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3D Printing Technology For Housing Construction Projects in Malaysia: The Perceptions of Construction Stakeholders

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ABSTRACT

The global construction landscape is undergoing a paradigm shift driven by Construction 4.0 and the Fourth Industrial Revolution (IR 4.0). Despite its potential for small-scale residential projects, Three-Dimensional Concrete Printing (3DCP) technology remains in its infancy within the Malaysian construction industry. This study investigates the readiness of the industry by assessing construction stakeholder's perceptions of its potential, suitable technological approaches, and best implementation practices. Utilizing a mixed-methods questionnaire survey analysed through descriptive statistics and thematic coding, the research identifies critical drivers and barriers to adoption. The findings provide a strategic framework for best practices, offering a roadmap for stakeholders to integrate 3DCP into the Malaysian housing market effectively. The results show that the perception of respondents regarding the potential of 3DCP technology for housing construction project is very high in minimising time in construction and generally, high potential of enhancing housing project delivery in Malaysia, with moderate to high opinion on the potential to minimise waste, reliance on foreign labour, long-term costs and the better quality of housing. Hybrid applications gained by using 3D printed parts with traditional construction and low-rise housing are considered the most appropriate ones, and extrusion-based 3D concrete printing and modular 3D printing are also considered the most appropriate, but with lower confidence. Among the best practices emerging are the formulation of clear guidelines and standards, specialised training, government, industry and academia collaboration and the pilot housing project, but it seems that the lack of skilled personnel, unclear regulations, high initial equipment cost and low public awareness are seen as the key detractors. Malaysian stakeholders recognise 3DCP's potential to save time, waste, and labour in housing construction project. However, they emphasize that mainstream success depends on better standards, specialized training, and the use of local materials.

Keywords: 3D printing technology, Housing projects, Construction stakeholders.

Abbreviations

AMF	Additive Manufacturing File
BIM	Building Information Modelling
CAD	Computer Aided Design
3DCP	Three Dimensional Concrete Printing
STL	Stereolithography

1.0 INTRODUCTION

The Malaysian construction industry is very important in the development of the country, especially to satisfy the housing requirements of an increasing and urbanising population but it still experiences delays, overruns, heavy labour reliance and high material wastage which lead to low productivity and even delays in providing a timely housing supply [1]. To this, more efficient and sustainable approaches like 3D printing of concrete are gaining traction and have demonstrated internationally the capability to provide a quicker method of construction, reduced labour requirements, enhanced use of materials and increased design adaptability of low- to medium-rise housing and prefabricated units. Additive manufacturing, also known as 3D printing, has become construction 3D printing or 3D concrete printing, in which cementitious materials are deposited in layers to structure and non-structure, and has demonstrated successful use in low to medium-rise housing around the world [2]. Construction 3D printing in Malaysia, however, remains at an early stage with limited implementation and concerns about the suitability of the system to local housing types and compatibility with local materials and climate, lack of specific standards and regulations, high initial cost and technical skills shortages.

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In this context, the level of systematic research on how Malaysian construction stakeholders view the potential of 3D printing, the technologies and methods used which are useful, and the best practices needed to make it happen, is still unclear to industry stakeholders and policymakers when it comes to its wider use. The study's objective is to evaluate the perceived potential of 3D printing technology in housing construction in Malaysia, investigate perceptions of suitable 3D printing technologies and methodologies within the industry, and assess the perceived best practices for implementing 3D printing in the Malaysian construction sector. The research focuses on low to medium-rise residential construction projects, drawing upon existing literature and responses from a questionnaire administered to Malaysian construction stakeholders engaged in the industry.

2.0 LITERATURE REVIEW

2.1 Overview of 3D printing in construction

Construction using 3D printing technology, also known as 3D concrete printing (3DCP), is a process in digital fabrication where cementitious materials that can be printed are deposited in layers that are automated and under machine control to form structural or non-structural building components with less use of conventional formwork and manual labour [3]. The 3D Printing construction begins with a CAD or BIM model, which is changed into machine instructions using slicing and tool-path generation, and material is extruded into a nozzle using a gantry or robotic system [4]. Appropriate printable concrete mixes should meet the requirements of pumpability, extrudability, buildability and early-age strength and recent studies have questioned the use of alternative binders, supplementary cementitious materials and local aggregates to balance the workability, strength and sustainability [5].

Two primary system configurations exist in the construction 3D printing method which are gantry-based and robotic-arm. Gantry systems have a fixed frame and X-Y-Z rails that allow the print head to move around a fixed build area, allowing printing of full-size walls or parts of low-rise buildings at high geometrical accuracy [6]. Robotic-arm systems utilise multi-axis industrial robots which are more liberated to complicated geometries but tend to range over smaller work areas unless mounted on tracks or mobile stages and can be positioned on-site or in factory locations [7]. All these methods of construction define how 3D printing can be adopted in numerous building systems such as low rise housing projects.

2.2 Process of 3D printing in construction

The workflow of 3DCP, or large-scale additive manufacturing, means a departure from conventional pouring to automatic layer-by-layer placement. Essential terms used to describe the above mentioned techniques range from Contour Crafting, Concrete Printing and Binder Jetting; however, the essential process can be roughly divided into 3 stages: digital design (input), material processing and delivery (delivery) and physical deposition, along with post-processing according to generally acceptable definitions. Figure 1 shows the overall process of 3D concrete printing.

2.2.1 Digital design and modelling

In construction using 3D printing method, the digital design is an essential early stage where advanced software is used to produce detailed architectural models. The digital design is usually created using Computer Aided Design (CAD) or Building Information Modelling (BIM) software [8]. This digital volume is brought into a machine-readable format such as STL (stereolithography) or AMF (additive manufacturing format) file [9].

When the model is ready, "*slicing*" software breaks the digital object into a stack of 2D slices. It creates G-code, a computer numerical control programming language that directs the movement of the printer's nozzle as well as its speed and the rate at which it extrudes material [9].

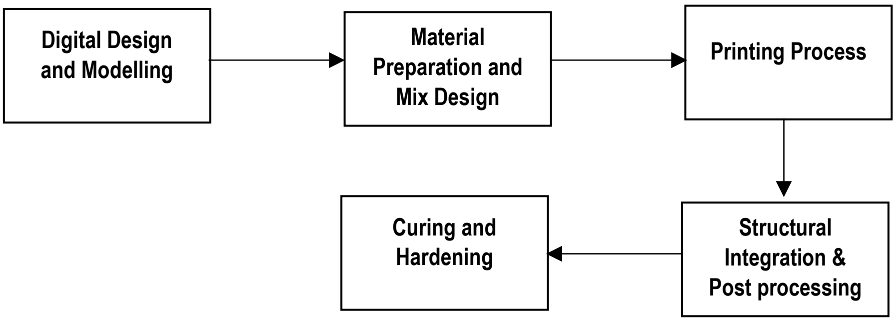

Figure 1. Process of 3D printing method for housing construction

Recent studies have indicated the strong influence of architectural geometry on performance of this stage. It shows that geometrical shapes influence both printing time, amount of material required and mechanical stability, while comparison demonstrates that circular shapes have better construction economy and are cost-effective than rectangular and sharp-cornered configurations [10].

2.2.2 Material preparation and mix design

The material system for 3DCP is complex and involves the delicate interplay between counteracting rheological properties, pumpability (ease of flow in the delivery system) and constructability which is the ability to maintain form upon addition of layers [11]. In contrast to conventional casting in moulds, there is no formwork during 3DCP [12]. As soon as the paste leaves the nozzle of a 3DCP printing head, it should be able to self-support.

The overall composition generally indicates cement-based material with additives such as superplasticizers for flow, viscosity stabilizers to prevent premature hardening, and retarders to control setting times [13]. Even though Portland cement is the dominant binder, researchers are increasingly searching for alternative, environmentally friendly binders. [11] emphasised the potential for geopolymers and recycled materials (e.g. glass or plastic) to increase sustainable properties, but they also pointed out that concrete materials impose a significant carbon footprint compared to bio-based ones. Moreover, the anisotropic behaviour of printed materials, whose mechanical response depends on the printing direction of layers, is still a major technological issue to be addressed in mix design [14].

2.2.3 Printing process (Layer-by-Layer Extrusion)

The 3D printing process is performed by automated material deposition, which is extrusion method. Other methods are Contour Crafting method and powder-based method. Contour crafting method uses trowels connected to the nozzle for smooth finishing surfaces, but Concrete Printing aims to achieve higher resolution deposition without trowelling while allowing more internal geometrical control. An alternative approach is the D-shape method, a powder-based technique that uses a binder jetted by an inkjet print head to bind the powder properly and subsequently form layers achievable for making stone like material without wetting the concrete. Notably, the machinery employed varies between gantry systems and robotic arms. For extensive or on-site manufacturing, a gantry-based system can be employed due to its stability and controllability; nevertheless, it may lack the flexibility of robotic arms, which can produce intricate geometries with 6-axis movement [15]. The printing parameters, including nozzle speed and layer height, must be meticulously regulated; excessive speed may lead to layer disruption, while feed failure might result in structural defects [16].

A large-scale 3D Concrete Printing (3DCP) substantially alters conventional construction techniques by delineating its applications into three principal workflows which is printing of construction elements, production of 3D printed formworks, and on-site monolithic 3D printing [15]. The initial category pertains to the fabrication of modular elements such as walls or columns within a factory environment, thereafter, transported and assembled, ensuring superior quality control and precision. The second category emphasizes the fabrication of elaborate, non-structural concrete shells that serve as permanent formwork for conventional reinforced concrete, enabling the realization of sophisticated geometric forms that would be prohibitively costly to produce using timber or steel molds. On-site monolithic printing employs large gantry or robotic systems to produce a building's complete vertical structure directly at the construction site, therefore substantially lowering labour costs, decreasing material waste, and expediting the total project timeframe. Figure 2 shows the three types of 3DCP method.

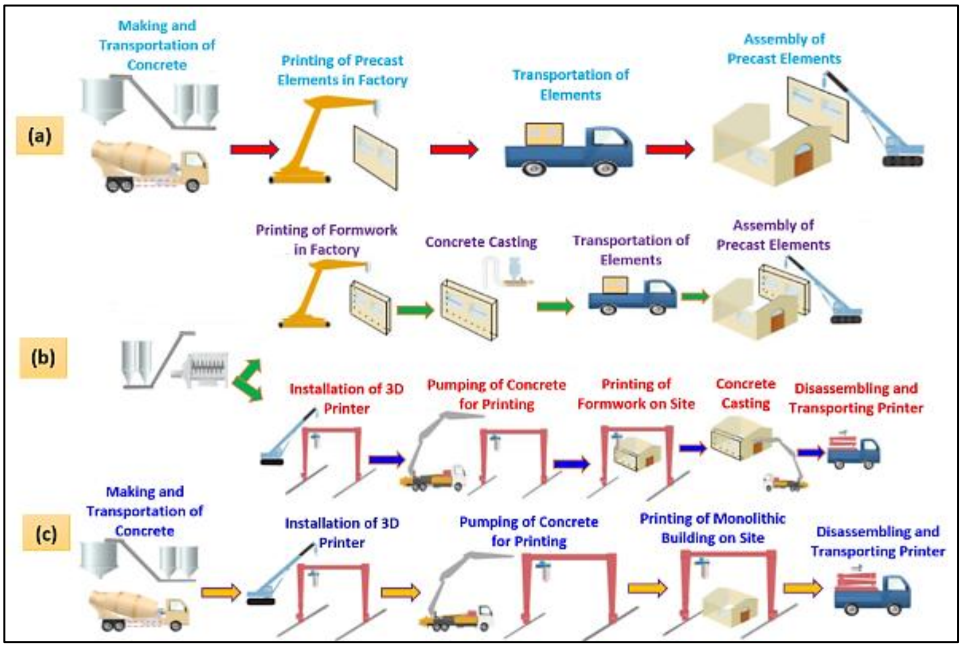

Figure 2. Three types of 3DCP methods [15]

2.2.4 Curing and hardening

After extrusion, curing is required to maintain shape. In comparison to conventional concrete curing process in formwork, where this hydration is controlled by a water-retentive formwork, 3D printed parts are directly exposed to ambient conditions [17]. This rapid water exposure requires close control of ambient conditions to avoid shrinkage, cracking and poor inter-layer bond strength [17]. The material must develop strength to support its own weight and loads applied after it is set, which are factors set by the setting time and mix design [18]. In 3D concrete printing, advanced curing strategies including steam curing, polymer membrane coatings, or chemical hydration stabilizers are increasingly adopted, with real-time monitoring via embedded sensors (temperature, humidity) or non-destructive ultrasonic pulse velocity testing to ensure uniform hydration and optimal mechanical development before post-processing [19].

2.2.5 Structural integration and post-processing

The final stage of the 3DCP workflow involves post-processing and the integration of non-printed elements to render the structure erectable [20]. As 3D printing primarily fabricates vertical structural elements (walls), the installation of roofs, windows, and doors typically employs traditional construction methods [4].

Reinforcement is a key technical issue discussed in this process. Concrete has high compressive strength but very little tensile strength, so it must be reinforced. Strategies include the manual placement of reinforcement in hollow printed cores, which may be filled with steel bars, conventional post-tensioning tendons or fibres (glass, carbon or basalt) added directly to the mix [21]. Also critical is the integration of Mechanical, Electrical and Plumbing (MEP) systems, and voids for such services can be printed directly into the, as part of wall cavity to minimize straight retrospective chasing, but the installation is carried out manually post-printing [21]. Finally, the quality control in quality assurance and defect inspection is employed to guarantee measurement consistency as well as structural safety [22].

2.3 Applications of 3D printing in house construction

Globally, 3D printing has been used more in housing construction due to its potential advantages in construction speed, labour savings, material efficiency, and design freedom [23]. Gantry- and robot-based extrusion-based printing of concrete has become the most common method for housing and prefabricated units, especially when repetitive wall and enclosure components can be produced quickly [24]. Reported projects indicate that layer-by-layer automated printing may take less time to construct, less time to reduce formwork, ease on-site construction and may further be able to define geometry digitally to place materials more accurately and possibly minimise wastage [25]. These characteristics, combined with reduced on-site labour needs, form the basis of assertions of better long-term cost efficiency, although the reality of economic performance is dependent upon equipment price, scale of projects and learning curves [25]. The literature also brings out various technical and practical constraints that must be ironed out so that more people can adopt it in housing. The important technical problems involve the control of fresh and hardened material behaviour, interlayer bonding and dimensional stabilization, and incorporation of reinforcement or hybrid structural systems that comply with safety and durability needs [26]. Key barriers include high initial costs, a lack of skilled workers, and missing regulatory codes. The technology also needs to be customized for local environments and materials [27]. Consequently, there are a lot of housing applications at a pilot or demonstration level, and researchers emphasise the need for implementation guidance and best practice frameworks.

2.4 3D Printing in the Malaysian construction industry

While 3D Concrete Printing (3DCP) is recognized as a transformative Construction 4.0 technology in Malaysia, it remains in the early stages of adoption with few completed housing projects to date. Industry pioneers such as *KA Bina* Malaysia and *Sarawak Consolidated Industries Berhad* (SCIB) are currently leading the integration of 3DCP for building applications [28]. The Malaysian literature mentions increasing awareness regarding construction 3D printing; however, it also indicates doubts about the suitability of the systems in relation to the specific types of houses, the compatibility of the imported technologies with local resources and climate, and the lack of local standards or regulatory processes of printed components [28], [29]. The barrier of high initial cost and inadequate technical skills and unclear processes of approval are often described as the major of the barrier, although the literature recognizes possible returns in productivity, sustainability and affordability, in as far as these challenges can be overcome [29]. Some of the authors suggested that the most viable Malaysian applications will be low-to medium-rise housing and modular units, commonly with hybrid solutions in which the printed walls are integrated with traditional foundations, roofs and structural systems [30].

They underline the necessity of local and context-specific printable mixes, which are to be designed based on local resources, pilot projects, more explicit regulation and specific training to establish some capacity among engineers, contractors and other construction stakeholders [30]. These suggestions emphasise the fact that technical preparedness requires the backing of institutional and human capital development to be successfully implemented.

2.5 Summary and research gap

In general, the literature has a very good technical and contextual foundation on the understanding of construction 3D printing and its housing potential, but it is not without gaps. Specifically, there is a lack of research that concentrates in the perceptions of the Malaysian construction stakeholders towards the potential of 3D printing in housing, the types of 3D printing technology, the methods that they view as most applicable to local environments, and the best practices that they see as necessary to support the implementation of 3D printing [30].

3.0 METHODOLOGY

3.1 Research design and approach

In this study, a quantitative descriptive research design is adopted where a questionnaire survey is used to explore the perceptions of construction stakeholders concerning the potential, appropriate technologies and the best practices in the 3D printing technology in housing construction in Malaysia. The focus is to have closed-ended Likert-scale questions to create numerical data that can be analysed by descriptive statistics (frequencies, means and ranking), without manipulating variables and testing interventions. Furthermore, the survey is designed with a small qualitative element in the form of open-ended questions, where the respondent can explain the difficulties and recommendations using the own words that will complement the quantitative results.

3.2 Target population

The target population consisted of construction stakeholders within the Malaysian housing construction industry who possess prior experience with Industrialised Building Systems (IBS). This group included engineers, contractors, consultants, architects, project managers, and technical draughtsmen. These stakeholders were selected as they are directly involved in planning, design, construction, and management processes where decisions related to the adoption of new construction technologies are typically made.

3.3 Data sampling

A non-probability purposive sampling method was adopted for this study. Questionnaires were distributed to construction stakeholders with experience or exposure to housing construction projects in Malaysia. Since the 3D-printed construction projects are currently very limited in Malaysia, the study specifically targeted construction stakeholders involved in Industrialised Building System (IBS) projects, as their expertise closely aligns with automated and off-site construction principles. A total of 100 questionnaires were disseminated through email and online platforms, resulting in 30 complete and usable responses. While the sample size is limited, it is considered appropriate for an exploratory, perception-based study, particularly within the context of an emerging technology where access to highly specialized respondents is constrained.

3.4 Data collection and procedure

A questionnaire was developed based on a comprehensive review of academic literature, industry reports, and past research on construction 3D printing, which was used to collect data and ensure that the data collection method is associated with the research objectives. The questionnaire consists of 5 sections, namely: Section A that collects demographic data (profession, years of experience working in construction and housing projects); Section B that measures the perceived potential of 3D printing in the housing sector (time, cost, labour, waste, sustainability and overall suitability); Section C that measures the perceptions of the suitable 3D printing technology and methods (e.g. extrusion-based concrete printing, appropriateness to low-rise housing, performance in the Malaysian climatic conditions, hybrid processes); and Section D that evaluates the perceptions of the best practice for implement 3D printing technology in house construction. Those in Sections B, C, D, and a few in Section E use a five-point Likert scale, where 1 is Strongly Disagree and 5 is Strongly Agree, which is suitable to measure and quantify responses based on perception.

3.5 Data analysis

Descriptive statistical methods were used to carry out result and analysis of the completed questionnaires to respond to the three research objectives. The frequency and mean score were used to summarise the Likert-scale responses, and where appropriate, items were ranked to point out the strongest perceived potential, appropriate technologies and best-practice actions. Such a quantitative analysis offers a general perspective of how the respondents perceive the potential of 3D printing in the context of housing as one whole, the appropriateness of various technologies and methods and the relative significance of the requirements and barriers of the implementation. Open-ended responses of Section E were checked and organised into themes, which allowed conducting primitive thematic analysis to enrich quantitative results by introducing other problems, concerns and recommendations that were not reflected in the closed-ended items completely.

4.0 RESULTS AND DISCUSSION

4.1 Respondent profile

The survey collected 30 responses from a broad spectrum of construction stakeholders, providing a holistic view of 3D Concrete Printing (3DCP) from both design and execution perspectives. The participant pool was led by engineers (33.33%) and contractors (26.7%), followed by project managers (13.3%), architects (10%), and M&E consultants (10%), with additional technical input from site supervisors (3.33%) and draughtswomen (3.33%). Meanwhile, most respondents are in the early stages of their careers (56.7%) with less than 3 years of experience and 30% with 3–5 years. The data also included insights from those with 6–10 years (6.7%) and over 10 years (6.7%) in the field. Notably, awareness of 3DCP technology is exceptionally high at 93.3%, with familiarity levels ranging from emerging to expert, signalling a workforce that is well-informed and prepared for innovation. Figures 3a and 3b illustrate the demographic distribution of the respondents, highlighting their roles as construction stakeholders and years of experience.

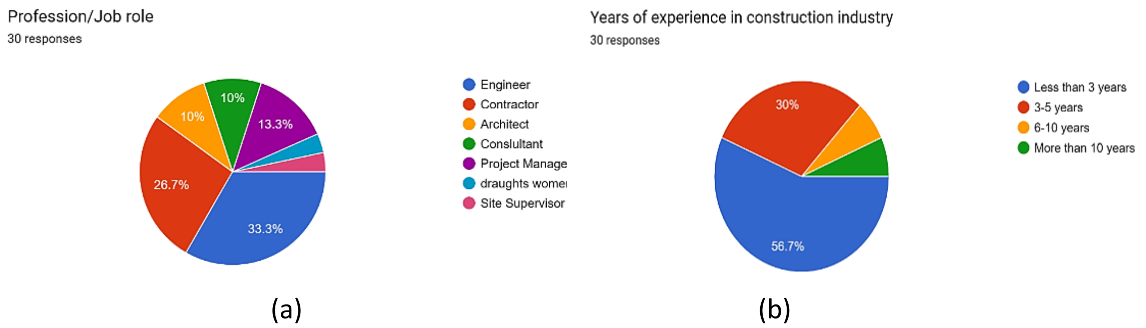

Figure 3. (a) Respondents Profession and (b) Respondents years of experience

4.2 Construction stakeholders perception of the 3D Printing Technology potential for housing construction projects in Malaysia

Table 4.1 illustrates construction stakeholders' perceptions for 3DCP technology within the Malaysian housing construction industry, revealing a strong consensus on its transformative efficiency. The statement that 3DCP can significantly minimize construction time compared to conventional methods achieved the highest mean score (4.2), identifying time efficiency as the most persuasive driver for adoption, which aligns with global findings that 3DCP can reduce project timelines [31]. The overall potential of the technology received a high mean of 4.0, while other factors such as housing quality, waste reduction, and sustainability scored slightly lower at 3.87 and 3.9, respectively. This shows that the stakeholders are cautiously optimistic because there are currently no local building regulations for 3DCP technology applied in housing project [32]. Nevertheless, the results underscore a significant perceived benefit in reducing dependence on foreign labour and achieving long-term cost savings, suggesting that 3DCP is viewed as a viable solution to the structural challenges facing the Malaysian construction industry [8].

Table 4.1: Mean scores and rankings of Construction Stakeholders perceptions of 3D printing technology potential for housing construction projects in Malaysia

No	Statement	Mean	Rank
1	3D printing technology has a high potential to be used for housing construction projects in Malaysia	4	2
2	3D printed housing can significantly reduce construction time compared to conventional methods	4.2	1
3	3D printed housing can reduce overall construction cost in the long term	3.87	4
4	3D printed housing can reduce dependence on foreign labour in Malaysia	3.87	4
5	3D printed housing can reduce construction waste and support sustainable construction	3.9	3
6	3D printed housing has the potential to improve the overall quality and performance of construction projects in Malaysia	3.87	4

4.3 Construction stakeholders' perceptions of 3D Printing Technology suitability for housing construction projects in Malaysia

Table 4.2 shows the perception of different respondents on the suitability of technologies and approaches of 3D printing in-house construction project in Malaysia. The mean of 3.97 is the highest for hybrid approaches, where 3D printed elements are used in combination with a conventional construction, which means that it is preferred to implement 3D printing into familiar systems instead of acting as an independent solution. This aligns with global trends where hybrid systems are used to bridge the gap between traditional reinforced concrete requirements and the current limitations of independent 3DCP structures [33]. The claim that 3D printing is better applied in low rise or single storey house and the present state of 3D printing materials could withstand the Malaysian climate and durability conditions both have record means of 3.87 with confidence in 3D printing use in low rise works and the material performance in the local environment. This result is consistent with existing literature, which indicates that while 3DCP is revolutionary, its most immediate and viable prospects lie in the construction of smaller villas and residential units rather than large-scale complex structures [34]. More moderate levels of agreement are rated positively but marginally less in prefabricated modular 3D printing and extrusion-based concrete 3D printing (means 3.80 and 3.77).

4.4 Construction stakeholders' perceptions of best practice for implementing 3D Printing Technology for housing construction projects in Malaysia

Table 4.3 shows the mean scores for best practices to 3D printing implementation in housing construction projects in Malaysia. The highest-rated item is the development of clear guidelines and standards for 3D printed housing with mean 4.45 and rank 1.

This underscores a critical industry need, as the current absence of universal regulatory frameworks and standardized building codes remains a significant barrier to mainstreaming 3DCP technology [35]. It is followed by specialised training programmes and collaboration between local universities, government agencies and industry with mean score of 4.37, highlighting respondents' strong emphasis on regulatory clarity and capacity-building. This highlights the respondents' emphasis on capacity-building and the complex, multidisciplinary nature of the technology. According to Hossain et al. (2020), the lack of a skilled workforce specifically trained in 3DCP operations is a global bottleneck, necessitating the types of collaborative educational curricular and professional certifications. Pilot 3D printed housing projects mean is 4.33, and local development of suitable materials and mix designs mean is 4.30, which are rated very positively. Meanwhile, government incentives such as grants and tax relief, although still important with the mean of 4.27, are ranked lowest among the best-practice items.

Table 4.2: Mean scores and rankings of Construction Stakeholders perceptions of 3D printing technology suitability for housing construction projects in Malaysia

No	Statement	Mean	Rank
1	Extrusion-based concrete 3D printing is suitable for housing construction in Malaysia.	3.77	5
2	Prefabricated modular 3D printing methods are suitable for housing construction in Malaysia	3.8	4
3	3D printing is more suitable for low-rise or single-storey housing than for high-rise buildings in Malaysia	3.87	3
4	Current 3D printing materials can meet Malaysian climate and durability requirements.	3.87	2
5	Hybrid approaches (3D printed elements combined with conventional methods) are more appropriate than fully 3D printed houses in Malaysia	3.97	1

Table 4.3: Mean Score and Ranking of Construction Stakeholders' perceptions of best practice for implementing 3D printing technology for housing construction projects in Malaysia

No	Statement	Mean	Rank
1	Clear guidelines and standards for 3D printing housing method should be developed in Malaysia before wide implementation.	4.45	1
2	Government incentives (grants, tax relief, subsidies) are important to encourage adoption of 3D printed housing.	4.27	6
3	Pilot 3D printed housing projects should be implemented to demonstrate feasibility in Malaysia.	4.33	4
4	Specialised training programmes on 3D printed construction should be provided for engineers, contractors, and architects.	4.37	2
5	Local development of suitable 3D printing materials and mix designs should be prioritised.	4.3	5
6	Collaboration between universities, government agencies, and industry is essential for successful implementation of 3D printed housing projects	4.37	3

5.0 CONCLUSION

This study assesses Malaysian construction stakeholders perceptions of 3D printing technology for housing construction projects in Malaysia, focusing on its perceived potential, suitable technologies and approaches, and implementation best practices. It emerges that the respondents have relatively positive perceptions of 3D printing, especially in terms of 3D printing accelerating construction, reducing labour dependence, enhancing material efficiency and enabling more sustainable housing provision, even though the technology is still in the early stages of local adoption.

In relation to the first objective, the results indicate that 3DCP technology have great potential for shortening the construction time which makes this technology can be potentially adopted in housing project of Malaysia. The results indicate moderate to strong agreement on possible reductions of waste, long-term costs and reliance on foreign labour, as well as improvements in housing quality. For the second objective, extrusion-based concrete 3D printing and, especially, hybrid construction approaches that combine 3D-printed elements with conventional methods are regarded as the most suitable options for low- to medium-rise and repetitive housing developments, reflecting a pragmatic stance that integrates innovation within existing technical and regulatory constraints. For the third objective, the study concludes that clear guidelines and standards, government support through incentives and pilot projects, and specialised training programmes, supported by collaboration between universities, government and industry, are critical best practices for successful implementation, while high initial investment costs, skills gaps and regulatory uncertainty remain major barriers that must be addressed.

In conclusion, although 3DCP technology method has not been widely implemented in Malaysian housing projects. The construction stakeholders are aware of its potential and have relatively clear expectations about appropriate of this technologies and key implementation requirements, providing a useful basis for policy, standard setting and construction industry direction.

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AUTHORS CONTRIBUTION
Natasya Hairanie Binti Mahadi: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Visualization, Writing riginal draft preparation.
Ir. Dr. Assrul Reedza Zulkifli: Supervision, Validation, Writing Review & Editing, Project administration, coresponding Author.

DECLARATION OF COMPETING OF INTEREST
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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