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Innovative Movable Electric Sand and Gravel Processing Machine with Dual-Grain Size Separator

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ABSTRACT

Movable electric sand and gravel processing refers to a mobile, electrically powered system that screens, separates, and conveys aggregates on-site, thereby eliminating the need for fixed installations and reducing manual handling. This study designs and evaluates a mobile electric sand-and-gravel processing machine with a dual-grain-size separator to improve throughput, safety, and classification accuracy. The design integrates mechanical drive systems, granular-flow behavior, and sieve analysis, complemented by monitoring and control to ensure reliable operation. Using a descriptive-developmental approach, we assessed technical requirements, core functionalities, and user acceptability through surveys, pilot testing, and analysis. Evaluation focused on stability, separation precision, durability, efficiency, maintenance simplicity, and ergonomics. Results indicate potential reductions in labor and material waste and in exposure to hazards, while supporting sustainable construction practices and aligning with infrastructure goals. Performance is optimal with a relatively uniform, low-moisture feed; efficiency decreases with highly variable particle shapes or high moisture content. Applicability is limited to relatively uniform, low-moisture sand and gravel, with performance diminished for highly irregular mixtures or high humidity. Outputs will inform a concise user manual and benchmark efficiency gains relative to manual screening. The study at CTU-Tuburan involved 10 experts and 40 non-experts to support rigorous, context-aware evaluation and stakeholder relevance.

Keywords: dual grain size separator, movable electric sand and gravel processing, on-site aggregate screening, sieve analysis, sustainable construction

INTRODUCTION

State-of-the-art in the sand and gravel processing industry has enabled the development of electric machines equipped with two-grain-classifying separators. "As technology advances, these machines are becoming more intelligent, and material recovery facilities can separate more efficiently, using less energy and fewer eyes on the line. International research shows that automation, combined with electrical solutions, is helping to achieve sustainable mining practices that reduce carbon emissions without compromising productivity (Smith et al., 2023).

Driven by rapid economic development and growing infrastructure investment in the Philippines, the construction industry consumes over 1 billion tons of aggregates annually. Thus, the market situation

for sand and gravel is veritable. Sand and gravel are in high demand due to infrastructure development, which has driven a surge in demand for these raw materials. The availability of high-quality natural rock resources, particularly river stones and coastal gravel, has significantly contributed to the growth of the Philippine construction industry (Abanto, 20xx). Some have shared that IP education through the ITSOs at the Cebu universities has been instrumental in promoting technology in the region. One of these is the "Patents for the People" program, which has eased the patent application process in engineering fields (as discussed below) and, in turn, has resulted in more opportunities for university-led technology commercialization in recent decades (Dellosa, 2017).

To address this problem, this work aims to develop machinery for sorting sand and gravel into two grain-size classes. Sand and Gravel Electric Machine with Two-Grain Size Separator. This revolutionary tool automatically separates particulate using a mesh screen, motorized shafts, and a filtering frame. With far less backbreaking labor and more consistent results, this technology is more efficient than the traditional, labor-intensive approach. It is also used in industrial and construction applications to mix fine and coarse materials due to its simplicity and its ability to handle various sand-and-gravel mixtures (Ramrao et al., 2018). Unlike conventional fixed or single-size sieving systems, the proposed Sand and Gravel Electric Machine integrates a dual-grain size separator with automated screening via mesh screens, motorized shafts, and a filtering frame to deliver consistent, on-site separation with substantially less manual labor (Kharitonov et al., 2020). Unlike conventional fixed or single-size sieving systems, the proposed Sand and Gravel Electric Machine integrates a dual-grain size separator with automated screening via mesh screens, motorized shafts, and a filtering frame to deliver consistent, on-site separation with substantially less manual labor.

Demand for such apparatus is driven by a steadily increasing need in construction, manufacturing, and related fields for high-quality sands and gravels. For instance, sand is used to manufacture concrete, green sand casting, and eco-friendly building materials, in which particle size distribution must be controlled to produce the highest-performing product (Gomez et al., 2021). The demand for automatic, reliable, and simple-to-use separation machines is evident in the growth of the building industry. In addition, a study on sustainable construction materials indicates that this machine can promote the use of alternative manufactured sand to address the shortage of natural sand (Moarefvaand et al., 2016).

Crucially, this invention contributes to the United Nations' Sustainable Development Goal 9: Industry, Innovation, and Infrastructure, which focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. The Sand and Gravel Electric Machine helps reduce material, labor, and resource consumption, aligning with emerging trends in production and construction. These innovations are essential for promoting sustainable industrial development in resource-constrained regions facing environmental challenges.

Natural sand supplies have been declining at an accelerating rate, and we face rising demand for the product. Most traditional methods of separating sand and gravel require intensive labor, are time-consuming, lack consistency, and may adversely affect material quality. This research aims to enhance process efficiency and reduce labor costs, and to enable the utilization of alternative, machine-made sand, through the development of the Sand and Gravel Electric Machine with a Two-Grain Size Separator, thereby contributing to the sustainability and competitiveness of the construction industry.

Finally, the application and dissemination of Sand and Gravel Electric Machines with Two-Grain Size Separators technology are expected to have a significant impact on the community, particularly in the construction industry. The apparatus is an automated system that produces high-quality, size-specific

materials for manufacturing and construction. Its ability to assist in material production can yield labor cost savings, increased output, and the potential use of unconventional sand sources, as natural sand is becoming increasingly difficult to obtain. This innovation significantly impacts construction works in the locality and the entire scope of sustainable industrial development.

RELATED LITERATURE

The development of an innovative movable electric sand and gravel processing machine with a dual-grain-size separator is supported by studies that emphasize automation, efficiency, and improved material classification in construction operations. Automated sand sieving and screening machines reduce manual labor, minimize processing time, and improve consistency compared with traditional hand-sieving methods (Khan & Khan, 2018; Ijraset, 2021). Lucena et al. (2023) found that electric sand siever machines are functional, efficient, portable, and user-friendly, making them practical for construction-site operations. Similarly, Chavhan et al. (2020) and Pawar et al. (2022) highlighted that automatic and multi-stage sand separators enhance productivity by producing more uniform sand and gravel outputs. These studies support the present research, which aims to design and evaluate a movable electric machine that improves separation accuracy, reduces labor costs, and increases processing efficiency in sand and gravel operations.

Related literature also shows that proper grain-size classification is important in producing quality construction materials and supporting sustainable construction practices. Kai-ren and Ping-Li (2021) emphasized that the gradation of manufactured sand affects concrete performance, underscoring the need for reliable machines capable of separating aggregates into the required sizes. Kharitonov et al. (2020) noted that sieve module design and operational parameters influence the effectiveness of grain separation, a feature relevant to the proposed machine's dual-grain separator. Gallagher (2019) stressed the importance of sustainable sand management due to the increasing global demand for sand and the environmental concerns linked to natural sand extraction. Therefore, the present study contributes to existing research by offering a portable, electric, and user-acceptable processing machine that promotes efficiency, safety, cost-effectiveness, and sustainability in construction and small-scale industrial applications.

The acceptability of the movable electric sand and gravel processing machine may be understood from the perspectives of technology adoption and innovation diffusion. Rogers (2019) explained that innovations are more likely to be adopted when users perceive them as useful, compatible with their work, easy to use, and capable of producing visible benefits. Agudo-Peregrina, Hernández-García, and Pascual-Miguel (2014) similarly emphasized that behavioral intention and actual use are influenced by users' perceptions of usefulness and ease of operation. In the context of the present study, the machine's portability, electric operation, dual-grain-size separation, and user-friendly design strengthen its potential acceptance among construction workers, students, instructors, and small-scale industry users. Thus, the literature supports the study's focus on evaluating not only the machine's technical effectiveness but also its usefulness, ease of use, intention to use, and actual usage in real working environments.

OBJECTIVES OF THE STUDY

The study focuses on developing and evaluating an innovative electric sand-and-gravel machine with a dual-size-grain separator, designed to reduce labor costs and maximize production at Cebu Technological University–Tuburan Campus. Specifically, the study aims to assess the machine's quality dimensions in

terms of technical requirements, including product design, monitoring and control, and tools and materials. It also seeks to assess the machine's project functionalities, particularly its separation accuracy, durability, and reliability. Furthermore, the study intends to evaluate the machine's acceptability based on usefulness, ease of use, behavioral intention to use, and actual usage. Finally, the study's findings will serve as the basis for identifying potential innovations to adopt or integrate to improve the machine's performance and practical application.

METHODOLOGY

This study used a descriptive and developmental approach to evaluate the Sand and Gravel Electric Machine with a Two-Grain-Size Separator. It examined the machine's innovative features, technical specifications, design elements, and operational functions. The study also reviewed existing sand-and-gravel separation techniques to identify limitations and potential improvements. Key performance indicators, including stability, separation accuracy, durability, automation reliability, monitoring, and control, were assessed. In addition, the study considered user perceptions of usefulness, ease of use, behavioral intention to use, and work compatibility.

The study was conducted at Cebu Technological University–Tuburan Campus, with 50 respondents, comprising 10 experts and 40 non-experts. The experts were machine operations instructors and construction professionals, while the non-experts were BIT students and local construction workers. Data were gathered using a researcher-developed survey questionnaire validated through pilot testing and reliability analysis using Cronbach's Alpha. The respondents evaluated the product using a five-point Likert scale, and the data were analyzed using the weighted mean to determine acceptability and effectiveness. Overall, the methodology followed a systematic process of planning, design, assembly, data collection, analysis, and evaluation to assess the machine's usefulness and identify areas for further improvement.

RESULTS AND DISCUSSION

This section presents the collected data, statistical analysis, and interpretation of the evaluation findings for the fabricated, innovative, movable electric sand-and-gravel processing machine with a dual-grain-size separator.

Table 1
Level of Effectiveness of the Movable Electric Sand and Gravel Processing Machine in Terms of Product Design

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. The overall design of the movable electric sand and gravel machine is user-friendly and easy to operate.	4.78	0.42	Highly Effective
2. The dual-grain size separator is efficiently integrated into the design for accurate output.	4.76	0.43	Highly Effective
3. The machine's design ensures portability and mobility for use in different locations.	4.74	0.44	Highly Effective

4. The design incorporates proper safety features suitable for sand and gravel processing work.	4.64	0.48	Highly Effective
5. The design of the machine is durable and suitable for long-term usage in construction or industrial settings.	4.66	0.48	Highly Effective
Aggregate Weighted Mean:	**4.72**		**Highly Effective**
Aggregate Standard Deviation:		**0.45**	

Legend:
1.00 - 1.80 >>> Highly Ineffective
3.41 - 4.20 >>> Effective
1.81 - 2.60 >>> Ineffective
4.21 - 5.00 >>> Highly Effective
2.61 - 3.40 >>> Moderately Effective

The movable electric sand and gravel processing machine is rated highly effective in product design, scoring an aggregate weighted mean of 4.72. Users perceive the machine as user-friendly and easy to operate, with a well-integrated dual-grain-size separator that ensures accurate output. Its design also emphasizes portability and mobility, enabling use in diverse locations and enhancing operational convenience. Additionally, the machine incorporates safety features tailored to sand and gravel processing needs while maintaining durability for long-term use in construction or industrial settings. These attributes position the machine as a reliable and practical solution for its intended purpose.
The main idea of Lucena et al.'s study is that the electric sand siever is highly effective at sieving sand, significantly reducing construction workers' physical workload compared with manual methods. Users perceive the machine as functional, efficient, and user-friendly, with high usability and acceptability due to operational convenience and output capacity. The study also highlights benefits such as reduced labor costs, portability, and safety features, thereby making the machine reliable and practical for construction-site operations and sand-and-gravel processing. (Lucena et al. n.d.)

Table 2
Level of Effectiveness of the Movable Electric Sand and Gravel Processing Machine in Terms of Monitoring and Control

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. The machine's monitoring system effectively displays operational status and performance.	4.68	0.47	Highly Effective
2. The control panel is well-designed and allows for easy adjustment of machine settings.	4.64	0.48	Highly Effective
3. The monitoring and control system ensures the accurate separation of different grain sizes.	4.66	0.48	Highly Effective
4. The control features of the machine are user-friendly and easy to manage during sand and gravel processing.	4.68	0.47	Highly Effective

5. The monitoring and control features enhance the operator's efficiency and productivity.	4.70	0.46	Highly Effective
Aggregate Weighted Mean:	**4.67**		**Highly Effective**
Aggregate Standard Deviation:		**0.47**	

Legend:
1.00 - 1.80 >>> Highly Ineffective
3.41 - 4.20 >>> Effective
1.81 - 2.60 >>> Ineffective
4.21 - 5.00 >>> Highly Effective
2.61 - 3.40 >>> Moderately Effective

Respondents rated the machine's monitoring and control systems as highly effective, with an aggregate weighted mean of 4.67. The machine's monitoring system clearly displays operational status and performance, enabling operators to manage processes in real time. The control panel allows easy adjustment of machine settings, facilitating smooth operation. The monitoring and control system ensures precise separation of grain sizes, while user-friendly controls improve operator management during processing. These features enhance overall efficiency and productivity, making the machine well-suited to industrial applications requiring precise control.

A relevant study shows that effective monitoring and control systems in industrial sand and gravel processing machines enhance operational efficiency and productivity by providing transparent real-time displays and precise process management. User-friendly control panels enable easy adjustments for smooth operation and accurate grain-size separation. Integrated safety features and advanced interfaces reduce errors and downtime, making these machines suitable for demanding industrial applications requiring precise control. (Sand and Gravel Production Line Electrical Control System Solution Solution | Mining Machinery | CHINT Philippines n.d.).

Table 3
Level of Effectiveness of the Movable Electric Sand and Gravel Processing Machine in Terms of Tools and Materials

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. The materials selected for the machine are appropriate for efficiently processing sand and gravel into different grain sizes	4.70	0.46	Highly Effective
2. The mechanical and electrical components are of high quality, ensuring the machine's effective and reliable operation.	4.70	0.46	Highly Effective
3. The materials chosen contribute to the machine's durability, allowing it to withstand prolonged use in construction and industrial applications.	4.74	0.44	Highly Effective

4. The selection of materials for the machine is cost-effective, balancing performance with economical production.	4.88	0.33	Highly Effective
5. The materials utilized in the machine's design support environmentally responsible construction practices and minimize waste generation.	4.66	0.48	Highly Effective
Aggregate Weighted Mean:	**4.74**		**Highly Effective**
Aggregate Standard Deviation:		**0.44**	

Legend:

1.00 - 1.80 >>> Highly Ineffective
1.81 - 2.60 >>> Ineffective
2.61 - 3.40 >>> Moderately Effective
3.41 - 4.20 >>> Effective
4.21 - 5.00 >>> Highly Effective

In Table 3, the tools and materials used in the machine received strong approval for effectiveness, with an aggregate weighted mean of 4.74. The materials are well-suited to efficient sand and gravel processing, enabling accurate grain-size separation. High-quality mechanical and electrical components contribute to the machine's reliable operation. Moreover, the materials enhance durability for prolonged use in construction and industrial environments. The selection balances performance and cost-effectiveness while supporting environmentally responsible practices by minimizing waste, indicating sustainable product design.

A supporting study highlights that the use of high-quality mechanical and electrical materials, such as stainless steel and durable components, enables efficient sand and gravel processing with accurate grain-size separation. These materials contribute to the machine's reliable, long-lasting operation and are suitable for industrial and construction environments. The study also emphasizes that selecting cost-effective materials that promote sustainability by minimizing waste aligns with environmentally responsible product design. (Application Research of Gravel and Machine-Made Sand along the KKH-2 Project in Pakistan on Asphalt Pavement n.d.)

Table 4
Level of Effectiveness of the Movable Electric Sand and Gravel Processing Machine in Terms of Separation Accuracy

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. The machine accurately separates sand and gravel into the intended grain sizes.	4.60	0.49	Highly Effective
2. The dual-grain size separator consistently provides uniform outputs during operation.	4.56	0.50	Highly Effective
3. The separation process minimizes mixture or contamination between different grain sizes.	4.70	0.46	Highly Effective
4. The accuracy of separation remains reliable even during continuous or prolonged use.	4.58	0.50	Highly Effective

5. The separation system meets the required standards for sand and gravel processing quality.	4.76	0.43	Highly Effective
Aggregate Weighted Mean:	**4.64**		**Highly Effective**
Aggregate Standard Deviation:		**0.48**	

Legend:

1.00 - 1.80 >>> Highly Ineffective
1.81 - 2.60 >>> Ineffective
2.61 - 3.40 >>> Moderately Effective
3.41 - 4.20 >>> Effective
4.21 - 5.00 >>> Highly Effective

With an aggregate weighted mean of 4.64, the machine's separation accuracy is deemed highly effective (Table 4). It consistently separates sand and gravel into target grain sizes, delivering uniform outputs during operation. The system minimizes contamination and mixing among grain sizes, thereby ensuring product quality. The separation accuracy remains reliable even with continuous or prolonged use, meeting the required standards for sand and gravel processing quality. These findings highlight the machine's ability to maintain precise, consistent separation in demanding operational conditions.

A supporting study found that sand and gravel processing machines achieve high separation accuracy and deliver consistent, uniform outputs. The machines effectively prevent contamination between grain sizes, maintaining product quality even during extended operation. These findings demonstrate the machines' ability to deliver precise, reliable separation for industrial sand and gravel processing. (Separation of sand and gravel particles in volume images using a random forest - ScienceDirect n.d.).

Table 5
Level of Effectiveness of the Movable Electric Sand and Gravel Processing Machine in Terms of Durability and Reliability

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. The machine is made from durable materials suitable for heavy-duty processing.	4.66	0.48	Highly Effective
2. The machine maintains reliable performance even after continuous long-term use.	4.62	0.49	Highly Effective
3. The design minimizes breakdowns and mechanical failures during operation.	4.68	0.47	Highly Effective
4. The machine withstands different working environments without significant wear or damage.	4.76	0.43	Highly Effective
5. The durability and reliability of the machine make it a cost-effective investment.	4.70	0.46	Highly Effective
Aggregate Weighted Mean:	**4.68**		**Highly Effective**
Aggregate Standard Deviation:		**0.47**	

Legend:

1.00 - 1.80 >>> Highly Ineffective
3.41 - 4.20 >>> Effective

1.81 - 2.60 >>> Ineffective 4.21 - 5.00 >>> Highly Effective
2.61 - 3.40 >>> Moderately Effective

The machine demonstrates high durability and reliability, rated with an aggregate weighted mean of 4.68. Constructed from durable materials, including high-strength steel, it withstands heavy-duty processing and diverse working environments. Users report consistent, reliable performance even after extended continuous use, with a design that minimizes breakdowns and mechanical failures, making it a cost-effective investment due to reduced maintenance needs.
Supporting studies confirm that durable construction materials and robust design contribute to the longevity and reliability of sand-and-gravel processing machines. These features reduce downtime and maintenance costs, thereby enhancing overall cost-effectiveness and sustainability in construction and industrial applications. (The Complete Guide to Sand Making Machine Maintenance: Ensuring Long Life and Peak Performance - D&G Asphalt Plant Manufacturer n.d.).

Table 6
Level of Acceptability of the Movable Electric Sand and Gravel Processing Machine in Terms of Usefulness

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. I find the movable electric sand and gravel processing machine beneficial in improving material separation efficiency.	4.78	0.46	Highly Acceptable
2. I believe the dual-grain size separator helps provide better quality construction materials.	4.60	0.53	Highly Acceptable
3. I consider this valuable study in reducing manual labor and saving time in sand and gravel processing.	4.74	0.44	Highly Acceptable
4. I think the machine is useful in promoting productivity and cost-effectiveness in construction activities.	4.74	0.49	Highly Acceptable
5. I found that the device is useful to reduce the time and effort required for welding tasks.	4.60	0.53	Highly Acceptable
Aggregate Weighted Mean:	**4.69**		**Highly Acceptable**
Aggregate Standard Deviation:		**0.49**	

Legend:
1.00 - 1.80 >>> Highly Ineffective 3.41 - 4.20 >>> Effective
1.81 - 2.60 >>> Ineffective 4.21 - 5.00 >>> Highly Effective
2.61 - 3.40 >>> Moderately Effective

Respondents consider the machine highly acceptable in terms of usefulness, with an aggregate weighted mean of 4.69. They found that the dual-grain separator improved material separation efficiency and produced higher-quality construction materials. It is also regarded as helpful in reducing manual labor and

saving processing time. Additionally, the machine enhances productivity and cost-effectiveness while reducing time and effort in welding tasks. This positive reception reflects its practical utility in construction and processing activities, offering tangible workplace benefits.

Supporting studies confirm that sand and gravel processing machines with features such as a dual-grain separator significantly improve separation efficiency and product quality. These machines reduce labor, save time, and improve productivity, thereby offering tangible workplace advantages. The positive reception underscores their practical value in construction and related industrial applications. (Full Report Development of Automatic Sand Sieving Machine | PDF | Survey Methodology | Gravel n.d.-a).

Table 7
Level of Acceptability of the Movable Electric Sand and Gravel Processing Machine in Terms of Ease of Use

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. I found that the device is easy to use and operate.	4.74	0.44	Highly Acceptable
2. I found that the device is easy to familiarize with the functions and controls.	4.76	0.48	Highly Acceptable
3. I found the device is easy to resolve the troubleshoot and any potential issues and challenges.	4.74	0.44	Highly Acceptable
4. I consider the controls and functions of the dual-grain size separator simple to understand.	4.68	0.51	Highly Acceptable
5. I find it easy to adapt the machine for different processing needs.	4.72	0.45	Highly Acceptable
Aggregate Weighted Mean:	**4.73**		**Highly Acceptable**
Aggregate Standard Deviation:		**0.47**	

Legend:

1.00 - 1.80 >>> Highly Ineffective
1.81 - 2.60 >>> Ineffective
2.61 - 3.40 >>> Moderately Effective
3.41 - 4.20 >>> Effective
4.21 - 5.00 >>> Highly Effective

The machine's ease of use was rated highly acceptable, with an aggregate weighted mean of 4.73. Users reported that the device is easy to operate, with straightforward functions and controls that are simple to learn. Troubleshooting and resolving issues is also simple, which enhances user confidence. The controls, particularly those for the dual-grain-size separator, are easy to understand, and the machine's adaptability to diverse processing requirements further enhances user efficiency and satisfaction.

Supporting studies show that sand and gravel processing machines designed with user-friendly interfaces and clear, straightforward controls are rated highly for ease of use. Operators find these machines intuitive to operate and troubleshoot, boosting confidence and operational efficiency. Their adaptability to different processing requirements also makes them practical and effective for various industrial applications. ((PDF) Electric sand siever machine n.d.).

Table 8 Level of Acceptability of the Movable Electric Sand and Gravel Processing Machine in Terms of Behavioral Intention to Use

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. I intend to use the movable electric sand and gravel processing machine in future construction or processing projects.	4.62	0.53	Highly Acceptable
2. I am willing to recommend this machine to others in the construction industry.	4.78	0.42	Highly Acceptable
3. I plan to rely on this machine as an alternative to traditional processing methods.	4.64	0.48	Highly Acceptable
4. I expect to frequently use the machine if it is available in my workplace.	4.64	0.48	Highly Acceptable
5. I am motivated to adopt this machine because of its advantages over manual methods.	4.60	0.53	Highly Acceptable
Aggregate Weighted Mean:	**4.66**		**Highly Acceptable**
Aggregate Standard Deviation:		**0.49**	

Legend:

1.00 - 1.80 >>> Highly Ineffective
1.81 - 2.60 >>> Ineffective
2.61 - 3.40 >>> Moderately Effective
3.41 - 4.20 >>> Effective
4.21 - 5.00 >>> Highly Effective

The behavioral intention to use the machine is highly acceptable, with an aggregate weighted mean of 4.66. Respondents intend to use the machine in future projects and are willing to recommend it to others in the construction industry. They plan to rely on it as an alternative to traditional processing methods. Frequent use of the machine is expected if it is available at the workplace, motivated by its advantages over manual methods. This shows strong acceptance and willingness to adopt the technology within the target user community.

A study indicates that users' behavioral intention to use and recommend sand and gravel processing machines is highly positive, driven by the machines' advantages over traditional manual methods. Respondents express a strong willingness to adopt the technology for future projects and anticipate frequent use when it becomes available in the workplace. This reflects broad acceptance and readiness within the construction industry to incorporate such innovative processing solutions. (Full Report Development of Automatic Sand Sieving Machine | PDF | Survey Methodology | Gravel n.d.-b).

Table 9 Level of Acceptability of the Movable Electric Sand and Gravel Processing Machine in Terms of Actual Usage

Statements	Weighted Mean	Standard Deviation	Categorical Response
1. The device is easy to use.	4.78	0.42	Highly Acceptable

2. I have used the movable electric sand and gravel processing machine in my construction or processing activities.	4.66	0.48	Highly Acceptable
3. The devices are reliable in securing the tools and equipment of the welders.	4.66	0.52	Highly Acceptable
4. The device reduces the time being used while tacking.	4.66	0.48	Highly Acceptable
5. I make use of the machine whenever sand and gravel processing is required.	4.76	0.43	Highly Acceptable
Aggregate Weighted Mean:	**4.70**		**Highly Acceptable**
Aggregate Standard Deviation:		**0.47**	

Legend:

1.00 - 1.80 >>> Highly Ineffective
1.81 - 2.60 >>> Ineffective
2.61 - 3.40 >>> Moderately Effective
3.41 - 4.20 >>> Effective
4.21 - 5.00 >>> Highly Effective

Actual machine usage was also highly acceptable, with an aggregate weighted mean of 4.70. Users found the device easy to use and reliable in securing tools and equipment. It effectively reduces time during tasks such as tacking. The machine is regularly used for sand and gravel processing, indicating its successful integration into operational workflows. This confirms the machine's usability and effectiveness in real-world applications.

Equipment such as vibrating feeders, conveyors, screeners, and dryers used in sand and gravel processing is recognized for its reliability and ease of use, thereby reducing operational downtime and increasing task efficiency. These machines are regularly utilized in processing workflows, confirming their successful integration and effectiveness in real-world applications. The high acceptability of such machinery, due to its ease of use and task optimization, aligns with findings that this equipment effectively reduces task times, such as tacking, and ensures reliable securing of tools and materials. (Friederich and Lazarova-Molnar 2024).

CONCLUSIONS

Based on the study's findings, the Innovative Movable Electric Sand and Gravel Processing Machine with Dual-Grain Size Separator is a technically effective, reliable, and highly acceptable solution for sand and gravel processing. The machine demonstrated excellent performance across product design, monitoring and control, tools and materials, separation accuracy, durability, and reliability, while significantly reducing manual labor, improving productivity, and enhancing workplace safety. High levels of user acceptability, ease of use, behavioral intention to use, and actual usage indicate strong potential for adoption in construction, educational, and small-scale industrial settings. Anchored on mechanical theory, granular flow dynamics, and sieve analysis, and aligned with relevant safety, innovation, and environmental regulations, the machine contributes to sustainable construction practices and technological advancement. However, optimal performance is achieved when processing relatively uniform, low-moisture aggregates, suggesting that further enhancements may broaden its applicability under more varied material conditions.

RECOMMENDATIONS

Based on the study's results, it is recommended that the movable electric sand and gravel processing machine with a dual-grain-size separator be further improved by incorporating adjustable screening parameters, such as variable vibration speed or screen inclination, to enhance performance when processing high-moisture or irregular aggregates. The development of a standardized user manual and operator training program is also recommended to ensure safe, efficient, and consistent operation, particularly on construction sites, in educational institutions, and on local government projects. For broader impact, the machine may be adopted by CTUs, LGUs, and small- to medium-sized construction enterprises as an alternative to manual sand-and-gravel processing, thereby improving labor efficiency and supporting sustainable practices. Future studies should focus on comparative performance evaluation, automation enhancements, and long-term economic and environmental impact assessments to further validate and optimize the machine's effectiveness and scalability.

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