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Analysis of Seabins Using Lightweight Concrete to Clean Up Plastic Waste on The Coast of Semayap Village, Kotabaru Regency

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ABSTRACT

The increasing plastic waste on the coast of Semayap Village poses a serious threat to the marine ecosystem and coastal community activities. Floating plastic pollutes the sea and disrupts fishing, tourism, and public health. An effective solution is using Seabin technology, as the area lacks a sustainable system to manage plastic waste. Current waste management remains conventional and relies on manual cleanups. This study used a literature review on Seabin technology and lightweight concrete, along with a field survey to assess coastal conditions in Semayap Village. It also involved modeling a suitable lightweight concrete structure to support the device. The results showed that the Seabin, made from lightweight concrete with pumice aggregate, weighs 105.46 kg, with a volume of 0.0628 m³ and density of 1,680 kg/m³, classifying it as lightweight concrete. It is 45.26 kg lighter than regular concrete, enhancing buoyancy and design efficiency with support from four 25-liter jerrycan floats. A 24-hour test at the Semayap coast captured 4.14 kg of surface waste, demonstrating its effectiveness, though performance can still be improved.

Keywords: *Light concrete; plastic waste; seabin; sea coast;semayap village.*

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ABSTRACT

Urgensi Peningkatan volume sampah plastik di pesisir Desa Semayap menjadi permasalahan serius bagi ekosistem laut dan aktivitas masyarakat pesisir. Sampah plastik yang mengapung di permukaan laut dapat mencemari lingkungan dan mengganggu kegiatan perikanan, pariwisata serta kesehatan masyarakat. Salah satu solusi yang efektif adalah menggunakan teknologi Seabin, karena di lokasi eksisting masih belum terdapat sistem atau teknologi khusus yang diterapkan secara berkelanjutan untuk menangani sampah plastik. Pengelolaan limbah masih bersifat konvensional, terbatas pada pembersihan manual oleh masyarakat atau gotong royong yang tidak terjadwal. Metode yang digunakan meliputi studi literatur mengenai teknologi Seabin dan karakteristik beton ringan, survei lapangan untuk mengidentifikasi kondisi perairan Desa Semayap. Penelitian juga mencakup pemodelan struktur beton ringan yang sesuai untuk mendukung alat ini di lokasi pesisir. Dari hasil penelitian diketahui bahwa Seabin berbahan beton ringan dengan agregat batu apung memiliki berat 105,46 kg, volume 0,0628 m³, dan massa jenis 1.680 kg/m³ sehingga masuk kategori beton ringan. Dibanding beton biasa, bobotnya lebih ringan 45,26 kg sehingga meningkatkan daya apung dan efisiensi desain dengan dukungan empat pelampung jerigen 25 liter. Uji 24 jam di pinggiran laut Desa Semayap menunjukkan alat mampu menangkap 4,14 kg sampah permukaan, membuktikan fungsinya efektif meski masih berpotensi untuk ditingkatkan kinerjanya

Kata Kunci: *Beton ringan; desa semayap; pesisir laut; sampah plastik; seabin*

INTRODUCTION

Plastic waste is one of the biggest environmental problems in coastal and marine areas. The difficult-to-decompose nature of plastic leads to long-term accumulation of waste, negatively impacting marine ecosystems, the health of biota, and the social and economic activities of coastal communities. In Semayap Village, Kotabaru Regency, the problem of plastic waste along the coastline is increasing due to residential activities, fishing, and maritime transportation, as well as the influence of tidal currents that carry waste from other areasThis research aims to design and build a Seabin prototype using lightweight concrete adapted to the characteristics of the coastal waters of Semayap Village. The results are expected to serve as a reference in the development of more effective, durable, and sustainable marine waste management technologies, particularly in coastal areas of Indonesia.

Efforts to control plastic waste in coastal areas require solutions that are not only effective but also sustainable and adapted to local conditions. One emerging technology for marine waste management is the Seabin, a floating trash capture device that uses a suction system to collect plastic waste and microparticles from the water's surface. Seabins are typically installed in harbor areas or calm waters and are capable of continuous operation. However, the use of conventional Seabins still faces challenges, particularly related to manufacturing costs and the materials used. The relatively high cost of standard materials and the limited utilization of local resources present challenges in implementing this technology in coastal areas like Semayap Village. Therefore, innovations in alternative materials are needed that are more economical, readily available, and have characteristics suitable for marine environments.

Lightweight concrete is a material with potential for use in Seabin structures. Lightweight concrete has a lower specific gravity than conventional concrete, increasing buoyancy, simplifying installation, and reducing structural loads. Furthermore, lightweight concrete exhibits considerable resistance to marine environments when designed with the right composition. The use of lightweight concrete is expected to reduce Seabin construction costs while enhancing the sustainability of its application in coastal areas. Based on these conditions, this study was conducted to analyze the use of lightweight concrete Seabins to clean up plastic waste on the coast of Semayap Village, Kotabaru Regency. This research is expected to provide insight into the effectiveness, performance, and potential of implementing lightweight concrete Seabins as an alternative solution for managing plastic waste in coastal areas.

The benefits of this research are to gain new knowledge regarding Seabin design and practical application, as a tangible contribution to the development of applicable civil engineering-based innovations, this research can serve as an academic reference, support community service activities, and strengthen the university's reputation for producing research that directly benefits the region. To provide the coastal community of Semayap Village with a clean aquatic environment free from waste and waste-related diseases.

LITERATURE REVIEW

A seabin is a device that sucks up trash from the water's surface. Its main component is a pump that sucks water into the seabin and then releases the sucked water back into the seabin's tube, which carries the trash and traps it in the inner float filter. Seabins are essentially made from plastic containers of various sizes. A seabin is a type of floating trash bin equipped with a suction device that captures all floating objects, such as trash, and places them in the bucket. The seabin is lined with a net that can be lifted when full of trash and replaced with a new net. The seabin is equipped with a suction device underneath, which then draws water in along with the trash. This device can also separate water and oil. The UK has been using seabins since 2017. The UK has deployed several seabins at sea to collect all the trash scattered in the ocean.

Meanwhile, according to an article published by National Geographic Indonesia by Erikania Julie, the water filtration system in a seabin is very similar to a water filter in a pet fish tank but is designed to clean the entire ocean. Seabins can be installed on any floating dock and are designed to suck up any floating debris or oil around the dock. The Seabin is essentially built with a simple concept: a bucket connected to a water pump, which then sucks floating debris into a removable mesh bag. Seabin technology was developed as a solution to automatically clean ocean water surfaces of plastic waste. However, most existing Seabin designs use expensive metal materials and do not fully consider sustainability and energy efficiency. This research presents an innovative solution by designing and analyzing a Seabin based on lightweight concrete as the primary material. Lightweight concrete designed with local aggregates has the potential to reduce production costs, increase buoyancy, and improve corrosion resistance in marine environments.

Design the Seabin structure by taking into account: the compressive strength and specific gravity of the concrete to ensure stable floating or semi-floating conditions, resistance to corrosion and abrasion, determining the dimensions and shape (cylindrical or vertical box) appropriate to the volume of water that can be filtered and the volume of waste that can be accommodated

Lightweight Concrete

Concrete is a mixture of sand, gravel, crushed stone, or other aggregates mixed together with a paste made of cement and water to form a rock-like mass. This mixture consists of one or more additives added to produce concrete with specific characteristics, thus facilitating the process and reducing the hardening time (workability). Positive properties of concrete include relative ease of processing and molding, resistance to pressure, and weather resistance. Negative properties include lack of water resistance, low tensile strength, and susceptibility to disintegration by sulfates in the soil.

Lightweight concrete is a type of concrete that contains an expanding agent to increase the volume of the mixture while providing additional properties such as lighter dead loads and better thermal insulation. Thus, lightweight concrete not only reduces the dead load of a structure but also offers better insulation properties than conventional concrete. Lightweight concrete is a type of concrete with a lower specific gravity than conventional concrete, with a specific gravity ranging from 300 kg/m^3 to 1,900 kg/m^3, depending on the type of aggregate used and the mix proportions. Lightweight concrete is made by using lightweight aggregate as a partial or complete replacement for coarse aggregate in the concrete mix, resulting in a lighter concrete that still maintains a certain structural strength with a compressive strength value that can be adjusted to suit its intended use, both structural and non-structural. This makes lightweight concrete highly flexible in modern building design applications.

According to SNI 03-3449-2002, "Lightweight concrete is concrete that uses lightweight aggregate, either partially or completely, with a unit weight of no more than 1,900 kg/m^3 in oven-dry conditions." The use of lightweight aggregates such as pumice, expanded clay (leca), perlite, or other synthetic aggregates offers the advantages of lower weight and improved thermal and acoustic insulation properties.

Plastic waste

Plastic waste is synthetic polymer waste derived from human activities, such as food packaging, plastic bottles, and plastic bags. This waste is difficult to decompose naturally and can persist in the marine environment for very long periods. Coastal areas are transitional areas between land and sea that are affected by human activities and ocean dynamics, such as tides and ocean currents. These areas are vulnerable to pollution, including the accumulation of plastic waste. Seabin is a floating trash collector placed on the surface of the water. This device works by using a water suction system that directs plastic waste and small particles on the sea surface into a collection container, thereby helping to reduce marine debris pollution.

Buoyancy is the ability of an object to float on the surface of the water. In this study, the buoyancy of lightweight concrete was crucial to ensure the Seabin's performance in marine waters. Device effectiveness is the Seabin's success rate in collecting plastic waste, measured by the amount or weight of waste captured within a specified period. Waterfronts are areas of water close to the coastline where waste often accumulates due to human activity and ocean currents. Lightweight concrete is widely used in various construction applications, both as structural and non-structural elements. Some common applications of lightweight concrete include precast wall panels and modular building partitions, floor slabs and roofs in high-rise buildings, rapid-build housing construction or earthquake-resistant housing, lightweight and precast bridge structures, floating elements such as pontoons, floating docks, and marine debris capture devices (such as lightweight concrete-based seabins) and thermal and acoustic insulation in commercial and industrial buildings.

METHOD

Research Location and Time

The research location is where the researcher can find relevant sources regarding the problem being studied. The location used for this research is the Coastal Area of Semayap Village, Pulau Laut Utara District, Kotabaru Regency.

Research Time

The research period is six months, using the design and construction method to design a new product and conduct trials on it.

Data collection methods were conducted in several ways:

a. Field observation.
   Field observation was conducted to identify and analyze the condition of the waters surrounding the research location, namely the Rampa Lama area of Kotabaru Regency. Observations were made on the level of waste pollution, as well as physical conditions such as water depth and ocean currents. This observation aimed at determining the appropriate location for
b. Documentation.
   Data collection involves directly examining related documentary sources. Documentation, in other words, is the collection of data through written and electronic documents. This is used to support the completeness of other data.
c. Literature Review
   To deepen the concept of seabins, lightweight concrete, and previously implemented technologies, a literature review was conducted from various academic sources and previous research. This literature included scientific journals, books, and articles relevant to the research theme to gain a theoretical basis and practical experience in implementing similar technologies.
d. Secondary data collection.
   Secondary data was collected through articles, news, and other sources obtained from the internet to obtain information about seabins that supported the design and installation of the seabin.

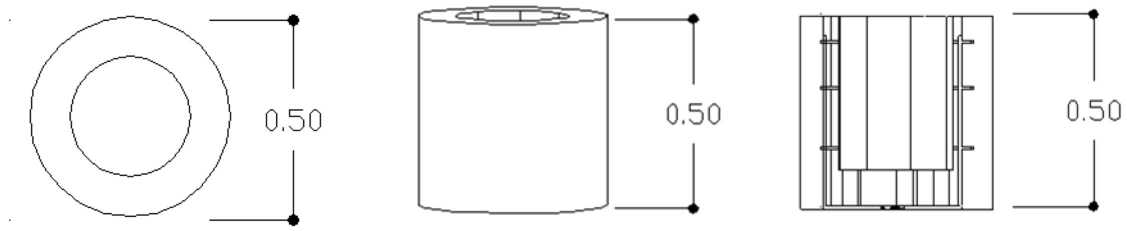
Research on the analysis of Seabins using lightweight concrete to clean up plastic waste on the coast of Semayap Village in Kotabaru Regency is highly relevant from various aspects. This research is important because the problem of plastic waste in coastal areas continues to increase and directly impacts marine ecosystems, water quality, and the sustainability of coastal resources. The application of Seabin technology is expected to be a real solution to reducing the accumulation of plastic waste in shallow waters. From a technological and innovative perspective, this research is relevant because it develops the use of lightweight concrete materials as an alternative Seabin structure. The use of lightweight concrete has the potential to reduce production costs, increase buoyancy, and facilitate the implementation of Seabin technology in coastal areas with limited resources and access to technology.

From an academic perspective, this research provides a scientific contribution through an integrative study of marine debris removal technology and construction material innovation. The results are expected to serve as reference for further research related to the development of more effective and sustainable marine debris removal tools. From a social and economic perspective, this research is relevant because it supports efforts to improve the quality of the coastal environment, which impacts fishing activities, tourism, and the health of the coastal community in Semayap Village. More economical and easily implemented technology can encourage community participation in environmental management. Therefore, this research topic has strong relevance because it not only addresses local issues but also has the potential to provide solutions that can be applied to other coastal areas with similar characteristics.

RESULTS AND DISCUSSION

Data Discussion I

Design and construction process for a lightweight concrete seabin. Seabin design drawing the planned seabin dimensions are approximately 50 cm high and 27 cm in diameter. The following seabin design dimensions can be seen in Figures 1,2 and 3.



(a) (b) (c)

Figure 1. a) Front View of Seabin, b) Top View of Seabin, c) Section A-A.

Figures 1, 2, and 3 explain that a seabin is a cylindrical container used to hold or filter something (usually water and floating debris). The images show three different perspectives to understand its shape and internal structure. Front View Circular shape with two rings: outer and inner. Indicates the outer and inner diameters.The dimension 0.50 indicates the width/height. Top View, this shows a cylinder with a hollow center. This suggests the Seabin has a cavity in the center to hold or drain something, and the outer circle is the cylinder wall, and the inner circle is the center hole. Section A-A (Cross Section), the vertical section shows the internal structure. The cylinder walls, base, and vertical/horizontal components that may function as support or filters are visible and the dimension 0.50 here indicates the height of the cylinder

Calculation of seabin dimensions and volume.

The hollow cylindrical Seabin structure has the following dimensions
Outer diameter (D_1): 50 cm = 0.50 m
Wall thickness: 10 cm = 0.10 m
Inner diameter (D_2): 30 cm = 0.30 m
Cylinder height: 50 cm = 0.50 m
Then, the volume of hollow cylindrical concrete is calculated using the formula

$$V = \pi \times h \times (R_1^{\,2} - R_2^{\,2}) \quad \ldots\ldots. \ (1)$$
$$= 3{,}14 \times 0{,}50 \times (0{,}25^2 - 0{,}15^2)$$
$$= 0{,}0628 \text{ m}^3$$

Data Discussion II

Trash Captured
The collected trash was collected after the one-day test was completed and weighed. The weight of the trash collected each day for 1 day, with the 24-hour operation time, is shown in Table 1.

Table 1. Results of seaben tool catches

Hours	Waste Volume	Description
12.00 – 13.00	0.35	starting to subside
13.00 – 14.00	0.2	starting to subside
14.00 – 15.00	0.2	starting to subside
15.00 - 16.00	0.2	Recede
16.00 - 17.00	0.14	Recede
17.00 - 18.00	0.1	Recede
18.00 - 19.00	-	Recede
19.00 - 20.00	-	Recede
20.00 - 21.00	-	Recede
21.00 - 22.00	-	Recede
22.00 - 23.00	0.1	Recede
23.00 - 00.00	0.1	Recede
00.00 - 01.00	0.1	start installing
01.00 - 02.00	0.1	start installing
02.00 - 03.00	0.1	start installing
03.00 - 04.00	0.1	Install
04.00 - 05.00	0.1	Install
05.00 - 06.00	0.1	Install

CONCLUSION

Based on the design, construction, and field testing of a concrete seabin prototype in the coastal area of Semayap, Kotabaru Regency, the following conclusions can be drawn: The Seabin prototype was designed using lightweight concrete with pumice aggregate, resulting in a weight of 105.46 kg and a volume of 0.0628 m^3, The addition of four 25-liter jerry can floats provided a total buoyancy of approximately 102.5 kg, equivalent to the device's weight of approximately 105.46 kg. The conclusions above indicate that the concrete used in the construction of this Seabin is classified as lightweight concrete based on the limits of SNI 03-3449-2002. The main advantage of using lightweight concrete is its lower weight, which directly contributes to the device's increased buoyancy in water. The use of lightweight concrete allows for a more efficient Seabin design without requiring significant additional floats.

During a 24-hour test, the device captured a total of 4.14 kg of surface debris, consisting of lightweight plastics, leaves, and other household waste. This figure indicates that the device is functional but still has room for improvement. The weight of the debris collected is relative, meaning it cannot be used as a benchmark for the same time. There is a research gap in the use of lightweight concrete-based alternative materials for Seabin structures, as well as their direct testing in local coastal environments such as Semayap Village and Kotabaru Regency. This study fills this gap by analyzing the performance, effectiveness, and potential application of lightweight concrete Seabins in cleaning up plastic waste on the coast. Thus, this study has a clear position and offers novelty in the aspects of materials, application locations, and a more economical and sustainable technological approach.

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