PRECAST WALL PANEL, GREEN, SUSTAINABLE SYSTEM, AND MANAGEMENT DESIGN MODEL

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ABSTRACT: Residential builders always try to solve problems as efficiently as possible from various sides to achieve the highest success. The completion cost always swells due to the lack of attention to efficiency in using materials and professional personnel. This research deals with aligning residents with adequate control according to their respective goals. The findings of this study are based on the investigative method that compared traditional technology with the new technology for household affaris to facilitate the public. The research concluded that precast foam technology which is currently widely discussed and thoroughly researched, is only at the planning/design and construction stages. However, it is still considered a new field for managing the facilities when the building operates. This study has theoretical as well as practical implications to develop the model sustainable system of housing for the public.

Keywords: Precast Foam, Green, Sustainable, Design, Wall Panel, Sustainable System, Management Design Model

1. Introduction

Residential builders always try to solve problems as efficiently as possible from various sides to achieve the highest success (Farrington et al., 2019). This type of management will be discussed as the background for completing this research, as finishing construction always pays attention to cost, quality, and time. The completion cost always swells due to the lack of attention to efficiency in using materials and professional personnel. One step without any forecast management or a more thorough discussion, the costs will swell beyond the plan (Munir & Afifuddin, 2020). All workers must follow the procedure and maintain their attitude while working. The quality of housing has always been the focus of its residents. So, service providers must be careful in choosing safe and robust residential-scale materials because it is the central moment in making housing (P. Liu et al., 2022). The general objective of this paper is to increase cost, quality, and time efficiency to generate various ideas so that residential development does not have to adapt to materials available in the market. The purpose is to: (1) Create a quick management system on a small scale for residential development in terms of cost, quality, and completion time; (2) Complete a building development where a review can be completed orderly and planned before implementation. Researchers identify possibilities to build a cluster-type simple house of 3 to 5 units, where the drawings and specifications are planned following the shape of the house. This review, in terms of quality, cost, and time will reduce the expenses of all service users and still get good quality results in a relatively shorter period.

Completion of a house indeed begins with excellent and purposeful management (Gu et al., 2020). This study deals with aligning residents with adequate control according to their respective goals. This type of management will be discussed as the background for completing this research, as finishing construction always pays attention to cost, quality, and time. One step without any forecast management or a more thorough discussion, the costs will swell beyond the plan. All workers must follow the procedure and maintain their attitude while working (Shalenny & Andronov, 2020). The quality of housing has always been the focus of its residents. Changing the old (conventional) culture to the new one (precast foam technology) will cause pros and cons between stakeholders who use PRECAST FOAM and those with traditional calculation methods (Guo et al., 2022). Here, the purpose is to provide understanding and knowledge directed to the incumbent/organization and every resource involved to start using PRECAST FOAM technology. It can be done by preparing all the supporting things in implementing PRECAST FOAM, including training on using software that supports BIM technology and preparing all the necessary supporting equipment such as computers and others (A. Syed & R. Sonparote, 2020). It is hoped that there will be a building facilities management system based on PRECAST FOAM, which is supported by proper and good standards of eligibility to facilitate appropriate management and function properly (Shi & Su, 2021). This technology is a spark and a breakthrough in completing residential buildings in clusters in any location (O'Hegarty & Kinnane, 2020). It accelerates completion and reduces development costs, especially for urban residents and generally all residential areas, both urban and rural (Y. Liu et al., 2022).

This research is significant because this area was not discussed in the earlier studies (Hao, Yang, & Liang, 2022). No doubt, there are studies on precast foam, but the studies have neglected the role of precast foam for sustainability of the housing to facilitate the public (A. Syed & R. S. Sonparote, 2020). Therefore, this research is based on the identified gap in the literature to contribute in the theory for enhancing the literature about sustainable housing management with modern technology. On the other hand, the study has practical implications that are critically important for quality of house management with modern technology that is useful for the people. Hence, this study is significant by its research gap, theoretical and practical implications. Moreover, the future directions of this research are critical to consider for sustainability and sustainable development. The future research may focus on the role precast foam technology importance for sustainable housing that could not be damaged from hazards. This contribution would be worthy because modern world is facing these challenges with environmental issues.

2. Literature Review

The cycle, which serves as the study context, is introduced in the first section. The development management phase, the reserch's main focus, is then detailed and thoroughly discussed. The paper then gives a building modelling example. The next step is making an implementation management plan, from designing the working drawings and calculating needed materials. The initial arrangement will be a collection of final results regarding well-controlled expenses, the quality desired by the owner, and a work schedule planned. The result is a model and depiction of a building that is not a global reference but can prove that cost, quality, and time can be obtained by changing the previously commonly used building materials and implementation theory. So, these cycles will alter the price to be more economical, quality is maintained, and the completion time is faster. Many factors affect the implementation of making housing (Saheed et al., 2021). The plan is to create a building that is more efficient and referred to as a green building. Meanwhile, population density and industry have become separate discussions and problems (Liu et al., 2021). This paper discusses eco-friendly and cost-effective prefabricated houses with all parts fabricated in a mill. After that, it is sent to the location for assembly, connection, and partially on-site cast construction. Antonio J. Sanchez-Garrido, Ignacio J. Navarro, and Víctor Yepes explain how to produce soil that can be used as a foundation because the conditions are always different.

It has been widely discussed by previous researchers and reviewed to analyze the impact of the life cycle from an individual financial, natural, and social standpoint. Furthermore, the multi-criteria decision-making model is used and evaluated comprehensively to assess the sustainability performance arising from each design. The model produces a comprehensive decision with multiple criteria reviewed (Farrington et al., 2019). In their research, Natalia Reggiani Manzo and Michalis F. Vassiliou state that every column at the Bottom must stand firmly in the foundation. It is discussed for rocking bridges where spring-loaded tendons can handle it with calculated forces to fit it better (Munir & Afifuddin, 2020). Mariam Abdulkareem, Jouni Havukainen, Jutta Nuortila-Jokinen, and Mika Horttanainen argue that the noise caused by trains and the invention of a compound that was better than its era. It is a mixture of several PCC components and geopolymers found in the rock in the pyramid. LHNB (Low height noise barrier) has become a topic of discussion to create noise-cancelling when a train passes by with a limit to the size of human hearing in Db units. Geopolymer is a material formed from several aluminium silicate particles. It is constructed so homogeneously that it becomes hard to destroy by natural acidification. It is like a pyramid standing strong with a long enough age of up to 40 years. More importantly, it has a low emission yield (P. Liu et al., 2022). Sara Reichenbach and Benjamin Kromoser prove that automation technology in precast concrete production is reviewed in detail from modelling with plans using PRECAST FOAM and mass production with robotic automation. It all aims to reduce costs and production time.

Production is done by moulding concrete from building infrastructure, utility completeness accessories, and all that is important until the building is finished. It is also mass-produced. Here, costs and time can be cut bigger (Gu et al., 2020). Ali Katebi, Peyman Homami, and Mohammad Najmeddin explain that the use of models based on TAM and TOE to solve all problems in institutional units or work that require improvement and a superior understanding than before by adopting a precast concrete component (PCC) approach through experience for civil engineer (Shalenny & Andronov, 2020). Cesario Tavares, Xincheng Wang, Sajib Saha, Zachary Grasley, and Zachry state that A cutting-edge material with remarkable mechanical qualities and superior durability is ultra-high performance concrete (UHPC). By promoting designs with more effective shapes and cross-sectional dimensions, its advanced rates encourage the development of creative superstructural elements. It is possible because of the material's high compressive strength, an important determinant of mechanical performance, cost, and sustainability. A satisfactory level of multi-objective performance is frequently required to optimize mixed proportions. Due to its discontinuous pore structure, dense matrix, and multi-cracking behaviour at the microscale, the durability is significantly better than that of traditional concrete. Cement, silica fume, fine quartz sand, a high distance water reducer, and fibres are the typical ingredients.

Mineral mixtures typically vary from 10 to 25 per cent silica fume, 25 to 30 per cent quartz sand, 10 to 40 per cent fly ash, and 55 to 59 per cent slag when replacing cement. Meanwhile, The usual water-to-cement ratio (w/cm) lies in the 0.15 to 0.25 range (Guo et al., 2022). The Life Cycle Assessment method is used by Jenan Abu Qadourah, Ala'a M. Al-Falahat, and Saad S. Alrwashdeh to assess and contrast the energy and carbon content of three different intermediate floor structures. To choose which floor construction material has the least ecological impact to employ in constructing a semi-detached house in the UK, it all uses prefabricated materials of cross-laminated timber, precast hollow core concrete, and solid concrete. The carbon footprint from the cradle to the grave was calculated using the ICE inventory and carbon calculator. It determines whether a CLT solution has better natural results than a conventional (A. Syed & R. Sonparote, 2020). Sani Muhammad Bida, Farah Nora Aznieta Abdul Aziz, Mohd Saleh Jaafar, Farzad Hejazi, and Nabilah Abu Bakar say how to construct a green building using precast concrete sandwich panels. It is targeted at a facility that uses PCSP wall modelling to reduce the air temperature coming in from the outside. The material's yield strength must be 40 MPa and pass a 10 mm maximum filtering. The middle of the precast wall has a wire mesh bar and heat isolation (Shi & Su, 2021). Triple bottom line is a model based on BIM-LCSA-FAHP, according to Marcus V. A. P. M. Filho, Bruno B. F. da Costa, Mohammad Najjar, Karoline V. Figueiredo, Marcos Barreto de Mendonça, and Assed N. Haddad.

It is the benchmark for a better-precast concrete manufacturing journal. The study aims to develop a new paradigm for evaluating the most sustainable building materials for low-income buildings. The proposed approach consists of describing a 3D building information modeling model and assessing its parameters using ten sub-criteria based on LCSA-TBL criteria (O'Hegarty & Kinnane, 2020): (1) ecological (primary energy, non-renewable energy, eutrophication, global warming, ozone depletion, smog generation, and total mass); (2) financial (construction expenses); (3) social politics issues (community impact). Daniel Ferrández, Engerst Yedra, Carlos Morón, Alicia Zaragoza, and Kosior-Kazberuk researched on wall panels that are strong enough to withstand thermal. The wall is made of lime which is given a mineral wall or rock wall with low thermal power that can catch fire. The type of mineral wall is obtained from solid waste disposal from a construction and demolition factory separated manually. This discovery changes the technology of retaining the temperature from the outside for a country with a microclimate. The following raw materials are used in the preparation of mortar: hydraulic lime, natural aggregate, graphite expanded polystyrene insulation for use in facades (EPS-F), expanded polystyrene insulation for indoor use (EPS-I), wool insulation minerals, and water (Y. Liu et al., 2022). Because of its high strength and good seismic performance benefits, Ying Chang Wu, Liu Peng Sheng, and Wei Jian Zhao think that the splice grounded sleeve connector has a significant market share in precast concrete.

Precast concrete is one of the main ones to realize green buildings because it is environmentally friendly. The material is very seismic, strong, and cost-efficient. The paper discusses splice grounded sleeve connectors made of ductile iron and systematically strong from developed countries' production (Hao et al., 2022). Evangelia Georgantzia, Themistoklis Nikolaidis, Konstantinos Katakalos, Katerina Tsikaloudaki, and Theodoros Iliadis discuss sustainable precast concrete composite that utilizes the PCSP-ISF test model. The base and fad are mixed with a steel structure to withstand lateral forces during an earthquake. With this theory, the value of a building will be cost and time efficient compared to conventional technology. The aim is to overcome the common shortcomings mentioned above. The Sustainable Preconstructed Innovative Module research project aims to develop advanced, precise bonding innovative wall modules that will meet high requirements for operation and

performance. It securely supports all imposed building loads, has outstanding hygrothermal behaviour, boasts enhanced energy performance, offers acoustic insulation protection, resists fire action, and reduces environmental impact throughout its life cycle. Given this comprehensive strategy and conceptual framework, this ground-breaking wall system promotes sustainability in the construction industry (A. Syed & R. S. Sonparote, 2020).

Jiasheng Zhang, Pengcheng Xiang, Jia Zhong, Jian Zhang, Zezhou Wu, and Maxwell Fordjour Antwi-Afari describe that population and industrial densities have become a matter in China. Their paper discusses prefabricated houses, which are environmentally friendly and very cost-effective. Compared with traditional construction methods, prefabrication has many advantages (4). Construction can be industrialized using premade parts, which lengthens projects and improves their quality and sustainability. The goal is the creation of environmentally friendly housing that refers to green buildings without having to ignore the aesthetics, functionality, and structure (Liu et al., 2021). According to Grzegorz Ludwik Golewski and Bartosz Szostak, utilizing fly ash in precast concrete mixtures lowers concrete preservation greatly. However, it is very good for hydration when the concrete is drying or improving its quality. A few additions to keep it working (BRANZ, 2016): (1) plain Portland cement from CC Plant; (2) Puawy thermal-electric generating plant silica fly ash; (3) a pit sand deposit in Markuszów; (4) gravel from the Las Suwalski deposit; (5) nano-mixture; (6) laboratory piped water; (7) plasticizer STACHEPLAST 125; (8) superplasticizer Master Glenium ACE 430. H. Hakim and T. Endangsih explain that the green building concept is their paper's main principle. The conclusion is based on a matrix that evaluates various facets of the work system, including zoning, working hours, employee count, and financial, social, and cultural factors. Steel as the primary structural material receives the highest rating. It can create a variety of material building components and has undergone structural strength testing. Strong, rust-resistant, lightweight, easy to install and recyclable scrap steel that can be reshaped are the requirements for ecologically safe materials.

In Indonesia, there are numerous manufacturing modular building system technologies in development. Of the 50 producers examined, 11 had site visits, and the other 39 had evaluations based on secondary data. There are, in sum, eight different types of modular manufacturing construction systems, including one) the mild steel system, two) the RISHA system, three) the steel system as the primary construction, four) Expanded Polystyrene (EPS) walls; six) Concrete Mix Walls (a combination of cement and Styrofoam); seven) Polyurethane (PU) walls; and eight) Styrofoam walls with plastered wire mesh. The development of green buildings has environmental, economic, and social advantages. Steel is used because it is eco-friendly. Cost-effectiveness and labour and time savings are examples of economic advantages. Last but not least, social benefits are widely available throughout Indonesia. The steel system is the primary framework, combined with manufactured wall materials to benefit from several advantages. The most effective method, EPS, is used in a unique, modular housing (Lee, An, & Yu, 2012). Jozef Jasiczak, Rene-Xavier Gerard, Lech Wojtasik, Blazej Przychocki, Jakub Bednarek, Krzysztof Cichocki, and Jaroslaw Kolodziej researche the concept of the green building that focus on time and cost. Precast concrete with a quality finish level used in the engineering and design of cutting-edge residential buildings is bonded on-site using unique connections or systems that take the place of conventional masonry techniques.

The labour force required for house construction will be 260 person-hours using precast production and installation methods. It won't be more expensive to manufacture and install these parts in a plant than to build the same partition conventionally (Hamzah et al., 2016). T-C Ling and M Tiong explain how to build an infrastructure by increasing efficiency that benefits people and nature. The production of crucial building materials like concrete necessitates cement, which is responsible for 7–10% of worldwide CO2 emissions. Around 2.8 billion m3 of concrete is produced globally (Gu et al., 2020). Academic research progress is mainly broken down into the following three areas (Spedding, 1994): (1) Production of carbonated steel slag grain aggregates; (2) Products of the dry mix press carbonation; (3) Concrete ready for usage has carbonation. The precast shear panel construction load is determined while being lifted by Jimin Liu, Hui Yu, and Pingfan Xu. The maximum tensile stress, the reinforcement stress in the tension section, the unit's ability for flexure, and the two- and three-point lifting design contracts are all examined. The difficulty of monitoring and validating them during lifting is resolved. Two-point lifting is more financially efficient to assure the safety of the lifting point acquired. Reconstructing precast concrete structures and choosing construction plans both benefit from inspection calculations. The paper's description of the lifting is based on precise engineering calculations. It tried to investigate high-rise precast components that might serve as a guide for related projects (Laird, 1994).

Jelena Šantek Bajto, Nina Štirmer, Sonja Cerkovic', Ivana Carevic,' and Karmen Kostanic' Juric' explain the possibility of reusing WBA waste in concrete products. In close cooperation with precast concrete producers, we produce and test concrete with various WBAs in fresh and hardened states. The mixture's test results will be utilized to create prototypes so that a full-scale commercial process may be implemented and its viability for use assessed. New, sustainable products can be produced more cheaply in large production facilities. Further research is advised to make and sell novel products using alternative ingredients worldwide (Rezaei & Honarpisheh, 2014). Using three wastes as the primary sources, Wanchai Yodsudjai and Kirati Nitichote compare the chloride penetration behaviour of concrete made from several forms of recycled aggregates: demolition building (B-RCA), laboratory (L-RCA), and precast concrete (P-RCA). The 28-day test of natural aggregate concrete compressive strength using replacement ratios of 30%, 60%, and 100%, respectively. The findings show that the behaviour of the concrete cannot be affected by the quality of the recycled aggregate waste signal. The finer aggregate may increase the interfacial transition zone's capacity to break down. It was discovered that there was a strong correlation between the amount of chloride permeation and the size of the ITZ area. The method allows for a concrete cross-sectional description of each element's features, with the results corresponding to the concrete behaviour. If there is a significant archive of data from its cross-section, it will be possible to anticipate the properties of concrete in the future (Atkin, Borgbrant, & Josephson, 2008).

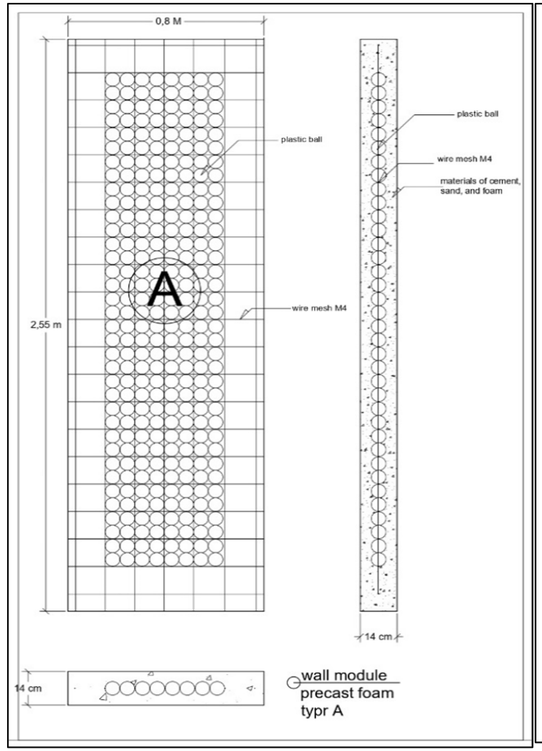
Viorel Ungureanu and Daniel M. Muntean state that Romania has undergone significant changes. Urban populations are expanding quickly, often tripling, which has raised housing demand (Kincaid, 1994). To promptly build new dwellings, large reinforced precast concrete components are used. It is a way to deal with issues that are getting more challenging and expensive (Teicholz, 2001). As a result, it engages in extensive activity to repress all lines of human requirements from all angles, including economic, social, and financial (IFMA, n.d.). Sustainable infrastructure necessitates assessing the greenhouse gas emissions a building project produces throughout its life cycle, according to KNR Putri, MI Tjandrawira, and TN Handayani. The Life Cycle Assessment method computes the source emissions from the materials, transportation activities, and construction (Roper, Cotts, & Payant, 2010). The Inventory of Carbon and Energy database's carbon data was used (Lin, Chen, & Su, 2017). According to the analysis, the precast building project emits 124.882.7 kgCO2eq or 283.18 kgCO2eq GHG per m2 of construction. Precast component installation, transportation, and material emissions contributed 119,649 kgCO2eq (95.81%), 632.41 kgCO2eq (0.51%), and 4,599.30 kgCO2eq, respectively (3.68 percent, respectively). LCA is a technique that is frequently used to assess how well a product performs environmentally throughout its entire life cycle. LCA research, according to ISO 14040 (William East, Nisbet, & Liebich, 2013), involves four interactive phases, including (Eastman et al., 2008): (1) defining the goals and the scope; (2) life cycle analysis; (3) impact evaluation, and (4) interpretation. The first stage determines the important elements.

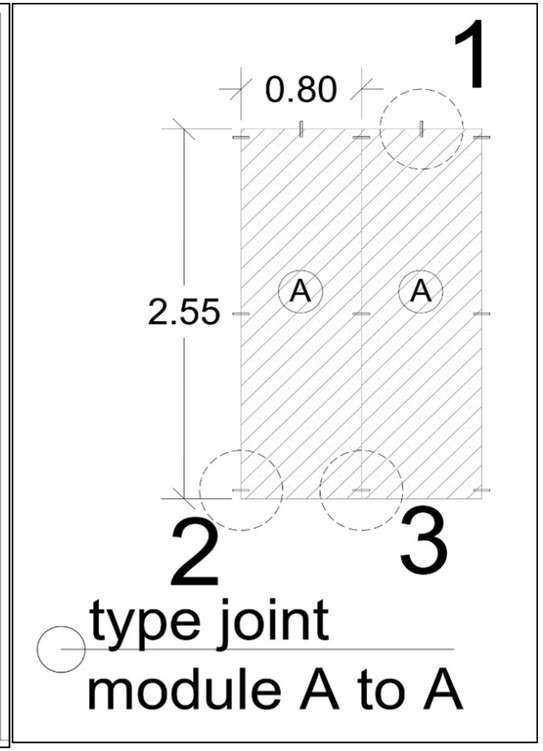
3. Methodology

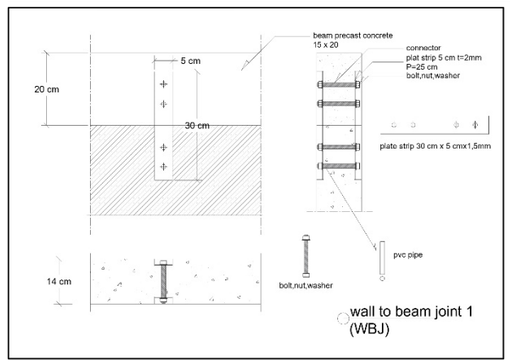
The methodology of this study is investigative that is based on the research and conclusion of earlier studies. Furthermore, many experts in 3D modelling are considered for determining the alternative facilites for housing. The analysis results suggest using 3D modelling as an alternative to managing the existing facilities in the building for managers/officers. It helps them to work the facility properly, correctly, and accurately. Changing the old (conventional) culture to the new one (precast foam technology) will cause pros and cons between stakeholders who use PRECAST FOAM and those with traditional calculation methods. Here, the solution is to provide understanding and knowledge directed to the incumbent/organization and every resource involved to start using PRECAST FOAM technology. It can be done by preparing all the supporting things in implementing PRECAST FOAM, including training on using software that supports BIM technology and preparing all the necessary supporting equipment such as computers and others.

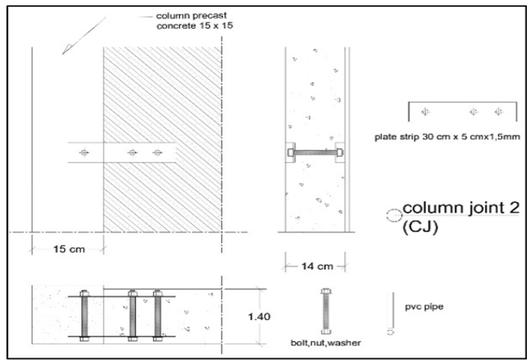
4. Design

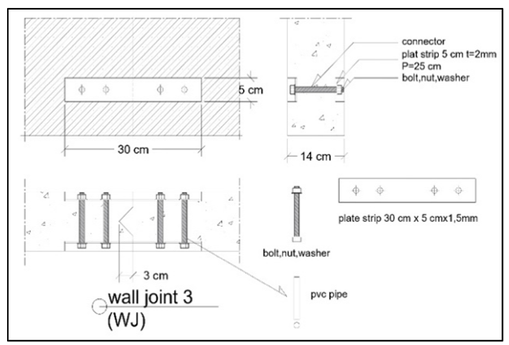
House from the Precast Model, The results of precast foam and the recommended and suggested modelling for an example of a 3x5 m type house can be seen in the following picture.

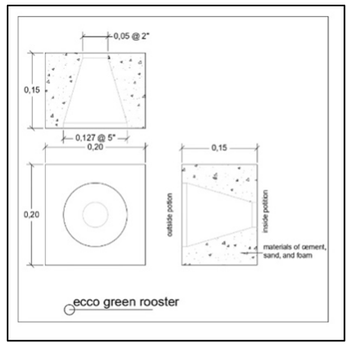


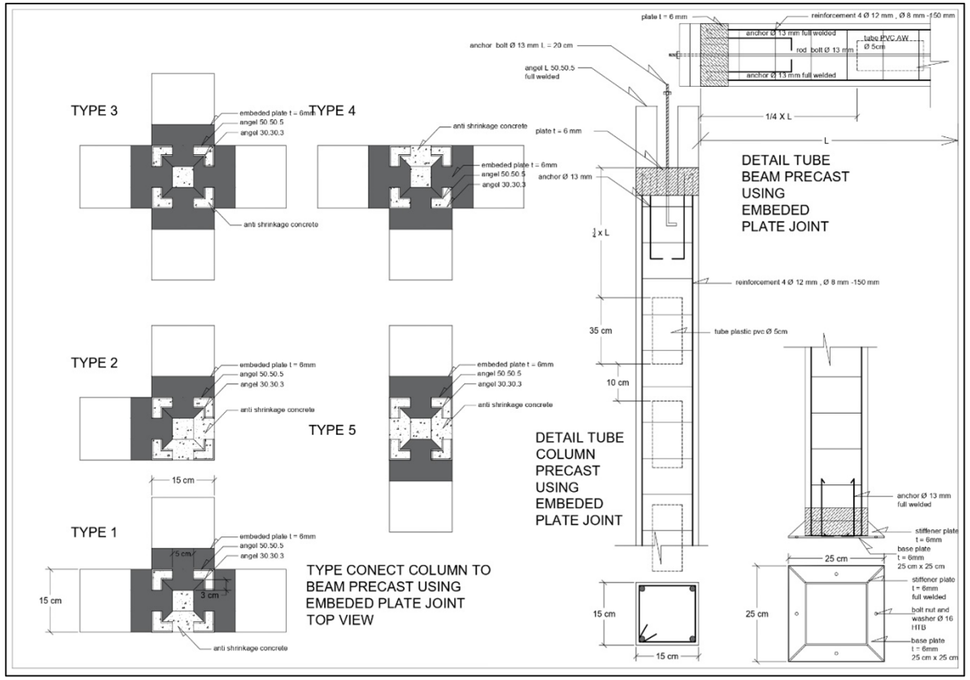


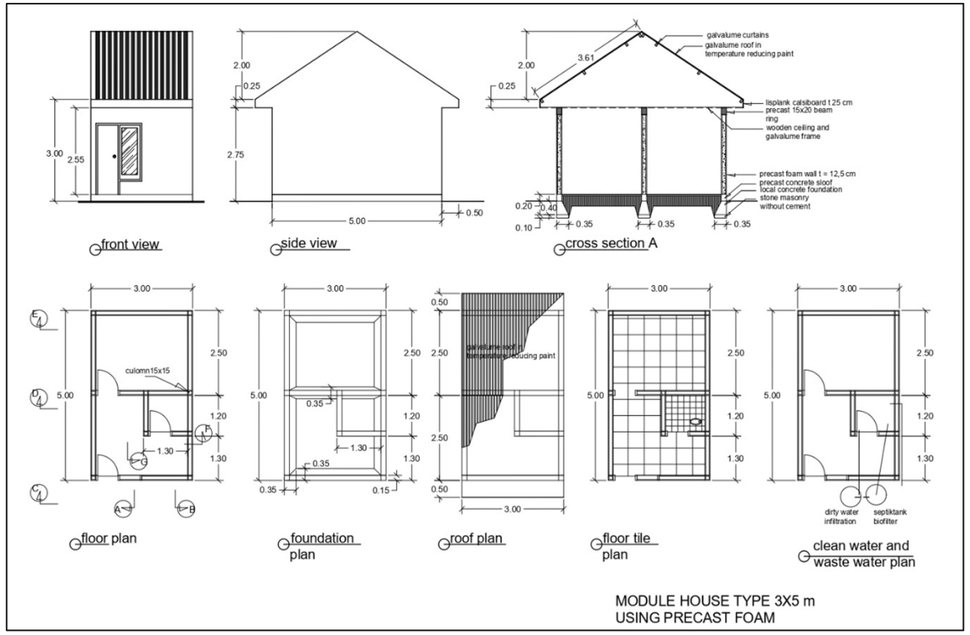












5. Conclusions and Implications

Precast Foam technology which is currently widely discussed and thoroughly researched, is only at the planning/design and construction stages (Volk, Stengel, & Schultmann, 2014). However, it is still considered a new field for managing the facilities when the building operates (Abdullah et al., 2014).The above can be used as information to manage all the facilities in a building. It is

hoped that there will be a building facilities management system based on PRECAST FOAM, which is supported by proper and good standards of eligibility to facilitate appropriate management and function properly. This technology is a spark and a breakthrough in completing residential buildings in clusters in any location (Barlish & Sullivan, 2012; Latham, 1994; Smith & Tardif, 2012). It accelerates completion and reduces development costs, especially for urban residents and generally all residential areas, both urban and rural (Becerik-Gerber et al., 2012; BIM Alliance Sweden, 2017; National Institute of Building Sciences, 2007; Teicholz, 2012).

This research has contributed in the literature by explaining the important role of precast foam technology for building design. This technology was not considered to the higher level in literature because it is on the introduction stage (Alexander, 2013; Arayici, Onyenobi, & Egbu, 2012; Aubin, 2019; Brinda & Prasanna, 2014; Kelly et al., 2013; Naghshbandi, 2016; Wetzel & Thabet, 2015). This research has determine that the role of precast foam is critical for modern building design and sustainability in the structure of building. In the earlier studies, this critical importance was not considered. Secondly, this study has contributed some design in the literature that extended the body of knowledge related to the budiling design with precast foam technology. These designs would enhance the understanding of future researchers for developing model with precast technology.

This study has remarkable practical implications because it has insisted on the role of sustainable housing with the help of precast foam teachnology. In this regard, the study recommended that in future the deisng on building should be based on the precast technology because it is best model for 3D developing of design. In this regard, the building designers should consider the important role of this technology. Secondly, the checks on the proper implementation of these design with precast technology should be done to ensure the safety of its installation. In the modern time, the bulding design should be sustainable with modern design to provide sustainable living experience to the people.

Reference

Abdullah, S. A., Sulaiman, N., Latiffi, A. A., & Baldry, D. (2014). Building information modeling (BIM) from the perspective of facilities management (FM) in Malaysia. In *International Real Estate Research Symposium*. INSPEN, Kuala Lumpur. http://dx.doi.org/10.13140/2.1.4886.0164

Alexander, K. (2013). *Facilities management: theory and practice*. Routledge. https://doi.org/10.4324/9780203475966

Arayici, Y., Onyenobi, T., & Egbu, C. (2012). Building Information Modelling (BIM) for Facilities Management (FM): The Mediacity Case Study Approach. *International Journal of 3-D Information Modeling (IJ3DIM), 1*(1), 55-73. http://doi.org/10.4018/ij3dim.2012010104

Atkin, B., Borgbrant, J., & Josephson, P.-E. (2008). *Construction process improvement*. John Wiley & Sons. https://cds.cern.ch/record/1620987

Aubin, P. (2019). *Revit Families: A Step-By-Step Introduction*. Autodesk, Inc. https://www.autodesk.com/autodesk-university/article/Revit-Families-Step-Step-Introduction-2018?linkId=80371415s

Barlish, K., & Sullivan, K. (2012). How to measure the benefits of BIM—A case study approach. *Automation in construction, 24*, 149-159. https://doi.org/10.1016/j.autcon.2012.02.008

Becerik-Gerber, B., Jazizadeh, F., Li, N., & Calis, G. (2012). Application areas and data requirements for BIM-enabled facilities management. *Journal of construction engineering and management, 138*(3), 431-442. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000433

BIM Alliance Sweden. (2017). *About BIM Alliance*. BIM Alliance Sweden. https://www.bimalliance.se/om-oss/in-english/

BRANZ. (2016). *New Zealand BIM Handbook*. BRANZ. https://www.biminnz.co.nz/nz-bim-handbook-v2

Brinda, T., & Prasanna, E. (2014). Developments of facility management using building information modelling. *International Journal of Innovative Research in Science, Engineering and Technology, 3*(4), 11379-11386. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1062.5338&rep=rep1&type=pdf

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2008). *Frontmatter*. Wiley Online Library.

Farrington, E. S., Anderson, T., Grant, L., & Seraderian, R. (2019). Precast concrete-to-precast concrete facade joints using precompressed expandable foam. *PCI Journal, 64*(6). https://www.pci.org/PCI_Docs/Publications/PCI%20Journal/2019/November-December/19-0001_Seraderian_ND19.pdf

Gu, G., Xu, F., Ruan, S., Huang, X., Zhu, J., & Peng, C. (2020). Influence of precast foam on the pore structure and properties of fly ash-based geopolymer foams. *Construction and Building Materials, 256*, 119410. https://doi.org/10.1016/j.conbuildmat.2020.119410

Guo, S.-Y., Wang, W., Jia, Z., Qi, X., & Liu, X. (2022). Nanoparticle-Stabilized Foam with Controllable Structure for Enhanced Foamed Concrete. *Available at SSRN 4206641*. https://dx.doi.org/10.2139/ssrn.4206641

Hamzah, N., Ismail, Z.-A., Kamaruzzaman, S. N., Mutalib, A. A., & Ani, A. I. C. (2016). A CMMS expert using BIM for IBS building maintenance. *MATEC Web of Conferences, 66*, 00052. https://doi.org/10.1051/matecconf/20166600052

Hao, Y., Yang, G., & Liang, K. (2022). Development of fly ash and slag based high-strength alkali-activated foam concrete. *Cement and Concrete Composites, 128*, 104447. https://doi.org/10.1016/j.cemconcomp.2022.104447

IFMA. (n.d.). *About IFMA*. IFMA. https://www.ifma.org/about/about-ifma/

Kelly, G., Serginson, M., Lockley, S., Dawood, N., & Kassem, M. (2013). BIM for facility management: a review and a case study investigating the value and challenges. In *Proceedings of the 13th International Conference on Construction Applications of Virtual Reality* (Vol. 2, pp. 30-31). https://research.tees.ac.uk/en/publications/bim-for-facility-management-a-review-and-a-case-study-investigati

Kincaid, D. (1994). Integrated Facility Management. *Facilities, 12*(8), 20-23. https://doi.org/10.1108/02632779410062353

Laird, S. (1994). Total Facilities Management. *Facilities, 12*(13), 25-26. https://doi.org/10.1108/02632779410795396

Latham, S. M. (1994). *Constructing the team*. HM Stationery Office. https://constructingexcellence.org.uk/wp-content/uploads/2014/10/Constructing-the-team-The-Latham-Report.pdf

Lee, S.-K., An, H.-K., & Yu, J.-H. (2012). An extension of the technology acceptance model for BIM-based FM. In *Construction research congress 2012: construction challenges in a flat world* (pp. 602-611). American Society of Civil Engineers. https://doi.org/10.1061/9780784412329.061

Lin, Y.-c., Chen, Y.-p., & Su, Y.-c. (2017). Integrated BIM/RFID-based Facility Management System. *International Journal of Advances in Mechanical and Civil Engineering, 4*(4), 68-72. http://www.iraj.in/journal/journal_file/journal_pdf/13-395-150849196868-72.pdf

Liu, P., Gong, Y. F., Tian, G. H., & Miao, Z. K. (2021). Preparation and experimental study on the thermal characteristics of lightweight prefabricated nano-silica aerogel foam concrete wallboards. *Construction and Building Materials, 272*, 121895. https://doi.org/10.1016/j.conbuildmat.2020.121895

Liu, P., Wu, W., Du, B., hua Tian, G., & feng Gong, Y. (2022). Study on the heat and moisture transfer characteristics of aerogel-enhanced foam concrete precast wall panels and the influence of building energy consumption. *Energy and Buildings, 256*, 111707. https://doi.org/10.1016/j.enbuild.2021.111707

Liu, Y., Zhang, J., Chang, J., & Zhao, Y. (2022). Use of Cement Hydration Heat as Heating Resource in Curing of Precast Concrete-Temperature Rise Simulation. *Journal of Advanced Concrete Technology, 20*(9), 564-580. https://doi.org/10.3151/jact.20.564

Munir, A., & Afifuddin, M. (2020). Thermal performance of precast foam concrete integrated with green roofs system. In *EduARCHsia & Senvar 2019 International Conference (EduARCHsia 2019)* (pp. 202-206). Atlantis Press. https://dx.doi.org/10.2991/aer.k.200214.031

Naghshbandi, S. N. (2016). BIM for facility management: challenges and research gaps. *Civil Engineering Journal, 2*(12), 679-684. https://doi.org/10.28991/cej-2016-00000067

National Institute of Building Sciences. (2007). *National Institute of Building Sciences*. National Institute of Building Sciences. https://buildinginformationmanagement.files.wordpress.com/2011/06/nbimsv1_p1.pdf

O'Hegarty, R., & Kinnane, O. (2020). Review of precast concrete sandwich panels and their innovations. *Construction and building materials, 233*, 117145. https://doi.org/10.1016/j.conbuildmat.2019.117145

Rezaei, A., & Honarpisheh, A. (2014). Application of Building Information Modeling in highway projects. In *11th International Congress on Advances in Civil Engineering, ACE 2014 At: Istanbul Technical University, Istanbul, Turkey*. https://www.researchgate.net/publication/280084098

Roper, K. O., Cotts, D., & Payant, R. (2010). *The Facility Management HandBook*. New York, NY, American Management Association.

Saheed, S., Amran, Y. M., El-Zeadani, M., Aziz, F. N. A., Fediuk, R., Alyousef, R., & Alabduljabbar, H. (2021). Structural behavior of out-of-plane loaded precast lightweight EPS-foam concrete C-shaped slabs. *Journal of Building Engineering, 33*, 101597. https://doi.org/10.1016/j.jobe.2020.101597

Shalenny, V., & Andronov, A. (2020). Contractual and technological methods for ensuring the reliability and efficiency of seismic protection systems for the precast-monolithic civil buildings. *IOP Conference Series: Materials Science and Engineering, 913*(3), 032052. https://doi.org/10.1088/1757-899X/913/3/032052

Shi, C., & Su, J. (2021). Study on Preparation and Installation Technology of Assembled Decorative and Thermal Insulation Integrated Wallboard. In *2021 International Conference on Mechanical, Aerospace and Automotive Engineering* (pp. 282-286). ACM Digital Library. https://doi.org/10.1145/3518781.3519221

Smith, D. K., & Tardif, M. (2012). *Building Information Modeling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers*. John Wiley & Sons. https://cds.cern.ch/record/1613183

Spedding, A. (1994). *CIOB handbook of facilities management*. Longman Scientific and Technical.

Syed, A., & Sonparote, R. (2020). A Review of Precast Concrete Pavement Technology. *The Baltic Journal of Road and Bridge Engineering, 15*(4), 22-53. https://doi.org/10.7250/bjrbe.2020-15.493

Syed, A., & Sonparote, R. S. (2020). Construction of Pretensioned Precast Concrete Pavement. *Iranian Journal of Science and Technology, Transactions of Civil Engineering, 44*(1), 507-514. https://doi.org/10.1007/s40996-020-00432-7

Teicholz, E. (2001). *Facility design and management handbook*. McGraw-Hill Education. https://www.accessengineeringlibrary.com/content/book/9780071353946

Teicholz, E. (2012). *Technology for Facility Managers: The Impact of Cutting-edge Technology on Facility Management*. John Wiley & Sons.

Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings—Literature review and future needs. *Automation in construction, 38*, 109-127. https://doi.org/10.1016/j.autcon.2013.10.023

Wetzel, E. M., & Thabet, W. Y. (2015). The use of a BIM-based framework to support safe facility management processes. *Automation in Construction, 60*, 12-24. https://doi.org/10.1016/j.autcon.2015.09.004

William East, E., Nisbet, N., & Liebich, T. (2013). Facility management handover model view. *Journal of computing in civil engineering, 27*(1), 61-67. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000196

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No	Journal Title	Author	Publication	Summary
1	Evaluating the sustainability of soil improvement techniques in foundation substructures	Antonio J. Sa´nchez-Garrido Ignacio J. Navarro Víctor Yepes	Journal of Cleaner Production 351 (2022) 131463	A study explains how to produce soil that can be used as a foundation because the conditions are always different. It has been widely discussed by previous researchers and reviewed to analyze the impact of the life cycle from an individual economic, environmental, and social perspective. Furthermore, the MCDM (multi-criteria decision-making) model is applied to evaluate sustainability performance resulting from each design and viewed from a holistic perspective. The MCDM model produces a comprehensive decision with multiple criteria reviewed.
2	Cyclic tests of a precast restrained rocking system for sustainable and resilient seismic design of bridges	Natalia Reggiani Manzo, Michalis F. Vassiliou	Engineering Structures 252 (2022) 113620	The notion is that every column at the Bottom must stand firmly in the foundation. It is discussed for rocking bridges where spring-loaded tendons can handle it with calculated forces to fit it better.
3	Life cycle assessment of a low-height noise barrier for railway traffic noise	Mariam Abdulkareem, Jouni Havukainen, Jutta Nuortila-Jokinen, Mika Horttanainen	Journal Cleaner Production 323 (2021) 129169	It explains the noise caused by trains and the invention of a compound that was better than its era. It is a mixture of several PCC components and geopolymers found in the rock in the pyramid. LHNB (Low height noise barrier) has become a topic of discussion to create noise-cancelling when a train passes by with a limit to the size of human hearing in Db units. Geopolymer is a material formed from several aluminium silicate particles. It is constructed so homogeneously that it becomes hard to destroy by natural acidification. It is like a pyramid standing strong with a long enough age of up to 40 years. More importantly, here, it has a low emission yield.
4	State of practice of automation in precast concrete production	Sara Reichenbach, Benjamin Kromoser	Journal of Building Engineering 43 (2021) 102527	Automation technology in precast concrete production is reviewed in detail from modelling with plans using PRECAST FOAM and mass production with robotic automation. It all aims to reduce costs and production time. Production is done by moulding concrete starting from building infrastructure, utility completeness accessories, and all that is important until the building is finished. It is also mass-produced. Here, costs and time can be cut bigger.
5	Acceptance model of precast concrete components in building construction based on the Technology Acceptance Model (TAM) and Technology, Organization, and Environment (TOE) framework	Ali Katebi, Peyman Homami, Mohammad Najmeddin	Journal of Building Engineering 45 (2022) 103518	Use of models based on the Technology Acceptance Model (TAM) and Technology, Organization, and Environment (TOE) to solve all problems in institutional units or work that require improvement and a superior understanding than before by adopting a precast concrete component (PCC) approach through experience for civil engineer
6	Machine learning-based mix design tools to minimize carbon footprint and cost of UHPC. Part 1: Efficient data collection and modelling	Cesario Tavares, Xincheng Wang, Sajib Saha, Zachary Grasley	Cleaner Materials 4 (2022) 100082	Ultra-high-performance concrete (UHPC) is an advanced material with outstanding mechanical properties and superior durability. The advanced properties of UHPC stimulate the development of innovative superstructural elements by promoting designs with more efficient shapes and cross-sectional dimensions. It is achievable due to the high compressive strength of the UHPC material, a significant factor determining mechanical performance, cost, and sustainability. Optimization of mixed proportions often involves a satisfactory level of multi-objective performance. The durability of UHPC is far superior to that of conventional concrete due to its discontinuous pore structure, dense matrix, and multi-cracking behaviour at the microscale. UHPC usually consists of cement, silica fume, fine quartz sand, a high distance water reducer (HRWR), and fibres. Typical ranges for replacing cement mass with mineral mixtures are 10-25% silica fume, 25-30% quartz sand, 10-40% fly ash, and 55-59% slag. Meanwhile, the typical water-to-cement ratio (w/cm) ranges between 0.15 and 0.25
7	INVESTIGATE THE CARBON FOOTPRINTS OF THREE INTERMEDIATE FLOORING SYSTEMS: CROSS-LAMINATED TIMBER, SOLID CONCRETE, AND HOLLOW-CORE PRECAST CONCRETE	Jenan Abu Qadourah Ala'a M. Al-Falahat Saad S. Alrwashdeh	doi:10.5937/jaes0-32783 Paper number: 20(2022)2, 943, 377-385	It evaluates and compares energy and carbon content using the Life Cycle Assessment (LCA) approach for three different intermediate floor structures. It all uses prefabricated materials of cross-laminated timber (CLT), precast hollow core concrete, and solid concrete to decide which floor construction material has the less environmental impact to use in the construction of a semi-detached house in the UK. The ICE inventory and carbon calculator were used to calculate the footprint from the cradle to the grave. It determines whether the use of a CLT solution provides improved environmental performance over that of traditional concrete.
8	Thermal Resistance of Insulated Precast Concrete Sandwich Panels	Sani Muhammad Bida Farah Nora Aznieta Abdul Aziz Mohd Saleh Jaafar Farzad Hejazi Nabilah Abu Bakar	Bida dkk. Int J Concr Struct Mater (2021) 15:41 https://doi.org/10.1186/s40069-021-00477-6	A precast concrete sandwich panel (PCSP) is a precast sandwich panel method that leads to a green building. It is directed to a structure that can lower the air temperature from outside with PCSP wall modelling. The material must pass a maximum sieve of 10 mm with a yield strength of 40 MPa. It is a precast with a wire mesh bar and temperature insulation in the middle of the PCSP wall.
9	Sustainability Assessment of a Low-Income Building: A BIM-LCSA-FAHP-Based Analysis	Marcus V. A. P. M. Filho Bruno B. F. da Costa Mohammad Najjar Karoline V. Figueiredo Marcos Barreto de MendonçaAssed N. Haddad 3,*	Buildings 2022, 12, 181. https://doi.org/10.3390/buildings12020181	Triple Bottom Line (TBL) is a model based on BIM-LCSA-FAHP, the benchmark for a better-precast concrete manufacturing journal. This study aimed to develop a new framework for assessing the choice of the most sustainable materials for low-income building construction. The proposed procedure consists of the description of the 3D Building Information Modeling (BIM) model, where the parameters are evaluated according to the Life Cycle Sustainability Assessment (LCSA)-TBL-based criteria, divided into ten sub-criteria: • environmental (acidification, eutrophication, global warming, ozone depletion, smog formation, primary energy, non-renewable energy, and total mass, • economic (construction costs) • social politics issues (community impact)
10	Circular Building Process: Reuse of Insulators from Construction and	Daniel Ferrández Engerst Yedra	Buildings 2022, 12, 220.	This research focuses a lot on wall panels that are strong enough to withstand thermal. The wall is made of lime which is given a mineral wall or rock wall with low thermal power that can catch fire. The type of mineral wall is obtained from solid

	Demolition Waste to Produce Lime Mortars	Carlos Morón Alicia Zaragoza Marta Kosior-Kazberuk	https://doi.org/10.3390/buildings12020220 https://www.mdpi.com/journal/build	waste disposal from a construction and demolition factory separated manually. This discovery changes the technology of retaining the temperature from the outside for a country with a microclimate. The following raw materials are used in the preparation of mortar: hydraulic lime, natural aggregate, graphite expanded polystyrene insulation for use in facades (EPS-F), expanded polystyrene insulation for indoor use (EPS-I), wool insulation minerals, and water.
11	Research and Development Status of Grouted Splice Sleeve in Precast Concrete Structure	Ying Chang WU Liu Peng SHENG Wei Jian ZHAO	E3S Web of Conference 38 03034 (2018) ICEMEE 2018	The splice grounded sleeve connector has a strong share in precast concrete because it has the advantages of high strength and good seismic performance. Precast concrete is one of the main ones to realize green buildings because it is environmentally friendly. The material is very seismic, strong, and cost-efficient. This paper discusses splice grounded sleeve connectors made of ductile iron and systematically strong from the production of developed countries worldwide.
12	Dynamic Performance Analysis by Laboratory Tests of a Sustainable Prefabricated Composite Structural Wall System	Evangelia Georgantzia Themistoklis Nikolaidis Konstantinos Katakalos Katerina Tsikaloudaki Theodoros Iliadis	*Energies* **2022**, *15*, 3458. https://doi.org/10.3390/en15093458	This paper discusses sustainable composite precast concrete that applies the representative test model “Precast Concrete Steel Panel-Infilled Steel Frame” (PCSP-ISF). The base and fad are mixed with a steel structure to withstand lateral forces during an earthquake. With this theory, the value of a building will be cost and time efficient compared to conventional technology. The aim is to overcome the common shortcomings mentioned above. The Sustainable Preconstructed Innovative Module research project aims to develop advanced, precise bonding innovative wall modules that will meet high requirements for operation and performance. It safely bears all the imposed building loads, features advanced energy performance, exhibits excellent hygrothermal behaviour, provides acoustic insulation protection and resistance to fire action, and minimizes the environmental footprint over its life cycle. Given this holistic approach and conceptual framework, this innovative wall system advances sustainability in the building sector
13	Recycling of Precast Concrete Waste Sludge With Paper Mill and Biomass Ashes for Lightweight Granulated Aggregate Production	Samira Moukannaa Kalle Kursula, Priyadharshini Perumal Katja Ohenoja Mirja Illikainen	April 13, 2022 Doi.103389/fmats.2022.877160	
14	EXPLORING KEY FACTORS FOR CONTRACTORS IN OPENING PREFABRICATION FACTORIES: A CHINESE CASE STUDY	Jiasheng Zhang Pengcheng Xiang Jia Zhong Jian Zhang Zezhou Wu Maxwell Fordjour Antwi-Afari	published: February 03, 2022 doi: 10.3389/fpubh.2022.837350	In China, population and industrial densities have become a matter of discussion and problem. This paper discusses prefabricated houses, which are environmentally friendly and very cost-effective. Prefabricated buildings are where all or part of the building is fabricated in a factory. It is then transported to the construction site for assembly, connection, and partial cast-in-site construction (1-3). Compared with traditional construction methods, prefabrication has many advantages (4). Using prefabricated components is a way to industrialize construction, increasing project duration, quality, and sustainability. The goal is the creation of environmentally friendly housing that refers to green buildings without having to ignore the aesthetics, functionality, and structure.
15	Application of the C-S-H Phase Nucleating Agents to Improve the Performance of Sustainable Concrete Composites Containing Fly Ash for Use in the Precast Concrete Industry	Grzegorz Ludwik Golewski Bartosz Szostak	Published: October 29, 2021	The disadvantage of using Fly Ash in precast concrete mixtures is that it greatly reduces the preservation of concrete. However, it is very good for hydration when the concrete is drying or improving its quality. A few additions to keep it working: • plain Portland cement (OPC) from Chełm Cement Plant; • silica FA from the Puławy thermal-electric power plant; • pit sand from the Markuszów deposit; • gravel from the Las Suwalski deposit; • nano-mixture; • laboratory piped water; • plasticizer STACHEPLAST 125; • superplasticizer Master Glenium ACE 430
16	The application of the green building concept through fabrication modular construction system in special house construction	H Hakim T Endangsih	IOP Conf. Series: Earth and Environmental Science 878 (2021) 012033	The concept of green building is the main principle of this paper. The conclusion is based on an assessment matrix of aspects of the work system, working time, number of workers, financial, social, cultural, and zoning. The one that gets the highest score is steel as the main structure. It has been tested for structural strength and can produce many building material components. The criteria for green materials include strong, anti-rust, easy to install and lightweight, and recyclable scrap steel that can be reshaped. Many manufacturing modular construction system technologies are developing in Indonesia. Of the 50 producers studied, 11 visited their production sites, and 39 were assessed through secondary data. It can be concluded that there are eight Modular Manufacturing Construction systems, namely: 1) Mild steel system, 2) RISHA system, 3) Steel system as the main construction, 4) Precast concrete system as the main construction structure, 5) Expanded Polystyrene (EPS) walls, 6) Concrete Mix Walls (a mixture of cement and Styrofoam), 7) Polyurethane (PU) walls, and 8) Styrofoam walls and plastered wire mesh. The benefits of Green Building Development include environmental, economic, and social. The ecological use of steel is that it is environmentally friendly. Economic benefits include cost efficiency and saving time and labour. Lastly, social benefits are easy access to all corners of Indonesia. With the advantages of various aspects, the steel system is the main structure combined with fabricated wall materials. EPS is the most optimal system implemented in a special house with a modular design.
17	Production of Elements for an Innovative Energy- Saving Prefabricated Construction under the	Jozef Jasiczak Rene-Xavier Gerard Lech Wojtasik	Jozef Jasiczak et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 471	The concept of the green building becomes a reference in the discussion of this paper. But the thing to focus on is time and cost. Engineering and design work to develop innovative residential buildings are made of precast concrete with a high finish level and bonded on-site through special connections or systems that replace traditional

	Project Plus Energy Prefab House	Blazej Przychocki Jakub Bednarek Krzysztof Cichocki Jaroslaw Kolodziej	022040	masonry methods. Adopting such a precast production and installation system will limit the labour force for house construction to 260 person-hours. The factory production cost of these elements and their installation will not exceed the execution cost of the same partition as the traditional method.
18	Developing carbon-neutral construction materials using water as a carbon sink	T-C Ling M Tiong	IOP Conf. Series: Earth and Environmental Science 861 (2021) 072018 doi:10.1088/1755-1315/861/7/072018	Zero emission is the target of discussion. It explains how to build an infrastructure by increasing efficiency that benefits people and nature. It is known that 7%-10% of global CO2 emissions are attributed to the cement industry, which is required to produce important construction materials, such as concrete. Every year, about 2.8 billion m3 of concrete is made worldwide [4]. Academic research progress is mainly broken down into the following three areas: • Production of steel slag grain aggregates through carbonation • Dry mix press carbonation products • Carbonation of ready-to-use concrete
19	Discussion on construction checking calculation of high-rise precast shear panel during lifting	Jimin Liu Hui Yu Pingfan Xu	IOP Conf. Series: Earth and Environmental Scienc2e18 (2019) 012061 doi:10.1088/1755-1315/218/1/012061	This paper determines the load of the precast shear panel construction during lifting. It examines the maximum tensile stress, the tension section’s reinforcement stress, the unit’s flexural capacity, and the two- and three-point lifting design contracts. The conclusion is that the two-point lifting is more economical to ensure the safety of the lifting point obtained, and the problem of checking and verifying the precast shear panels during lifting is solved. Inspection calculations are important in reconstructing precast concrete structures and determining construction schemes. The lifting process of precast shear panels described in this paper is based on actual engineering with detailed calculation processes. It attempted to examine high-rise precast elements that could be used as a reference for similar projects.
20	Pilot Scale Production of Precast Concrete Elements with Wood Biomass Ash	Jelena Šantek Bajto Nina Štirmer Sonja Cerkovic Ivana Carevic Karmen Kostanic´ Juric	Materials 2021, 14, 6578. https://doi.org/10.3390/ma14216578	The aim is to find the possibility of reusing WBA waste in concrete products. The production and testing of concrete with different WBAs in the fresh and hardened state are carried out in close collaboration with precast concrete manufacturers. The test results of the mixture will be used for prototype production to evaluate its feasibility for use and implement a full-scale commercial process. Existing substantial production facilities can separate new, sustainable products at lower costs. Recommendations are made for further investigations to promote and commercialize innovative products with alternative ingredients in the global market.
21	Chloride Penetration Behavior of Concrete Made from Various Types of Recycled Concrete Aggregate	Wanchai Yodsudjai Kirati Nitichote	Sustainability 2022, 14, 2768. https://doi.org/10.3390/su14052768	This study aims to relate the chloride penetration behaviour of concrete made from various types of recycled aggregates from three wastes as the main sources: demolition building (B-RCA), laboratory (L-RCA), and precast concrete (P-RCA). 28-day natural aggregate compressive strength test with replacement ratios of 30%, 60%, and 100%, respectively. The results reveal that the quality of the recycled aggregate waste signal cannot influence the concrete behaviour. The finer aggregate can potentially increase the interfacial transition zone (ITZ) to decompose. Using the image processing method to consider ITZ in this experiment, it was found that a very consistent relationship between the size of the ITZ area and the amount of chloride permeation was found. This technique can describe each element’s characteristics in a concrete cross-section, where the results follow the concrete behaviour. In the future, it will be possible to predict the properties of concrete if there is a large archive of information from its cross-section.
22	Life Cycle Assessment of Retrofitting Large Prefabricated Panels Low-Rise Collective Dwellings	Viorel Ungureanu Daniel M. Muntean	Viorel Ungureanu and Daniel M. Muntean 2019 IOP Conf. Ser.: Mater. Sci. Eng. 471 112070	Romania has undergone significant changes. Rapid urban population growth, doubling in some cases, has led to increased demand in the housing market. Large reinforced precast concrete components (LRPCC) are used to provide new homes quickly. It is a solution to dealing with increasingly difficult and costly situations. So, it carries out activities in large portions to suppress all lines regarding human needs from all sides, economic, social, cost, etc.
23	Greenhouse Gases (GHG) Emissions during the Construction Stage of a Precast Building in Indonesia	K N R Putri M I Tjandrawira T N Handayani	IOP Conf. Ser.: Earth Environ. Sci. 933 012007 IOP Conf. Series: Earth and Environmental Science 933 (2021) 012007 doi:10.1088/1755-1315/933/1/012007	Implementation of sustainable infrastructure requires calculating the greenhouse gas emissions generated by a construction project through its life cycle. This study analyzes it to construct a three-story precast building. Source emissions are calculated from materials, transportation activities, and erection using the Life Cycle Assessment (LCA) approach. Carbon data was adopted from the Inventory of Carbon and Energy (ICE) database. From the analysis that has been carried out, the precast building project produces 124.882.7 kgCO2eq or 283.18 kgCO2eq GHG per m2 of building. Emission contributions from materials, transportation precast components, and installation of precast components were 119,649 kgCO2eq (95.81%), 632.41 kgCO2eq (0.51%) and 4,599.30 kgCO2eq (3.68%, respectively). LCA is a widely used method for evaluating the environmental performance of the entire product life cycle. According to ISO 14040 [5], LCA research consists of four interactive phases, namely • definition of objectives and scope, • life cycle inventory, • impact assessment, and • (iv) interpretation. The first stage determines the important elements.