Economic Engineering: Economic Viability of Industrialized Mortar Applied with Projector and Applied in the Conventional Form

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Abstract— *The present article analyzed the return and risk bound to the execution of coating in mortar, from the two possibilities of execution, being mechanically designed or manually, plated by hand. The main difference between the two mortars is in the execution process, being the hand-plated mortar made by the mason with the aid of a spoon, allowing the application and the closing of the mortar, already for the execution of the projected mortar uses mechanical equipment to apply the mortar to the substrate. It is an applied research as to its nature, descriptive as to its purpose, case study on the strategy to approach the problem. For the development of this research was assumed a commercial / residential venture, which will be coated with industrialized mortar, with an estimated demand of 9,497 m² or 189,94 m³ and estimated 20 days of service execution per month. As for productivity, for the projected mortar coating, will run 60.00 m² per day and worked 5 hours / day. As for the productivity of the coating of hand-plated mortar, will run 20.00 m² per day and worked 8 hours / day. Regarding the composition of costs for services and labor, the unit costs of the SINAPI Reference Worksheet (National System of Prices and Indices for Civil Construction), of the period of preparation in August / 2018, were used. the information and data necessary for structuring the projected cash flow in the respective periods (24 months), using a TMA of 8% pa For the analyzes of risks and returns involved, the Multi-Index Methodology was used. The two executive methods have a high return. The confirmation of the values is based on the Monte Carlo simulation using the Crystal Ball software, which is considered as uncertain variables, or input variables for the simulation, the quantity 9,497 m² of coating for 24 months of execution.*

Keywords— *Economic viability. Mortar. Coating. Designed. Chapada.*

I. INTRODUCTION

In view of the current Brazilian economic scenario that we have been facing, we have faced the need to reduce expenses, and in return, the quality of services and products offered must be preserved. Consequently, through these requirements, the search for differentiated construction methods, new materials and technological innovation has become fundamental, always guaranteeing the quality of the final product offered.

The mortar coating is considered to be one of the most performed services in civil construction, and according to Carneiro (1993), because it is a coating in external mortar, its main functions refer to the contribution in the water tightness of the facades, for the thermal and acoustic comfort of the built environment, for fire safety and good visual appearance, providing harmony to the building. By satisfactorily fulfilling these functions, the required performance of the external mortars is obtained. However, more and more skilled labor has become scarce, requiring construction companies to invest in new construction techniques where the number of professionals is reduced and the quality of the final product is maintained or exceeded.

As for the mode of application, the coating mortars can be divided into hand-drawn mortar and projected mortar.

The plated mortar is known as the manual execution process performed by the mason with the aid of a spoon, allowing the application and closing of the mortar (PEREIRA JUNIOR, 2010). Already for the execution of the projected mortar mechanical projection equipment is used to apply the mortar on the substrate.

In Brazil, as well as in developing countries, the execution of mortar coatings with continuous mechanical projection has grown in recent years, and its use has great

potential in contributing to the improvement of the quality of mortar coatings.

Defined as a technological innovation, the execution of the projected mortar demands qualification of the workforce, and consequently, it offers a significant reduction of cost, acceleration of the rhythm of the work and the process of execution of the coating.

Based on the above considerations, the economic viability of a Civil Construction enterprise was analyzed, with the objective of verifying its economic capacity, given the profitability - or not - of the adoption of materials and equipment, compared to the external coating service of façades, executed with mortar designed (mechanically) and with mortar plated by hand (manual), taking into account the reduction in costs and deadlines. The analysis was based on the Multi-Index methodology, two sets of indicators, the first being VPL, VPLa, IBC and ROIA, to evaluate the perception of the return of the activity, while the second set includes the IRR, TIR Index / TMA, Risk Management and Business Risk, aiming to improve the perception of risk, with Monte Carlo simulator application, through the Crystal Ball software simulator.

II.   THEORETICAL FOUNDATION

Civil Construction in the world is developed through different techniques.

In Europe, the United States and the United Arab Emirates the buildings are constructed from galvanized steel frame structures with glass closures. In Brazil, the constructions are composed of elements in reinforced concrete and masonry sealing walls of ceramic blocks or concrete blocks.

These differences between the construction systems are due to the availability of natural resources, raw material, water, among others. To provide a good finish, these materials require the application of coatings that give surfaces adhesion, dewatering ability, mechanical strength, wear and durability.

According to Brazilian Standard 13.281, mortar is the homogeneous mixture of aggregate (s), inorganic binder (s) and water, with or without additives or additions, with adhesion and hardening properties, and may be either on site or in an own facility (industrialized mortar).

Mortars can be produced in construction sites (manually or in concrete mixers), produced in central, bagged, or supplied in silos.

The mechanically designed mortar comes as a strong allied to the new requirements of the construction industry. Increased productivity and increased coating quality are characteristics provided by the use of mortar designing equipment, provided care is taken (ABCP, 2012). In order to reach the desired standard, the specifications recommended by the equipment manufacturer and the mortars must be followed, ensuring the full operation of the projectors (ABCP, 2012).

2.1 Economic engineering

Economic engineering is a discipline that represents the set of principles and techniques necessary for making decisions about investment alternatives, evaluating the long-term investment.

The Multi-Index Methodology is intended to support the decision-making process in the acceptance and rejection of investment projects through the use of various indicators. The use of the various indicators compromises more consolidated information than using indicators in isolation.

The Multi-Index consists of using two groups of indicators. The first group is formed by VP (Present Value); NPV (Net Present Value); VPLa (Annualized Net Present Value); IBC (Benefit / Cost Index) and ROIA (Additional Return Due to Investment). However, the second group is formed by the TMA / TIR (Minimum Attractiveness / Internal Rate of Return) indicators; Risk Management and Business Risk. The two groups aim to improve the perception of the project analyzed.

There are several methods to evaluate an enterprise, among them we highlight:

a) Simple Payback

b) Discounted Payback

c) Net Present Value (NPV)

d) Internal Rate of Return (IRR)

e) Internal Rate of Return (TIRM)

Simple payback is defined as the number of periods (years, months, weeks) to recover the initial investment. In order to calculate the payback period of a project, it is sufficient to add up the values of the cash flows, until this sum equals the value of the initial investment. The payback period is found as the cash flows "pay" investment.

Discounted payback is similar to simple payback, but with the addition of using the minimum attractiveness rate (TMA) before summing the cash flows.

The net present value (NPV) method consists in bringing to zero date, using the company's or project's TMA as the discount rate, all the cash flows of the investment and adding them to the initial investment value.

The IRR is the rate of return of the enterprise, considering the amount of money in time. It is the discount rate that zeroes the net present value of the cash flows of a project, that is, it causes all inputs to equal all the cash outflows of the project.

Considering that the mechanization of the processes reduces personnel expenses and increases productivity, a civil construction company specializing in the application of road coverings will be evaluated. Through the calculations of simple payback, net present value (NPV) and internal rate of return (IRR), at an estimated minimum attractiveness rate of 8% per year, the acquisition of an industrialized mortar projector was evaluated in comparison to hand of conventional work.

The equipment under analysis is the Menegotti Mortar Projector, which according to the manufacturer's specifications, has a mixing capacity of 150 liters, a pressure of 30 Bar, requires a three-phase voltage of 220 volts, with working autonomy for 5 hours per day. While conventional manpower produces about 20.00 to 35.00 square meters of daily towed area, the industrial mortar projector produces about 250.00 square feet per day. The area covered by the projector is about 40 meters horizontally and 20 meters vertically. In addition to increasing the coverage area, it reduces the amount of splicing in the plaster and reduces the use of scaffolding and rocker arms.

To obtain the cost of preparation of the mortar for the coating, the tables of SINAPI (National System of Prices and Indices for Civil Construction) were used. The values obtained for the industrialized mortar were measured in cubic meters per month and the number of employees was estimated from the monthly production predicted as a function of the number of operators; helpers and equipment.

2.1.1 Simulation of Monte Carlo and Crystal Ball

In the simulation of risk analysis, "one type of simulation in a spreadsheet is the Monte Carlo simulation, which generates random values for uncertain variables, repeatedly, to simulate a model" (CHARNES, 2007, p.6).

According to Jeronimo (2017), the Monte Carlo simulation is a powerful tool to support the decision-making process as well as the definition of strategic goals in companies. Through their use, managers can respond to the probability of an outcome occurring before making a decision, which was previously based on the result derived from a few specific scenarios. Its use is indicated for any stage of the planning process that involves decision making and risk, mainly in the support of the strategic planning budget, which is used to support the analysis of important medium and long term decisions.

Recent technological developments have made it possible for this type of study to be made accessible to companies in general. Currently there are several software that carry out this process, and they are inserted in electronic spreadsheets or in specialized budget planning systems. An example of a tool that makes Monte Carlo simulation possible is Crystal Ball.

Crystal Ball is an easy program to perform forecasting and risk analysis by eliminating uncertainty in decision making. Through the power of simulation, Crystal Ball becomes an effective tool in the hands of a decision maker (CHARNES, 2007, p.1).

Through the process carried out based on the application of the Crystal Ball method, one has more security, because in this procedure the projection, the probability of reaching the profitability of an enterprise, the variables that most affect a forecast are realized, helping to maintain competitive advantage, unlike other risk analysis and forecasting simulation programs.

III. METHODOLOGY

Consistent with the current reality of an increasingly competitive and demanding market, the industrialization of construction systems is essential for companies seeking to stay in the market and seek to offer products that meet acceptable technical and financial standards.

As already pointed out above, the consumer market for mortar coatings is expanding, being one of the most relevant services in Civil Construction, where contributions are fundamental to the work, and justified due to the scarce labor force, the implantation of technological innovations, in the case, through mortar designed mechanically.

This research is characterized as descriptive, aiming to demonstrate from an analysis the costs of the production of mortar coatings, the risk and return perspectives, identifying the most prosperous way of execution of mortar coatings, being mechanically designed or manually, hand-plated.

Characterized as an applied research in relation to its nature, since it intends to generate knowledge for practical applications directed to the solution of specific problems.

For the development of the present research was assumed a commercial / residential venture, which will be coated with industrialized mortar, with an estimated demand of 9,497 m² or 189,94m³ (thickness of 2,0cm) and estimated 20 days of services execution a month.

In this venture, we opted for the acquisition of a mortar projection machine, whose investment demands R $ 65,732.37 reais. This technology aims to reduce costs, ensure quality and expedite the completion of services.

As for productivity, for the projected mortar coating, will run 60.00 m² per day and worked 5 hours / day. For a satisfactory yield a team of three specialized employees is required, being a servant in charge of preparing the mortar and operating the machine, a mason to design and after a mason to sew and finish.

As for the productivity of the coating of hand-plated mortar, will run 20.00 m² per day and worked 8 hours / day. For a satisfactory yield a team of three employees is required, being a servant responsible for moving the mortar to the place of execution, and two masons for plating, finishing and finishing.

Regarding the composition of the costs for services and labor, the unit costs of the SINAPI reference sheet (National System of Prices and Indices for Civil Construction), of the elaboration period in August / 2018 with exemption, were used.

IV.   RESULTS

4.1. Investment initial

For Buarque (2004), the objective of the investment stage is to determine the financial resources needs to execute the project, put it into execution and guarantee its initial operation. The initial investment of the project is formed by the purchase and installation of the machines / equipment, and EPI's (Individual Protection Equipment). Table 1 below shows the values for the initial investment of the project, with acquisition of a mortar projector.

Table 1 - Initial Investment for Mortar Projector Acquisition

Description	Price (R$)
Acquisition of Mortar Projector	65.732,00
Epi's	1.500,00
TOTA	**67.232,00**

Source: produced by the authors

It is verified that the volume of investments, necessary to start the activities of the company in analysis is of R $ 67.232,00.

We consider that for the company that will use hand-plated mortar, it would only have initial investments related to the acquisition of PPE.

For the calculation of viability, the fixed costs, variable costs, investment values, taxes and number of employees required to carry out such operations were taken into account. The cost summary is shown in Tables 2 and 3, showing in detail the expenses for mechanically designed mortar and mortar applied by the traditional method, respectively. After the costs were raised, a minimum profit equivalent to 29.79% and 34.24%, respectively, was estimated for the projected and manual.   For the composition of labor costs, the costs with FGTS, INSS and 13th salaries were calculated.

Table 2 - Monthly Costs for Projected Mortar

FACADE WITH PROJECTED MORTAR				
Description			PRICE (R$)	TOTAL (R$)
Industrial mortar for plaster	24	m³	590,10	14.162,40
Labor	1	month	6.551,36	6.551,36
Third party services	1	month	730,00	730,00
Water	1	month	300,00	300,00
Rental of suspended scaffold, type fachadeiro, capacity of 250kg / m²	1	month	600,00	600,00
Electricity	1	kW/month	400,00	400,00
SUBTOTAL				22.743,76
		Lucro	29,79%	32.392,08

Source: produced by the authors

Table 3 - Monthly Costs for Hand-Held Mortar

FACADE WITH ARGAMASSA HINGED				
Description			PRICE (R$)	TOTAL (R$)
Industrial mortar for plaster	24	m³	590,10	4.720,80
Labor	1	month	8.090,33	8.090,33
Third party services	1	month	3.900,00	730,00
Water	1	month	300,00	300,00
Rental of suspended scaffold, type fachadeiro, capacity of 250kg / m²	1	month	600,00	600,00
Electricity	1	kW/month	200,00	200,00
SUBTOTAL				22.743,76
		Lucro	34,74%	32.392,08

Source: produced by the authors

It is evidenced that the expenses with material in the mechanized method are 3x higher than the conventional method, and this is due to the fact that the expected productivity is higher (24.00 m³ per month), although the input is the same - industrialized mortars. Compared to the item labor, one observes a greater expense referring to the traditional method, while the mechanized method does not need exaggerated human involvement, in controversy, the other one is based on the work mostly human.

It was considered that the mortar supplied for the works would be of the industrialized type, dosed in central. The acquisition of mortar of the industrialized type, guarantees uniformity in the trace and confers superior

quality to the coating. A flow chart was established, as shown in flowchart 1 and 2 below, with the necessary operations for the application of mortar with the use of a projector and hand-plated.
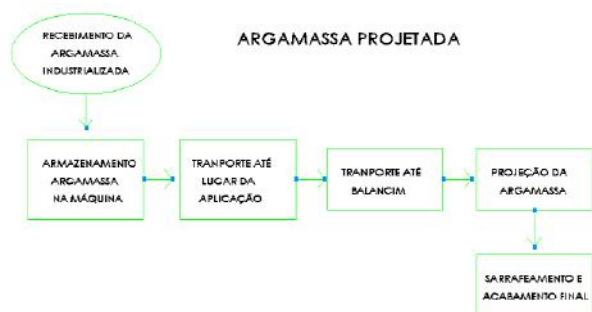
Flowchart 1 - Executive Process Using Mortar Projector

Source: produced by authors
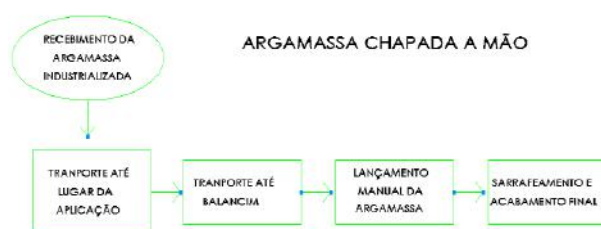
Flowchart 2 - Executive Process Hand-Held Mortar

Source: produced by the authors

In the economic viability analysis, the following Internal Rate of Return (IRR), NPV (Net Present Value), TIR (Internal Rate of Return) and Payback indicators were generated, comparing them with a TMA (Minimum Rate of Attractiveness) of 8, 00% per year.

The aforementioned indicators were analyzed using classic investment analysis methods according to two different scenarios, considering the acquisition of equipment for the projection of mortar and hand-plated mortar.

The cash flow summary, shown in Tables 4 and 5, shows in detail the inputs and outputs for mechanically designed mortar and mortar applied by the traditional method, respectively.

Table 4 - Monthly cash flow for Projected Mortar

MONTH	PROJECTED MORTAR - 24M³/MONTH		
	DISBURSEMENT (R$)	RECIPE (R$)	CASH FLOW (R$)
0º MONTH	-67.232,00		-67.232,00
1º MONTH	-22.743,76	32.392,08	9.648,32
2º MONTH	-22.743,76	32.392,08	9.648,32
3º MONTH	-22.743,76	32.392,08	9.648,32
4º MONTH	-22.743,76	32.392,08	9.648,32
5º MONTH	-22.743,76	32.392,08	9.648,32
6º MONTH	-22.743,76	32.392,08	9.648,32
7º MONTH	-22.743,76	32.392,08	9.648,32
8º MONTH	-22.743,76	32.392,08	9.648,32
9º MONTH	-22.743,76	32.392,08	9.648,32
10º MONTH	-22.743,76	32.392,08	9.648,32
11º MONTH	-22.743,76	32.392,08	9.648,32
12º MONTH	-22.743,76	32.392,08	9.648,32
13º MONTH	-22.743,76	32.392,08	9.648,32
14º MONTH	-22.743,76	32.392,08	9.648,32
15º MONTH	-22.743,76	32.392,08	9.648,32
16º MONTH	-22.743,76	32.392,08	9.648,32
17º MONTH	-22.743,76	32.392,08	9.648,32
18º MONTH	-22.743,76	32.392,08	9.648,32
19º MONTH	-22.743,76	32.392,08	9.648,32
20º MONTH	-22.743,76	32.392,08	9.648,32
21º MONTH	-22.743,76	32.392,08	9.648,32
22º MONTH	-22.743,76	32.392,08	9.648,32
23º MONTH	-22.743,76	32.392,08	9.648,32
24º MONTH	-22.743,76	32.392,08	9.648,32

Source: produced by the authors

Table 5 - Monthly Cash Flow for Manual Mortar

MONTH	ARGAMASSA MANUAL - 8M³ / MONTH		
	DISBURSEMENT (R$)	RECIPE (R$)	CASH FLOW (R$)
0º MONTH	-67.232,00		-67.232,00
1º MONTH	-14.641,13	22.263,12	7.621,99
2º MONTH	-14.641,13	22.263,12	7.621,99
3º MONTH	-14.641,13	22.263,12	7.621,99
4º MONTH	-14.641,13	22.263,12	7.621,99
5º MONTH	-14.641,13	22.263,12	7.621,99
6º MONTH	-14.641,13	22.263,12	7.621,99
7º MONTH	-14.641,13	22.263,12	7.621,99
8º MONTH	-14.641,13	22.263,12	7.621,99
9º MONTH	-14.641,13	22.263,12	7.621,99
10º MONTH	-14.641,13	22.263,12	7.621,99
11º MONTH	-14.641,13	22.263,12	7.621,99
12º MONTH	-14.641,13	22.263,12	7.621,99
13º MONTH	-14.641,13	22.263,12	7.621,99
14º MONTH	-14.641,13	22.263,12	7.621,99
15º MONTH	-14.641,13	22.263,12	7.621,99
16º MONTH	-14.641,13	22.263,12	7.621,99
17º MONTH	-14.641,13	22.263,12	7.621,99
18º MONTH	-14.641,13	22.263,12	7.621,99
19º MONTH	-14.641,13	22.263,12	7.621,99
20º MONTH	-14.641,13	22.263,12	7.621,99
21º MONTH	-14.641,13	22.263,12	7.621,99
22º MONTH	-14.641,13	22.263,12	7.621,99
23º MONTH	-14.641,13	22.263,12	7.621,99
24º MONTH	-14.641,13	22.263,12	7.621,99

Source: produced by the authors

The NPV obtained shows us, in terms of today's currency, that the investment would yield us, respectively,

in projected mortar and hand-rolled mortar, a total of R $ 164,149.72 and R $ 115,714.77 above expectations. As the decision criterion is a zero or positive NPV, we can conclude that such an investment is attractive.

Figures 1 and 2, below, demonstrate the probability of project profitability from NPV. Considering the execution of 5,000.00 m² of hand-plated mortar the probability of return on investment is less than 5%. In the case of projected mortar, the probability of return is greater than 5%. The higher the NPV, the more profitable the project or new business (ROCHA and MELO, 2012).

Table 6 - Indicators

INDICATORS		
VP	231.378,98	182.946,77
VPL	164.146,98	115.714,77
VPLa	14.945,60	4.821,45
IBC	3,442	2,721
ROIA	5,28%	4,26%
TIR	13,69%	10,25%
ÍndiceTMA/TIR	0,55	0,73

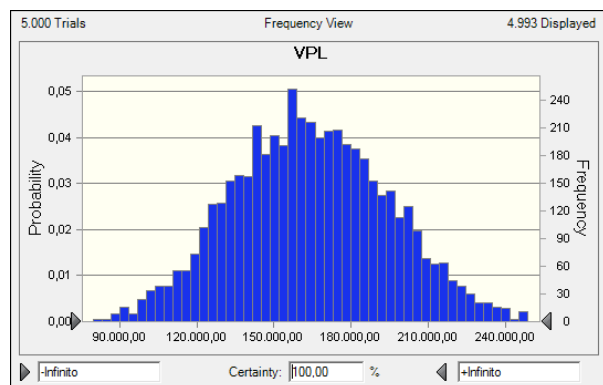Source: produced by the authors

Fig.1 - NPV for Projected Mortar
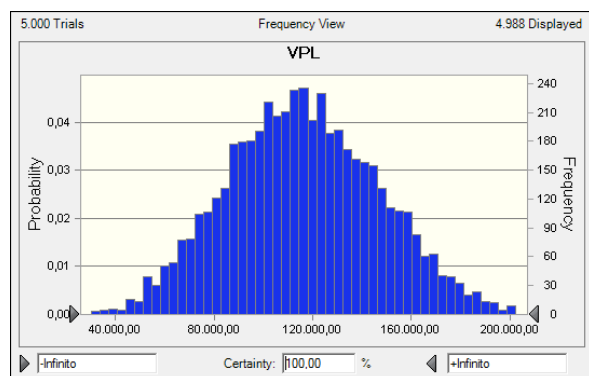
Source: produced by the authors

Fig.2 - NPV for Hand-Held Mortar

Source: produced by the authors

Table 7 - Statistics of Crystal Ball

STATISTICS OF THE CRYSTAL BALL ARGAMASSA PROJECTED			
Forecast: VPL		Forecast: ROIA	
Statistic	Forecast values	Statistic	Forecast values
Trials	5.000	Trials	5.000
Mean	164.251,99	Mean	5,25%
Median	163.345,76	Median	5,27%
Mode	'---	Mode	'---
Standard Deviatio	30.199,58	Standard Devia	0,58%
Variance	912.014.341,12	Variance	0,00%
Skewness	0,09164	Skewness	-0,23456
Kurtosis	2,7	Kurtosis	2,81
Coeff. of Variabili	0,18386	Coeff. of Variab	0,11036
Minimum	73.883,31	Minimum	3,14%
Maximum	261.529,74	Maximum	6,84%
Mean Std. Error	427,09	Mean Std. Erroi	0,01%

Source: produced by the authors

Table 8 - Statistics of the Crystall Ball

STATISTICS OF CRYSTALL BALL ARGAMASSA MANUAL			
Forecast: VPL		Forecast: ROIA	
Statistic	Forecast values	Statistic	Forecast values
Trials	5.000,00	Trials	500000,00%
Mean	116.261,53	Mean	4,00%
Median	115.345,78	Median	0,04
Mode	'---	Mode	'---
Standard Deviatio	30.782,36	Standard Devia	1,00%
Variance	947.553.606,86	Variance	0
Skewness	0,12143	Skewness	-0,30953
Kurtosis	2,73	Kurtosis	2,92
Coeff. of Variabili	0,26	Coeff. of Variab	17,67%
Minimum	24.262,68	Minimum	1,00%
Maximum	218.397,73	Maximum	6,00%

Source: produced by the authors

The IRR, which represents the true rate of return on investment, shows that such investment pays well above expectations (above 8% pa), which confirms the previous result (NPV), since the investment remains attractive, remunerating a rate of 13.69% per year and 10.24% a.a., respectively for the projected mortar and in the hand-plated mortar.

Finally, the discounted payback (PD), which consists of the time of recovery of the initial investment considering the amount of money in time, shows us a very satisfactory result, a recovery of the investment for the projected mortar within 7 months, and already for the hand-rolled mortar, due to the low investments, since the first month already recovers the initial investment.

Figures 5 and 6 show ROIA (Additional Return on Investment). For the projected mortar we have a market penetration average of 5.25% and for hand-plated mortar, the value reduces to 4.21%. These percentages show the tendency of the civil construction market, which seeks

more agile processes, increasing productivity and reducing the time the work fronts remain in the works.
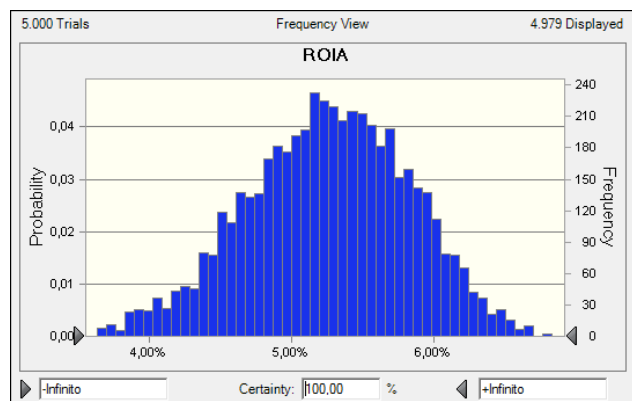

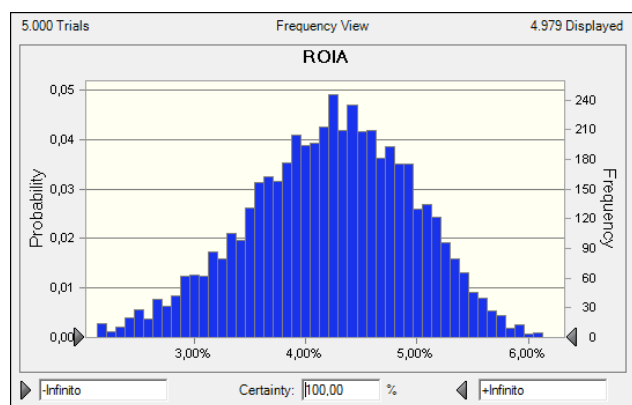*Fig.3 - ROIA for Engineered Mortar*

Source: produced by the authors

Fig.6 - ROIA for Hand-Held Mortar

Source: produced by the authors

V.   CONCLUSION

The general objective of this work was to evaluate the technical and economic viability of the use of the projected mortar in relation to the conventional mortar, based on a bibliographical review about the subject.

Regarding the technical feasibility, according to the results obtained, the implementation of the mechanically designed mortar system becomes viable. The gain with execution speed is very high, thus allowing less expenses with the team, engineers, administrative staff, financial and warehouse. The search for the productivity of civil works has been motivated, among others, by the absence of skilled labor aiming at a growth of the civil construction sector. These are factors that encourage companies to invest in technologies to increase productivity and at the same time improve quality.

In view of the above, after analyzing the results obtained, it is observed that this is an economically feasible investment because it presents advantageous results, quite attractive in all items analyzed and in the two executive methods presented.

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