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Managing Construction and Demolition Waste Using BIM: A Comprehensive Review

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Abstract- This article provides a thorough analysis of current research on the topic of Revit and Building Information Modelling (BIM) waste management in the building and demolition industries. In order to demonstrate the efficacy of each method, the analysis analyses and contrasts their precision and accuracy. With a precision of 98% and an accuracy of 92%, Han and Abbas (2024) proved to have the most trustworthy and strong system for trash management. Impressive performance with some restrictions in accuracy was demonstrated by Yousfani et al. (2023), who attained a somewhat lower precision of 97% and an accuracy of 87%. In a balanced strategy where accuracy may be more important than precision, Soeiro et al. (2022) achieved a comparatively high accuracy of 91% while displaying the lowest precision at 89%. According to the results, building waste management initiatives need for a delicate balancing act between exactitude and precision. The purpose of this evaluation is to help professionals select the best building information modelling (BIM) approaches to environmentally responsible waste management.

Keyword Used- Construction, Waste Management, Demolition Waste, Revit Building Information, Modeling (BIM), Precision, Accuracy

Sustainability

1. Introduction

Deconstruction, remodeling, retrofitting, and construction all contribute to the accumulation of construction and demolition waste (CDW) [1]. Inadequate material handling techniques [2,3], low-quality designs [4,5], traditional operating procedures [6], and changes to the project scope and subsequent reworks [7] are just a few of the many causes of the massive amounts of CDW that are produced. The end consequence is an enormous amount of CDW produced annually. Depending on the country, CDW makes up a variable percentage of total solid waste: "32% in England, 20%-30% in Australia, 20%-29% in the US, 27% in Canada, and 50% in Brazil" [8]. Soil and water contamination, excessive consumption of natural resources, and other disastrous environmental impacts are caused by CDW regardless of its magnitude [9,10]. Construction companies' bottom lines take a blow when landfill levies, waste processing, and transportation expenses, and overall project prices rise [11–13]. All-important parties, including architects, engineers, and construction managers, are expected to actively participate in managing CDW [6], and waste minimization policies are advocated [14,15] to address these issues. The regulatory shift and policy enforcement that have formed the basis of these remedial solutions have had limited and short-lived influence in several jurisdictions [16,17]. Consequently, the construction industry must take further action; a sea change is required in the sector as a whole, with technical advancements bringing about improvements in construction methods and techniques that lead to more efficiency and less waste [18].

1.1 The Role of Building Information Modeling (BIM) in Sustainable Construction

Building Information Modelling (BIM) is a relatively new but highly successful construction technology that has just arisen [19]. It offers remedial answers to the contentious issues related to building while also improving many areas of project delivery. Based on anecdotal evidence, building information modeling (BIM) is seen as a game-changer for the construction sector and a key to more environmentally friendly projects [20].

Figure 1. BIM Lifecycle: Design, Build, Operate

After a building's lifecycle, while deconstructing it, BIM technologies can manage and optimize CDW [21]. They can also help optimize the size of building elements [22] and decrease waste during construction as a design optimization tool. Furthermore, building information modeling (BIM) can be applied to the following tasks: calculating the amount of waste that will be generated; creating plans for the administration of “construction and demolition waste (CDW)”; selecting the most effective locations for disposal [23]; compiling data regarding the entire construction life cycle [24], and even evaluating the environmental impacts of dismantling and reusing building components when they reach the end of their useful life [21,25]. Through the integration of data regarding material resources, geometry, costs, and schedules, data-rich BIM models facilitate the just-in-time arrival of equipment, supplies, and manpower [26]. Also, throughout a project's lifetime, BIM lessens the effects of inefficient procedures [27,28]. Reducing CDW by as much as 2% is possible with just design-phase BIM integration, according to the available evidence [22]. Some estimates put the percentage of CDW that can be prevented at 4.3-25.2 percent [5].

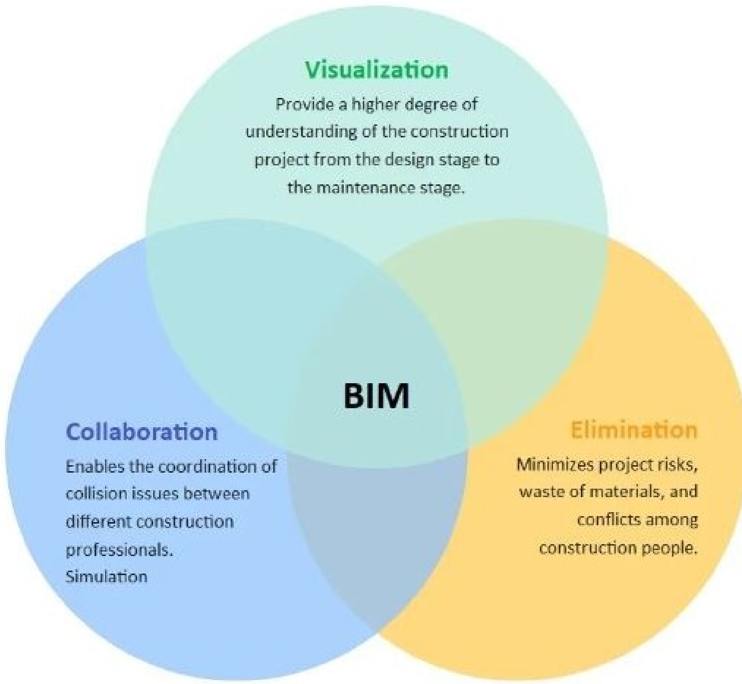

Figure 2. Advantages of Building Information Modelling

The numerous advantages of "building information modeling (BIM)" have led to an increasing amount of study on its use in CDW management [29]. But what it has so far is a disjointed and uncoordinated field of study; it addresses different parts of projects independently [19]. In other words, as a decision-making tool for CDW management during the design phase, BIM has been the subject of some research [30]. Still, others have zeroed in on the building phase as a means to cut down on waste by raising the efficiency of the construction crew, the flow of the process, and the amount of rework that needs to be done. Collision detection, digital prefabrication, site utilization planning, 3D controlling and planning, and quantity take-off are other areas that have attracted research attention [31,32]. Another set of research has looked at different, more efficient disassembly designs by separating the operation and end-of-life stages. There is also a body of literature that has examined and modeled different end-of-life situations, made recommendations for more efficient building operations, detailed processes for identifying recyclable materials, and improved stakeholder engagement [21,28,33]. Confusion in setting priorities and the increased likelihood of important areas being ignored are both caused by the absence of a unified and comprehensive picture of research efforts [34,35]. The dispersed nature of a topic's previous research calls for rigorous critical review studies [36].

1.2 Revit: An Overview and Its Features for Managing Construction and Demolition Waste

Revit is Autodesk's "BIM (building information modeling) software". It may mimic the process of creating a three-dimensional building model, much like AutoCAD or SketchUp. Parametric linking enables elements inside a building model to be specified and described by configurable characteristics [37]. In contrast, AutoCAD and SketchUp only simulate the geometry of a building. Design and digital modeling are affected in multiple ways by this. For starters, it implies that all linked building elements in a Revit model will be immediately updated whenever the location or extent of one element is changed [38,39]. Consider a building whose walls are parametrically connected to the bottom of the roof; when the roof is raised in the model, the height of those walls is automatically increased. Alternately, if any drag one wall in the model, all the other walls with linked ends will have their lengths adjusted as well. Just like repositioning a window in an elevation view updates the corresponding plan, modifying a floor's height in a section view updates the corresponding building elevations, etc., the same holds for other views.

Secondly, Revit allows users to construct families of comparable elements. When one component within a family is changed, all instances of that family are updated across the model [40,41]. A common mullion profile and trim design can be applied to a single family of windows of varying sizes. All windows in the project, regardless of size, will be instantly updated when a modification is made to the trim design at the family level.

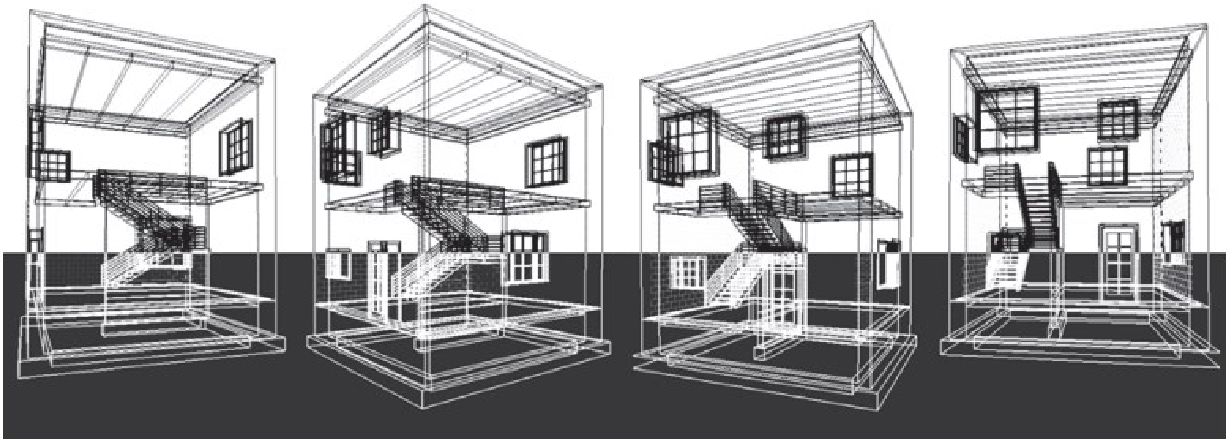

Figure 3. Model in Revit Finalized

Unlike the majority of the software that new students will be familiar with, Revit does not utilize layers [42]. This includes programs like AutoCAD, Photoshop, InDesign, and Illustrator. Alternatively, Revit models are classified according to types and families, as well as levels that reflect building datum lines like floor plans or window sills.

1.3 Effective Waste Management and Its Crucial Role in Building Projects

Due to its role in developing infrastructure and amenities, the construction industry is a major engine for other sectors of the economy, and it contributes around 13% to the world economy overall [43]. For environmental sustainability, it has continued to be a major target, despite its importance to the world economy [44]. The reasonis, that it uses the most energy, water, and materials, and it also produces the most trash, which ends up in landfills [46,47]. Some have also stated that the industry's ability to control waste creation is crucial to its long-term sustainability [48,49]; this is particularly true given that reducing trash is essential to avoiding the depletion of resources [50,51]. Even while demolition and construction both contribute to construction industry waste, cutting down on construction waste is great for the environment and could even bring down project costs. Given that waste accounts for a significant share of building cost overruns, this is particularly relevant [52]. Several studies have sought to identify causes and potential solutions to bring construction waste down to an acceptable level. It has been discovered that several activities contribute to construction waste during "the design, procurement, and construction phases of a project's lifecycle" [53,54,55].

Most studies and laws have focused on construction waste reduction during the actual building phase, even though everyone agrees that other parts of project delivery are just as important [56, 57]. Legislative and fiscal initiatives in the United Kingdom, for example, that aim at the construction phase of project delivery include site waste management plans, landfill tax, and aggregate tax. Numerous studies on the topic of construction waste management have also concentrated on this phase of project delivery specifically [56,59]. Research on design elements and methods that can reduce construction-related waste has also been conducted [60,56]. Nevertheless, there has been scant research into how to optimize the material procurement process to increase waste efficiency in building projects, in contrast to the extensive investigation into waste efficiency in design and, more especially, construction-related activities.

2. Review of Literature

Han Dongchen, and Abbas Rajabifard (2024) [61]said more is being done to encourage life-cycle demolition waste management (DWM). A sustainability evaluation framework for trade-offs among many criteria is needed for sustainability-oriented DWM planning. The study used Dynamo visual scripting to integrate "LCSA-related features and hybrid Multi-Criteria Decision-Aiding (MCDA) methodologies into a BIM environment for life cycle sustainability assessment (LCSA) and decision-making. The faster BIM-based LCSA process uses richer Industry Foundation Class (IFC) models and specific LCSA data templates to share data between the BIM platform and external LCA technologies". Based on evaluation results, hybrid MCDA techniques grade DWM situations. Pilot testing demonstrates how the BIM framework works. Recycling boosted sustainability. The best DWM with the highest recycling rate scores 91.63 for sustainability. The ‘status quo’ DWM choice for China's recycling company scores 8.37, substantially lower than the baseline scenario with a 50% recycling rate. Sustainability score growth flattens when the desired recycle rate climbs. From the “Australian standard” scenario to the best scenario, the recycling rate increases by 18.4%, and the sustainability score increases by 2.3%, suggesting that “the former scenario” obtained an optimal DWM cost-efficiency under the predefined variables.

Yousfani Abdul Mueed, et al. (2023) [62]studied modern society's values of sustainable building and demolition. Governments and businesses worldwide are developing waste-reduction strategies. Construction and demolition trash should be reduced, reused, and recycled. These tasks require accurate trash estimations from building and destruction. Construction waste estimation and audit are compromised by current practice. This anomaly prompted this research to design a BIM-based waste estimating method. The system estimates garbage production and classifies recyclable and post-demolition rubbish. First, waste estimation systems and their limitations are examined. A Revit buildings residential building model is used to estimate waste. Revit data is fed into C++ software to estimate waste. Research creates a system to assess waste for demolished buildings. The framework can estimate total, recyclable, and disposal waste. Along with that, the framework estimates the overall cost of trash production, including recycling/reusing savings.

ParsamehrMohammadsaeid, et al. (2023) [63]discussed large amounts of data are needed for modern construction management project delivery. However, implementation issues make crucial construction management data difficult to access. Management is rapidly changing to enable predictive decision-making, which requires digitalizing construction data. “The Architectural, Engineering, and Construction (AEC) industry” has lagged in management and technology adoption. However, construction management must be reengineered to compete with manufacturing, oil, and gas. The field of construction management has undergone a sea change due to BIM. When it comes to management, BIM includes tools that are both distinctive and strong. Traditional approaches to construction management and decision-making based on building information modeling were both found wanting in this study. In this review, we looked at how a building information modeling (BIM) platform keeps an eye on the four main metrics of construction management: time, money, quality, and safety. Researchers placed a premium on automated prediction models based on building information modeling (BIM) and participant communication and participation, according to this review. A building information modeling (BIM) decision-making framework was proposed in this study. Building information modeling (BIM) is a decision support system that this study aided construction organizations in implementing. Lastly, the review uncovered areas where more research is needed and gaps in current understanding.

Soeiro Alfredo, et al. (2022) [64]studied the Architectural, Engineering, and building (AEC) business is improving methods to reduce environmental consequences and building and devastation waste. “Building Information Modeling (BIM)” automates construction and waste management throughout “the life cycle”. To verify BIM's use in building waste management, a 2009–2020 scientific database literature review was conducted. British, American, and Chinese periodicals dominate the findings. The literature study demonstrated that BIM is mostly used for CDW management during design, but it may also be used to coordinate teamwork throughout the construction life cycle. BIM in CDW improves material control, but studies showed the need for better indicators to describe construction site conditions and include sustainability practices in the building model. The results also showed that BIM tool interoperability is the biggest hurdle to merging BIM and CDW management, which offers a research opportunity.

Wang Jingjing, et al, (2022) [65]evaluated using creative methods to reduce waste and Environmental Impacts (EIs) during building has grown in popularity. Certain frameworks' construction waste estimation tools are limited to the end of building projects. Life Cycle Evaluation (LCA), one of the most comprehensive approaches for building environmental impact evaluation, is used for quantification. BIM is a good framework for integrating LCA for this procedure. Current BIM and LCA tools are not entirely compatible. An approach to quantify building lifecycle waste is proposed in this research. The main causes of waste are explored and waste-reduction methods are given. To evaluate the ecologicalinfluence of resources changed to waste in acombined environment, a BIM tool add-in computes“waste produced” in each step of the building's lifecycle for the LCA tool. “An actual building project” will be used to demonstrate the techniques' helpfulness and abilities.

Hu Xingyi, et al. (2022) [66]said rising urbanization has led to numerous building demolitions, resulting in significant “construction and demolition waste (CDW)” in various countries. There is a lack of information prior to demolition due to the inadequate documentation of alterations and decay to older buildings. Proper demolition trash management, pre-demolition audits, and on-site operations are all essential for a successful demolition. To improve the efficiency and informatization of building destruction and CDWM, this research proposes an Image-to-BIM smart system. Autonomous collection of interior and exterior images of buildings to be demolished is achieved using a UAV and handheld camera setup. Consideration of the target region is made in the motion route planning. Extracting geometric data for the target BIM model is possible with this method, which can also detect line features in image-based reconstruction models. Optimizing schedules, assessing safety, taking CDW quantities off, and economically estimating utilizing BIM model data are all made possible by additional frame components for demolition planning and waste management. Smarter deconstruction is made possible by integrating the framework into masonry structures, which improves the flow of information during building deconstruction and CDWM.

Quiñones Rocío, et al. (2022) [67]discussed "construction and demolition waste as a growing environmental, social, and economic" challenge for Europe and the world. Early quantification decreases building waste production and optimizes management. Design-based methods are needed to understand building waste. BIM can simulate, store, and manage data throughout building design, making it popular in AECO. The WE-BIM Add-in software in this study quantifies construction waste (CW) during Revit BIM model design. A proven CW quantification model in Revit forecasts waste kinds and volumes per building element based on the European List of Waste. Early designers could simply model design choices in real time to make selections. "The reinforced concrete Option 1 (O1) and steel Option 2 (O2) structural systems of a Spanish residential structure were compared". O2 would have decreased (56%) of O1's waste and augmented waste recycling (by 49%), as automatically estimated and showed in Revit, similar to previous research comparing prefabricated to in situ systems. This research prepared for automated BIM building waste estimation, which could improve waste prevention.

Han Dongchen, et al. (2021) [68]studied "construction and demolition waste (C&DW)" accounts for 30% of global trash creation, causing resource depletion, global warming, and land degradation. Few studies have integrated Building Information Modeling (BIM) into demolition waste management, despite efforts to reduce building waste through BIM-aided design. This comprehensive literature review examined major constraints and future research directions for BIM adoption in C&DWM. This study first examined the barriers to C&DWM deployment in Australia and then examined the pros and cons of using BIM tools. The findings showed that older buildings without updated design drawings must increase data collecting and object recognition accuracy to avoid "BIM-DWM integration constraints". One way to bring BIM-based sustainability analysis to DWM is to create material banks focused on specific regions and then integrate them with databases that track life cycle assessments. A research program was proposed in this assessment to address these constraints and make the most of BIM's DWM capabilities.

Shi Yi, and Jiuping Xu(2021) [69]said rising "construction and demolition waste (CDW)" has led to source limitations and ecological degradation, necessitating scientific disposal solutions. Based on the 3R concept, this study established"a BIM-based CDW" information system utilizing "Revit software to reduce CDW" overcome adoption difficulties, and present CDW-related information. After proposing a "Reverse Logistics (RL)" network to manage end-of-life CDW disposal, mathematical formulas are used to determine "disposal costs and carbon emissions for environmental and economic balance". The technology was effectively deployed, yielding exact CDW data for disposal cost and emission estimations and high CDW recovery for sustainable waste development. Future studies can focus on CDW 3D visualization interfaces and social advantages.

Xu Jiuping, et al. (2019) [70]discussed global warming and climate change are caused by GHG emissions. GHG emissions from "construction and demolition waste (CDW)" end-of-life must be appropriately assessed and reduced. GHG computation and reduction require correct CDW estimation. Present CDW data and GHG estimation methodologies are imprecise. For precise information and complete estimation, this study proposes a "BIM-based CDW IMS". Calculations with multiple greenhouse gas emission factors quantify "CDW disposal GHG emissions". Chinese case studies demonstrate how the technique quantifies and minimizes it(CDW disposal GHG emissions). The GHG emissions of 15 CDW disposal methods are precisely measured and compared. Material had the highest transport and handling emissions (of carbon dioxide, methane, and nitrous oxide), whereas organics had the highest decomposition methane emissions. Based on emission characteristics, "source-separated CDW disposal GHG" emission reductions are suggested. The BIM-based CDW IMS and mathematical equations quickly and precisely calculated CDW information and GHG emissions, helping reduce CDW disposal's primary environmental impact.

Balaa Anju, et al. (2019) [71]explained construction and demolition (C&D) generate massive trash. Inefficient design, sourcing, planning, and processing of materials, raw material residuals, and unexpected construction design changes cause most development waste. BIM may reduce C&D waste by eliminating plan issues, revisions, and tuning. This study analyzed how BIM innovation can help C&D waste stewardship architecture plans and development cycles. This study proposed BIM-based methods to "reduce, reuse, reuse, and steward development waste through conflict recognition, exit, development exercises, site use, and building". In response to the expanding population, development exercises with possible climatic impact are mainly done. The development zone, which follows creative events closely, must ensure ecological equilibrium in the world. Experts should build a structure according to their blueprint and consciously comply with nature. Incorrect plan choices, appropriate plans to get the job done, unforeseen climate resistances, and capitulation in element supply might directly or implicitly disturb the development reaction, making construction waste on the site last longer. These wastes harm alive and lifeless climates. Development waste cannot be eliminated, but it can be controlled and recovered. Creative applications are crucial to progress. BIM applications are tested for their capacity to reduce development waste. Thus, studies on development waste, BIM innovation, development wastage, board exercises, and discovery assessments are needed. BIM applications are suggested to reduce construction waste.

Hamzakadı Aysu, and İlterTurkdogan (2019) [72]emphasizedto preserve natural resources and lessen pollution through the use of technical advancements, sustainable buildings are essential. One of the benefits of modern technology is building information modeling, which allows for the creation of a virtual model of a construction project in three dimensions. With the use of analytical instruments, one may determine the building's yearly energy consumption and carbon emissions. Building Information Modeling analytic tools can be used to forecast the effects of carbon emissions on window thickness, window wall ratio, and window shades; this is underscored within the study's scope.

Ge Xin Janet, et al. (2017) [73]said construction generates 50% of global solid waste. To reduce waste and environmental damage, governments worldwide have passed laws on recycling and reusing building materials. Researchers are also creating waste management models for building development and destruction. BIM illustrates this. "BIM is an emerging technology used to optimize design, construction, and maintenance throughout the lifecycle". BIM is rarely used in deconstruction or demolition, especially for building fixtures and fittings. 2D drawings or sketches are used to generate BIM, which may not be accurately transformed into 3D models. Also, past studies focused on construction waste management. Few demolition deconstruction waste management studies exist. This study intended to bridge this gap by developing a framework integrating a reconstructed 3D model with BIM to increase BIM accuracy and design a deconstruction waste management system to promote demolition efficiency, recycling, and cost savings. As-built "BIM" will be utilized to identify, measure, and plan recycling.

Kim Young-Chan, et al. (2017) [74]discussed most "demolition waste (DW)" quantification studies lack an approved standard to determine DW amount and kind. Thus, the literature on calculating DW with a uniform classification method has drawbacks. From design to demolition, building information modeling (BIM) can generate and manage all building information. However, there is little research on its use in building demolition. For a successful waste management plan, DW type and volume should be estimated during building design. The lack of instruments hampers initialapproximation. This study provided"a BIM-based framework" to estimate "DW" early in design to streamline planning, processing, and management. "Korean construction classification system and BIM library construction material" inputs were matched. Based on this matching integration, weight/unit volume factors and DW volume change rates were used to estimate "DW" by type. The framework was tested using BIM modeling and literature comparisons. This work should help estimate "DW" at the construction and district levels for mechanical estimates.

Akinade Olugbenga O., et al. (2016) [75]identifiedevaluation criteria to assess existing construction waste management solutions and use the results to create a holistic BIM framework. The literature classified 32 instruments for managing building waste into five groups: (a) plans and templates for waste management, (b) tools for collecting and auditing waste data, (c) models and tools for quantifying and predicting building waste, and (d) technologies that are enabled by geographic information systems for managing building waste. Six assessment criteria were identified after analyzing these tools and conducting four focus groups: waste data, waste prediction, commercial and procurement, building information modeling (BIM), design, and technological. At the design stage, the technologies do not meet the evaluation criteria for handling construction waste. The research concluded that a six-tiered BIM architecture would be the most effective, including domains for applications, services, BIM business, presentation, data, and infrastructure. “The BIM framework” organizes important knowledge to effectively manage building waste during design using an architecture-based layered approach. “Software developers and BIM practitioners” who want to add building waste management features to BIM software will like this framework.

Soltani Sahar (2016) [76] saidDue to their environmental impact and usage of natural resources, global environmental concerns have increased demand for novel construction methods. “Greener design” can be used during structure phases employing building“sustainability tools, methods, and techniques”. In this regard, “Building Information Modelling (BIM)” analytical and combined models may help streamline this procedure. “The architectural, engineering, and construction (AEC)” business has recently focused on “BIM and construction sustainability” which are separate. A careful investigation of their relationships suggests a synergy that, if recognized, can lessen the AEC industry's environmental effect. BIM-based design models can promote sustainability in three ways: environmental, economic, and social. This study discussed many relationships between BIM and construction sustainability by analyzing the literature and utilizing a matrix to examine “construction sustainability dimensions and BIM functionalities”. Despite significant improvements in BIM implementation in ecological and financial sustainability, its potential impact on the social dimension has not been examined, therefore additional studies are needed.

Jalaei Farzad, and Ahmad Jrade (2014) [77]explained quantifying environmental implications and simulating building component energy consumption at “the conceptual design stage”benefitengineers choose the optimum design solution for more energy-efficient construction. “Building Information Modelling (BIM)” allows creators to evaluate design options at the conceptual stage to achieve “energy and life cycle assessment (LCA) methods and systems”. An automated model linking BIM, LCA, energy analysis, and lighting simulation tools with green building certification systems is proposed in this work. Implementation involves designing BIM plug-ins to measure building component EI and embodied energy. This technology gave designers a new method to envisage and recognize energy gains or losses for the structure and its components. “The Leadership in Energy and Environmental Design (LEED) rating system” will also help designers assess construction sustainability. An actual building project will demonstrate the methodology's viability.

Cheng Jack CP., and Lauren YH Ma (2013) [78]studied global environmental awareness requires government and contractors to handle C&D waste. Over the past two decades, demolition and rehabilitation (D&R) activities and landfill disposal of D&R waste have increased, notably in large cities like Hong Kong. Waste management needs quantitative forecasts. That helps contractors identify waste-generating processes and plan waste reduction. Waste estimation can help government waste management plans like Hong Kong's garbage disposal pricing. The studylacked accurate and convenient trash estimates for construction, remodeling, and demolition. To address this research need, this study introduced a BIM-based “D&R waste assessment and planning system”. A “BIM digital building model” can contain multi-disciplinary information. “Material and volume data from the BIM model” can be used for waste estimation and planning. The authorrecycled and repurposed waste. To boost efficiency, recyclers may get extracted material information before destruction or restoration. The used technique predicts site-specific pick-up vehicle and waste disposal demands. Results may caution contractors during project planning. the study demonstrateda “D&R waste estimating and planning system” using a 47-floor Hong Kong residential building. As the architectural, engineering, and construction industries adopt “BIM technology and digital building information models become available for most buildings” (including historical ones, Thissystem can be used in demolition and renovation projects and extended to facilitate project control).

Bynum Patrick, et al. (2013) [79]discussed how building information modeling (BIM) has improved project quality, quantity take-offs, and scheduling, reducing “project contingencies and costs”. BIM is new, but much investigation has been done to recover its design and construction capabilities. BIM's impact on sustainable construction has been lightly studied. Thus, this study examined designers' and builders' views on “BIM for sustainable design and construction”. A web-based poll was created to assess BIM application trends and their use in sustainable design and construction. Although most survey accused believed that “*sustainable design and construction practices were* *important in their company, most still believed that project coordination and visualization were more important than sustainability*". Though "BIM" is considered a transdisciplinary tool, industry BIM programs still struggle with interoperability. The majority of studies said "design/build and integrated project delivery (IPD)" were the best ways to use BIM for sustainability. BIM is still new, but as more (design and construction professionals) realize its aids, it will become important for maintainable design and building.

Nguyen T. H., et al. (2010) [80]said many AEC companies have lately begun using BIM (Building Information Modeling) because of the efficiency and cost savings it offers in the long run. To ascertain the degree of sustainability, this studydetailed the process of creating and implementing a sustainability assessment agenda for "an architectural design". The framework makes use of "building information modeling (BIM) technology" to extract data from the digital building model. An internationally recognized benchmark for environmentally responsible construction in the US, "*the Leadership in Energy and Environmental Design (LEED) Green Building Rating System*" forms the basis of the sustainability evaluation. To prove the framework's usefulness, it is used in the architectural design of a hotel project.

Table 1. Approaches to Review of Literature

S.no.	Author	Technique	Research Gap	Findings
1.	Han, and Abbas (2024)	BIM Integration, HybridMCDA Methods	Addresses the absence of BIM-integrated LCSA for DWM and focuses on assessing trade-offs among multifaceted criteria.	Higher recycling rates improve sustainability scores, but with diminishing returns, as shown by "the status quo scenario" in China, which has the lowermost score of 8.37.
2.	Yousfani, et al. (2023)	Analysis of existing systems, Waste estimation using Revit, Data processing in C++	Inaccurate waste estimation and audit in current practices.	BIM-based system for accurate waste estimation, Framework for total, recyclable, and disposable waste estimation, Cost estimation for waste management.
3.	Parsamehr, et al. (2023)	Analysis of BIM-based construction management platforms	Limited implementation of modern management techniques in the "AEC industry".	BIM improves "schedule, cost, quality, and safety management", BIM enhances association and communication among project participants.

4.	Soeiro, et al. (2022)	Literature review from scientific databases (2009-2020)	Need for better indicators for real construction site situations, and the Necessity to integrate sustainability practices into BIM models.	The main BIM application is at the design stage, but it can enhance team coordination and activities throughout the construction life cycle, Most publications are from the UK, US, and China, BIM helps with material control but has limitations that need addressing.
5.	Wang, et al, (2022)	Integration Development: Creating an add-in within BIM tools for waste quantification, and Case Study Application: Applying the methodology to a real building project.	BIM and LCA tools lack full integration, Existing methods primarily focus on waste quantification at the end-of-life stage.	Waste Quantification: Methodology successfully calculates waste produced at each stage of the building's lifecycle, Environmental Impact Evaluation: Integrated environment for assessing the environmental impact of waste materials.

3. **Research Gap**

- There is a limited integration of waste management methods for construction and destruction (C&D) within the workflows of BIM in Revit, which results in inefficiencies in waste reduction tactics.
- There are insufficient tools or plug-ins within Revit that are expressly developed for tracking, estimating, and controlling construction and demolition waste throughout the lifecycle of the project.
- Diverse projects have diverse results due to the lack of standardization in research and processes for C&D waste management's incorporation into BIM models.
- There is a lack of study on the effectiveness of building information modeling (BIM) in promoting sustainable demolition practices, particularly about the recovery of resources and the reuse of materials.
- There are not enough case studies or empirical data on the real-world implementation of Revit and BIM for construction and demolition waste management, which makes it difficult to validate theoretical models and business strategies.

4. **Research Objective**

- To assess how Revit and BIM can be leveraged to optimize the management of construction and demolition waste, focusing on reducing material wastage and improving recycling processes.
- To investigate the integration of waste management practices into BIM's design and planning phases, aiming to enhance sustainability in construction projects.
- To explore the potential of BIM tools like Revit to track, quantify, and analyze waste generation throughout the lifecycle of construction projects.
- To evaluate the effectiveness of BIM in facilitating collaboration among stakeholders for more efficient waste management strategies and regulatory compliance.

5. Background Study

The most recent innovations in "building information modeling (BIM)"--based solutions for managing "construction and demolition waste (CDW)"were illustrated in this review. This study seeks to fill knowledge gaps by reviewing the depth and breadth of published literature on building information modeling (BIM) based solutions for dealing with construction debris during the entire construction "life cycle". Although many BIM-based technologies are intrinsically linked to CDW, the majority of the literature on the subject has concentrated on the pre-and post-construction phases of a project, with very little study of the latter. Furthermore, there is a lack of theoretical rigor and cross-phase insights into project waste elements in the currently available techniques and technologies. By outlining the logical flaws in providing BIM-based solutions for CDW, this essay makes a valuable contribution to the area. Additionally, it highlights key areas where further research on the subject is needed. The study highlighted the most cutting-edge BIM-based solutions for CDW issues and served as a resource for practitioners by providing information on where to find them. [81].

6. Result Layout

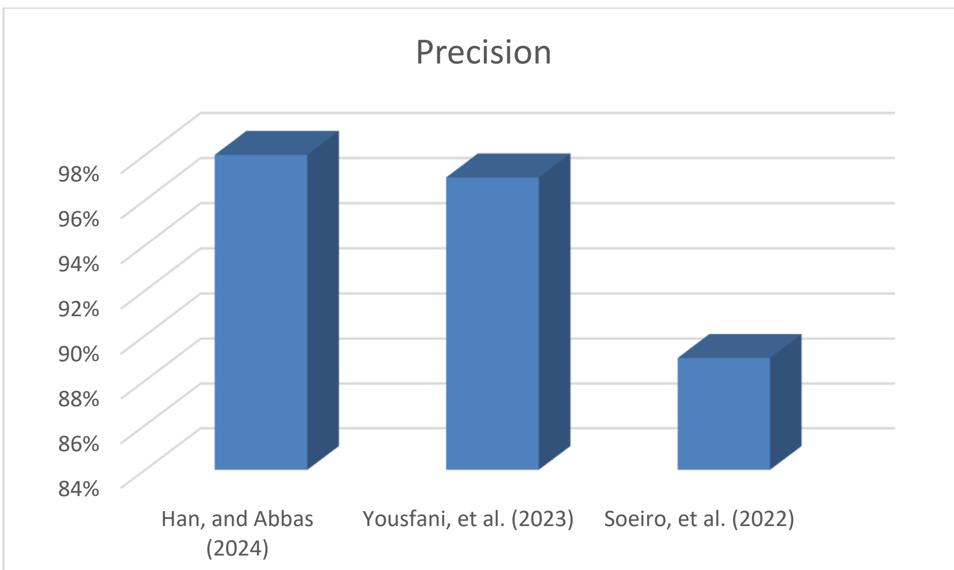

Figure 4: Precision comparison Analysis

The authors Han and Abbas (2024) demonstrated an incredibly effective way for managing construction and demolition trash, reaching the maximum level of precision with their approaches. Their accuracy rate shown in fig.4 was 98%. Following closely behind, yousfani et al. (2023) showed strong results in using BIM for trash management with a precision of 97%. Soeiro et al. (2022) found a lower accuracy of 89%, which could be due to methodological issues. Review results show that several approaches to using Revit and BIM for waste management are to varied degrees effective, with Han and Abbas's method coming out on top in terms of reliability.

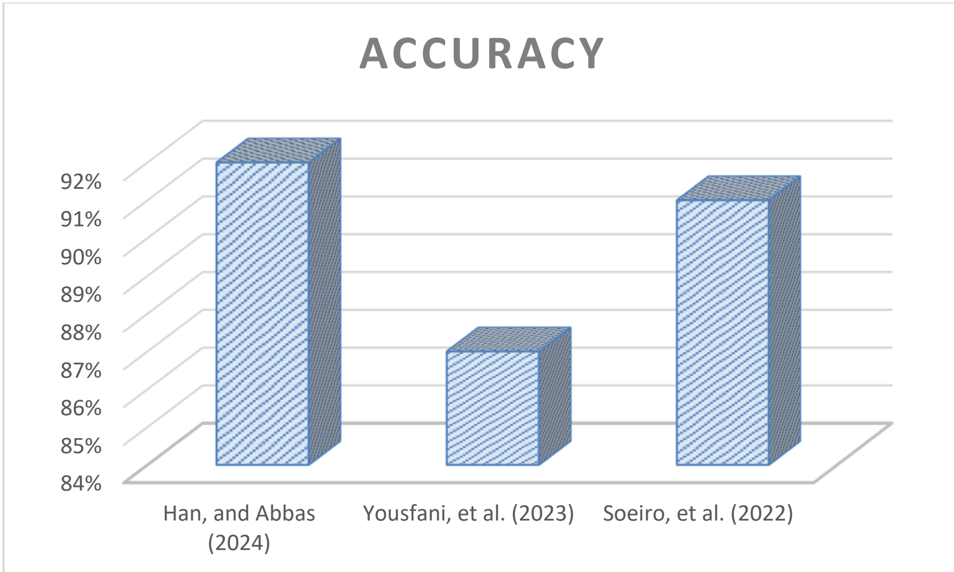

Figure 5: Accuracy comparison Analysis

Different studies have shown different results when analysing the accuracy of controlling construction and demolition waste using Revit and BIM. The high dependability and efficacy of Han and Abbas's (2024) technique were demonstrated by their 92% accuracy shown fig.4. A somewhat lower, but nevertheless adequate, level of performance was indicated by Yousfani et al. (2023), who reported an accuracy of 87%. At the same time, Soeiro et al. (2022) showed a 91% accuracy rate, putting their method just below but close to the best-performing one by Han and Abbas. The studied literature demonstrates the efficacy of various ways through these accuracy rates; the most precise are Soeiro et al., Yousfani et al., and Han and Abbas.

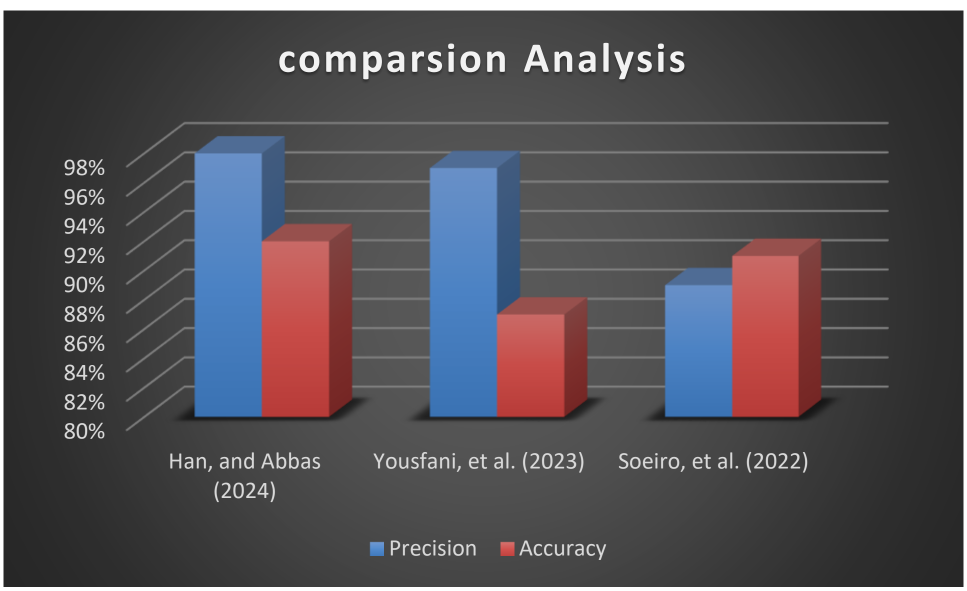

Figure 6: Comparison Analysis

Studies comparing Revit and BIM for managing construction and demolition waste show that the two tools aren't always interchangeable when it comes to accuracy and precision. As far as approaches go, Han and Abbas (2024) showed the best results, with a 98% accuracy and a 92% precision. There may have been some compromises in the efficacy of the method used by Yousfani et al. (2023), who came very near with a precision of 97% but demonstrated a somewhat lower accuracy of 87%. Soeiro et al. (2022) demonstrated a more balanced approach, although with slightly lower precision, with an accuracy of 91% despite an accuracy of 89%. From these comparisons, we can see that each method has its advantages and disadvantages; the method proposed by Han and Abbas is the most exacting and accurate, while the one proposed by Soeiro et al. provides excellent accuracy with moderate precision shown in fig.6.

Conclusion-The most successful method for controlling waste from building and demolition projects using Revit and BIM was reported by Han and Abbas (2024), who also achieved the highest accuracy (92%), and precision (98%) of any study analysed. This suggests that their approach is accurate and dependable when used. Yousfani et al. (2023) demonstrated a somewhat lower accuracy rate of 87%, but they followed closely in terms of precision at 97%, indicating potential for improvement in efficacy. Despite having the lowest precision (89%), Soeiro et al. (2022) were able to attain a pretty high accuracy (91%), suggesting that their approach would be appropriate in situations when accuracy is more important than precision. Overall, the results highlight the advantages and disadvantages of each strategy, with Han and Abbas dominating in both major measures, indicating the specific robustness of their methodology for real-world application in the field of BIM-enabled construction waste management.

References

1. Shen, L.; Tam, V.W.; Tam, C.; Drew, D. Mapping approach for examining waste management on construction sites. J. Constr. Eng. Manag. 2004, 130, 472–481.
2. Ling, F.Y.Y.; Nguyen, D.S.A. Strategies for construction waste management in Ho Chi Minh City, Vietnam. Built Environ. Proj. Asset Manag. 2013, 3, 141–156.
3. Nikmehr, B.; Hosseini, M.R.; Oraee, M.; Chileshe, N. Major factors affecting waste generation on construction sites in Iran. In Proceedings of the 6th International Conference on Engineering, Project, and Production Management (EPPM2015), Gold Coast, QLD, Australia, 2–4 September 2015.
4. Osmani, M.; Glass, J.; Price, A.D. Architects' perspectives on construction waste reduction by design. Waste Manag. 2008, 28, 1147–1158.
5. Won, J.; Cheng, J.C.; Lee, G. Quantification of construction waste prevented by BIM-based design validation: Case studies in South Korea. Waste Manag. 2016, 49, 170–180.
6. Nikmehr, B.; Hosseini, M.R.; Rameezdeen, R.; Chileshe, N.; Ghoddousi, P.; Arashpour, M. An integrated model for factors affecting construction and demolition waste management in Iran. Eng. Constr. Archit. Manag. 2017, 24, 1246–1268.
7. Esin, T.; Cosgun, N. A study was conducted to reduce construction waste generation in Turkey. Build. Environ. 2007, 42, 1667–1674.
8. Luangcharoenrat, C.; Intrachooto, S.; Peansupap, V.; Sutthinarakorn, W. Factors influencing construction waste generation in building construction: Thailand's perspective. Sustainability 2019, 11, 3638.
9. Coelho, A.; De Brito, J. Influence of construction and demolition waste management on the environmental impact of buildings. Waste Manag. 2012, 32, 532–541.
10. Nagapan, S.; Rahman, I.A.; Asmi, A.; Memon, A.H.; Latif, I. Issues on construction waste: The need for sustainable waste management. In Proceedings of the 2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER), Kota Kinabalu, Malaysia, 3–4 December 2012; pp. 325–330.
11. Alwi, S.; Mohamed, S.; Hampson, K. Waste in the Indonesian construction projects. In Proceedings of the 1st CIB-W107 International Conference-Creating a Sustainable Construction Industry in Developing Countries, Pretoria, South Africa, 11–13 November 2002; pp. 305–315.
12. Cheng, J.C.; Ma, L.Y. A BIM-based system for demolition and renovation waste estimation and planning. Waste Manag. 2013, 33, 1539–1551.
13. Zoghi, M.; Kim, S. Dynamic modeling for life cycle cost analysis of BIM-based construction waste management. Sustainability 2020, 12, 2483.
14. Oyedele, L.O.; Regan, M.; von Meding, J.; Ahmed, A.; Ebohon, O.J.; Elnokaly, A. Reducing waste to landfill in the UK: Identifying impediments and critical solutions. World J. Sci. Technol. Sustain. Dev. 2013, 10, 132–141.
15. Phillips, P.S.; Tudor, T.; Bird, H.; Bates, M. A critical review of a key waste strategy initiative in England: Zero waste places projects 2008–2009. Resour. Conserv. Recycle. 2011, 55, 335–343.

16. Yu, A.T.W.; Poon, C.S.; Wong, A.; Yip, R.; Jaillon, L. Impact of Construction Waste Disposal Charging Scheme on work practices at construction sites in Hong Kong. Waste Manag. 2013, 33, 138–146.
17. Kabirifar, K.; Mojtahedi, M.; Wang, C.C. A Systematic Review of Construction and Demolition Waste Management in Australia: Current Practices and Challenges. Recycling 2021, 6, 34.
18. Hosseini, M.R.; Jupp, J.; Papadonikolaki, E.; Mumford, T.; Joske, W.; Nikmehr, B. Position paper: Digital engineering and building information modeling in Australia. Smart Sustain. Built Environ. 2020, in press.
19. Hosseini, M.R.; Maghrebi, M.; Akbarnezhad, A.; Martek, I.; Arashpour, M. Analysis of Citation Networks in Building Information Modeling Research. J. Constr. Eng. Manag. 2018, 144, 04018064.
20. Sun, C.; Jiang, S.; Skibniewski, M.J.; Man, Q.; Shen, L. A literature review of the factors limiting the application of BIM in the construction industry. Technol. Econ. Dev. Econ. 2017, 23, 764–779.
21. Akbarnezhad, A.; Ong, K.C.G.; Chandra, L.R. Economic and environmental assessment of deconstruction strategies using building information modeling. Autom. Constr. 2014, 37, 131–144.
22. Banihashemi, S.; Tabadkani, A.; Hosseini, M.R. Integration of parametric design into modular coordination: A construction waste reduction workflow. Autom. Constr. 2018, 88, 1–12.
23. Hannan, M.; Al Mamun, M.A.; Hussain, A.; Basri, H.; Begum, R.A. A review on technologies and their usage in solid waste monitoring and management systems: Issues and challenges. Waste Manag. 2015, 43, 509–523.
24. Eadie, R.; Browne, M.; Odeyinka, H.; McKeown, C.; McNiff, S. BIM implementation throughout the UK construction project lifecycle: An analysis. Autom. Constr. 2013, 36, 145–151.
25. Akinade, O.O.; Oyedele, L.O.; Bilal, M.; Ajayi, S.O.; Owolabi, H.A.; Alaka, H.A.; Bello, S.A. Waste minimization through deconstruction: A BIM-based Deconstructability Assessment Score (BIM-DAS). Resour. Conserv. Recycle. 2015, 105, 167–176.
26. Eastman, C.; Teicholz, P.; Sacks, R.; Liston, K. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors, 2nd ed.; John Wiley & Sons: Hoboken, NJ, USA, 2011.
27. Won, J.; Cheng, J.C. Identifying potential opportunities of building information modeling for construction and demolition waste management and minimization. Autom. Constr. 2017, 79, 3–18.
28. Pärn, E.A.; Edwards, D.J.; Sing, M.C. The building information modeling trajectory in facilities management: A review. Autom. Constr. 2017, 75, 45–55.
29. Xu, C.; Hu, X.; Tivendale, L.; Hosseini, M.R.; Liu, C. Building information modeling in sustainable design and construction. Int. J. Sustain. Real Estate Constr. Econ. 2018, 1, 164–181.
30. Lu, W.; Webster, C.; Chen, K.; Zhang, X.; Chen, X. Computational Building Information Modelling for construction waste management: Moving from rhetoric to reality. Renew. Sustain. Energy Rev. 2017, 68, 587–595.
31. Cheng, J.C.; Won, J.; Das, M. Construction and demolition waste management using BIM technology. In Proceedings of the 23rd Annual Conference of the International Group for Lean Construction, Perth, Australia, 19–23 July 2015; pp. 381–390.
32. Aleksanin, A. Potential for the use of information systems in the management of construction waste. MATEC Web Conf. 2018, 196, 04081.
33. Akinade, O.O.; Oyedele, L.O.; Omoteso, K.; Ajayi, S.O.; Bilal, M.; Owolabi, H.A.; Alaka, H.A.; Ayris, L.; Looney, J.H. BIM-based deconstruction tool: Towards essential functionalities. Int. J. Sustain. Built Environ. 2017, 6, 260–271.
34. Volk, R.; Stengel, J.; Schultmann, F. Building Information Modeling (BIM) for existing buildings—Literature review and future needs. Autom. Constr. 2014, 38, 109–127.
35. Yalcinkaya, M.; Singh, V. Patterns and trends in Building Information Modeling (BIM) research: A Latent Semantic Analysis. Autom. Constr. 2015, 59, 68–80.
36. Lu, Y.; Li, Y.; Skibniewski, M.; Wu, Z.; Wang, R.; Le, Y. Information and Communication Technology Applications in Architecture, Engineering, and Construction Organizations: A 15-Year Review. J. Manag. Eng. 2014.

37. OBANDO UTRERAS, ERIK SANTIAGO. "Generative building massing optimization in parametrical BIM environment: evaluating different parametric BIM workflows from Grasshopper to Revit at the conceptual design stage." (2018).
38. Demchak, Greg, Tatjana Dzambazova, and Eddy Krygiel. *Introducing Revit architecture 2009: BIM for beginners*. John Wiley & Sons, 2009.
39. Davis, Patrick. *Introducing Autodesk Revit Architecture 2012*. John Wiley & Sons, 2011.
40. Lin, Li, Xiqing Song, Minyuan Huang, Yunhui Sun, Jin Li, Yu Zhu, and Zheng Yang. "Retracted: The Creation and Exploration of Revit Family Based on BIM Technology." In *2016 International Conference on Smart City and Systems Engineering (ICSCSE)*, pp. 241-244. IEEE, 2016.
41. Aubin, P. "Revit families: A step-by-step introduction." *Hentet fra: https://www. Autodesk. com/Autodesk-university/article/Revit-Families-Step-Step-Introduction-2018* (2020).
42. Congdon, Roark Taylor. "The Y model, simultaneous instruction in digital fabrication and representation." PhD diss., 2014.
43. HM Government, 2008. Strategy for Sustainable Construction. Department of Business, Enterprise and Regulatory Reform, London.
44. Ajayi, S.O., Oyedele, L.O., Bilal, M., Akinade, O.O., Alaka, H.A., Owolabi, H.A., Kadiri, K. O., 2015. Waste effectiveness of the Construction Industry: understanding the impediments and requisites for improvements. Resour. Conserv. Recycle. 102, 101–112.
45. Anderson, J., Thornback, J., 2012. A Guide to Understanding the Embodied Impacts of Construction Products. CPA, London.
46. Bilal, M., Oyedele, L.O., Akinade, O.O., Ajayi, S.O., Alaka, H.A., Owolabi, H.A., Qadir, J., Pasha, M., Bello, S.A., 2016b. Big data architecture for construction waste analytics (CWA): a conceptual framework. J. Build. Eng
47. Edwards, B., 2014. Rough Guide to Sustainability: A Design Primer. RIBA Publishing, London.
48. Ajayi, S.O., Oyedele, L.O., Akinade, O.O., Bilal, M., Owolabi, H.A., Alaka, H.A., Kadiri, K. O., 2016. Reducing waste to landfill: a need for cultural change in the UK construction industry. J. Build. Eng. 5, 185–193.
49. Udawatta, N., Zuo, J., Chiveralls, K., Zillante, G., 2015. Improving waste management in construction projects: an Australian study. Resour. Conserv. Recycle. 101 (2015), 73–83.
50. Oyedele, L.O., Ajayi, S.O., Kadiri, K.O., 2014. Use of recycled products in UK construction industry: an empirical investigation into critical impediments and strategies for improvement. Resour. Conserv. Recycle. 93 (2014), 23–31.
51. Akinade, O.O., Oyedele, L.O., Bilal, M., Ajayi, S.O., Owolabi, H.A., Alaka, H.A., Bello, S. A., 2015. Waste minimization through deconstruction: a BIM based deconstructability assessment score (BIM-DAS). Resour. Conserv. Recycle. 105, 167–176.
52. Ameh, O.J., Itodo, E.D., 2013. Professionals' views of material wastage on construction sites and cost overruns. Org. Technol. Manage. Constr.: Int. J. 5 (1), 747–757.
53. Faniran, O.O., Caban, G., 1998. Minimizing waste on construction project sites. Eng. Constr. Archit. Manage. 5 (2), 182–188.
54. Ekanayake, L.L., Ofori, G., 2004. Building waste assessment score: design-based tool. Build. Environ. 39 (7), 851–861.
55. Dainty, A.R.J., Brooke, R.J., 2004. Towards improved construction waste minimization: a need for improved supply chain integration? Struct. Surv. 22 (1), 20–29.
56. Osmani, M., Glass, J., Price, A.D.F., 2008. Architects' perspectives on construction waste reduction by design. Waste Manage. (Oxford) 28 (7), 1147–1158.
57. Akinade, O.O., Oyedele, L.O., Munir, K., Bilal, M., Ajayi, S.O., Owolabi, H.A., Alaka, H. A., Bello, S.A., 2016. Evaluation criteria for construction waste management tools: towards a holistic BIM framework. Int. J. Sustain. Build. Technol. Urban Dev., 1–19.
58. Al-Hajj, A., Hamani, K., 2011. Material waste in the UAE construction industry: main causes and minimization practices. Archit. Eng. Design Manage. 7 (4), 221–235.

59. Bilal, M., Oyedele, L.O., Qadir, J., Munir, K., Akinade, O.O., Ajayi, S.O., Alaka, H.A., Owolabi, H.A., 2016a. Analysis of critical features and evaluation of BIM software: towards a plug-in for construction waste minimization using big data. Int. J. Sustain. Build. Technol. Urban Dev., 1–18.
60. Wang, J., Li, Z., Tam, V.W., 2015. Identifying best design strategies for construction waste minimization. J. Cleaner Prod. 92, 237–247.
61. Han, Dongchen, and Abbas Rajabifard. "Improving the Decision-Making for Sustainable Demolition Waste Management by Combining a Building Information Modelling-Based Life Cycle Sustainability Assessment Framework and Hybrid Multi-Criteria Decision-Aiding Approach." *Recycling* 9, no. 4 (2024): 70.
62. Yousfani, Abdul Mueed, Muhammad Saleem Raza, Muhammad Ali Moriyani, and Tauha Hussain Ali. "Building Information Modelling (BIM) based framework for construction and demolition waste estimation and management." *JurnalKejuruteraan* 35, no. 5 (2023): 1101-1109.
63. Parsamehr, Mohammadsaeid, Udara Sachinthana Perera, Tharindu C. Dodanwala, Piyaruwan Perera, and Rajeev Ruparathna. "A review of construction management challenges and BIM-based solutions: perspectives from the schedule, cost, quality, and safety management." *Asian Journal of Civil Engineering* 24, no. 1 (2023): 353-389.
64. Soeiro, Alfredo, Annelise NairneSchamne, and Andre Nagalli. "The use of BIM to automated construction and demolition waste management: A literature review from 2009 to 2020." (2022).
65. Wang, Jingjing, Jiajia Wei, Zhansheng Liu, Chun Huang, and Xiuli Du. "Life cycle assessment of building demolition waste based on building information modeling." *Resources, Conservation and Recycling* 178 (2022): 106095.
66. Quiñones, Rocío, Carmen Llatas, Maria Victoria Montes, and Isidro Cortés. "Quantification of construction waste in early design stages using bim-based tool." *Recycling* 7, no. 5 (2022): 63.
67. Hu, Xingyi, Yin Zhou, Simon Vanhullebusch, Robbe Mestdagh, Zhongyu Cui, and Jiabin Li. "Smart building demolition and waste management frame with image-to-BIM." *Journal of Building Engineering* 49 (2022): 104058.
68. Han, Dongchen, Mohsen Kalantari, and Abbas Rajabifard. "Building information modeling (BIM) for construction and demolition waste management in Australia: A research agenda." *Sustainability* 13, no. 23 (2021): 12983.
69. Shi, Yi, and Jiuping Xu. "BIM-based information system for econo-enviro-friendly end-of-life disposal of construction and demolition waste." *Automation in Construction* 125 (2021): 103611.
70. Xu, Jiuping, Yi Shi, Yachen Xie, and Siwei Zhao. "A BIM-Based construction and demolition waste information management system for greenhouse gas quantification and reduction." *Journal of Cleaner Production* 229 (2019): 308-324.
71. Balaa, Anju, Deepak Nolkyab, and Divya Rastogic. "Construction and Demolition Waste Minimization Using BIM Technology (2019)."
72. Hamzakadı, Aysu, and İlterTurkdogan. "Integrated study of building information modeling (BIM) with green buildings for a sustainable environment." *Environmental Research and Technology* 2, no. 1 (2019): 46-54.
73. Ge, Xin Janet, Peter Livesey, Jun Wang, Shoudong Huang, Xiangjian He, and Chengqi Zhang. "Deconstruction waste management through 3d reconstruction and bim: a case study." *Visualization in engineering* 5 (2017): 1-15.
74. Kim, Young-Chan, Won-Hwa Hong, Jae-Woo Park, and Gi-Wook Cha. "An estimation framework for building information modeling (BIM)-based demolition waste by type." *Waste Management & Research* 35, no. 12 (2017): 1285-1295.
75. Akinade, Olugbenga O., Lukumon O. Oyedele, Kamran Munir, Muhammad Bilal, Saheed O. Ajayi, Hakeem A. Owolabi, Hafiz A. Alaka, and Sururah A. Bello. "Evaluation criteria for construction waste management tools: towards a holistic BIM framework." *International Journal of Sustainable Building Technology and Urban Development* 7, no. 1 (2016): 3-21.
76. Soltani, Sahar. "The contributions of building information modelling to sustainable construction." *World Journal of Engineering and Technology* 4, no. 2 (2016): 193-199.

77. Jalaei, Farzad, and Ahmad Jrade. "An automated BIM model to conceptually design, analyze, simulate, and assess sustainable building projects." *Journal of Construction Engineering* 2014, no. 1 (2014): 672896.
78. Cheng, Jack CP, and Lauren YH Ma. "A BIM-based system for demolition and renovation waste estimation and planning." *Waste management* 33, no. 6 (2013): 1539-1551.
79. Bynum, Patrick, Raja RA Issa, and Svetlana Olbina. "Building information modeling in support of sustainable design and construction." *Journal of construction engineering and management* 139, no. 1 (2013): 24-34.
80. Nguyen, T. H., T. Shehab, and Z. Gao. "Evaluating sustainability of architectural designs using building information modeling." *The Open Construction & Building Technology Journal* 4, no. 1 (2010).
81. Nikmehr, Bahareh, M. Reza Hosseini, Jun Wang, Nicholas Chileshe, and RaufdeenRameezdeen. "BIM-based tools for managing construction and demolition waste (CDW): A scoping review." *Sustainability* 13, no. 15 (2021): 8427.