	**113**	m3
14	12	32	20	17	**128**	m3
15	10	35	19	33	**118**	m3

Figure 2: Sample of the data collected from daily reports of a concrete batch plant

Model Development

Based on the results obtained from the questionnaire, a computer model is developed using artificial neural network (ANN) by SPSS.

The model results are shown in the next tables.

Hypothesis:

There is significant relationship between Productivity and Number of working pumps, number of working trucks (capcity10), number of working trucks (capcity12) & Temperature (◦C)

Table 1: Research variables

Variable	Type of variable	Code
Number of working pumps	Independent	X_1
number of working trucks (capacity 12)	Independent	X_2
number of working trucks (capacity 10)	Independent	X_3
Temperature (◦C)	Independent	X_4
Productivity per hour	Dependent	Y

Table 2: Descriptive analysis, normality test and Correlation matrix

	Y	X_1	x2	x3	x4
Mean	119.7580	10.99400	32.04700	18.10500	25.93900
Median	120.0000	11.00000	32.00000	18.00000	26.00000
Maximum	132.0000	12.00000	36.00000	20.00000	38.00000
Minimum	107.0000	10.00000	28.00000	16.00000	14.00000
Std. Dev.	5.929300	0.826224	2.574766	1.416327	7.246778
Skewness	- 0.008742	0.011143	- 0.043237	- 0.103428	0.020321
Kurtosis	2.184850	1.466438	1.763369	1.727513	1.797111
	Normality test				
Jarque - Bera	27.69896	98.01293	64.03060	69.25048	60.35810
Probability	0.000001	0.000000	0.000000	0.000000	0.000000
	Correlation matrix				
Y	1				
x_1	0.840319	1			
X_2	0.450544	0.007661	1		
x_3	0.319737	- 0.002883	0.032134	1	
x_4	- 0.002091	0.001443	- 0.013741	0.010865	1

From above table (2) it is shown that:

- There is significant relationship between Productivity and Number of working pumps, where the Pearson correlation coefficient equal (0.840) at p value 0.01.
- There is significant relationship between Productivity and number of working trucks (capcity12), where the Pearson correlation coefficient equal (0.451) at p value 0.05
- There is significant relationship between Productivity and number of working trucks (capcity10), where the Pearson correlation coefficient equal (0.320) at p value 0.05
- There is not significant relationship between Productivity and & Temperature (◦C) where the Pearson correlation coefficient equal (0.002) at p value 0.05
- All variables not follow normal distributed, where the researcher took the natural logarithm.

To test the hypothesis used, the Stepwise multi linear regression

Table 3: Regression result

Variable	Coefficient	Std. Error	St. Coefficient	t - Statistic	Prob.
C	1.753465	0.172337		10.17460	0.0000
X1	6.012949	0.009472	0.838	634.8257	0.0000
X2	0.999945	0.003041	0.434	328.8217	0.0000
X3	1.290243	0.005528	0.308	233.3954	0.0000
R - squared		0.998265		F - statistic	191028.9
Adjusted R - squared		0.998260		Prob (F - statistic)	0.000000
S. E. of regression		0.247343		Sum squared resid	1.952274

From the above table show statistically significant effect of Number of working pumps, number of working trucks (capacity 12) & number of working trucks (capacity 10) on Productivity per hour by 99.8%, where f test and t test are significant at p value less than 0.05 & the change in Productivity per hour by unit due to the change in (Number of working pumps) by 6.013, & by 0.999 for number of working trucks (capacity 12& 1.292 for number of working trucks (capacity 10)

Finally, the independent variable (Number of working pumps, number of working trucks (capacity 12) & number of working trucks (capacity 10) may interpret (99.8%) of the changes occurring in the dependent variable (Productivity) and the rest (0.2%) due to the other factors.

Independent Variable Importance:

1) Number of working pumps effect on Productivity by 0.838
2) number of working trucks (capacity 12) effect on Productivity by 0.434
3) number of working trucks (capacity 10) effect on Productivity by0.308

Model: y= 1.753+ 6.013 x1+ 0.999x2+1.29x3

To test the accuracy of model used

- Residuals normality test
- autocorrelation test
- Multi Collinearity test: (VIF)
- Heteroscedasticity Test Breusch - Pagan - Godfrey

Table 4: Statistic test for accuracy of model

Test statistic	Statistic value	Prob.	Decision
Normality test: (Jarque - Bera)	0.313	0.8550	Normal distributed
Autocorrelation test: Durbin - Watson stat dl (1.61) du (1.74)	1.952274		No autocorrelation
Multi Collinearity test: (VIF)	Ranged between (1.00, 1.001)		No Multi Collinearity
Heteroscedasticity Test Breusch - Pagan - Godfrey	1.8740	0.1323	homoscedasticity
Paired Sample Test	0.000	1.00	No significant

Normality test of residual (Jarque - Bera test): test value is not significant at p 0.05, so the residuals follow normal distribution

Autocorrelation test (Durbin - Watson): test value more than du value (1.74) and less than 2, so here is no autocorrelation problem.

Multi Collinearity test: test value ranged between (1.00, 1.001), which are values below 5, indicating to no problem.

Heteroscedasticity Test: test value is not significant at p 0.05, so the model has not Heteroscedasticity problem.

The predictive ability of the model (Paired Sample Test): test value is not significant at p 0.05, where no significant difference between actual value and estimated value.

Table 5: Case Processing Summary and Network Information

		N	Percent
Sample	Training	664	66.4%
	Testing	336	33.6%
Input Layer	X1, x2 & x3	3	
Hidden Layer (Number of Units)		10	
Output Layer (Dependent Variables)	y	1	

from above table show: 66.4 % from sample used to training the model, and 33.6% used to testing model.

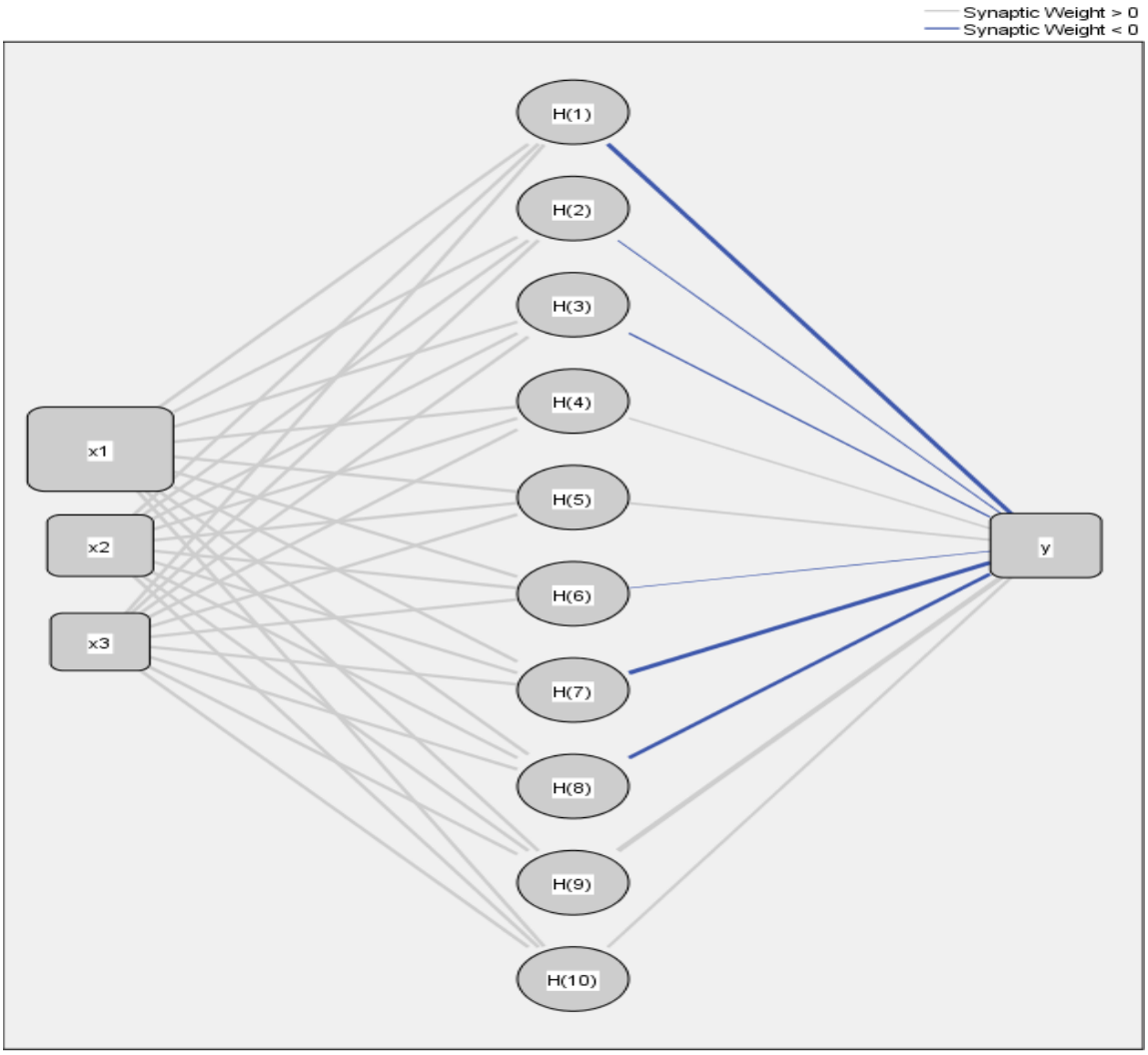

Table 6: Model Summary

Training	Sum of Squares Error	20.806
	Relative Error	.063
	Training Time	0: 00: 00.22
Testing	Sum of Squares Error	11.917[a]
	Relative Error	.077

from above table show: the relative error percent for training model equal 6.3% and the relative error percent for testing model equal 7.7%, which indicates the quality of the model.

Table 7: Independent Variable Importance

	Importance	Normalized Importance
x1	.569	100.0%
x2	.243	42.7%
x3	.188	32.9%

- Number of working pumps variable is importance for Productivity by 56.9%
- number of working trucks (capacity 12) variable is importance for Productivity by 24.3%
- number of working trucks (capacity 10) variable is importance for Productivity by 18.8%

3. Conclusion

The following issues could be encountered by Ready Mix Concrete companies during the implementation phase, according to a literature research and case study interviews:

- The most effective factor on the productivity of concrete batch plant is the number of working concrete pumps because based on the SPSS model results it has a high correlation coefficient with the productivity.
- The secondary effective variable is the number of working trucks with capacity (12 m3)
- The following effective factor is the number of working trucks with capacity (10 m3)
- The temperature has a very low effect on the productivity.

4. Recommendation for Future Researches

- It is important that the management team and site engineers focus on the maintenance of the concrete pumps as it is a very important factor affecting the productivity of concrete batch plant.
- The availability of mixing trucks with capacity (12) are the next effective factors after the number of working concrete pumps according to the model created, that's

why it is necessary for the manager to check the availability and the efficiency of the trucks to achieve great productivity for the concrete batch plant.

- The availability of mixing trucks with capacity (10) are the next effective factors after the number of working concrete pumps according to the model created, that's why it is necessary for the manager to check the availability and the efficiency of the trucks to achieve great productivity for the concrete batch plant.
- Developing a guide for every single resource working in concrete batch plant included in the effective factors is essential for future researches.
- Measuring productivity before and after working on the improvement of the concrete pumps and the truck mixer with different capacities to check the availability of the study results.
- Studying the effect of leadership on productivity in each plant.

References

[1] Explain the importance of construction industry for the economic development of the country? - The Constructor
[2] Guhathakurta and Yates 1993, Factors affecting labour productivity in building projects in the Gaza stripMcTague and Jergeas 2002, Effect of Covid - 19 Pandemic in Construction Labor Productivity
[3] Nabil Semaan 2016, STOCHASTIC PRODUCTIVITY ANALYSIS OF READY MIX CONCRETE BATCH PLANT IN KFARSHIMA, LEBANON
[4] Abdel - Samad 2006, "Predicting Production Rates of Pouring Concrete in Egypt Using Artificial Neural Networks Model" MSc. Thesis, College Of Engineering And Technology, Arab Academic For Science, Egypt.
[5] Polat, G., and Arditi, P, 2005, The JIT materials management system in developing countries
[6] A. W. Dhawale, Kazi Rizwan Nizamuddin (2016) "Concrete Productivity and Performance Comparison of Pumped Concrete for High Rise Structure", International Journal on Recent and Innovation Trends in Computing and Communication.
[7] Debasis Sarkar, Jishnu Gohel, 2019, Optimization of ready mixed concrete delivery for commercial batching plants of Ahmedabad, India