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ANALYSIS OF MATERIALS TECHNOLOGY DEVELOPMENT IN SUPPORTING SUSTAINABLE DEVELOPMENT IN THE FIELD OF CIVIL ENGINEERING

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Abstract

In supporting sustainable development in the field of civil engineering, the development of materials technology plays an important role. Sustainable materials technology can help create environmentally friendly, efficient and long-lasting construction. The development of materials technology in the field of civil engineering is an important step in supporting sustainable development. By focusing on the use of environmentally friendly materials, efficient use of materials, structural sustainability, and innovation in construction technology, civil engineering can contribute to creating sustainable and environmentally friendly infrastructure. The development of materials technology in civil engineering contributes significantly to sustainable development goals. By prioritizing environmentally friendly, energy efficient, durable and innovative materials, the construction industry can build infrastructure that not only meets today's needs, but is also sustainable for the future. Apart from that, this approach also supports the social and economic welfare of society, making it a main pillar in sustainable development.

Keywords: development, materials technology, sustainable development, civil engineering

INTRODUCTION

Human needs in the era of society 5.0 are increasing and require several innovations in the creation and development of methods to meet human needs (Manzoor et al., 2021). Sustainable development is development that meets current needs without ignoring the impact on meeting the needs of future generations. The sustainable development agenda in 2030 is to achieve the "Sustainable Development Goals" or SDG's goals by realizing 17 points which are the main issues in the international world. In the world of construction, sustainable development is applied with the principles of sustainable construction. Baloi (2003) states that sustainable construction is part of sustainable development which is applied in the construction industry. Apart from that, it was also emphasized that sustainable construction refers to main issues including social, economic and environmental issues. Zavadskas

et al., (2017) reiterate that the United Nations has identified 17 main points of sustainable development which are categorized into three pillars, including social, economic and environmental sustainable goals.

According to Khan, M., & McNally, C. (2023) civil engineering is one of the departments that is crucial in building and maintaining modern development. Solid and sustainable infrastructure is an important foundation for a country's economic development and quality of life. In an era of ever-growing globalization, civil engineering faces new challenges that require innovation to remain relevant and competitive. Civil engineering plays an important role in planning, designing and construction of various types of infrastructure. Some examples of infrastructure built by civil engineering include roads, bridges, dams, buildings, clean water systems and drainage systems. The role of civil engineering in building sustainable infrastructure includes several aspects, such as environmental sustainability.

Civil engineering must consider the environmental impacts of infrastructure projects. Environmentally friendly design and the use of recycled materials are important to reduce carbon footprints and environmental degradation. Modern infrastructure needs to be designed to use energy resources efficiently. The application of the latest technology and design strategies that focus on energy performance will help reduce energy consumption and optimize the built infrastructure (Omer, M. A., & Noguchi, 2020).

In areas prone to natural disasters, civil engineering must design infrastructure that is able to survive and function during emergency conditions. The construction of dams that are capable of handling floods, or the construction of buildings that are earthquake resistant are examples of the application of civil engineering in disaster resilience. Civil engineering also plays a role in designing and building efficient and integrated transportation systems. The development of good transportation infrastructure will increase the mobility of people and goods, support economic growth, and reduce traffic congestion (de Almeida Barbosa Franco et al., 2022).

In building sustainable infrastructure there are also several challenges, such as climate change. Climate change causes an increased risk of natural disasters such as floods, landslides and sea level rise. Civil engineering must integrate climate change adaptation strategies in infrastructure design. The availability of resources such as land and construction materials is a concern in infrastructure development. The use of environmentally friendly materials and sustainable design concepts is an opportunity to overcome this challenge.

Kanwar, V. S., & Shukla, S. K. (2020) stated that civil engineering needs to continue to innovate and adopt technology to improve efficiency and quality of infrastructure. Technological developments have influenced almost every aspect of the civil engineering industry, including surveying, BIM (Building Information Modeling) modeling, robot-based construction and modern construction technology that can increase productivity and accuracy. Innovations in information technology enable better collaboration between project teams and stakeholders. The use of cloud-based platforms, project management applications, and geographic information systems (GIS) helps improve efficiency and coordination in civil engineering projects. Innovation also enables civil engineering to seek creative solutions to increasingly complex project challenges. The development of more sophisticated analytical models, the use of artificial intelligence, and innovative construction methods can help address this problems that were previously difficult to solve (Roure et al., 2018).

In infrastructure projects, community participation is important to take into account local needs and aspirations. Involving communities in the planning and decision-making process can produce infrastructure that is more sustainable and acceptable to the public.

The civil engineering department has a strategic role in creating modern, sustainable structures. Through thoughtful planning and design, civil engineering can build infrastructure that is environmentally friendly, energy efficient, and disaster-resistant. Challenges such as climate change and resource limitations can be overcome with innovation and active community participation. Sustainable infrastructure will be an important pillar in achieving sustainable development and improving the quality of life for future generations (Horry et al., 2022).

Sustainable construction cannot be separated from sustainable development. Sustainable development covers all aspects of life, from government political policies, business strategies, to lifestyle. Sustainable development includes not only the planning process but extends to the final results. The realization of sustainable development is complex and must implement an indisciplinary system (Vemury et al., 2018).

RESEARCH METHOD

This research in-depth investigates the analysis of materials technology development in supporting sustainable development in the field of civil engineering using a literature review approach. The results include a

comprehensive understanding of the concept of sustainable development, new technological innovations in building materials for development, and the role of civil engineering in sustainable development. Literature analysis involves an in-depth review of the literature on materials technology development in supporting sustainable development in the field of civil engineering. With a strong conceptual foundation, this research makes an important contribution to enriching the discussion regarding how material technology analysis supports sustainable development in the field of civil engineering.

RESULT AND DISCUSSION

Sustainable Development Concept

Tomislav, K. (2018) states that sustainable development is a development concept that optimizes the benefits of natural and human resources, by harmonizing natural resources with humans in development. This concept aims to improve people's welfare in meeting their needs without sacrificing the abilities of future generations.

According to Beckerman, W. (2017), several concepts related to sustainable development include:

Use natural resources wisely: Sustainable development focuses on managing natural resources well so that they can be used in the future. This involves using natural resources efficiently, avoiding waste, and protecting the environment.

Maintaining the quality of human life: Sustainable development aims to maintain the quality of human life both now and in the future. This involves efforts to meet human needs without compromising environmental sustainability and natural resources.

Progressive transformation: Sustainable development involves progressive transformation of social, economic, and political structures. The aim is to create positive changes in various aspects of people's lives.

Cultural diversity: Sustainable development recognizes the importance of cultural diversity for humans, just as biodiversity is important for nature. This concept emphasizes the need to maintain and respect cultural diversity in the development process.

Sustainable development also involves certain principles, such as sustainable economic development, environmental protection, social justice, and community participation in decision making (Hajian, M., & Kashani, 2021).

New Technological Innovation in Building Materials for Development

Goi, C. L. (2017) stated that the development of science and technology in the field of construction related to building materials has experienced significant progress. Many new innovations have been discovered regarding unique building materials. Many researchers and scientists explore knowledge in the field of building materials. One of those who actively contributes to the development of technology in the field of building materials is PUSKIM (Center for Housing and Settlement Research and Development).

According to Ahmadizadeh et al., (2024) the concept of building materials developed by Puskim uses unusual materials, namely by utilizing something that is considered unimportant. For example, waste to sludge. Through this innovation, the building materials created are able to reduce excessive use of natural resources. Some of the concepts that will be explained are:

1. Lightweight Concrete Bricks from Residual Cracking Catalyst
   Residual cracking catalyst is waste from processing crude oil in the reactor. Using waste as building materials is a step to reduce waste pollution. RCC This was developed for the walls of multi-storey buildings and this technology has been tested. This type of lightweight concrete brick product has a mixture proportion of 75% RCC, 25% silica sand and 1.6% foam agent. This lightweight concrete brick has a compressive strength of n35 Kgf/cm2 with a development technique using foam agent substitution.
2. Coal Waste (Fly-Ash) for Building Components
   Fly-Ash is the residue from burning coal waste produced from steam power plants. Coal waste processing aims to overcome environmental problems resulting from the development of industries that use coal as energy. This processing has been applied in various regions. The type of product produced has an aggregate mixture proportion (60% fly ash + 405 sand). The type of product produced is hollow concrete brick with a mixture proportion of 1 cement = 8 aggregate; interlock blocks with a mixture proportion of 1 cement = 6 aggregates; concrete roof tiles with a mixture proportion of 1 cement = 3 aggregate; paving blocks with a mixture proportion of 1 cement = 4 aggregates; solid concrete bricks with a mixture proportion of 1 cement = 10 aggregate.

3. Utilization of Sidoarjo Mud for Building Materials

   This building material was developed to utilize the mud that comes out of the Lapindo mudflow. The production unit was built near the mudflow site. The building materials derived from this mud are as follows.

   a. Warp Light Concrete

      Lusi Light Concrete is a concrete component formed from Sidoarjo mud with Portland cement as a binder. This concrete has a light weight, medium quality, and a stable shape. Aggregates (gravel, sand and ash) are made from Sidoarjo mud through a combustion process to obtain a material that is light, strong, resistant to high temperatures and aggressive environments. In making Lusi aggregate, substitute materials can be added with coal ash or rice husk ash. This concrete is suitable for construction that requires fire resistance, sound and temperature absorption, light weight, and exposure to sulfate and chloride salts. The goals and benefits of creating Isi are related to the advantages that can be created through this technology. The target of making Isi is to produce lightweight aggregate and lightweight concrete from Lusi; increasing the use value of Lusi, reducing environmental impacts, and supporting the supply of building materials; provides technical instructions for making lightweight concrete from Lusi. The benefits of making Isi, namely the growth and development of aggregates and lightweight concrete from Lusi and supporting development programs and increasing business opportunities.

   b. Application of Polymer and Ceramic Base Building Material Technology

      The output and outcomes of polymer and ceramic base building materials technology are related to the results and impacts felt when applying this technology. The output of polymer and ceramic base building materials technology is applied technology in the form of production units and houses. An example is using building materials from Lusi materials. The outcomes that can be produced from this technology are the use of Lusi material as raw material for making building components, thereby reducing the negative impact of mudflows; the availability of building components from Lusi materials which can support the provision of building materials for housing.

4. Lime Pozzolan Cement

   This cement was developed as an alternative to pozzolan cement for simple buildings, especially in areas where transportation is difficult, but has the

potential for lime and trace. This technology has been pioneered to be implemented in Wamena, Nagrek and Sukabumi.

5. Laminated Bamboo
   The development of laminated bamboo was carried out in order to provide an alternative building material to replace wood which is increasingly difficult to obtain on the market, especially for strength class I wood. Using bamboo as an alternative to wood with this lamination technique can be used as beams, columns or planks like wood. This laminated bamboo can be applied to almost all building components, except roof coverings.
6. Tawon's Nest Bamboo Tawon's Nest Bamboo is a type of panel sheet made from a combination of log bamboo and people's booths, the manufacturing process of which uses a hot press machine. This technology is still in the assessment stage before it can be implemented.
7. Zephyr Bamboo
   This type of bamboo is the result of bamboo being flattened and glued to each other using organic adhesive. This technology already has one applicator and the product has been tested on riverbanks in the Netherlands. The following is an explanation of this Zephyr bamboo. The types of materials used are bamboo sticks, split bamboo, fiber/foam, slices, and Zephyr. The adhesive materials are UF, PF, MF, and Isocyanate, etc. Furthermore, the products produced are bamboo panels, bamboo blocks, and building structures and walls and water gates.
8. Innovation Shingles from Bamboo
   This innovation in developing bamboo shingles was carried out in order to preserve the local wisdom of the community and to develop local, environmentally friendly building materials. Bamboo, which is a plant that grows quickly and is spread throughout Indonesia, has great potential for development. For this reason, this innovation is intended to improve the performance, efficiency and durability of bamboo shingles when used in the community. The innovative bamboo shingle design has the same shape as conventional shingles in general. However, when viewed in terms of quantity and installation requirements, innovative shingles are 60% more efficient than conventional shingles.
9. Laminate Bebak from Gewang
   This application of bebak laminate was carried out in order to improve the quality of partition wall components in residential houses on Timor Island, NTT Province, carried out through lamination and gewang compression technology. Lamination technology can increase strength and make the

appearance more attractive compared to a complete goal. Laminated Gewang boards are made from gewang tree fronds which are processed using lamination techniques into board sheets measuring 60 x 120 cm.

The Role of Civil Engineering in Sustainable Development

Civil engineering has a very important role in sustainable development. This field is involved in planning, designing, implementing, operating and maintaining the infrastructure needed by a country (Berglund et al., 2020).

The following are some of the roles of Civil Engineering in sustainable development (Hao et al., 2023):

1. Planning: Civil Engineering plays a role in planning environmentally friendly and sustainable infrastructure development. This includes choosing the right location, efficient use of resources, and reducing negative impacts on the environment.
2. Design: Civil Engineering is responsible for designing structures and infrastructure systems that are safe, strong and sustainable. They consider factors such as sustainability, energy efficiency and the use of environmentally friendly materials.
3. Implementation: Civil Engineering is involved in implementing infrastructure development projects. They ensure that construction is carried out to a high standard and in accordance with applicable regulations.
4. Maintenance: Once the infrastructure is completed, Civil Engineering also has a role in maintenance and upkeep. They ensure that the infrastructure remains functioning properly and is safe for long-term use.
5. Environmental Management: Civil Engineering must eliminate or reduce environmental problems that may arise in development projects. They must integrate climate change adaptation strategies in infrastructure design and use environmentally friendly materials and sustainable design concepts

In facing the challenges of climate change and sustainability, Civil Engineering needs to continue to innovate and adopt technology to improve the efficiency and quality of infrastructure. With this important role, Civil Engineering can make a significant contribution in creating a better future for our planet (Mei, L., & Wang, 2021).

The development of modern infrastructure is one of the main pillars in supporting a country's progress. In this context, the role of civil engineering becomes very vital. Civil engineering does not only focus on construction aspects, but also includes planning, design, management and maintenance of

infrastructure. As time progresses, the challenges and needs in infrastructure development continue to experience significant changes, encouraging civil engineers to continue to innovate and adapt.

Technological developments have changed the way we build and manage infrastructure. The use of advanced technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and artificial intelligence (AI) has had a major impact on this sector. This technology allows civil engineers to design buildings more efficiently, estimate material requirements more accurately, and monitor infrastructure conditions in real-time. This not only increases efficiency, but also reduces costs and risks in development projects (Pregnolato et al., 2022). In addition, the need for sustainable infrastructure is becoming increasingly urgent. Civil engineering plays an important role in creating environmentally friendly and long-lasting solutions. The use of greener building materials, such as recycled concrete and environmentally friendly steel, as well as the application of sustainable design principles, is a main focus. In addition, civil engineering also plays a role in developing efficient and environmentally friendly water management systems, which is very important in the face of climate change and rapid urbanization.

Rapid urbanization in many countries, especially in urban areas, adds complexity to infrastructure development. Civil engineering must be able to respond to these challenges by designing and building infrastructure that can not only accommodate an ever-increasing population, but can also improve the quality of life. The development of mass transportation, bridges, highways and other public facilities is a top priority to ensure efficient mobility and connectivity.

The role of civil engineering in infrastructure development also includes social and economic aspects. Good infrastructure can facilitate economic growth by opening access to markets, increasing productivity and creating jobs. In addition, well-designed infrastructure can also improve community welfare by providing better access to health services, education and other public facilities. Civil engineering, thus, has a great responsibility in ensuring that infrastructure development can provide maximum benefits for society (Qin et al., 2023).

Resilience to natural disasters is an important aspect of modern infrastructure design. Civil engineering plays a role in designing buildings and infrastructure that are resistant to earthquakes, floods and other disasters. This involves in-depth risk analysis and the application of technologies and

materials that can increase the structure's resistance to various threats (Mulder, 2017). Thus, civil engineers focus not only on construction, but also on mitigating risks to protect lives and property. Education and research in civil engineering also play a key role in supporting the development of modern infrastructure. Educational institutions continue to develop curricula that suit current and future industry needs. Research in new materials, construction technologies and innovative design methods makes a major contribution to creating more efficient and sustainable infrastructure. Collaboration between academics and practitioners is also important to ensure that theory and practice go hand in hand.

Infrastructure development cannot be separated from regulatory aspects and government policies. Civil engineering plays a role in ensuring that the projects carried out comply with applicable standards and regulations. Apart from that, they are also often involved in the planning and decision-making process regarding infrastructure development policies. With good regulations, development can be carried out in a structured and sustainable manner.

The role of civil engineering in modern infrastructure development is very complex and multidimensional. Civil engineers must continually adapt to technological developments, environmental challenges, and changing socio-economic needs. With innovation, collaboration and commitment to sustainability, civil engineering will continue to be a key pillar in building a better future for society and the country (Zamora-Polo, F., & Sánchez-Martín, 2019).

CONCLUSION

In supporting sustainable development in the field of civil engineering, the development of materials technology plays an important role. Sustainable materials technology can help create environmentally friendly, efficient and long-lasting construction. The following are several analyzes related to the development of materials technology in supporting sustainable development in the field of civil engineering:

1. Use of environmentally friendly materials: The development of sustainable materials technology can involve the use of materials that have a lower environmental impact. For example, using concrete with fewer additives such as cement can reduce carbon emissions. Apart from that, the use of recycled materials or alternative materials that are more environmentally friendly can also be a focus for developing materials technology.

2. Efficient use of materials: The development of materials technology can also focus on the efficient use of materials in construction. For example, the use of porous concrete technology can reduce material and energy use in infrastructure construction. In addition, the use of materials technology that allows the reuse or recycling of construction materials can also help reduce waste and use of natural resources.
3. Structural sustainability: Materials technology development can also focus on structural sustainability. This involves developing materials that have a longer service life, are resistant to damage, and require minimal maintenance. By using durable materials, it can reduce the need for structural repairs and replacement, which in turn reduces environmental impact.
4. Innovation in construction technology: Development of materials technology can also involve innovation in construction technology. For example, the use of robots and automation in construction can increase efficiency and accuracy, reduce time and costs, and reduce environmental impact. In addition, the use of sensors and monitoring technology can help in more efficient infrastructure maintenance and management.

The development of materials technology in the field of civil engineering is an important step in supporting sustainable development. By focusing on the use of environmentally friendly materials, efficient use of materials, structural sustainability, and innovation in construction technology, civil engineering can contribute to creating sustainable and environmentally friendly infrastructure.

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