GLOBUS PUBLICATION

Cosmos Journal of Engineering & Technology
A Refereed Research Journal
Vol 12 / No 2 / Jul-Dec 2022 ISSN: 2231-4210

FOOTING MAT BAR SETTER

[*] Roberto T. Aguillon, PhD
[**] Rolem L. Basiya, PhD

Paper Received: 11.09.2022 / **Paper Accepted**: 26.09.2022 / **Paper Published**: 28.09.2022
Corresponding Author: Roberto T. Aguillon, PhD; Email: robertoaguillon@yahoo.com; doi:10.46360/cosmos.et.620221005

Abstract

The study aimed to develop and fabricate a footing mat bar setter with technical features faster placement of reinforcements, adaptable to design of one and two-story building and easy installation. Moreover, the device will be subjected to functionality testing on assembly time, installation time and accuracy of placement. The research method employed was developmental and descriptive research utilizing the fifteen (15) construction experts along design, built and construction, Negros Occidental. A researcher-made questionnaire was formulated to evaluate the acceptability of the footing mat bar setter. The research instrument underwent validity and reliability testing. The statistical method used were the standard deviation, mean and Cronbach–alpha. The results of the study revealed that the device was able to meet the identified technical features. Furthermore, test trials showed that assembly time of the device will take eleven (11) minutes, the placement time of rebars for 1200x1200 mm is 7.08 minutes, 1000x1000mm is 3.45 minutes and 800x800mm is 2.22 minutes. The level of acceptability of the device in the aspects of design, functionality and features is very highly acceptability. It is recommended that the footing mat bar setter can be used as an alternative construction device in accomplishing mat bar assembly in shorter period of time.

Keywords: Footing, Foundation, Mat Bar, Reinforcement.

Introduction

Laying up a solid foundation that can support weight and keep structural integrity for the longest amount of time and conditions is the first step in creating great architectural marvels. If the proper foundation design, construction methods, and materials are followed, this first stage of a building's construction plays a significant role in assuring the safety of its occupants.

The foundation is a crucial structural component that transmits loads to the soil directly [3]. It can take the form of a widened portion of a wall or column, spreading courses beneath a foundation wall, or the foundation of a column, and its purpose is to spread the load over a larger area to prevent or reduce settling. A foundation's main job is to transport loads safely into the earth while supporting and anchoring the superstructure above it [2].

In constructing the foundation, there is a critical link in the distribution and resolution of building loads wherein the foundation system must be designed to both accommodate the form and layout of the superstructure above.

The footings distribute the load that they take on from columns or walls to the soil below in a way that limits settlement of the building, especially uneven or relative settlement, and prevents failure of the underlying soil [5].
Several steps go into building a structure's desired depth, fabricating and putting together the rebars, and then pouring the concrete. For estimators and quantity surveyors, estimating the labor cost for cutting, bending, inserting, and tying steel reinforcement has proven difficult since it depends on the design and specifications of the structural part. For footing with 10mm-25mm reinforcement, some industry experts estimate that cutting, bending, and placing rebar manually costs 30 manhours per metric ton of steel [9]. On another page, the labor cost is calculated at 0.07 manhours per kilogram of steel reinforcement [10]. These demonstrate how labor-intensive this procedure's cutting, bending, tying, and installation of reinforcing bars is.

Although building technology has advanced, construction workers still fabricate and install steel reinforcement manually, which frequently results in mistakes being made on the job [7]. A steelman is typically tasked with measuring, cutting, bending, and placing rebars under the direction and supervision of the construction supervisor or leadman. Ordinary workers typically assist in tying rebars to speed up the process. This approach frequently leads to incorrect installation and setting of steel reinforcement when carried out by unskilled individuals.

The proper implementation of structural details during construction is critical in the structure's reaction during unexpected seismic activities. The placement of rebars in footing has a big effect on the

*_**Carlos Hilado Memorial State University, Talisay City, Negros Occidental, Philippines.*

load carrying capacity of the footing. Any improper placement can cause serious structural failures.

This study seeks to develop a footing mat bar setter as an additional tool in the construction industry. The study further envisions to make the process of rebars placement faster and accurate for footings of structures up to two-floors in height. It is along the above-cited reasons that a study of this nature was conducted.

Methodology

This study used the technology and development research design. The invention, design, improvement, and construction of new types of products, equipment, and machinery is referred to as technology research and development [6]. In contrast, developmental research is the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet internal consistency and effectiveness criteria [4]. The footing mat bar setter was designed, manufactured, tested, and evaluated using the development method. Furthermore, the study adheres to the PASUC VI format, specifically on the design and evaluation model.

The descriptive method was used by construction industry experts to evaluate the level of acceptability of the footing mat bar setter. Descriptive research is defined as the process of gathering, analyzing, categorizing, and tabulating data about current conditions, practices, beliefs, and cause-effect relationships in order to make an adequate and accurate interpretation of such data [1].

The study follows the Input-Process-Output-Outcome (IPOO) model from its conceptualization to its completion, as shown in Figure 1.

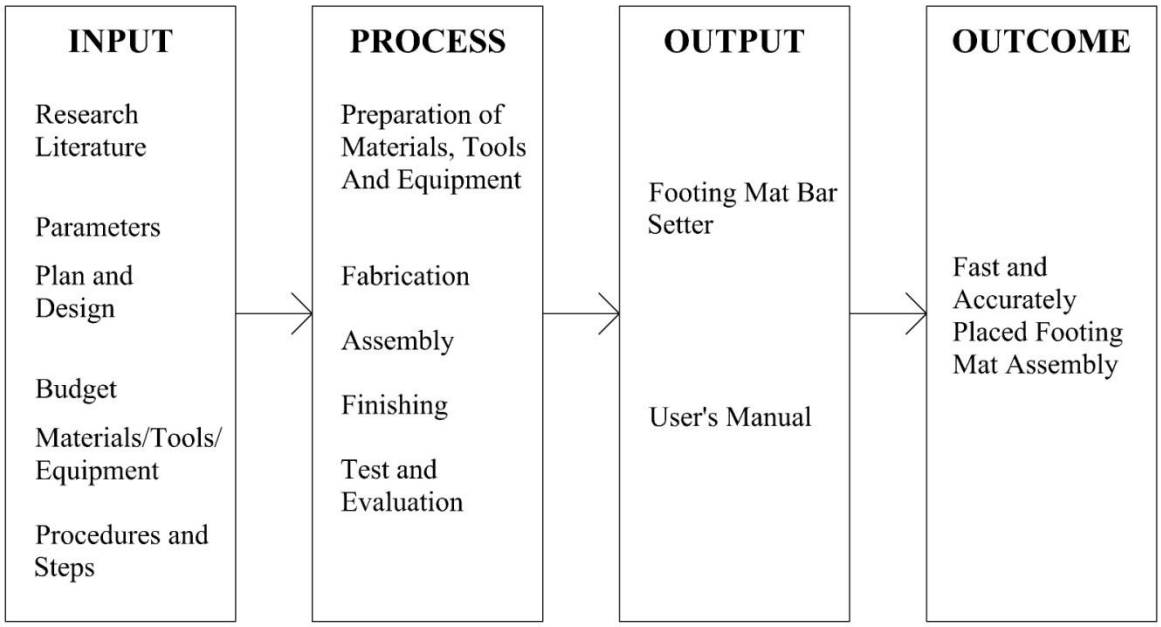

Figure 1: Framework of the Study

The conceptualization of the design starts with consultation from the industry practitioners to solicit their inputs as to the standard design of footings for structures up to two-floors. The input consists of research literature, parameters, plan and design, budget, materials/tools/equipment, procedure and steps taking into consideration the desired design features and functional requirements of the study.

The process consists of the preparation of materials, tools and equipment, fabrication, assembly, finishing, testing and evaluation of the footing mat bar setter.

The outputs of the study are the footing mat bar setter and the users' manual. The outcome is the fast and accurately placed footing mat bar assembly.

Design Plan, Preparation and Fabrication

The development of the footing mat bar setter begins with the conceptualization of its design, which is based on feedback from construction industry experts and other design-build professionals regarding the standard design of footings for structures up to two stories tall. The design of the new tool was inspired by the suggestions and recommendations of industry experts. After the

design features and functional aspects were satisfied, the scheme was finalized.

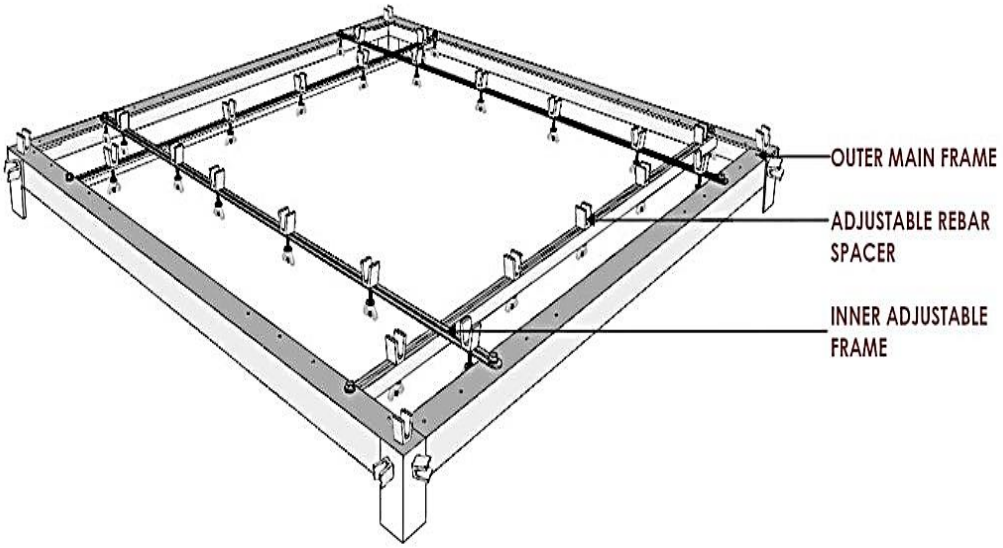

Figure 2: Perspective Drawing of the Mat Bar Setter and Parts

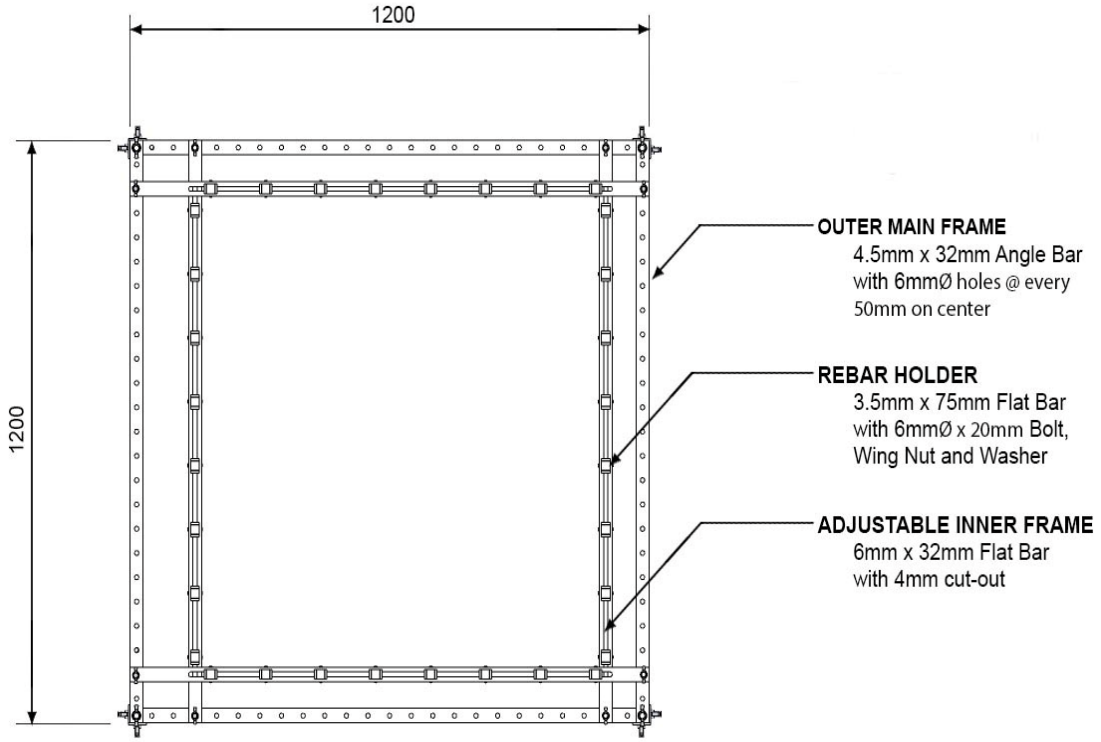

Figure 3: Perspective Drawing of the Mat Bar Setter with Measurement

Figures 2 and 3, show the perspective view and the plan of the footing mat bar setter, its measurements and the three main parts, namely; the outer main, the adjustable inner frame and the rebar holders.

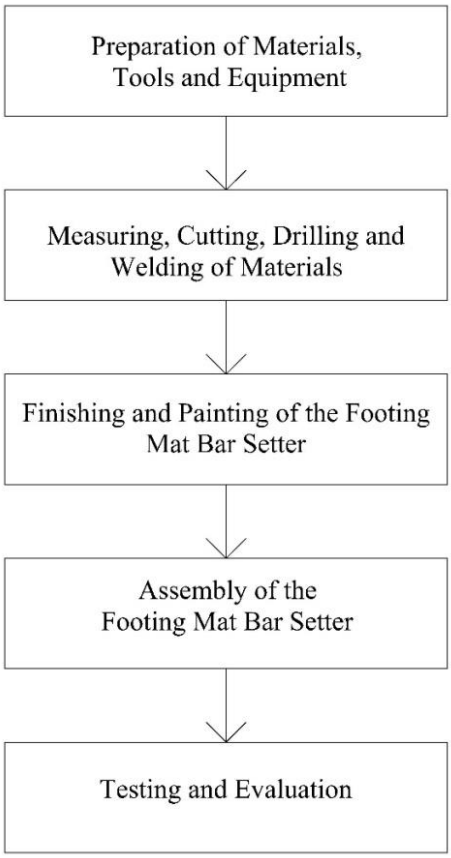

Figure 4: Workflow Development of the Mat Bar Setter

The mat bar setter's workflow progress is depicted in Figure 4. The building of the mat bar setter begins with the preparation of the necessary materials, tools, and equipment. The materials for the main frame and outer frame are then measured and cut. Bolt holes are marked and then drilled. The slots for the inner adjustable frames were carved at the machine shop. The rebar holders are then shaped to fit both 12mm and 16mm rebars by cutting and welding them together. The bottom of the bolts is then welded. After that, the footing mat bar is put together. The initial assembly's goal is to inspect the setter for mistakes. During the initial construction, it was found that the tool is too heavy to be carried by one person and that the outside main frame is unstable and kept sliding. The angle bars in the main frame were consequently reduced from 6mm to 4.5mm, and corner protectors were fitted to each corner. The footing bar setter was put back together after the changes were made to see if the issues and problems highlighted before had been fixed. The components are then taken apart for cleaning before being painted with metal priming paints to guard the tool from rust.

The footing mat bar setter is fully put together and ready for technical testing and expert review.

Evaluation Procedure

The footing mat bar setter was subjected to two (2) rounds of technical testing. Series of trials are conducted to determine the time required to assemble the footing mat bar setter for three (3) different sizes of footing. Trials were also carried out to determine the time required to place 12mm and 16mm rebars on the three (3) sizes of footings using both the footing mat bar setter and by manual method. The mean placement time scores obtained using the tool were compared to the data obtained using manual methods. Actual rebar placement and measurements were taken and compared to pre-determined distances for discrepancy. Finally, construction industry experts evaluated the tool in terms of design, functionality, and features.

Instrumentation

The following instrumentations were used to gather salient data for processing, analysis, and conclusions of the study.

The footing mat bar setter was used to place 12mm and 16mm rebars on three (3) sizes of footings: 800mm x 800mm, 1000mm x 1000mm, and 1200mm x 1200mm, to test its technical features for

easy installation and adaptability to different size of footing for structures up to two floors in height.

Trials were conducted to record the time of assembly of 12mm and 16mm rebars on three (3) different designs of footings for its functionality test in the area of assembly. The mean scores of the tool's assembly time were computed. In terms of rebar placement time, three (3) trials were carried out for 12mm and 16mm rebars on 800mm X 800mm footing, 1000mm x 1000mm footing, and 1200mm x 1200mm footing, using both the tool and the manual method. The mean scores of the tool-assisted placement times were compared to the manual-assisted placement times. In terms of placement accuracy, the distances of rebars placed with the footing mat bar setter and were measured and compared to the distances computed. The percentage of correct answers was recorded. Statistical tools were used in the trial results covering all areas of functionality.

In order to assess the acceptability of the rebar setter, a researcher-made questionnaire was distributed to fifteen (15) construction industry experts, who evaluated the footing mat bar setter in terms of design, functionality, and features. Five (5) members of the academe from Carlos Hilado Memorial State University (CHMSU) and La Consolacion College-Bacolod School of Architecture, Fine Arts, and Interior Design validated the questionnaires. The obtained mean score was 4.68, which was interpreted as valid. For test of reliability, the research instrument was administered to five (5) architects and five (5) civil engineers. Their responses yielded a score of 0.856, which was interpreted as reliable using the Cronbach's Alpha's reliability coefficient estimate. The researcher considered the suggestions of both validators and experts for improving the research instrument footing mat bar setter.

Data to be Gathered

The following data were computed in conducting series of testing and acceptability evaluation. Data on the assembly time and placement time of the rebars using the tool and manual method, and actual measurements of the distances of the rebars placed using the footing mat bar setter are required for the functionality features of the footing mat bar setter.

In terms of level of acceptability of the tool, mean scores and standard deviations were used in terms of design, functionality, features, and overall areas.

To facilitate accurate and statistical treatment of data, responses to the questionnaires were arranged into 5-point Likert scale and categorized into the following score range and interpretation:

Scale	**Range**	**Interpretation**
5	4.21- 5.00	Very High
4	3.41- 4.20	High
3	2.61- 3.40	Moderate
2	1.81- 2.60	Low
1	1.00 – 1.80	Very Low

Parameters for Analysis

The researchers set the following parameters for analysis: the assembly time of the device for three (3) different sizes of footings, a comparison of the mean scores of actual time incurred in placing 12mm and 16mm rebars on three sizes of footings using the footing mat bar setter and by manual installation, and a comparison of the measurements of the actual spacing of the footing mat bars placed using the tool against pre-determined spacing.

Cost Analysis

Table 1: ***Total Cost of Mat Bar Setter and Case***

Materials and Description	**Unit**	**Qty.**	**Unit Cost**	**Total Cost**
A. Cost of Mat Bar Setter				
4.5 mm x 32mm x 6.00 meters Angle Bars	lengths	1.00	₱ 307.00	₱ 307.00
6mm x 32mm x 6.00 meters Flat Bars	lengths	1.00	610.00	610.00
3.5 mm x 20mm x 6.00 m Flat Bar	lengths	1.00	83.20	83.20
6mm x 32mm Bolt w/ G.I. Washer & Wing Nut	Set	28.00	3.35	93.80
6mm x 20mm Bolt w/ G.I. Washer & Wing Nut	Set	16.00	4.50	72.00
10mm x 20mm Bolt w/ G.I. Washer & Wing Nut	Sets	8.00	8.50	68.00

4" Cutting Disk	Pcs.	4.00	35.00	140.00
14" Cutting Disk	Pcs.	1.00	339.00	339.00
10mm diam. Drill Bit	Pcs.	1.00	295.00	295.00
6mm diam. Drill Bit	Pcs.	6.00	119.75	718.50
6mm diam. Circular File	Pcs.	1.00	282.00	282.00
25mm Masking Tape	Pcs.	1.00	₱ 45.00	45.00
Others (10%)				305.35
Labor Cost: Cutting, Welding, Boring, Cleaning, Painting, & Assembly	9.00	days	480.00	4,320.00
Labor Cost of Slot Incision	4.00	set	1,200.00	4,800.00
Cost Footing Mat Setter				**₱12,173.50**
B. Cost of Case				
3/4" Ordinary Plywood	Pcs.	0.50	₱1,170.00	₱585.00
Steel Caster	sets	1.00	210.00	210.00
Consumables (20%)				159.00
Labor Cost				480.00
Total Cost of Case				**₱ 1,434.00**
Total Cost of Footing Mat Bar Setter and Case				**₱13,607.50**

The footing mat bar setter and the case cost a total of P13,607.50. The footing mat bar setter costs P12, 173.50, and the casing costs P1,434.00. Table 1 shows the cost breakdown for the footing mat bar setter in the amount of P3,053.50 for materials and P9,120.00 for labor. Labor costs include both on-the-job and contract labor. One skilled worker completed all of the device's cutting, boring of holes, grinding, filing, painting, and assembly. The numerous reworks to solve the problems encountered during the initial assembly and usage are not included in the total cost calculation. After the first incision by skilled labor revealed inaccurate and rough workmanship, the slot on the flat bar was incised by a local machine shop.

The total cost of the footing mat bar setter and the case may be easily recovered due to the tool's ability to be reused in multiple projects and the reduction in rebar placement time. The results revealed that the footing mat bar setter can be considered an excellent investment for the construction industry.

Users' Manual

In order to ensure that the tool is used to its full potential, the researchers developed a user manual that gives users pertinent information on the many elements of the instrument, their specifications, the functionalities of each part, appropriate usage, and safety measures to be observed.

Results and Discussion

Design and Fabrication of the Footing Mat Bar Setter

The first objective of this study was to design and construct a footing mat bar setter with the following technical features: faster reinforcement placement, adaptability to designs of one and two-story buildings, and ease of installation. This objective was accomplished because the footing mat bar setter adheres to the design plan and fabrication precisely. Figure 5 shows the finished footing mat bar setter with the steelbars.

Figure 5: The Developed Mat Bar Setter with Steel Bars

Testing the Functionality of the Footing Mat Bar Setter

The study's second objective was to establish the footing mat bar setter's functionality in terms of tool assembly time, steel reinforcement placement time, and placement accuracy. The corresponding data are presented in Tables 3 to 7.

a. Assembly Time of the Footing Mat Bar Setter

Table 2: **Actual Time Spent on Footing Mat Bar Setter Assembly on Three Different Sizes of Footing**

Size of Footing	No. of Rebars	Trial 1	Trial 2	Trial 3	Mean
1200mm x 1200 mm	14	14 .53	13.50	15.00	14.34
1000mm x 1000 mm	10	10.67	10.10	9.50	10.09
800mm x 800 mm	8	8.68	9.12	9.03	8.94

Table 3 shows the actual time spent assembling the footing mat bar setter. It demonstrates that the obtained mean scores of three (3) trials for the assembly of a 1200mm x 1200mm footing with 14 reinforcement is 14.34 minutes, 10.09 minutes for a 1000mm x 1000mm footing with 10 steel reinforcement, and only 8.94 minutes for an 800mm x 800mm footing with 8 steel reinforcement. The finding implies that the tool's assembly time is affected by the size of the footing and the number of rebars. The larger the size and the more reinforcement, the longer it takes to put it together. According to the data, assembling the setter takes about the same amount of time in minutes for every number of rebar (14 minutes for 14 rebars, 10 minutes for 10 rebars and 8.94 minutes for 8 rebars). Based on the size of the footing and the number of rebars, this information can be used to estimate the time required for assembly.

b. Placement time of rebars

Table 3: Time Incurred in the Placement of Rebars Using Manual Method (in Minutes)

Size of Footing	No. & Size of Rebars	Trial 1	Trial 2	Trial 3	Mean
1200mm x 1200 mm	14- 16mm	18.68	14.40	12.65	15.24
1200mm x 1200 mm	14- 12mm	13.55	11.70	11.58	12.28
1000mm x 1000 mm	10- 16mm	8.65	8.95	6.82	8.14
1000mm x 1000 mm	10- 12mm	7.27	6.40	6.93	6.87
800mm x 800 mm	8- 16mm	5.02	4.73	5.45	5.07
800mm x 800 mm	8- 12mm	5.85	5.67	5.02	5.51

Table 4 shows the time spent manually in placing rebars. The data revealed that it takes an average of 15.24 minutes to manually place 14 units of 16mm rebars on a 1200mm x 1200mm footing, but only 12.28 minutes to manually place 14 units of 12mm rebars on the same size of footing. The average time for manual placement of 10-16mm rebars in a 1000mmx1000mm footing is 8.14 minutes and 6.87 minutes for 10- 12mm rebars. In addition, the average time to place 8- 16mm rebars for an 800mm x 800mm footing is 5.07 minutes, and 5.51 minutes for 8-12mm rebars.

Table 4: Time Incurred in the Placement of Rebars Using the Footing Mat Bar Setter (in Minutes)

Size of Footing	No. & Size of Rebar	Trial 1	Trial 2	Trial 3	Mean
1200mm x 1200 mm	14- 16mm	8.65	8.52	8.42	8.53
1200mm x 1200 mm	14- 12mm	7.50	6.88	6.85	7.08
1000mm x 1000 mm	10- 16mm	3.45	3.35	3.43	3.41
1000mm x 1000 mm	10- 12mm	3.42	3.75	3.30	3.49
800mm x 800 mm	8- 16mm	2.35	2.08	2.18	2.21
800mm x 800 mm	8- 12mm	2.40	2.03	2.25	2.23

Table 5 shows that the average time to place 14-16mm rebars on 1200mm x 1200mm footings using the footing mat bar setter is 8.53 minutes and 7.08 minutes for 14-12mm rebars on the same size of footing. For 1000mm x 1000mm footings, the average time to place 10 - 16mm rebars is 3.41 minutes, and 3.49 minutes for 10-12mm rebars. Finally, for an 800mm x 800mm footing, the actual time required to place 8- 16mm rebars using the tool is 2.21 minutes, with an almost identical time of 2.23 minutes for 8- 12mm rebars.

Table 5: Summary of Mean Scores on the Time Incurred on Manual Rebar Placement and Using Footing Mat Bar Setter (in Minutes) and Variance

Size of Footing	No. & Size of Rebar	Placement by Manual Method	Placement by Footing Mat Rebar Setter	Variance	Percentage of Variance
1200mm x 1200 mm	14- 16mm	15.24	8.53	6.72	44.06%
1200mm x 1200 mm	14- 12mm	12.28	7.08	5.20	42.35%
1000mm x 1000 mm	10- 16mm	8.14	3.41	4.73	58.09%
1000mm x 1000 mm	10- 12mm	6.87	3.49	3.38	49.19%
800mm x 800 mm	8- 16mm	5.07	2.21	2.86	56.47%
800mm x 800 mm	8- 12mm	5.51	2.23	3.28	59.58%

The average amount of time required to install rebar using both the manual method and the footing mat bar setter is shown in Table 6. It also details the time difference between the two rebar placement techniques. The data also shows that the biggest difference in the average amount of time required to install rebar while utilizing a footing mat bar setter compared to hand placement is 59.58 percent, while the smallest difference is 42.35 percent. This is demonstrated by the fact that using the footing mat bar setter saves 3.28 minutes, or 59.58 percent, when compared to manually placing 8-12mm rebars on 800mm x 800mm rebars. The placement time for 10-16mm rebars on a 1000mm by1000mm footing is reduced by 4.73 minutes, or 58.09 percent; for 8-16mm rebars on an 800mmby 800mm footing, it is reduced by 2.86 minutes, or 56.47 percent; for 10-12mm x 12mm rebars on a 1000mm by 1000mm footing, it is reduced by 3.38 minutes, or 49.19 percent; and for 44.06 percent. When using the footing mat bar setter to install 14- 12mm x 12mm rebars on 1200mm x 1200mm footings, the mean time is decreased by 42.35 percent. For the sake of consistency, it should be mentioned that the worker who put the rebar during the footing mat bar setter is also the one who carried out the task manually.

Table 6 demonstrates that, when compared to the manual method, employing a footing mat bar setter speeds up the placement of rebar. The findings also indicate that the quantity of rebars has an impact on insertion time. Steelworks for footings are estimated to have a productivity rate of 0.07 manhours per kilogram of steel. Compared to 12mm, which weighs 0.89 kg/meter, 16mm is 1.58 kg/meter heavier. An average of 0.011 manhour/kg was found for all six footing mat bar assemblies using the information from Table 6 to determine the number of manhours/kg of rebar manually inserted. On the other hand, utilizing the footing mat bar setter to calculate the number of manhours/kg of rebar installation results in an average of 0.005 manhours/kg of rebars. This falls well short of the declared productivity requirement for the sector. This might be explained by the fact that cutting, bending, tying, and positioning are all part of the industry productivity norm. Of the four rebar work operations, placing rebars is the only one covered by the technical testing. Nevertheless, using the footing mat bar setter cuts down rebar placement time and manhours by over 50%, according to the placement time in the trials and conversion to manhours/kg of steel. This suggests that any contractor or builder would benefit from using a footing mat bar setter in the building sector. Labor costs may be reduced as a result, saving money. In addition, the additional time saved can be used for other crucial construction jobs, enabling the project to be finished on schedule.

c. Accuracy of rebar placement

The accuracy of the rebars using the tool is the final technical testing of the footing mat bar

Table 6: Actual Rebar Measurements, Crosswise and Lengthwise, Using the Footing Mat Bar

Rebars	Computed Distance (in mm)	Lengthwise (in mm)		Crosswise (in mm)	
		Actual Distance	Variance	Actual Spacing	Variance
A. 14- 16mm rebars on 1200mm x 120mm footing					
Rebars 1-2	15.50	15.50	0.00	15.50	0.00
Rebars 2-3	15.50	15.50	0.00	15.50	0.00
Rebars 3-4	15.50	15.50	0.00	15.50	0.00
Rebars 4-5	15.50	15.50	0.00	15.50	0.00
Rebars 5-6	15.50	15.50	0.00	16.00	0.50
Rebars 6-7	15.50	15.50	0.00	15.00	0.50
B. 10- 16mm rebars on 1000mm x 1000mm footing					
Rebars 1-2	18.25	18.50	0.25	18.25	0.00
Rebars 2-3	18.25	18.25	0.00	18.25	0.00
Rebars 3-4	18.25	18.25	0.00	18.50	0.25
Rebars 4-5	18.25	18.25	0.00	18.00	0.25
C. 8- 16mm rebars on 800mm x 800mm footing					
Rebars 1-2	18.00	18.00	0.00	18.50	0.50
Rebars 2-3	18.00	18.00	0.00	18.50	0.50
Rebars 3-4	18.00	18.00	0.00	18.00	0.00

Table 7 compares the calculated distances to the actual measurements of 16mm rebar distances that were installed longitudinally and crosswise on three different types of footings. Rebars are categorized as either lengthwise or crosswise and are distinguished by the quantity of locations.

The table demonstrates that there are some occasions where the computed spacing and the actual placement of rebars diverge. On the first footing, the actual distances between rebars 5 and 6 and rebars 6 and 7 exceeded the computed distance by 0.50mm (1200mm x 1200mm). On the second rebar, there were three occurrences documented. In terms of length, note the separations between the rebars 1 and 2, 3 and 4, and 4 and 5. The measuring difference is 0.25mm. On the other hand, spacing in all the rebars placed crosswise in the third footing (800mm x 800mm) exceeded by 0.50 mm each.

The discrepancy between the calculated spacing and the actual measurements of the rebar distances is significantly below the 2 percent tolerance threshold and above the minimal standard established by the American Concrete Institute (ACI) and the National Structural Code of the Philippines. This implies that the footing rebar setter is also acceptable in terms of placement and accuracy.

Acceptability of the Footing Mat Bar Setter

The third objective of this study was to determine the level of acceptability of the footing mat bar setter in the aspects of design, functionality and features. The corresponding data are presented in Table 8 to 11.

Table 7: Mean Scores in the Level of Acceptability of Footing Mat Bar Setter in Terms of Design

Item	Mean	SD	Interpretation
a. the design is appropriate for its purpose and function	4.87	0.35	Very Highly Acceptable
b. the device can endure wear and tear if used several times which makes it economical and a good investment	4.67	0.49	Very Highly Acceptable
c. the materials used for fabrication are carefully selected	4.73	0.59	Very Highly Acceptable
d. size of the device is convenient for users	4.73	0.59	Very Highly Acceptable
Mean	**4.75**	**0.46**	**Very Highly Acceptable**

According to Table 8, the footing mat bar setter's overall degree of acceptance in terms of design is 4.75, which is considered to be very highly acceptable. The chart also reveals that the footing mat bars setting item received the highest rating of 4.87 from respondents for being appropriate for its intended use and function. Both user convenience and careful material selection received mean scores of 4.73. With a mean score of 4.67, which is interpreted very high, the item on wear and tear gets the lowest mean score in the area of design.

The finding implies that the respondents rated the design as well-thought-out, with its four detachable components made of angle bars, flat bars, and bolts. The video demonstration of the tool's operation was viewed by respondents, who gave it favorable reviews. They appreciate the size because it is manageable to carry from place to place. Respondents recommended that the footing mat bar setter be produced for commercial use because there is currently no tool of this kind available on the market.

Table 8: Mean Scores in the Level of Acceptability of Footing Mat Bar Setter in Terms of Functionality

Item	Mean	SD	Interpretation
a. can expedite faster placement of steel reinforcement	5.00	.00	Very Highly Acceptable
b. can facilitate accurate placement of steel reinforcement	5.00	.00	Very Highly Acceptable
c. can accommodate square and rectangular footing with a maximum dimension of 1200mm x 1200 mm	4.93	0.26	Very Highly Acceptable
d. can adapt to two types of reinforcements, namely: 12mm and 16mm	4.73	0.46	Very Highly Acceptable
Mean	**4.91**	**0.12**	**Very Highly Acceptable**

Table 9 depicts the footing mat bar setter's level of acceptability in terms of functionality. The total mean score was 4.91, which is interpreted as very highly acceptable. The mean score of all the items under functionality is interpreted as very high. Respondents gave a perfect mean score of 5.00 to items faster steel reinforcement placement and accuracy of steel reinforcement placement. The item

on the footing mat bar that can accommodate square and rectangular footing obtained a mean score of 4.93. The item describing the footing mat bar as being adaptable to 12mm and 16mm reinforcement obtained the lowest mean score of 4.73 in this category.

The data further reveal that the respondents believe that the footing mat bar met the objectives and purpose of this study. The footing mat bar is regarded by the respondents as a prospective construction tool that will greatly aid in expediting the placement of footing rebars, particularly for projects up to two stories tall.

Table 9: Mean Scores in the Level of Acceptability of Footing Mat Bar Setter in Terms of Features

Item	Mean	SD	Interpretation
a. the parts are easy to assembly and dismantle even by ordinary workers	4.60	0.51	Very Highly Acceptable
b. the tool is easy to handle and can be transferred from one site to another with ease.	4.40	0.74	Highly Acceptable
c. easy to maintain or clean its parts	4.73	0.59	Very Highly Acceptable
d. The tool does not make up much space in storing	4.73	0.59	Very Highly Acceptable
Mean	**4.62**	**0.47**	**Very Highly Acceptable**

The footing mat bar setter has a total mean score of 4.62, as shown in Table 10, which is interpreted as very highly acceptable in terms of its features. The table also showed that out of the four aspects in this category, the footing mat bar setter had mean scores of 4.73, making it very acceptable in terms of how simple it is to maintain or clean its parts. The item with the highest mean score, easy assembly and disassembly, has a mean of 4.60, while the item with the lowest mean score, easy handling and transferability, has a mean of 4.40, which is interpreted as very high.

The results suggest that, along with ease of assembly and disassembly and portability, the respondents find ease of maintenance and the tool's capacity to be kept without taking up a lot of room to be its most advantageous features.

Table 10: Mean of the Mean Scores on the Level of Acceptability of Footing Mat bar Setter

Aspects	Mean	SD	Interpretation
Design	4.75	0.46	Very Highly Acceptable
Functionality	4.91	0.12	Very Highly Acceptable
Features	4.62	0.47	Very Highly Acceptable
Grand Mean	**4.76**	**0.35**	**Very Highly Acceptable**

The footing mat bar setter's overall degree of acceptability in terms of design, use, and features is shown in Table 11. The footing mat bar setter's overall mean score, which is 4.76 in the table, is considered to be very high. The chart also reveals that respondents gave the functionality of the footing mat bar setter the highest mean score of 4.91 out of the three areas of acceptability, followed by

design with a mean score of 4.75 and features with a mean score of 4.62.

According to the data, it appears that respondents evaluate the footing mat bar's functionality as its most valuable asset. This suggests that the tool will probably help to expedite the assembling of the footing mat setter and rebars.

Development of The Users' Manual of The Footing Mat Bar Setter

The fourth objective of the study was to develop a user manual for the users of the footing mat bar setter. The technical manual contains related information on the technical specification of the materials used, the features of the tool, the different parts, functions, assembly and disassembly procedures, safety measures to be observed, care and maintenance. The sample of users' manual is shown in Figure 6.

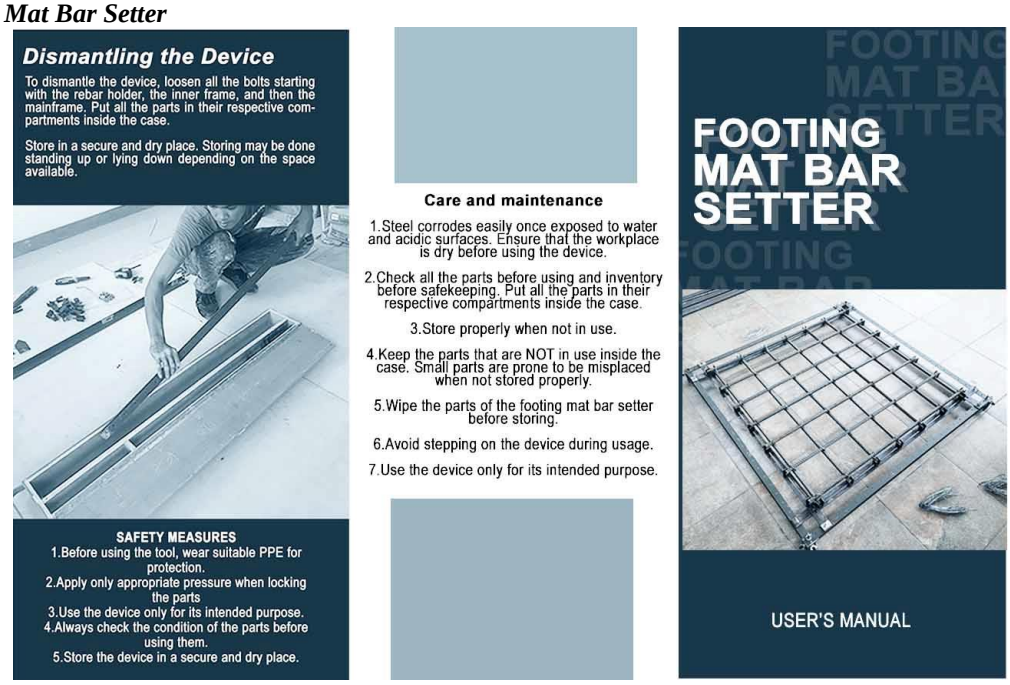

Figure 6*:* The Design and Content of Technical Users' Manual of The Footing Mat Bar Setter

Summary, Conclusion and Recommendations

Summary of Findings

The following are the summary of the findings of the study.

1. The concept, requirements, and workflow of the study served as the foundation for the design and manufacture of the footing mat bar setter. It has complied satisfactorily with its technical features of easy installation, adaptability to different footing designs for structures up to two floors, faster placement of steel reinforcement, and portability. According to technical testing, the footing mat bar setter can be used with 12mm and 16mm rebars on square or rectangular footings up to 1200mm x 1200mm in length. The footing mat bar setter can reduce the time it takes to install rebars on three (3) different footing sizes by up to 60%. The footing mat bar setter also allows for correct placement of rebars.
2. The respondents rated the footing mat bar setter as very highly acceptable in all technical aspects. It might therefore have a substantial market potential among developers, builders, and other industry professionals.
3. The Footing Mat bar setter user manual was formulated to guide the users on proper operation, parts functionality, assembly, and safe use.

Conclusion

With the foregoing findings, the following conclusions were formulated:

1. The footing mat bar setter's design and fabrication may provide a solution for users who need to rapidly and precisely install rebar in footings for structures of up to two floors in height.
2. The footing matbar setter offers faster footing mat bar assembly when compared to manual footing mat bar assembly.
3. The footing matbar setter was well-liked by construction industry professionals, implying that it has the potential to be used as an additional tool to complete construction tasks.

4. The user's manual will extend the machine's lifespan and protect the user from accidents.

Recommendations of The Study

Based from the findings and conclusions of the study, the following recommendations are formulated:

1. Future designs and construction of the footing mat bar setter may take into account other stronger materials that can support the weight of the rebars while being lighter in weight, making the instrument lighter and more portable.
2. Additional research on the casing might be done to improve its design and requirements.
3. For quicker assembly and to accommodate larger steel reinforcements, other rebar holder design configurations could be investigated and implemented.
4. The footing mat bar setter may be produced for the commercial market and used in building as a result of the extremely high acceptability assessment given by experts in the construction industry.

Conflict of Interest

There is no conflict of interest between the authors in this manuscript.

References

1. Calderon, J. (2006). Methods of research and thesis writing (2nd Ed.). Mandaluyong City: National Bookstore.
2. Ching, F. D. K. (2019). Building Construction Illustrated (Sixth Edit). John Wiley & Sons, Inc.
3. Harris, C. M. (2006). Dictionary of Architecture and Construction (Fourth Edi). The McGraw-Hill Companies, Inc.
4. Richey, R. C. (1994). Developmental Research: The Definition and Scope. 1994 National Convention of Teh Association Fr Educational Communications and Technology, 714-720. http://files.eric.ed.gov/fulltext/ED 373753.pdf
5. Varghese, P. (2010). Design of Reinforced Concrete Foundations. New Delhi, PH Learning Private Ltd.

Web Sources

1. Jeffress. What is Technology Research and Development? Retrieved Septemebr 25, 2022, from (*https://www.smartcapitalmind.com/what-is-technology-research-and-development.htm*)
2. CRSI- Field Inspection of Reinforcing Bars. Retrieved November 15, 2021, from https://www.scribd.com/document/434329208/CRSI-Field-Inspection-of-Reinforcing-Bars
3. Data Engineering Report No. 54: Field Inspection of Reinforcing Bars. Retrieved November 15, 2021, fromhttps://www.sefindia.org/forum/files/30edr54_103.
4. Philconprices (n.d.). Philippine Manpower and Equipment Productivity Ratio. Retrieved January 24, 2021, from https://philconprices.com/2021/01/philippine-manpower-and-equipment-productivity-ratio/
5. Rebar Productivity Rate. Retrieved from https://www.theprojectestimate.com/rebar-productivity-rate
6. Info. projectestimate (n.d.). *Rebar Productivity Rate*. Retrieved February 12, 2021, from https://www.theprojectestimate.com/rebar-productivity-rate/