Bagh-e Nazar
DOI: 10.22034/bagh.2026.577258.5998

Bagh-e Nazar, *23*(158), 45-56 / 2026
Persian translation of this paper entitled:
مروری جامع بر چارچوب ارزیابی چرخهٔ حیات
چاپ سه‌بُعدی بتن: روش‌ها، فرایند و ابزار
is also published in this issue of journal.

Original Research Article

A Systematic Review of Life Cycle Assessment in 3D Printing Concrete: An Analytical Investigation of Methods, Processes, and Assessment Tools in Architecture and Construction*

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Received: 22/02/2026 Accepted: 07/07/2026 Availableonline:23/07/2026

Abstract

Problem statement: The environmental and economic challenges of the construction industry have made the necessity of utilizing new technologies more evident than ever. In the meantime, 3D printing concrete, as an emerging approach, has a significant capacity to reduce waste, save time, and improve productivity. Numerous pioneering studies have addressed these issues with methodologies and case studies, but there is still a lack of an analytical framework among them.

Research objective: To investigate and achieve a framework that clearly defines the effective method, process, and tool in the field of life cycle assessment knowledge in the discussion of 3D printing.

Research method: The present study, using the method of logical-analytical reasoning and a systematic review of research literature and library research, has examined life cycle assessment frameworks and identified key factors in this field.

Conclusion: The results show that concrete materials, especially cement, have the largest share in carbon dioxide emissions and account for about 52% of the total environmental impacts. In contrast, the replacement of recycled materials, especially in the aggregates sector, depending on the consumption ratio, can reduce these impacts by 24 to 47%. From an economic perspective, this technology also has the potential to save up to about 78%. Despite these advantages, the variability in the performance unit, system limitations, and the limitations of industrial-scale data prevent direct comparison of results. Accordingly, standardization of life cycle assessment methodology and development of real-scale experimental studies are prerequisites for the sustainable use of 3D printing of concrete in future architecture and urban development.

Keywords: *3D printing concrete, Life Cycle Assessment, Carbon, Recycled materials, Concrete Mix Optimization.*

Introduction and Problem Statement

The construction sector is one of the world's largest consumers of natural resources and producers of construction waste, accounting for about 50% of the world's resources (Javed et al., 2025). With the growth of urbanization and increasing demand for housing, the global infrastructure area is expected to reach more than 230 billion square meters over the next four decades (Kuzmenko et al., 2019). The construction industry currently accounts for more than 40% of energy consumption, 38% of greenhouse gas emissions, more than

*This article is extracted from "Amir Bahador Baradaran"' doctoral dissertation entitled "Evaluation of carbon emissions in two types of common construction and 3D printing using concrete materials in small-scale buildings in Tehran" which has been done under the supervision of Dr. "Katayoun Taghizade" at the School of Architecture, College of Fine Art , University of Tehran in 2026.

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40% of sand consumption, and a significant share of water consumption and waste generation (Agusti-Juan & Habert, 2017; Huang et al., 2024; Yu et al., 2024; Zhuang et al., 2025; Llorente-García et al., 2025; Sakthibala et al., 2025). Meanwhile, cement-based materials are known as one of the main sources of carbon emissions in the construction industry (Kumar et al., 2025). The construction industry must take steps as quickly as possible to reduce its carbon footprint, greenhouse gas emissions, and excessive energy consumption in order to achieve environmental sustainability in the world (Mosly, 2025). Also, in Iran, according to reports from the IEA[1], the trend of energy consumption and carbon dioxide emissions is still assessed to be higher than the global average (Ritchie & Rosado, 2025; IEA, 2025).

In response to these challenges, the development of new construction technologies with the aim of reducing resource consumption, waste, and carbon footprint has become one of the main priorities of the construction industry. Meanwhile, 3D printing technology, as one of the emerging approaches of digital manufacturing, has attracted widespread attention due to the elimination of molds, reduction of material waste, increased design freedom, and improved productivity (Hassan et al., 2024; Banihashemi et al., 2025). Studies have shown that this technology can reduce energy consumption and overall emissions by about 5% in large-scale projects (Kuzmenko et al., 2020). For construction applications, both small and large-scale additive manufacturing have been considered and discussed (Agegn et al., 2026). Therefore, research in the field of large-scale 3D printing technology reveals the potential and applications of this technology in the construction field (Hasani & Dorafshan, 2024). Despite these advantages, an accurate assessment of the environmental performance of this technology is not possible without using the concept of life cycle assessment[2]. Life cycle assessment, as a systematic framework for measuring environmental impacts from raw material extraction to end-of-life, allows for scientific comparison of construction technologies. Although several studies have examined the environmental capabilities of 3D printing concrete, there is still a lack of a coherent analytical framework for comparing methods, processes, and tools used in this field (Asprone et al., 2018; De Schutter et al., 2018; Valencia-Barba et al., 2021). Therefore, the present study, focusing on integrating life cycle assessment knowledge and 3D printing concrete technology, seeks to identify and explain an analytical framework for effective methods, processes, and tools in the environmental assessment of this technology in the field of architecture and construction.

Literature Review

3D printing has made significant progress in recent years and has established itself as an emerging technology in the field of architecture and construction due to its features such as speed, accuracy, cost reduction, waste reduction, and labor injury reduction. However, it is still vital that it is also evaluated from the perspective of environmental performance in order to achieve the principles of sustainability in this field. For this purpose, the following is an attempt to review the research that has addressed the life cycle assessment of 3D printing concrete technology in recent years in the categories of functional unit[3] (International ..., 2022), materials, life cycle assessment analysis platform, life cycle assessment step, and life cycle assessment environmental indicators (Table 1 & Fig. 1).

A review of the studies in Table 1 shows that in the field of materials, the main focus of research has been on reducing the share of cement and replacing part of the raw materials with alternative and recycled compounds. In this regard, Kashani & Ngo (2018) showed that the use of alternative materials in 3D printing requires simultaneous optimization of rheological parameters, flowability, setting time, and final durability of the product. Also, Nerella et al. (2016), introducing a mixture including partial replacement of cement with fly ash and microsilica, reported that this mixture has a more favorable performance than conventional concrete in almost all environmental indicators. In this regard, El-Alfi & Gado (2016) also introduced

Table 1. Global Experiences in Urban Visual Management. Source: Authors.

Ref.	Functional Unit	LCA	Materials	Analysis tool	Indicators
Yao et al. (2019)	Wall	Cradle to Gate	Geopolymer powder, slag, fly ash, sand, silicate as binder, water, additives	CMLCA	GWP[4]; ODP[5]; AP[6]; EP[7]; HTP[8]; FAETP[9]; TETP[10]; POCP[11]; ADP[12]
Abu-Ennab et al. (2022)	Building	Cradle to Gate	Calcium sulfoaluminate cement concrete based on kaolinite, water, sand, polycarboxylate ether superplasticizer, and kaolin clay as binder	GaBi	GWP; AP; EP
Agusti-Juan et al. (2017)	Wall (Fig. 1-1)	Cradle to Gate	Cement, silica fume, water, aggregate up to 4 mm, polycarboxylate ether superplasticizer	Sima Pro	GWP; ODP; AP; EP; HTP; FAETP; TETP; ADP; WD[13]
Muñoz et al., (2021)	Column	Cradle to Gate	Concrete with grades 400 and 700	Sima Pro	GWP
Mohammad et al. (2020)	Wall	Cradle to Gate	Structural concrete, rebar, building concrete, mortar, plywood, cement, fly ash, micro silica, perlite, water, microfiber, superplasticizer, accelerator	GaBi	GWP; AP; EP; POCP; ADP
Alhumayani et al. (2020)	Exterior Wall (Fig.1-2)	Cradle to Gate (Before Construction)	Cement, fly ash, silica fume, sand/grit, water, superplasticizer, fibers, straw, cement block, wooden formwork, mortar reinforced with rebar	Sima Pro	GWP; ODP; EP; HTP; ADP; LU[14]
Abdalla et al. (2021)	Exterior Wall	Cradle to Gate (Before Construction)	Fly ash, microsilica, superplasticizer, viscosity modifier, cement, soft aggregate, water, steel, coarse aggregate, wood	Sima Pro	GWP; ODP; AP; EP; HTP; FAETP; MAETP[15]; TETP; POCP; ADP; LU; WD
Kuzmenko et al. (2019)	Wall (Fig. 1-3)	Cradle to Gate	Cement, silica fume, sand, water, superplasticizer, quick-setting	-	GWP; ODP; AP; EP; HTP; FAETP; MAETP; TETP; POCP; ADP; LU; WD
Sambucci et al. (2023)	1m^3	Cradle to Gate	Rubber waste, cement, water, sand, silica fume, polycarboxylate ether, calcium oxide	Sima Pro	GWP
Wang et al. (2014)	Bathroom (Fig. 1-4)	Cradle to Gate	Cement, fly ash, silica fume, sand	-	GWP; ODP; AP; EP; HTP; ADP; LU
Ye et al. (2024)	Building	Cradle to Gate (Before Construction)	Cement, fly ash, silica fume, fine aggregate, coarse aggregate, water, kiln ash, crushed rubber, limestone powder, Plasticizer	Sima Pro	GWP; ODP; AP; EP; POCP
Elias (2021)	Building	Cradle to Gate	Cement, fly ash, silica fume, sand, water, fibers	Sima Pro	GWP; FTA[16]; FTOX[17]; FEP[18]; MEP[19]; TEP[20]; CE[21]; IR[22]; NCE[23]; ODP; POCP; RE[24]; DW[25]; FF[26]; LU; MM[27]
Rossi et al. (2024)	1m^2	-	Cement, water, sand, clay, lime, polypropylene fibers	Sima Pro	GHG[28]
Mantha et al. (2024)	1m^3	Cradle to Construction	Fly ash, microsilica, plasticizer, perlite, microfibers, accelerator, cement, water	OneClickLCA	GWP
Roux et al. (2023)	Hexagonal Module	Cradle to Cradle	Sand, cement, silica fume, water, accelerator, plasticizer	Brightway2 tool	GWP; FTA; FTOX; FEP; MEP; TEP; CE; IR; NCE; ODP; POCP; RE; DW; FF; LU; MM
Han et al. (2021)	Building	Cradle to Construction	Cement, water, recycled aggregate, natural aggregate, sand, additives	-	GWP; AP; PP[29]; EP

kaolinite-based calcium sulfoaluminate cement concrete as a suitable option for reducing the environmental impacts of energy consumption and cement production due to its high potential. From the perspective of mix design development and printability, Markin et al. (2021) evaluated the

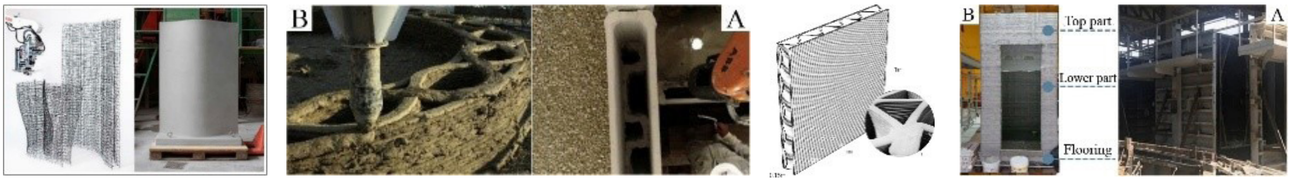

Fig. 1. 1. 3D printed reinforced wall sample Source: Alim-Khan et al., 2021/ 2. A) Concrete 3D printed wall B) Thatch 3D printed wall. Source: Alhumayani et al., 2020/ 3. Wall system with sinusoidal cross -section Source: Kuzmenko et al., 2020/ 4. A) Prefabricated bathroom with steel formwork B) 3D printed concrete bathroom. Source: Wang et al., 2014.

possibility of using foam concrete with a density of 800 to 1200 kg/m³ in the 3D printing process, while Long et al. (2021) investigated the printability of calcined clay cement mixtures and emphasized the role of particle distribution and packing density in improving printing behavior. On the other hand, Passuello et al. (2017) showed that silicate and fly ash production, sand and silicate transportation, and printer energy consumption are factors affecting environmental outcomes; thus, reducing the silicate content and replacing alkaline activators derived from waste, such as rice husk ash, can lead to a significant reduction in environmental impacts. In summary, the analysis of previous studies shows that reducing the cement ratio, using complementary cementitious materials, utilizing recycled aggregates and additives, and simultaneously optimizing printing parameters are among the most important strategies to improve the environmental and technical performance of 3D printing concrete; however, heterogeneity in the definition of the functional unit, system boundaries, and analysis methods still limits direct comparison of results between studies.

Theoretical Foundations

Life cycle assessment is not just a computational tool, but an analytical framework to guide design decisions, material selection, and construction policymaking for environmental sustainability. In recent literature, life cycle assessment is defined as a systems approach that allows for the comparison of technology and design scenarios by measuring the environmental impacts from material extraction to the end of a building's life. This framework, based on the principles developed in ISO 14040–14044 (International ..., 2022), is particularly important in the field of digital construction, as emerging technologies such as 3D printing concrete blur the boundaries between design, production, and implementation, requiring integrated process assessment. Recent research shows that in this technology, the main contribution of environmental impacts is still attributed to cement production and process energy, but in contrast, the elimination of formwork, the reduction of material waste, and the possibility of geometric optimization can lead to a significant reduction in carbon emissions (Roux et al., 2023; Sambucci et al., 2023; Rossi et al., 2024). Therefore, life cycle assessment in this area is considered the theoretical basis for analyzing the actual efficiency of the technology and not simply for quantifying emissions. From the perspective of digital architecture, 3D printing of concrete represents a transition from a construction model based on industrial standardization to a construction model based on data and algorithms; a transition whose consequences are reflected in resource consumption, project economics, and design logic. Recent studies have shown that the combination of parametric design, topological optimization, and additive manufacturing can reduce material consumption and embodied carbon intensity at the building scale, especially when alternative or recycled materials are used in the mix design (Ye et al., 2024; Mantha et al., 2024; Agegn et al., 2026). Accordingly, the theoretical foundations in this study suggest that the environmental performance of 3D printed concrete is not an intrinsic property of the technology, but rather the result of the interaction between functional unit definition, system boundaries, material selection, and life cycle modeling. This view justifies the need to develop a coherent analytical framework for evaluating this technology in architecture.

Research Method

The present research method is a logical-analytical reasoning method with a library collection and systematic literature review to analyze and compare existing studies on life cycle assessment and 3D printing of concrete. The methodological framework is based on the principles of transparency, reproducibility, and alignment with the international PRISMA[30] guidelines. The search strategy in this study was based on searching for sources in reputable scientific databases, including Scopus, Web of Science, ScienceDirect, Google Scholar, Noormags, and Civilica. The time period examined for the publication of articles was between 2014 and 2024, and the last search was conducted within the past 6 months to a year. The combination of keywords used for the search is: life cycle assessment, environment, sustainability, 3D printing of concrete, and concrete materials. Boolean operators (and, or, not) and exact phrase search ("") were also used to increase the accuracy of the results. In the article selection process, the initial search results showed 150 articles. After removing duplicates and reviewing titles and abstracts, 80 articles were selected for full-text evaluation. These articles were first reviewed with two criteria of language (English-Persian) and year of publication (last 10 years), and then in the next step, with four main criteria of approval, including: 1. Review of life cycle assessment, 2. Addressing 3D printing technology, 3. Application and review of concrete materials, and 4. Addressing the field of architecture and construction. The exclusion criteria in this process also included: 1. Articles with indirect or marginal reference to 3D printing of concrete, 2. Failure to mention or use the life cycle assessment methodological framework, and 3. Articles in which concrete materials or 3D printing technology were not reviewed. Finally, based on the stated inclusion and exclusion criteria, sixteen articles were selected with direct reference to the topic of life cycle assessment of 3D printing concrete (Fig. 2).

Research Findings

Based on the findings of the studies in the five parameters of the functional unit, the life cycle assessment

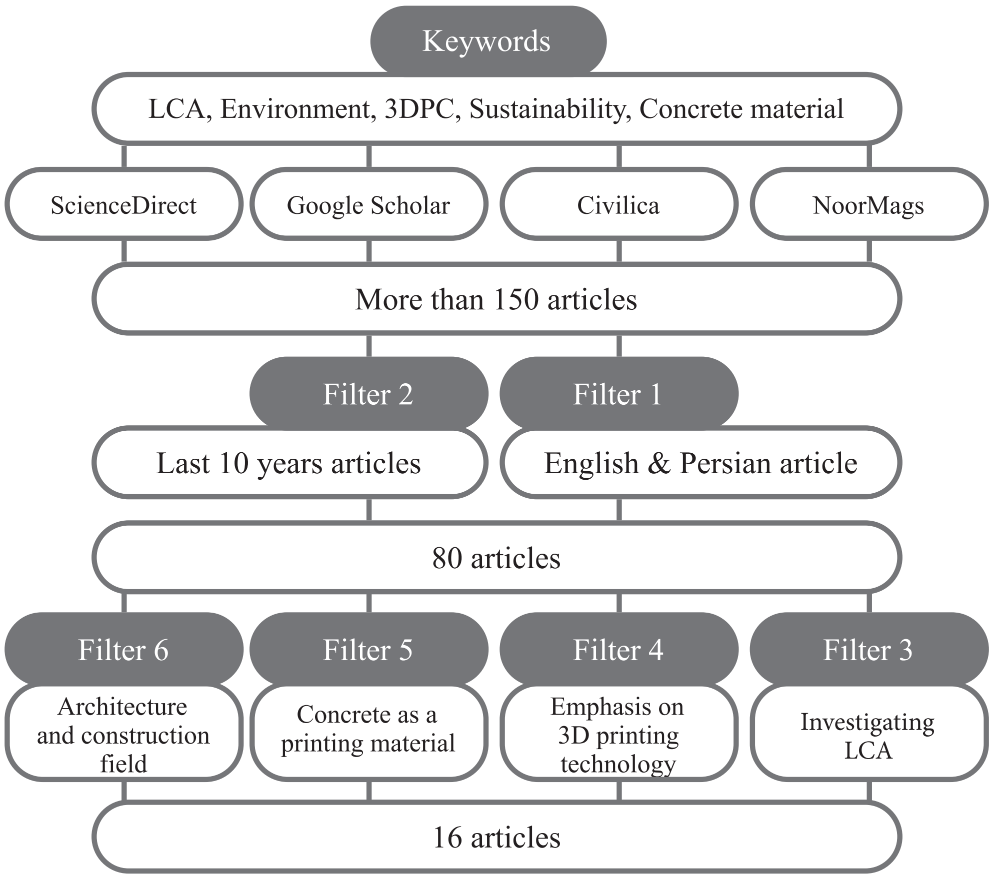

Fig. 2. Structure of the research method for extracting criteria and the basis of the research background Source: Authors.

stage, materials (mixing plan), analysis tools, and environmental indicators of life cycle assessment, the tools, process, and method of life cycle assessment of 3D printed concrete can be examined as follows. This helps to determine the direction and assessment factors for future research and serves as a roadmap for researchers and activists in the field of life cycle assessment and 3D printed concrete.

- **Functional unit**

The functional unit is a key aspect in life cycle assessment to analyze and compare the environmental impacts of different products or processes. This unit may examine a part or the entire building, which has the advantage of assessing the environmental impacts related to the entire production process of building components, including raw material extraction, transportation, and erection. Studies show that in most research in the field of functional units, in the first step, about 37.5% of researchers have used a functional unit to measure the performance of a wall as an example to generalize to their entire research. In the subsequent stages of the study, a complete building was used as 31.25%, a cubic meter of consumable materials was used as 12.50%, and a square meter, column, and structural module were used jointly as 6.25% as a functional unit (Fig. 3). Of course, it should be noted that the type of functional unit depends on the subject and scope of the research and is defined based on the criteria and details required for the study in a study. In the studied examples, the wall included the largest amount of study because the main goal of the study was to achieve the performance of specific materials with 3D printing concrete technology, but the second case, which included the study of the complete building, aimed to study all the details of the construction of a building and its behavioral characteristics. In this way, as the project progresses towards the complete building in the life cycle assessment process, more details and data are required to enable the study. Of course, it should be noted that this will lead to more comprehensive and accurate results.

- **Life cycle assessment**

In terms of the life cycle assessment stages in a construction process based on the EN 15978 and EN 15804 standards, the stages can be outlined in the following order: 1. Cradle to Gate: Production of materials (A1-A3), 2. Cradle to Construction: Construction methods (A4-A5), 3. Cradle to Death: Operation of the building (B1-B7), End of life of the building (C1-C4), 4. Cradle to Cradle: Any benefits or burdens that occur beyond the life cycle of the building (D). This process is applied to a construction process from the moment of production of materials to the possibility of recycling or destruction of all building components. In the studies conducted in this field, based on the life cycle assessment stage in relation to 3D printing concrete, it can be found that about 75% of the studies have completed their life cycle assessment process until the end of stage A3, about 12.5% until the end of stage A5, and only 6.25% have fully examined stages A1 to D. Therefore, in the field of 3D printing concrete, given the limitations and challenges of the novelty of this technology in the production and examination of the sample, most studies continue to advance their work until the end of the initial step of this analysis. As is clear from the statistics, most studies in the field of life cycle assessment have focused on steps A1 to A5, i.e., the cradle to construction stage. According to the studies, the main factor in this field is 3D printing concrete

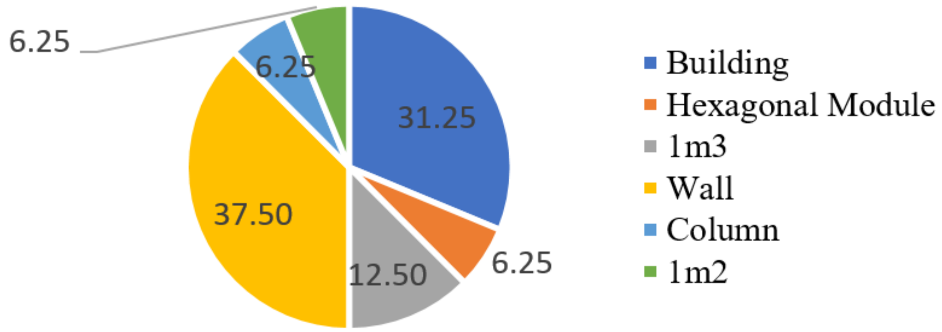

Fig. 3. Distribution of functional unit type in research. Source: Authors.

technology. Due to the newness of this technology and the lack of a standard 30–50-year lifespan in any of the examples, there is virtually no practical knowledge of the very low-level exploitation phase and the possible degradation and recycling phases. Therefore, only through simulation can the performance of other steps of the life cycle assessment be measured, which can also be confirmed by statistics.

- **Material (Mix design)**

One of the main and most important discussions in the field of 3D printing concrete is related to the materials used and the mixing plan. Because concrete and its constituent components can play a fundamental role in the environmental discussion, as well as the properties and characteristics required for 3D printing, including printability, rheology, extrudability, print time, pumpability, construction, and other factors affecting printing. According to the analysis of articles in the field of 3D printing concrete, the general frequency of using materials to achieve the appropriate mixing plan and composition of 3D printed concrete can be seen in Fig. 4. This image illustrates the type of materials used in a suitable and practical mixing plan to benefit from a final composition that is resistant, lightweight, and sustainable. It should be noted that the use of special materials and compounds, such as geopolymer concrete, calcium sulfoaluminate cement, and concrete based on kaolinite or special compounds that are not readily available everywhere have concerns in terms of cost, curing, complexity in compounds, and similar matters. The outcome of the above-mentioned matters should also be considered along with the importance of the environmental challenge from the production stage to the exploitation of the concrete mixture. Therefore, with the mentioned factors and the analyses carried out, it is possible to introduce and mention a mixture of fly ash, microsilica, plasticizer, perlite, microfibers, accelerator, cement, and water as a compound with high strength and curing speed, as well as easy access to the compounds.

- **LCA indicators**

In the life cycle assessment of 3D printing concrete, one cannot ignore the range and diversity of materials in the construction and 3D printing industry and their impact on the environmental indicators of life cycle assessment, some of which are given higher priority in the field of architecture and the construction industry. The research reviewed in this field, according to Fig. 5, examined indicators in the field of life cycle assessment of 3D printing concrete, from which it is possible to distinguish and identify vital indicators in this field based on the frequency of their analysis. These indicators are analyzed in different categories and types. Based on Fig. 5, it can be stated that the indicators of global warming potential, acidification potential, eutrophication potential, ozone depletion potential, water supply network depletion, photochemical oxidants (atmospheric pollutants), land use, and human toxicity potential are prominent. These indicators are of great importance in assessing environmental impacts, and it seems that the criteria of climate change, pollution, and depletion of natural resources are prominent in these assessments. Among the mentioned indicators, the four indicators of global warming potential, acidification potential, eutrophication potential, and ozone depletion

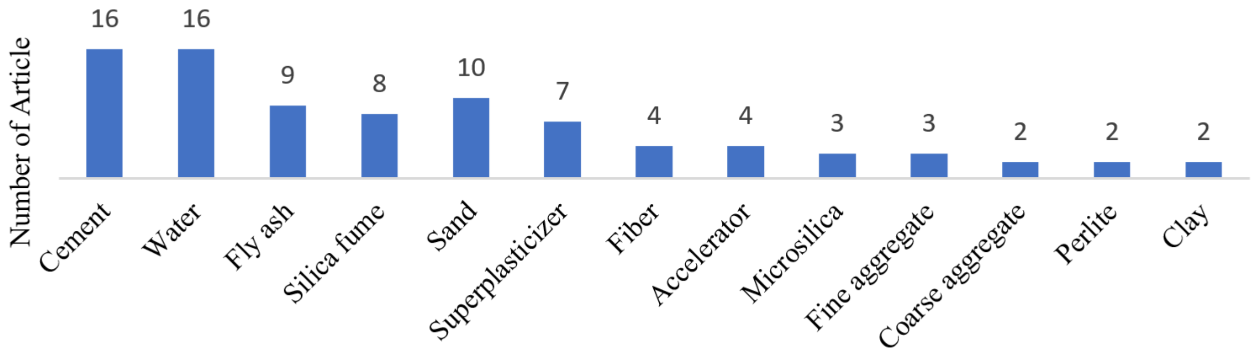

Fig. 4. Multimedia Principle in the Weltformat Poster. Source: www.maximage.biz/ b. Multimedia Principle in the Arsenic Poster. Source: Wilson & Gilchrist, 2024, 200.

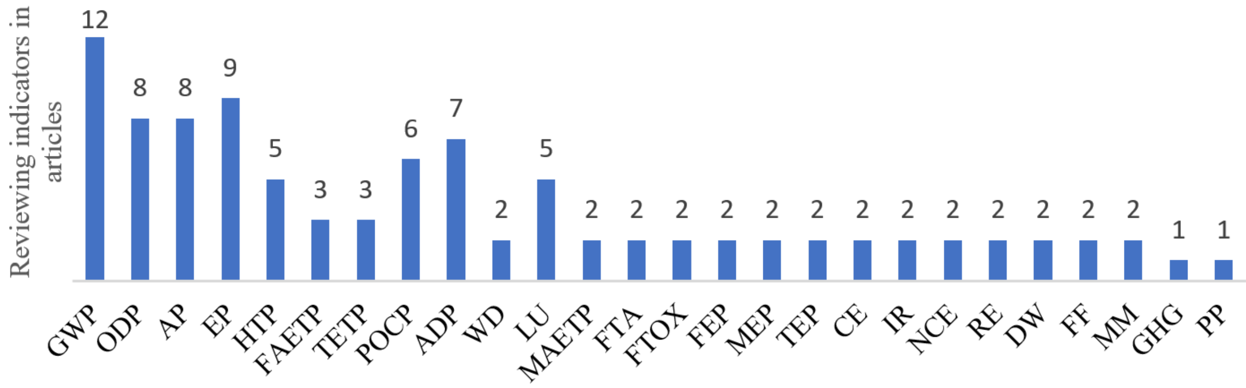

Fig. 5. Dispersion of Life Cycle Assessment Indicators Analysis. Source: Authors.

potential are in the category of comprehensive indicators, based on which other indicators can also be determined.

- **LCA analysis tool**

In order to evaluate and examine these indicators, there are various tools that are used in the field of life cycle assessment, but the SimaPro software has been used more than other software in these studies, followed by Gabi and OneClickLCA. Although the choice of software depends on the type of research, evaluation criteria, and access to data, each of these computational software can respond better and more accurately to its specialized and functional area, according to the tools and standards they have. Of course, a detailed examination of the analysis tools in the field of life cycle assessment requires independent research to examine all the effective aspects and dimensions in this field, so that a suitable example can be introduced for the field of architecture and construction.

Discussion

Analysis of studies shows that in the life cycle assessment of 3D printing concrete, cementitious materials are still the dominant factor in the formation of environmental impacts; in such a way that reducing the cement ratio and modifying the mixing design in some studies has been able to reduce environmental impacts by about 90%. Also, in large-scale projects, concrete still accounts for the dominant share in embodied carbon and accounts for about 52% of life cycle carbon dioxide emissions. Therefore, simultaneously modifying the material composition with solutions such as geometric optimization, reducing section thickness, and managing material consumption is considered one of the most important technical levers for improving the environmental performance of this technology. On the other hand, a review of the research literature shows that one of the most important existing limitations is the lack of sufficient transparency in the input data, the analysis path, and the method of reporting the results. This highlights the need for standard frameworks based on ISO 14040/44, EN 15978, and EN 15804. In addition, most studies have been conducted on a laboratory scale or on modular samples, and the lack of assessments based on real and industrial projects has limited the generalizability of the results. Also, the focus of most research on the early stages of the life cycle, especially A1–A3 and A1–A5, has led to the study of the exploitation, end-of-life, recycling, and benefits beyond the life cycle still receiving less attention, while these stages are essential for the long-term analysis of environmental performance. Furthermore, the results show that geographical diversity, the type of energy network, and the share of renewable or non-renewable resources can also affect the results of life cycle assessments, making it necessary to validate the findings in different regional conditions. Overall, combining 3D printing concrete technology with low-carbon materials, recycled materials, and engineered composites, especially modified calcium-based systems, can provide an effective path to reducing carbon emissions, energy consumption, and construction waste, and strengthen the position of this technology as a reliable approach in the development of sustainable construction.

Conclusion

The results of the research conducted in the field of life cycle assessment of 3D printing concrete technology show that five main parameters or factors play a key role in advancing this goal, including the functional unit, life cycle assessment stage, materials (mix design), analysis tools, and environmental indicators of life cycle assessment. Each of these parameters also has its own subsets in which the level of progress and review of work is important. The results of the analyses conducted on each of these parameters are shown in the table below (Table 2).

The results showed that cementitious materials are still the most important source of environmental impacts in 3D printing systems, and optimizing the mixing design, using alternative materials, and reducing material consumption are among the most effective solutions to reduce carbon emissions. The analysis of studies also showed that despite the high capacity of 3D printing concrete in reducing waste, eliminating formwork, optimizing geometry, and improving construction efficiency, heterogeneity in functional unit, system boundaries, analysis tools, and input data quality still limits direct comparison and generalization of existing research results. In addition, the focus of most studies on the early stages of the life cycle and the lack of data based on real projects are considered to be the most important knowledge gaps in this field. Accordingly, the development of standardized assessment frameworks based on ISO standards, the creation of specialized databases for digital construction materials and processes, and the expansion of studies on an industrial scale and in diverse climatic and geographical conditions can provide a more accurate and reliable path for the development of this technology towards sustainable construction.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Endnotes

1. International Energy Agency
2. Life Cycle Assessment
3. A performance unit is defined in the international life cycle assessment standard ISO 44/14040 as “the quantitative performance of a product system to be used as a reference unit.”
4. Global Warming Potential
5. Ozone Depletion Potential
6. Acidification Potential
7. Eutrophication Potential
8. Human Toxicity Potential
9. Freshwater Aquatic Eco Toxicity Potential
10. Terrestrial Ecotoxicity Potential
11. Photochemical Oxidant Creation Potential
12. Abiotic Depletion Resources
13. Water Depletion
14. Land Use
15. Marine Aquatic Ecotoxicity Potential
16. Freshwater and Terrestrial Acidification
17. Freshwater Ecotoxicity
18. Freshwater Eutrophication
19. Marine Eutrophication
20. Terrestrial Eutrophication
21. Carcinogenic Effects
22. Ionizing Radiation
23. Non-Carcinogenic Effects
24. Respiratory Effects, Inorganics
25. Dissipated Water
26. Fossil Fuels
27. Mineral and Metals
28. Greenhouse Gas
29. Photochemical Pollution
30.Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Table 2. Results of key parameters of life cycle assessment of 3D printing concrete technology. Source: Authors.

No.	Parameter	Amount	Results
1	Functional unit	37.5	A wall
2	Life cycle assessment stage	75	A3 Stage or Cradle to Gate
3	Material (Mix design)	More than 70	Fly ash, microsilica, plasticizer, perlite, microfibers, accelerator, cement, and water as a mixture with high strength and curing speed
4	Analysis tool	50	SimaPro
5	Environmental indicators	More than 70	GWP, AP, EP, ODP

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HOW TO CITE THIS ARTICLE

Baradaran, A.B., & Taghizade, K. (2026). A systematic review of life cycle assessment in 3D printing concrete: An analytical investigation of methods, processes, and assessment tools in architecture and construction.. *Bagh-e Nazar*, *23*(158), 45-56.

DOI: 10.22034/bagh.2026.577258.5998
URL: https://bagh-sj.com/article_244772.html?lang=en