Al-Qadisiyah JournalFor Engineering Sciences 18 (2025) 391 – 396

Contents lists available at: http://qu.edu.iq

Al-Qadisiyah Journal for Engineering Sciences

Journal homepage: https://qjes.qu.edu.iq

Research Paper

Smart sea pontoon production by reinforcement HDPE for sea current behavior in Thailand

Tanapat Virit [1], ***Rerkchai Fooprateepsiri*** [2]✉, ***Kritsada Anantakarn*** [1]✉, ***Bhattharadej Witchayangkoon*** [3], ***and Koltouch Anantakarn*** [3]

[1] *Division of Civil Engineering and Construction Management, Faculty of Engineering and Architecture, Rajamangala University of Technology, Thailand.*
[2] *Faculty of Business Administration and Information Technology, Rajamangala University of Technology Tawan-ok, Thailand.*
[3] *Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, Rangsit, Khlong Luang District, Pathum Thani, Thailand.*

ARTICLE INFO

Article history:
Received 15 July 2024
Received in revised form 25 March 2025
Accepted 11 October 2025

keyword:
Smart sea pontoon
Internet of things
High-density polyethylene
Sea current behavior monitoring.
Real-time data transmission

ABSTRACT

This paper introduces an advanced smart sea pontoon designed to enhance sea current behavior monitoring in Thailand's coastal areas. Traditional pontoon systems used in surveying practices face operational challenges and limited durability. In response, the newly developed pontoon integrates Internet of Things (IoT) technology for precise real-time data transmission over long distances, reducing operational duration and minimizing risks to surveyors. Constructed with high-density polyethylene or HDPE and reinforced with steel, the pontoon offers superior strength and resistance to withstand marine extreme conditions. Specialized equipment enables convenient data transfer and pontoon monitoring, eliminating the need for physical presence on the pontoon and generating cost savings while providing detailed insights into current speed, direction, temperature, and salinity. This paper explores the design, production, and deployment of the smart sea pontoon, demonstrating its performance in Thailand's marine environments and showcasing its potential to enhance maritime safety and operational efficiency with less cost.

1. Introduction

The coastal and maritime sectors in Thailand are vital to the nation's economy and safety. Effective sea current monitoring is crucial for maritime operations, environmental conservation, and disaster preparedness. Traditional pontoons, though functional, often fall short in durability and technological integration. This paper introduces an advanced smart sea pontoon designed to enhance sea current behavior monitoring in Thailand coastal areas [1–3]. In conventional surveying practices, a comprehensive approach typically involves the deployment of surveyors, computer systems, specialized surveying instruments, and other pertinent equipment installed onto a pontoon structure. However, the conventional pontoon systems are beset by several drawbacks. They are characterized by operational challenges, limited durability, imprecise measurements, inadequate coverage, and susceptibility to data recording errors. Furthermore, environmental factors such as high tides and pollution, coupled with constraints related to manpower availability and the inability to conduct surveys during nighttime, present additional hurdles. These challenges contribute to project delays and escalate the investment costs. Instances of inaccuracies in data monitoring, unanticipated locations lacking real-time notification capabilities, and excessive heat generated by the computing apparatus leading to system instability, vulnerability to damage, overutilization of internal batteries, and susceptibility to moisture and heat-induced degradation within the pontoon framework. In light of these factors, the development of an enhanced iteration of the smart sea pontoon has been undertaken. Constructed with high-density polyethylene (HDPE) and reinforced with steel, the newly developed pontoon offers superior strength and resistance to withstand marine extreme conditions. Its integration of Internet of Things (IoT) technology enables precise real-time data transmission over long distances via wireless internet systems [4], thereby reducing operational duration. Specialized equipment facilitates convenient and rapid data transfer and pontoon monitoring, eliminating the necessity for surveyors to be physically present on the pontoon.

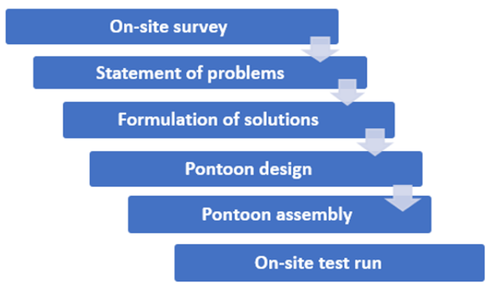

Figure 1. Schematic diagram of smart pontoon production.

This approach minimizes the risk of waterway accidents to surveyors, reduces manpower requirements, and generates cost savings. Moreover, the outcomes comprise fully-efficient data presented through cutting-edge technology, ready for immediate real-time utilization, providing detailed insights into current speed, direction, temperature, and salinity, this solution eliminates the necessity of integrating a computer unit into the pontoon, thereby mitigating potential risks to both the computer and the pontoon's integrity.

*Corresponding Authors.
E-mail address: rerkchai@rmutto.ac.th; (Rerkchai F.) and kritsada_an@rmutto.ac.th; (Kritsada A.)

https://doi.org/10.30772/qjes.2025.156007.1455

Nomenclature			
HDPE	High-Density Polyethylene	*IoT*	Internet of thing
PE	Polyethylene	*BMS*	Battery Management System
MCU	Low-cost open source IoT platform		

The invaluable nature of this data extends its utility to researchers, maritime operators, and environmental agencies alike [5–7]. The utilization of petty-patented colored HDPE, characterized by its inherent property of color permanence and resistance to paint film fragmentation, enhances visibility and facilitates identification, enhancing safety and ease of deployment. This smart pontoon represents a significant upgrade from the traditional models, combining advanced materials and cutting-edge technology to improve maritime safety and operational efficiency. This paper examines the design, production, and deployment of the smart sea pontoon, assessing its performance in Thailand's marine environments. It demonstrates how modern engineering and technology can enhance maritime infrastructure, contributing to better water resources management and safety in coastal area.

2. Literature review

The steel-reinforced HDPE rain harvesting system has been meticulously engineered to efficiently collect, store, and distribute harvested rainwater for a multitude of non-potable applications. Central to its design is a rain filter featuring a 20-micron filter cloth, ensuring the maintenance of water quality standards throughout the system's operation. To safeguard functionality, a high-water alarm system promptly alerts maintenance personnel to the need for filter cleaning, thus guaranteeing uninterrupted performance. Effluent conveyance from the wet well to the designated target area is facilitated by a submersible pump housed within an HDPE sleeve, seamlessly connected to a forcemain. This configuration not only enhances operational effectiveness but also facilitates smooth and efficient water transfer. Furthermore, the inclusion of a level monitoring system within the wet well enables precise control over the pumping mechanism, selectively activating it to optimize water distribution according to demand. In conclusion, the steel-reinforced HDPE rain harvesting system emerges as a reliable and sustainable solution, adept at meeting the challenges of rainwater collection and utilization while maintaining stringent quality standards and operational efficiency. Additionally, the new smart pontoon has the prototype from the PE pontoon that aims for river monitoring [8–10]. The utilization of IoT technology has proven instrumental in safeguarding maritime signals' health within the Taranto harbor, ensuring both navigation safety and signal integrity. Through the implementation of the developed Buoy Monitoring System (BMS), reliability in monitoring these signals has been achieved. The study conducted in 2017 outlines the development of an IoT platform tailored for ocean observation buoys, emphasizing its application in enhancing maritime signal surveillance [11]. Furthermore, a multi-hop relay network, based on a mesh network architecture, has been introduced to extend communication coverage beyond conventional buoy systems. This innovation has been validated through measurements of received signal strength indication between buoy nodes and data analysis collected from deployed buoy systems, as highlighted by the authors' monitoring site [12]. In a separate endeavor, in the study conducted by Aoife, Hegarty, Guy, Westbrook, Damien, Glynn, Declan, Murray, Edin, Omerdic, and Daniel, Toal in 2019 [13], have described the design, construction, and testing of a low-cost Energy Monitoring System tailored for remote monitoring of autonomous power generators, such as solar panels, in Marine IoT applications. This system aims to enhance cost-efficiency and minimize downtime, empowering remote decision-making processes [14–18]. Moreover, the same team of researchers has introduced a sea level detection system, catering to fishermen and anglers, employing Node MCU and Internet of Thing (IoT)-based Water level Sensors integrated with Telegram Messenger. This innovation provides accurate and timely information to fishermen and anglers, aiding in their activities [6].

3. Methodology

The methodology employed in this paper is rooted in a comprehensive analysis of several key factors, including the shortcomings associated with conventional pontoons, challenges posed by harsh marine environments, and constraints related to existing instrumentation and human resources. By systematically addressing each of these challenges, the resultant outcome culminates in the creation of an innovative solution: the development of a smart sea pontoon constructed with reinforced HDPE. This novel approach not only overcomes the deficiencies identified in prior pontoon designs but also enhances operational efficiency and resilience in extreme marine conditions. Through meticulous consideration of these various elements, the methodology outlined in this paper lays the foundation for the successful production and implementation of the advanced sea pontoon, poised to address the evolving needs and challenges of maritime operations.

3.1 On-site survey

The on-site survey process is meticulously conducted, employing the current conventional model of pontoon, within the vicinity of the targeted waterbody. This approach is integral to the thorough examination of the pontoon's performance in real-world conditions, enabling the identification and scrutiny of its inherent weaknesses and operational challenges. Furthermore, this investigative process is enriched through direct engagement with key stakeholders, including surveyors, pontoon users, and other relevant parties.

Figure 2. Physical appearance of the previous model pontoon.

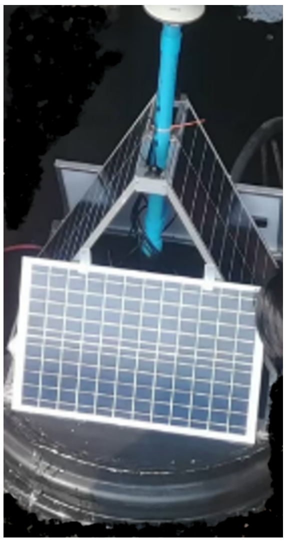

Figure 3. The process of assessing the previous model pontoon is considered a part of the on-site survey.

The on-site survey process is meticulously conducted, employing the current conventional model of pontoon, within the vicinity of the targeted waterbody. This approach is integral to the thorough examination of the pontoon's performance in real-world conditions, enabling the identification and scrutiny of

its inherent weaknesses and operational challenges. Furthermore, this investigative process is enriched through direct engagement with key stakeholders, including surveyors, pontoon users, and other relevant parties. Through structured interviews and consultations, invaluable insights are garnered, shedding light on the practical nuances and concerns associated with pontoon utilization. By integrating these multifaceted perspectives, the survey endeavors to comprehensively understand the intricacies of pontoon functionality and the specific requirements of stakeholders. This emphasis on direct observation and stakeholder input underscores the commitment to precision and relevance in informing subsequent design enhancements and operational improvements.

3.2 State of Problems

Following a comprehensive on-site survey, inclusive of rigorous testing of the previous pontoon model within a proximate water body and extensive interviews with both users (surveyors) and stakeholders of the pontoon, a meticulous examination of the encountered challenges during the survey process has culminated in the identification of a myriad of issues. These issues, delineated into a systematic enumeration, encapsulate the following:

3.2.1 Short durability

The observed limitation in the longevity of the pontoon structure, indicative of a need for enhanced structural resilience and material durability to withstand prolonged operational demands.

3.2.2 Imprecise data measurement

An inherent deficiency in the precision and accuracy of data acquisition methods, necessitating refinement to ensure the reliability and fidelity of collected data sets.

3.2.3 Incomplete work

The observed limitation in the longevity of the pontoon structure, indicative of a need for enhanced structural resilience and material durability to withstand prolonged operational demands.

3.2.4 Data recording errors

Noteworthy discrepancies and inaccuracies identified within recorded data sets, underscoring the significance of robust data management protocols and quality assurance measures.

3.2.5 Limited technological advancements

A discernible deficiency in the integration of advanced technological solutions and machinery, signaling the requisite exploration and adoption of cutting-edge innovations to optimize pontoon performance and functionality.

3.2.6 Environmental adversities

Challenges stemming from environmental factors such as heightened oceanic tides, diverse forms of pollution, and adverse weather conditions, necessitating adaptive strategies and resilient design considerations to mitigate operational vulnerabilities.

3.2.7 Manpower insufficiency

Insufficiency in available manpower resources and logistical constraints impeding consistent monitoring and supervision of the pontoon, thereby precluding the real-time utilization of pertinent data. Addressing these multifaceted challenges demands a concerted and interdisciplinary approach, encompassing innovative engineering solutions, robust quality management frameworks, and proactive environmental stewardship initiatives. By systematically addressing each identified issue with diligence and foresight, the endeavor to enhance pontoon efficacy and resilience stands poised for realization.

3.3 Formulation of solution

Subsequent to the comprehensive enumeration of challenges in the preceding phase, the subsequent stage entails the meticulous formulation of tailored solutions to address each identified issue. First and foremost, the persistent concern surrounding the short durability of the preceding pontoon model necessitates a strategic redesign approach. To this end, the integration of reinforced High-Density Polyethylene (HDPE) material within the framework of the newly conceptualized smart pontoon structure emerges as a pivotal solution. This innovative approach augments the pontoon's resilience, enabling it to withstand the formidable impacts of tidal fluctuations, prevailing sea breezes, inclement weather conditions, and tempestuous storms inherent to the harsh coastal and maritime environments. The incorporation of anti-sea barnacle agents within the formulation of the reinforced HDPE further mitigates the detrimental effects of barnacle accumulation, thereby averting associated operational impediments. Additionally, the inclusion of pigmentation during the fabrication process enhances the pontoon's visibility and facilitates swift identification, thereby enhancing safety measures within coastal areas. Moreover, the concomitant challenges pertaining to imprecise data measurement, incomplete task execution, data recording errors, technological limitations, environmental adversities, and manpower inadequacies are effectively ameliorated through the strategic adoption of Internet of Things (IoT) technology. By harnessing the capabilities of IoT, seamless real-time data transmission over extended distances via internet connectivity is facilitated, obviating the need for manual intervention in device installation, data monitoring, and transmission processes. This transformative paradigm shift ensures the continuous availability of high-precision, high-efficiency data sets, impervious to the deleterious effects of environmental exigencies. The recorded data comprehensively captures essential parameters including sea current velocity, directionality, seawater temperature, chronological timestamps, and salinity levels, facilitated by cutting-edge sensor technology. Such invaluable data insights serve as indispensable resources for stakeholders encompassing surveyors, researchers, pertinent public and private entities, as well as environmental regulatory agencies and research institutes. In sum, the adept integration of reinforced HDPE materials within the pontoon's architecture and the strategic deployment of IoT technology collectively engender a paradigmatic advancement, heralding a new era of resilience, efficiency, and data-driven operational efficacy within the domain of pontoon infrastructure. (TH potent number 22580 (2566)).

3.4 Pontoon design

Following the meticulous consideration and resolution of each identified issue through its corresponding tailored solution, a comprehensive redesign process ensues to align the pontoon with the anticipated enhancements and outcomes derived from the preceding iterative process. The physical structure described comprises two floating pontoons constructed primarily of high-density polyethylene (HDPE), engineered to facilitate the flow of water current and support specific equipment. The first floating pontoon, characterized by its cylindrical shape and substantial diameter, serves as the foundational element. Internally, this pontoon is outfitted with several fins strategically positioned along its walls. These fins serve the dual purpose of reinforcing the structure and delineating a narrower central area onto which the second floating pontoon is affixed. Within this narrower central area, the wall surface at a lower depth is deliberately left open to accommodate the installation of the second floating pontoon. This configuration allows for a portion of the second pontoon to be situated lower than the first, creating a designated space for the installation of specialized equipment, such as an echo sounder, which is utilized for collecting data pertaining to seawater depth. The second floating pontoon, also crafted from HDPE and featuring a cylindrical design with a smaller diameter, is securely installed onto the narrower central area of the first pontoon. Notably, this second pontoon incorporates at least one partition wall, subdividing the interior space into distinct compartments. This partitioning facilitates the creation of a dedicated room extending from the bottom to the top of the pontoon, providing enclosed space for housing equipment, personnel, or other operational necessities. Overall, this structured arrangement of floating pontoons demonstrates a purposeful design, tailored to optimize functionality and accommodate the specific operational requirements, particularly in the context of marine data collection and analysis [19–23]. The design paradigm of the intelligent pontoon is distinguished by its integration of cutting-edge technological advancements, specifically engineered to ensure the precise transmission of data over extended distances via wireless internet connectivity, while mitigating discrepancies and errors to the utmost degree. This innovative approach embodies a commitment to leveraging the forefront of technological progress to optimize data transmission efficacy. By harnessing state-of-the-art wireless internet protocols, the smart pontoon establishes a seamless conduit for the dissemination of data across vast expanses, thereby facilitating real-time communication and information exchange with unparalleled efficiency. Central to this design ethos is a rigorous emphasis on minimizing discrepancies and errors inherent in data transmission processes. Through meticulous engineering and implementation of advanced error-correction mechanisms, the smart pontoon endeavors to uphold the integrity and fidelity of transmitted data, ensuring that information conveyed remains faithful to its original source and intent. In essence, the design ethos of the smart pontoon represents a convergence of technological sophistication and meticulous attention to detail, culminating in a solution engineered to excel in the demanding realm of long-distance data transmission. By embracing the forefront of technological innovation and prioritizing precision and reliability, the intelligent pontoon stands poised to redefine the landscape of marine data communication, setting new standards of excellence in the field. From Fig. 4 and Fig 5, tha main components of the smart pontoon is GNSS receiver, GNSS main, Camera, Solar cell and battery [18] which is number 5,7,4,41-44 and 7-8 in ordered.

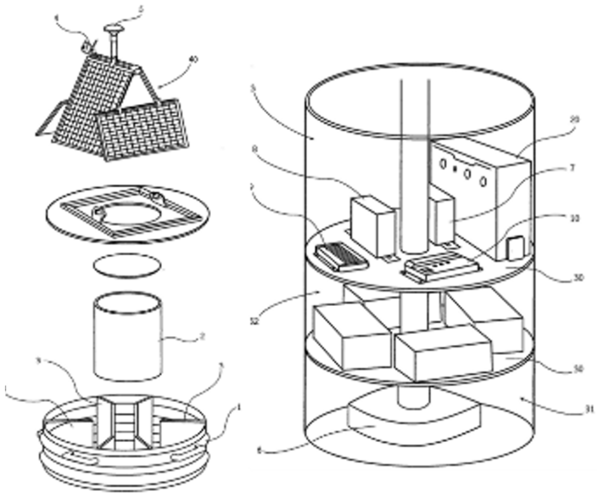

Figure 4. Components and internal structure of the smart pontoon.

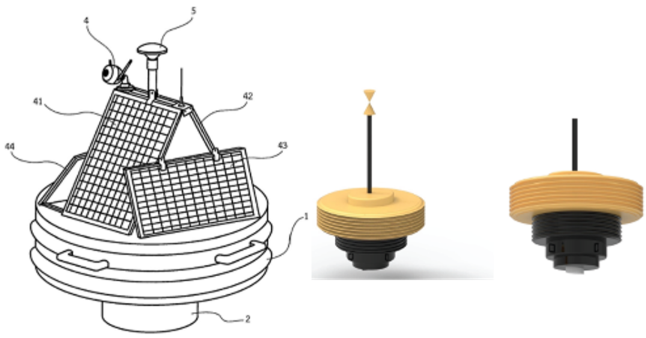

Figure 5. Schematic physique of the smart pontoon fabricated with colored reinforced HDPE.

3.5 Pontoon assembly

Following an exhaustive design phase characterized by meticulous planning and precision engineering, the smart pontoon undergoes assembly, during which its constituent components are integrated alongside pertinent sensors and recording instruments.

Figure 6. Physical appearance of the smart pontoon fabricated with colored reinforced HDPE.

This assembly process adheres rigorously to exacting standards, ensuring seamless compatibility and optimal functionality of each component within the pontoon's framework. Through meticulous attention to detail and rigorous quality control measures, the final product emerges as a testament to the culmination of sophisticated design principles and technological innovation. Crucially, the resulting smart pontoon epitomizes portability and ease of deployment, embodying a design ethos that prioritizes convenience and accessibility. Crafted with lightweight yet durable materials, the pontoon is inherently maneuverable, facilitating effortless transportation and relocation as dictated by operational requirements. Moreover, the design incorporates intuitive features and streamlined interfaces to simplify setup and utilization, enabling rapid deployment and integration into existing infrastructure with minimal effort. This user-centric approach ensures that the smart pontoon is not only technologically advanced but also inherently user-friendly, empowering operators to harness its capabilities with ease and efficiency. In essence, the culmination of the assembly process yields a sophisticated yet accessible solution, poised to address a myriad of marine data collection and monitoring needs. By seamlessly integrating advanced technology with user-centric design principles, the smart pontoon stands as a testament to innovation and ingenuity in the realm of marine infrastructure [24].

3.6 On-site test run

Upon completion of assembly, the smart pontoon undergoes rigorous testing in a nearby waterbody to evaluate its structural integrity, ergonomic design, and operational effectiveness. Testing includes assessments of physical robustness, buoyancy, stability, and technological functionality. Any discrepancies are addressed to ensure readiness for operational deployment in marine environments.

Figure 7. General appearance of the smart pontoon fabricated with colored reinforced HDPE during it's the test.

4. Result and discussion

The outcomes of the testing regimen for the smart pontoon have proven to be highly encouraging. Compared to its earlier prototype, the latest version of the smart pontoon demonstrates marked improvements in both performance and reliability. Throughout a series of controlled experiments and real-world deployments, the pontoon showcased not only structural integrity but also enhanced functionality in data acquisition and processing.

One of the most significant advancements lies in the performance of the onboard sensors. These sensors, carefully selected and integrated into the system, performed their tasks with a high degree of precision and consistency. Data related to environmental parameters such as water temperature, salinity, wave activity, and other marine conditions were captured accurately, validating the effectiveness of the sensor array and the robustness of the data transmission module. The seamless communication between the sensors and the central processing unit enabled real-time monitoring, a feature critical for long-term deployment in marine environments.

Furthermore, the energy system, which incorporates solar panels and battery storage, successfully maintained continuous operation during the test period. This autonomy is essential for remote monitoring applications where manual maintenance is infrequent or impractical. The power management algorithm ensured efficient energy use, prolonging operational time and preventing downtime during periods of low solar irradiance [25, 26].

However, despite these successes, the testing also revealed areas that warrant further improvement. In particular, minor adjustments are needed to refine the pontoon's ergonomic design. Field observations and feedback indicated that certain components may be vulnerable to the harsh and variable conditions of marine environments—especially prolonged exposure to saltwater, strong currents, and intense UV radiation. Enhancing the protective casings and streamlining the structural layout could further improve durability and reduce the risk of mechanical wear or sensor drift over time.

In addition, consideration must be given to the pontoon's ease of deployment and recovery. Simplifying the assembly and disassembly process, while maintaining structural integrity, would make the smart pontoon more user-friendly and better suited to rapid deployment scenarios often required in research or disaster response missions.

Overall, the current iteration of the smart pontoon stands as a significant step forward. Its successful performance in testing conditions confirms its potential for reliable, autonomous monitoring in marine environments. By addressing the identified ergonomic and resilience challenges through targeted design enhancements, the pontoon can be further optimized to meet rigorous operational demands. These improvements will not only extend its lifespan but also enhance its effectiveness as a tool for long-term oceanographic studies and environmental monitoring missions.

5. Conclusion

The development and successful testing of the newly designed smart pontoon mark a significant milestone in advancing marine monitoring infrastructure. This smart pontoon, featuring a robust construction from reinforced HDPE and embedded with state-of-the-art IoT technology, has demonstrated its capability to overcome the persistent limitations associated with traditional pontoon systems. Notably, the new design directly addresses challenges such as limited structural durability, inconsistent data recording, operational inefficiencies, and the high risks associated with manual data collection in marine environments. Through the integration of real-time data transmission capabilities, the pontoon eliminates the need for continuous physical presence, thereby enhancing safety for field personnel and drastically reducing operational costs. The system's ability to continuously monitor key oceanographic parameters—such as current speed and direction, salinity, and temperature—with high accuracy and minimal maintenance, offers immense value to researchers, environmental agencies, and maritime operators.

Equally important is the pontoon's thoughtful ergonomic and structural design, which supports user-friendly deployment, easy equipment integration, and long-term functionality under demanding coastal conditions. While minor refinements have been identified to further improve ergonomics and durability, the platform in its current state already represents a major leap forward in the realm of autonomous marine monitoring.

In essence, this smart pontoon is more than just an upgrade—it is a transformative tool poised to redefine how marine data is collected, managed, and utilized. It not only meets but anticipates the evolving needs of stakeholders by combining practical design with advanced technology. With further refinement and wider implementation, this innovation holds the promise to contribute significantly to maritime safety, environmental research, and sustainable coastal development.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Funding source

This study didn't receive any specific funds.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgements

The authors would like to acknowledge Rajamangala University of Technology Tawan-ok that provide the space for the pontoon.

References

[1] A. Shukla, R. Ross, B. Bhattacharya, and A. Stumpf, "Autonomous water sampling and quality monitoring in remote locations: A novel approach using a remote-controlled boat," *HardwareX*, vol. 22, p. e00634, 2025. [Online]. Available: https://doi.org/10.1016/j.ohx.2025.e00634

[2] V. Lakshmikantha, A. Hiriyannagowda, A. Manjunath, A. Patted, J. Basavaiah, and A. A. Anthony, "Iot based smart water quality monitoring system," *Global Transitions Proceedings*, vol. 2, no. 2, pp. 181–186, 2021, international Conference on Computing System and its Applications (ICCSA- 2021). [Online]. Available: https://doi.org/10.1016/j.gltp.2021.08.062

[3] H. Gu, T. Zhang, Q. Pan, H. Zhang, and J. Xia, "Design and implementation of a water quality monitoring system based on cc2630," *2022 IEEE 6th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*, pp. 203–208, 2022. [Online]. Available: https://doi.org/10.1109/IAEAC54830.2022.9929725

[4] Y. Gao, D. Chang, and C.-H. Chen, "A digital twin-based approach for optimizing operation energy consumption at automated container terminals," *Journal of Cleaner Production*, vol. 385, p. 135782, 2023. [Online]. Available: https://dx.doi.org/10.1016/j.jclepro.2022.135782

[5] T. Phasinam, K. Phasinam, A. U-kaew, K. Piyathamrongchai, R. Hataitara, V. Raghavan, Nemoto, and S. Choosumrong, "Real-time monitoring and positioning of agricultural tractors using a low-cost gps and iot device," *International Journal of Geoinformatics-Special Issue FOSS4G ASIA 2024*, vol. 21, no. 1, pp. 580–583, 2025. [Online]. Available: https://doi.org/10.52939/ijg.v21i1.3799

[6] S. Anand, M. Enayati, D. Raj, A. Montresor, and M. V. Ramesh, "Internet over the ocean: A smart iot-enabled digital ecosystem for empowering coastal fisher communities," *Technology in Society*, vol. 79, p. 102686, 2024. [Online]. Available: https://doi.org/10.1016/j.techsoc.2024.102686

[7] C. V. Subbiah, N. Vijayaraghavan, M. D. A. Praveena, A. Christy, and D. U. Nandini, "Iot based ocean cleaning and weather monitoring and boat tracking system," *2024 International Conference on Science Technology Engineering and Management (ICSTEM)*, pp. 1–7, 2024. [Online]. Available: https://doi.org/10.1109/ICSTEM61137.2024.10560529

[8] P. M. K. D. e. a. Vidakis, N., "Reinforced hdpe with optimized biochar content for material extrusion additive manufacturing: morphological, rheological, electrical, and thermomechanical insights." *Biochar*, vol. 6, no. 37, 2024. [Online]. Available: https://doi.org/10.1007/s42773-024-00314-5

[9] S. M. Kim, U. H. Lee, H. J. Kwon, J.-Y. Kim, and J. Kim, "Development of an iot platform for ocean observation buoys," *IEIE Transactions on Smart Processing and Computing*, vol. 6, no. 2, pp. 109–116, April 2017. [Online]. Available: https://doi.org/10.5573/IEIESPC.2017.6.2.109

[10] R. A. I. A. K. W. K. D. S. R. E. W. . G. A. Wibawa, P. A. I., "Analysis of tensile and flexural strength of hdpe material joints in ship construction," *Journal of Applied Engineering Science*, vol. 21, no. 2, pp. 668–677, 2023. [Online]. Available: https://doi.org/10.5937/jaes0-41924

[11] S. M. Kim, U. H. Lee, H. J. Kwon, J.-Y. Kim, and J. Kim, "Development of an iot platform for ocean observation buoys," *IEIE Transactions on Smart Processing and Computing*, vol. 6, no. 2, pp. 109–116, 2017. [Online]. Available: https://doi.org/10.5573/IEIESPC.2017.6.2.109

[12] P. K. U.-k. A. P. K. H. R. R. V. N. T. . C. S. Phasinam, T., "Real-time monitoring and positioning of agricultural tractors using a low-cost gps and iot device," *International Journal of Geoinformatics*, vol. 21, no. 1, p. 111–120, 2024. [Online]. Available: https://doi.org/10.52939/ijg.v21i1.3799

[13] A. Hegarty, G. Westbrook, D. Glynn, D. Murray, E. Omerdic, and D. Toal, "A low-cost remote solar energy monitoring system for a buoyed iot ocean observation platform," *2019 IEEE 5th World Forum on Internet of Things (WF-IoT)*, pp. 386–391, 2019. [Online]. Available: https://doi.org/10.1109/WF-IoT.2019.8767311

[14] O. Munoz, A. Ruelas, P. Rosales, A. Acuña, A. Suastegui, and F. Lara, "Design and development of an iot smart meter with load control for home energy management systems," *Sensors*, vol. 22, no. 19, 2022. [Online]. Available: https://doi.org/10.3390/s22197536

[15] K.-Y. Kim, D.-H. Park, J.-B. Shim, and Y.-H. Yu, "A study of marine network nmea2000 for enavigation," *Journal of the Korean Society of Marine Engineering*, vol. 34, no. 1, pp. 133–140, 2010. [Online]. Available: https://doi.org/10.5916/jkosme.2010.34.1.133

[16] I. Jarraya, A. Al-Batati, and A. M.-A. A. . o. Kadri, M. B., "An autonomous underwater vehicle and sunset to bridge underwater networks composed of multi-vendor modems," *Annual Reviews in Control*, vol. 46, pp. 295–303, 2018. [Online]. Available: https://doi.org/10.1186/s43020-025-00162-z

[17] B. M. Tabi Fouda, L. Wang, D. Han, P. C. Ngoumou, and J. Atangana, "Design and implementation of a novel iot architecture for data release system between multiple platforms: Case of smart

offshores," *Sensors*, vol. 25, no. 11, 2025. [Online]. Available: https://doi.org/10.3390/s25113384

[18] A. Ridolfi, D. Spaccini, F. Fanelli, M. Franchi, N. Monni, L. Picari, C. Petrioli, and B. Allotta, "An autonomous underwater vehicle and sunset to bridge underwater networks composed of multi-vendor modems," *Annual Reviews in Control*, vol. 46, pp. 295–303, 2018. [Online]. Available: https://doi.org/10.1016/j.arcontrol.2018.10.005

[19] K.-Y. Kim, D.-H. Park, J.-B. Shim, and Y.-H. Yu, "A study of marine network nmea2000 for e-navigation," *Journal of Advanced Marine Engineering and Technology*, no. 1, pp. 133 – 140, 2010.

[20] L. O. F. Susanto, A. B. Raharjo, and F. Haq, "Asset monitoring of water meters using integration of gis and low-cost gnss," *IOP Conference Series: Earth and Environmental Science*, vol. 1127, no. 1, p. 012005, jan 2023. [Online]. Available: https://dx.doi.org/10.1088/1755-1315/1127/1/012005

[21] S. O. G.-I. Diouf, D. and F. Ndiaye, "Performance evaluation of low-cost dual-frequency gnss receivers for precise positioning in senegal: Issues and challenges," *Journal of Analytical Sciences, Methods and Instrumentation*, vol. 14, pp. 23–37, 2024. [Online]. Available: https://dx.doi.org/10.4236/jasmi.2024.142003

[22] M. R. Ubaidillah and M. N. Cahyadi, "Low cost gnss trimble bd982 and u-blox performance test analysis f9 series for several measurement methods (case study: Sidoarjo regency)," *IOP Conference Series: Earth and Environmental Science*, vol. 1095, no. 1, p. 012028, oct 2022. [Online]. Available: https://dx.doi.org/10.1088/1755-1315/1095/1/012028

[23] P. Manurung, H. Pramujo, and J. BP Manurung, "Development of gnss receiver for mobile cors with rtk correction services using cloud server," *E3S Web Conf.*, vol. 94, p. 01010, 2019. [Online]. Available: https://dx.doi.org/10.1051/e3sconf/20199401010

[24] A. J. C. Bautista, A. D. T. Cruz, J. A. S. Adams, and E. L. C. Giron, "Development of arduino based autonomous navigation platform for water monitoring boat prototype," *8th International Conference on Control, Automation and Robotics (ICCAR)*, pp. 237–241, 2022. [Online]. Available: https://doi.org/10.1109/ICCAR55106.2022.9782657

[25] L. A. Bonza and M. M. Sejera, "Autonomous arduino based solar rechargeable navigating water monitoring boat for taal lake," *2024 15th International Conference on Computing Communication and Networking Technologies (ICCCNT)*, pp. 1–7, 2024. [Online]. Available: https://doi.org/10.1109/ICCCNT61001.2024.10724716

[26] S. Engin, H. Çınar, and Kandemir, "A rule-based energy management technique considering altitude energy for a mini uav with a hybrid power system consisting of battery and solar cell," *Energies*, vol. 17, no. 16, 2024. [Online]. Available: https://dx.doi.org/10.3390/en17164056

How to cite this article:
Tanapat Virit, Rerkchai Fooprateepsiri, Kritsada Anantakarn, Bhattharadej Witchayangkoon, and Koltouch Anantakarn. (2025). 'Smart sea pontoon production by reinforcement HDPE for sea current behavior in Thailand', Al-Qadisiyah Journal for Engineering Sciences, 18(4), pp. 391-396. `https://doi.org/10.30772/qjes.2025.156007.1455`