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REDUCING REINFORCED CONCRETE MATERIALS WASTE IN CONSTRUCTION PROJECTS USING BUILDING INFORMATION MODELING IN EGYPT

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SUMMARY: *Reduced Reinforced Concrete Material Waste (RRCMW) is recognized as a major issue that must be controlled in building projects. The primary goal of the study is to demonstrate the significance of BIM in construction and the importance of BIM in reducing reinforced concrete material waste. To achieve the study's goal, a questionnaire survey is undertaken to estimate the benefit of using BIM in Egyptian building projects. According to the survey results, about 41% of respondents are believed that BIM may reduce project costs by 16% to 20% when compared to the traditional method. In addition, the proportion of variations in reinforced concrete amount survey between traditional methods (AutoCAD) and (Revit) is discovered to be 44%, with a range of 11% to 15%. Approximately 46% of respondents are believed that BIM eliminates design errors, with a percentage ranging from 21% to 25%, and about 51% are believed that BIM helps in reducing rework, with a total percentage ranging from 21% to 25%. Then, case studies of building ("Residential projects") and infrastructure ("Bridges projects") projects are analyzed to determine the difference between waste minimization using traditional methods and waste minimization using BIM. Waste management is a critical issue since it is the only approach to optimize waste throughout the project phases. As a result, factors managing (RRCMW) are extracted, and BIM software should be used to manage these factors in order to optimize waste. The relevant BIM applications are used in this case study: site utilization planning, quantity take-off, 3D coordination, visualization, digital prefabrication, design validation, "design review and clash detection," and optimized workflow and communication structure. So, based on the preceding case studies, it is discovered that using BIM is far more successful and economical than using the traditional method, because it aids in the resolution of many issues before and during construction, such as clash detection, material storage, material ordering, and so on. As a result, while BIM is not widely used in Egypt, engineers should be familiar with it because it will be a vital tool to reduce waste in the future.*

KEYWORDS*: Reinforced Concrete (RC), Building Information Modeling (BIM), Construction Projects (CP), Waste Management (WM)), Construction Industry (CI)), Material Waste (MW), Reducing Reinforced Concrete Material waste (RRCMW), Residential projects (RP)*

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1. INTRODUCTION

To protect existing natural resources, building waste must be managed properly, which necessitates comprehensive training on the identification and separation of recyclable materials at construction sites (Swetha et al. 2020). One of the key reasons of waste creation has been identified as a lack of on-site waste management strategy (Vilventhan et al. 2019). On-site waste management is an important aspect of the construction industry's sustainable building process. Without a forecast of construction waste quantities related to the project execution plan, proper execution and planning are impossible (Wimalasena et al. 2016). Building Information Modeling (BIM) is a new construction industry revolution that represents the most significant way for correctly estimating all the components of any building project. On-site rework is responsible for the enormous amount of waste and inefficiency. Every change order that costs the owner or builder money but adds no value to the project is considered waste. Procedures based on monitoring, controlling systems, and careful planning should be used to minimize or decrease construction waste (Ahankoob et al. 2014). As a result, the most appropriate strategy is to apply building information modelling (BIM). BIM is a technique for reducing waste in building projects throughout the design and pre-construction phases. It includes representing a design as objects with relationships, geometry, and properties (Eastman & Liston, 2008). The basic principles of BIM have been developed since 1970, even if they aren't called BIM (Eastman & Fisher, 1974). It is also discovered that in the Scandinavian construction industry, roughly 70% to 80% of designs are being created digitally (Penttila, 2007). Traditional techniques for drawing sections, plans, and elevations are used in the past, using rulers and papers, before the introduction of the 2D application, AutoCAD (2D). The primary distinction between 2D CAD and BIM is that 2D CAD represents buildings as sections, plans, and elevations, and changing one of these views requires reviewing and updating all of the others. Another significant distinction is that the building is represented as lines, arcs, and circles in standard 2D CAD, while objects in BIM are defined as spaces, beams, columns, and walls. BIM contains all information, quantities, and properties of building elements, as well as material inventories, cost estimates, and project schedules, and represents the whole building life cycle, allowing for easy and accurate extraction of results from the BIM model (CRC Construction Innovation, 2007).

This research provides an example of the many BIM dimensions. The use of 3D BIM, which is crucial for eliminating waste, reworks, and cost savings, which eventually leads to a decrease in initial costs, while 4D BIM is helpful for improving the schedule, 5D BIM allows participants to do early cost studies of the whole lifecycle cost. BIM 6D and 7D are associated with sustainability and facilities management (FM) (Sertyesilisik, B., et al. 2021).

BIM (Building Information Modeling) is widely regarded as the most important technique in the construction industry. BIM permeates the major source of waste generation and reduces non-value adding operations that are not consistent or essential. The basic BIM solutions for waste reduction are as follow: Conflict, Interference and Collision detection, Construction Sequencing and Construction Planning, Reducing Rework, Synchronizing Design and site layout, Detection of errors and omissions (Clash detection) and Precise Quantity take- off (Ahankoob et al. 2014).

According to an Autodesk (2011) study, 42 percent of non-users of BIM believe that BIM will be highly or very highly important in five years, and the growth of BIM in 2009 increased from 28 percent in 2007 to 48 percent. According to WRAP UK Construction (2011), a separate study by McCraw (2012) discover that BIM adoption in the US increased from 49 percent in 2009 to over 71 percent in 2012, with an estimated 15,000 hours saved across the entire design. BIM also provides accurate visualization for all project members, allowing them to have a complete understanding of material and machinery layout, activity procedure, and conflicts between building elements (Ahankoob et al. 2014). BIM is divided into two categories: design BIM and construction BIM. Design BIM demonstrates coordination within the design team (architects, structural engineers, and mechanical engineers), design BIM is at a Level of Development (LOD) of either 200 or 300 and Construction BIM relates to the actual fabrication and construction of materials to ensure 100 percent accuracy dimensioning, construction BIM is LOD 400. Because design and construction BIM have important and valuable applications that improve the overall quality and economy of construction, integrated BIM can be defined as the process that eliminates waste and adds value by minimizing costs, risks, and construction schedules (Hoffman, 2013).

BIM has several advantages. The main advantage is being able to create the model virtually and test its constructability in the real world before it is completed. This allows for greater efficiency and better-designed structures, which reduces resource waste. It also allows for better planning and scheduling, lowers costs, and improves collaboration on the job site (Ahankoob et al. 2014). Two of the most significant benefits of BIM are early design analysis throughout the design process and the ability to quickly transport highly accurate information (Autodesk, 2011).

Nawari et al. (2014) want to develop deep learning about the fundamentals of structural analysis and design, enhance digital modelling, and improve quality to meet today's demands (Nawari et al. 2014). BIM improves communication, promotes efficiency, and decreases mistakes, all of which help to save resources, energy, materials, and waste. It also allows you to modify, test, reject, and accept design concepts in real time (Europe Innova, 2008). With project team parities, Figure (1) illustrates the benefits of the BIM process.

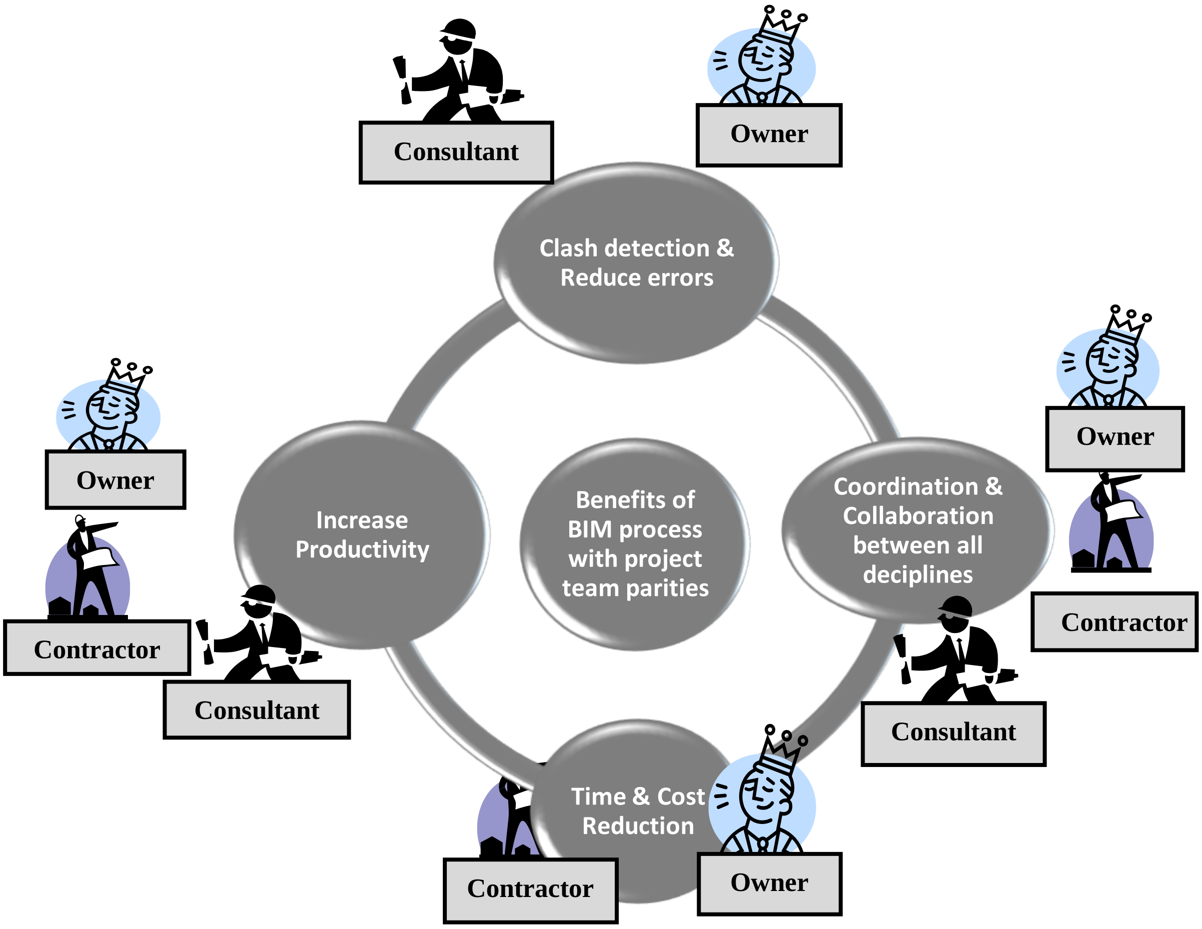

FIG. 1: Benefits of BIM process with project team parties

2. RESEARCH METHODOLOGY

The most frequent method of data collection is through social research interviews and questionnaire surveys. There are two aspects to the research methodology: The first step is to collect data using a structured questionnaire to determine the importance of applying BIM (RRCMW) in building projects. About (200) construction site managers' "consultant's site engineers and contractor's site engineers" who work in major companies and sites and deal with reinforced concrete projects on a regular basis and use BIM in their work are chosen to answer the questions. The questionnaire comprises of four questions that are reviewed in order to demonstrate the necessity of adopting BIM by choosing one answer from a 1-5 scale. It is chosen from a range of "zero percent to 25%" because it relates to BIM's maximum capability (RRCMW) as compared to the traditional method based on the opinions of participants and experts. A Likert scale with five options: 1 = "0 percent –5%," 2 = "6 percent –10 %," 3 = "11 percent –15 %," 4 = "16 percent –20 %," and 5 = "21 percent –25 %," based on the Likert scale. After completing the questionnaire, the data is entered into excel sheets and analyzed using the Statistical Package for Social Science (SPSS). The fundamental purpose of SPSS is to verify for data consistency. In this study, a reliability test is used to examine the data uniformity using Cronbach's alpha to ensure that the data is consistent. A reliability coefficient of 0.7 and above is generally regarded excellent and acceptable (Pallant, J. 2007). As a result, the data used in this study is acceptable and reliable. Based on SPSS analysis, the Cronbach's alpha for this study is 81 percent, which is regarded sufficient and acceptable. The study technique is illustrated in detail in Figure (2).

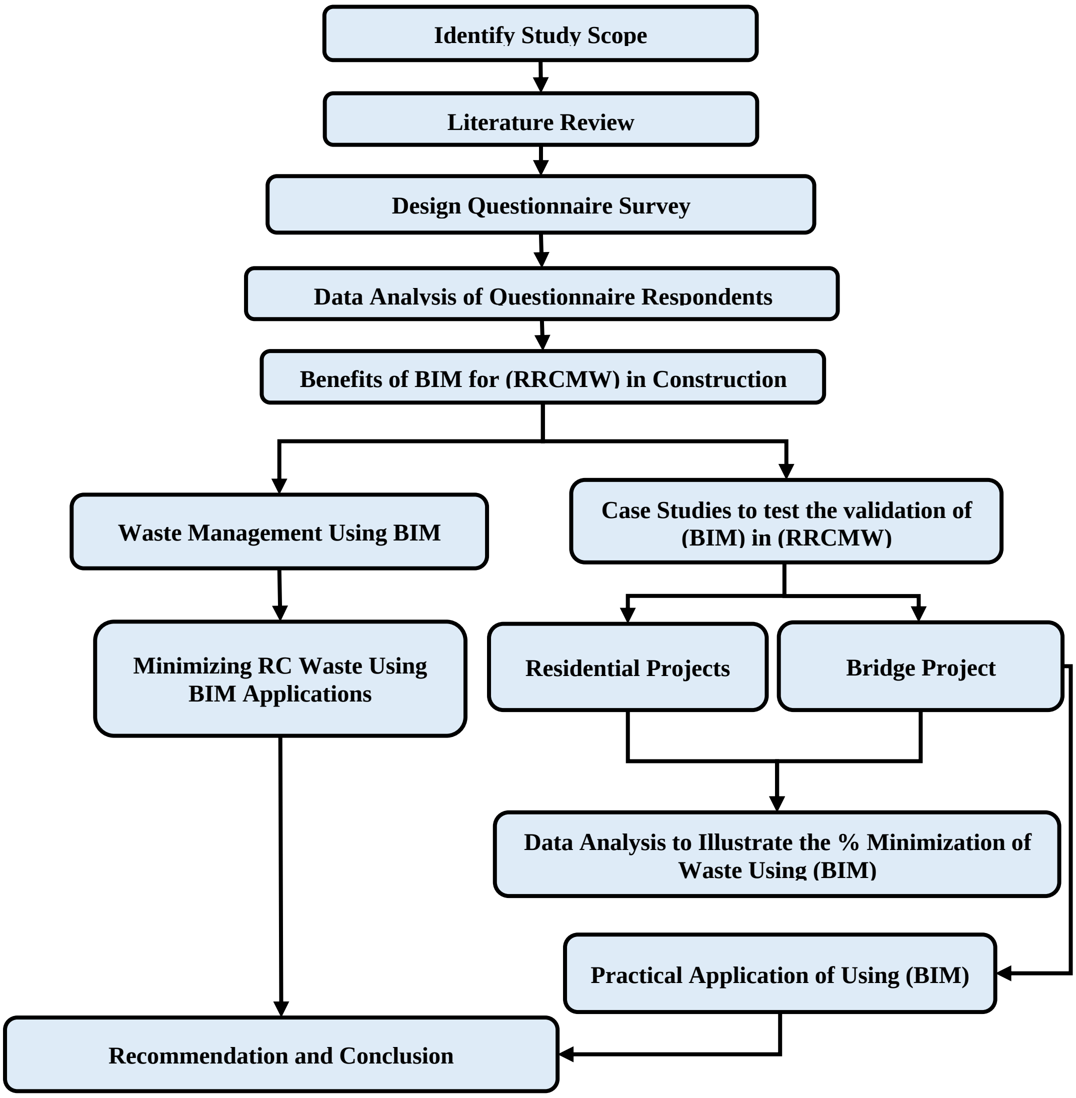

FIG. 2: Study Methodology

3. QUESTIONNAIRE DESIGN

Contractor and consultant site engineers from various types of construction projects, such as residential and bridge projects, are given a questionnaire. The purpose of the questionnaire is to explore the practice of building information modelling (BIM) in the Egyptian construction industry in 2021, as well as the benefits of BIM practice for decreasing reinforced concrete material waste (RRCMW). The questionnaire is sent to 200 construction site managers at the top, middle, and lower levels that deal with reinforced concrete projects on a regular basis and use BIM in their work. Only 180 people have completed the survey and answered the questions. Thus, there are 180 participants in this study, with 81 contractor site engineers and 99 consultants' engineers dispersed among them. The methodology's second section provides various case studies that demonstrate the importance of BIM in (RRCMW). The importance of BIM in (RRCMW) compared to traditional methods is demonstrated in this study via three case studies: two residential projects and a bridge project.

4. QUESTIONNAIRE RESPONDENTS

BIM is a powerful tool for minimizing project costs, eliminating design errors, and reducing rework. Based on the questionnaire analysis, respondents are asked about their perspectives on using BIM versus the traditional method. The responders are divided into two groups: contractor site engineers and consultant site engineers. Because the use of BIM is more effective in the fields of design and consultancy than on site, the number of respondents from consultants and site engineers is greater than the number of respondents from contractors. Figure 3 shows the number of respondents based on level of experience (E).

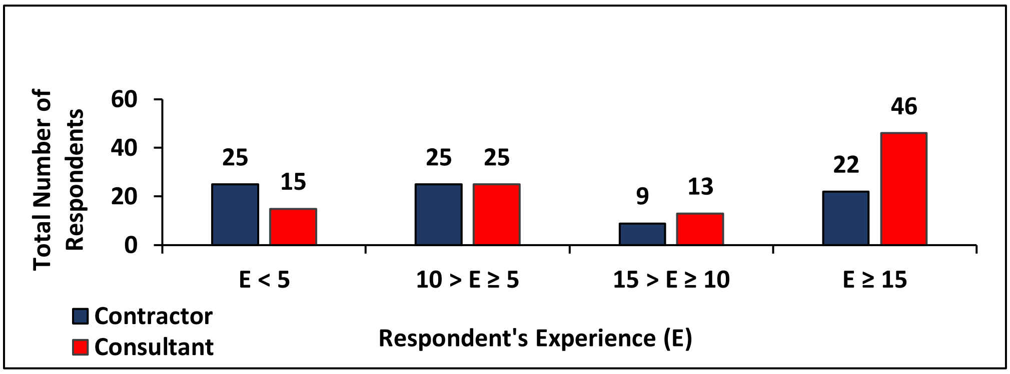

FIG. 3: Participants respondents' according to experience

4.1 Benefits of Building Information Modeling Practicing for Reducing Reinforced Concrete Material Waste (RRCMW)

The use of BIM in construction modelling against traditional methods is examined in the second part of the questionnaire. Some questions in this part of questionnaire are intended to highlight the relevance of BIM in comparison to traditional methods. According to the results of the survey, about 41% of respondents believe that BIM may reduce project costs by 16% to 20% when compared to traditional methods. Furthermore, the proportion of variances in reinforced concrete quantity survey between traditional methods (AutoCAD) and (Revit) is shown to be 44%, with a range of 11% to 15%. With a percentage of 21% to 25%, around 46 % of respondents believe BIM eliminates design mistakes, and about 51% of respondents believe BIM helps reduce rework with a percentage of 21% to 25%. The importance of BIM as seen by respondents is detailed in Table (1).

TABLE 1: Practicing Index (Pi) of using BIM

Questions / Respondents Type No.		BIM minimize project cost compared with traditional methods	the percentage differences in reinforced concrete QS between (AutoCAD) and (Revit)	BIM eliminate design errors	BIM help in reducing rework
6% – 10%	Consultant	3	3	0	2
	Contractor	4	2	1	1
	Total	7	5	1	3
	%	4	3	1	2
11% – 15%	Consultant	29	56	17	15
	Contractor	16	23	14	15
	Total	45	79	31	30
	%	25	44	17	17
16% – 20%	Consultant	46	30	31	28
	Contractor	28	29	33	26
	Total	74	59	64	54
	%	41	33	36	30
21% – 25%	Consultant	21	10	51	54
	Contractor	19	17	31	39
	Total	40	27	82	93
	%	22	15	46	51

4.1.1 Reinforced Concrete Waste Management Using BIM

Managing waste is a very critical issue, according to literature review and brain storming knowledge, since managing waste is the means to optimize waste throughout the project phases. The key ten factors that control RC waste have been gathered from a pilot study that is conducted with (200) construction site managers at the top, middle, and lower levels that deal with reinforced concrete projects. The pilot study result is, as illustrated in Figure (4).

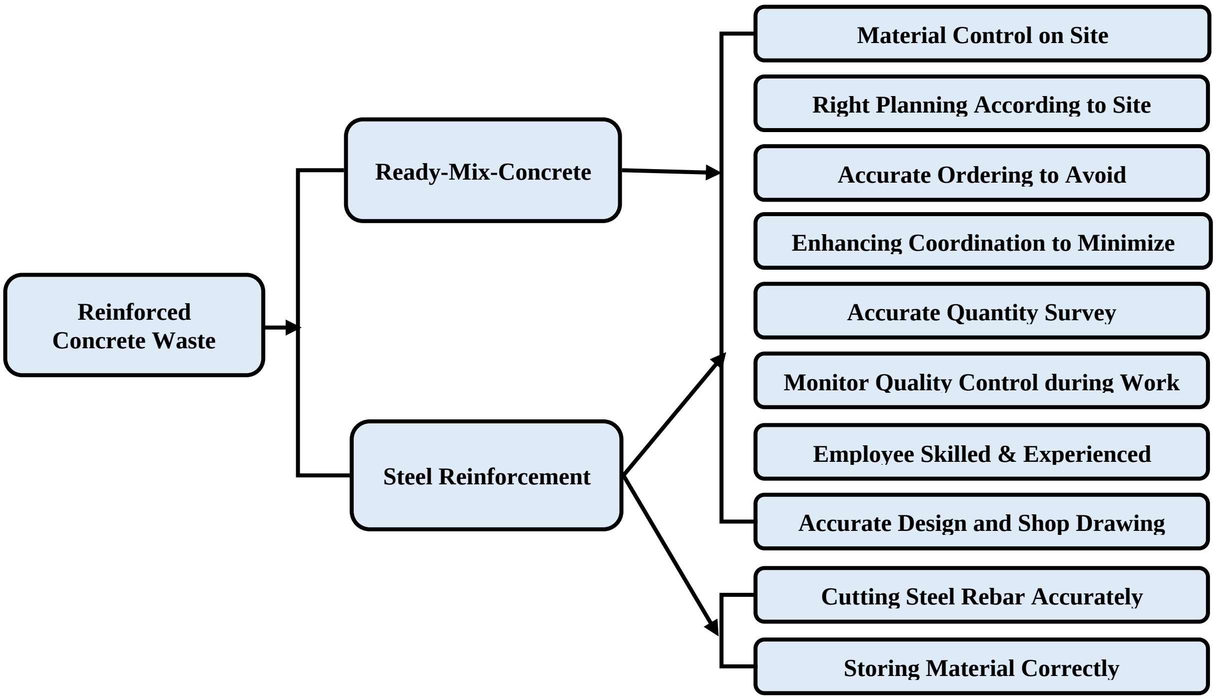

FIG. 4: Factors managing RC waste on site

In order to optimize waste, a BIM application should be utilized to control factors impacting RC waste on site. Site utilization planning, quantity take-off, 3D coordination, visualization, digital prefabrication, design validation, "design review and clash detection," and an optimized workflow and communication structure are the most essential BIM applications used in this case study. In Table (2), these factors will be discussed in further detail.

TABLE 2: Minimizing RC waste using BIM applications

Factors Managing RC waste	BIM Applications	How to Use BIM Applications to Minimize Waste
Storing materials correctly (Method & Place) Right Planning According to Site Conditions	• Site Utilization planning	Site layout planning, which reduces material wastage by reducing the number and distance of material handlings based on a 4D model and reduce, reuse, and recycle waste throughout the project lifecycle. Managers may also use 3D-BIM to examine a site layout plan against pre-defined rules and ensure that there are no conflicts with the design prior to construction.
Accurate Quantity Survey Accurate Ordering to avoid deterioration Material Control On Site	• Quantity Take - Off	It refers to determining the amount of materials required in order to avoid overproduction of unnecessary materials. Materials may be purchased with the proper length, area, and volume based on the quantity take-off.

Factors Managing RC waste	BIM Applications	How to Use BIM Applications to Minimize Waste
Enhancing Coordination Between Project Disciplines	• 3D Coordination	Coordination allows engineers to make necessary model improvements. Monitoring coordination is also necessary for proving that model changes are coordinated. For example, if an architect makes changes to the structural model in terms of levels, grids, or columns, the structural engineer will be alerted, and will have the option to reject, approve, or postpone the process depending on the impact of the changes on the design's structural integrity.
Monitor Quality Control During Work	• Visualization	Providing for a complete picture of the project before it begins, allowing for a comparison of the mock-up model to the client's expectations prior to construction and helps in the avoidance of unnecessary change orders and the reduction of risks from the beginning of the project. Also, it helps in providing accurate information on the building's dimensions, area, and shape. It assists in determining the exact number of raw material take-offs necessary as well as any associated costs.
Cutting Steel Rebar Accurately (Prefabrication)	• Digital Prefabrication	The utilization of prefabricated elements has the potential to minimize waste by 52 %. Because BIM gives accurate measurements early in the design phase, information collected from BIM models may assist fabricators control and automate a fabrication process. Prefabricated elements may be manufactured with greater quality and lower cost. In general, it's an effective way to avoid delays caused by time spent on finding suitable elements or late delivery of materials.
Minimize Reworks Employee Skilled & Experienced Labor	• Visualization • Design validation " design review and clash detection "	Visualization: As it is discussed before Design validation helps in the rapid resolution of design. To evaluate design alternatives, a design review is quickly implemented. Clash detection is also defined as a procedure for determining field conflict by comparing a 3D model of the building system and resolving conflicts before installation. To resolve and build element conflicts, a BIM–based design validation procedure is used, which can decrease the amount of design errors, change orders, and rework.
Accurate Design & Shop Drawing	• 3D Coordination	3D Coordination: As it is discussed before

Factors Managing RC waste	BIM Applications	How to Use BIM Applications to Minimize Waste
	• Optimized workflow and communication structure	Using BIM, all project parts may be merged into a single model that incorporates all model-related information such as designs, costs, materials utilized, and so on. This data is exchanged and updated across all users, simplifying conventional communication methods. As a result, it improves information delivery in terms of content, clarity, and speed.

4.1.2 Case Studies to test the validation of (BIM) in (RRCMW)

Site visits are conducted on several building and infrastructure projects in order to quantify the variation of waste in project elements and compute the percentage of waste on site by comparing RC waste on site using traditional methods (AutoCAD) and using BIM (Revit). It is concentrated on a few construction projects, including "residential and non-residential projects" and "bridge projects." Which starts in the middle of 2020 and planned to be finished by the end of 2021, these projects are almost starts when it took as a case studies. The case studies and detailed results are presented below.

Case Study (1) “Typical Villa”

"New Giza Compound" is the name of one of the projects being implemented in Giza, on the Cairo-Alexandria route. The villa, according to the owner, "New Giza Company," and the contractor, "Devicco Company," consists of a ground floor, a first floor, and a second floor, with a total area of 350 m2 and a cost of 4.1 million pounds. The project is started in the traditional method with AutoCAD, then BIM technology is introduced, and in this case study, a comparison of the results and the differences that appeared in the quantities of reinforced concrete and reinforcing steel will be made before and after the application of BIM technology to show the effectiveness of using BIM as a system to reduce losses Existing in the material.

Case Study (2) “Housing Project”

"New Giza Compound" is the name of one of the projects being implemented in Giza, on the Cairo-Alexandria route. At a cost of 20 million pounds, the owner, "New Giza Company," and the contractor, "Talinco Company," have a basement, a ground floor, and three typical stories, with a total area of 600 m2. The project is started in the traditional way with AutoCAD, then BIM technology is introduced, and in this case study, a comparison of the results and the differences that appeared in the quantities of reinforced concrete and reinforcing steel before and after BIM technology application will be made to show the effectiveness of using BIM as a system to reduce material losses. Figures (5, 6, 7, and 8) demonstrate the project in reality and using BIM.

FIG. 5: Reality image of villa project

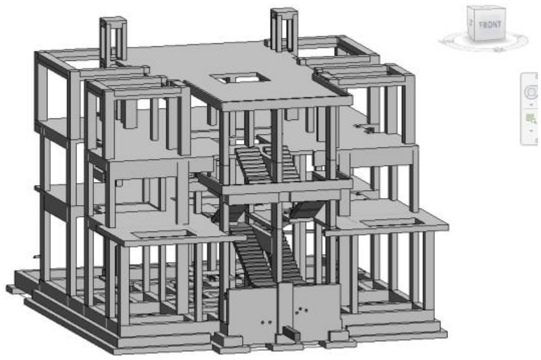

FIG. 6: Revit 3D model of villa project

FIG. 7: Reality image of housing project

FIG. 8: Revit 3D model of housing project

In these studies, numerical values are computed by subtracting the AutoCAD quantity survey from the Revit quantity survey, as indicated in Equ (2). The difference between calculated concrete and steel reinforcement quantities from AutoCAD and Revit is also determined, as the waste minimization utilizing BIM from Revit vs AutoCAD, as illustrated in Equ (3).

$$Variance\ for\ each\ element\ = (AutoCAD\ Quantity\ Survey - \ Revit\ Quantity\ Survey)\ (2)$$

$$\%Waste\ Minimization\ Using\ BIM\ for\ each\ element = \ (Variance/AutoCAD\ Quantity\ Survey)(3)$$

Table (3) illustrates the comparison of AutoCAD and Revit quantities in a typical villa and housing project, whereas Table (4) demonstrates waste minimization using BIM in the Hesham Barakat Bridge Project.

TABLE 3: Comparison between AutoCAD & Revit quantities in Typical Villa & Housing Project

Project type	Element	CAD	BIM	Variance	%Minimization using BIM
Villa Project	Comparison Between AutoCAD & Revit Concrete Quantities				
	Foundation	129.0	113.1	15.9	12%
	Column	66.0	57.6	8.4	13%
	Beams	63.9	56.1	7.8	12%
	Floors	177.8	156.6	21.2	12%
	Stairs	18.6	14.9	3.7	20%
	Total	455.3	398.3	57.0	13%
	Comparison Between AutoCAD & Revit Steel Reinforcement Quantities				
	Foundation	6.7	6.2	0.5	7%
	Column	11.1	10.0	1.1	10%
	Beams	9.3	8.5	0.8	9%
	Floors	17.7	15.0	2.7	15%
	Stairs	1.7	1.4	0.3	18%
	Total	46.5	41.1	5.4	12%
Housing Project	Comparison Between AutoCAD & Revit Concrete Quantities				
	Foundation	662.0	598.3	63.7	10%
	Column	175.9	145.2	30.7	17%
	Beams	111.6	87.6	24.0	22%
	Floors	1280.7	1137.6	143.1	11%
	Stairs	23.4	17.2	6.2	26%
	Total	2253.6	1985.9	267.7	12%
	Comparison Between AutoCAD & Revit Steel Reinforcement Quantities				
	Foundation	35.0	33.2	1.8	5%
	Column	29.4	24.9	4.5	15%
	Beams	16.8	12.8	4.0	24%
	Floors	117.6	108.1	9.5	8%
	Stairs	1.9	1.5	0.4	21%
	Total	200.7	180.5	20.2	10%

Concrete and steel reinforcement waste varies from one element to another in the same building in previous case studies for a lot of different reasons, including site conditions, material ordering, material handling, design change, unskilled labor, and lack of material storage. As a result, it's critical to manage resources on-site to reduce waste.

Case Study (3) "Hesham Barakat Bridge"

Tayaran Street is traversed by the Hesham Barakat Bridge project, which intersects with the Autostrad Road. With a direct assignment order and a 90-day implementation deadline, it is implemented inside the Nasr City neighborhood development plan and the eastern districts of Cairo by the Arab Contractors Company and under the supervision of the Armed Forces Engineering Authority. The bridge is 500 meters long and 19.30 meters wide, and it costs 53 million pounds to build. The bridge has around 4800 m3 of concrete and roughly 1200 tons of reinforcing iron. The bridge has 11 axes and four lanes, and each axis has a number of piles, a separate base, a column, and a pillow, and the beam is installed after being manufactured at the company's yard and installed, and then the tiles are cast.

TABLE 4: % Waste Minimization in Hesham Barakat Project Using BIM

Project type	Element	CAD	BIM	Variance	% Minimization using BIM
Hesham Barakat Bridge	Comparison Between AutoCAD & Revit Concrete Quantities				
	Piles	619.1	555.8	63.3	10%
	Plain concrete	45.7	41.1	4.6	10%
	Isolated footing	1175.0	1039.8	135.2	12%
	Columns	201.4	179.5	21.9	11%
	Frames	1119.7	981.1	138.6	12%
	Slap	1134.2	965.0	169.2	15%
	Beams	1898.8	1643.9	254.9	13%
	Total	6193.9	5406.2	787.7	13%
	Comparison Between AutoCAD & Revit Steel Reinforcement Quantities				
	Piles	122.4	111.5	10.9	9%
	Isolated footing	140.5	127.6	12.9	9%
	Columns	81.1	74.5	6.6	8%
	Frames	205.0	187.0	18.0	9%
	Slap	327.0	293.1	33.9	10%
	Beams	765.8	720.6	45.2	6%
	Total	1641.8	1514.3	127.5	8%

This variance between concrete waste using AutoCAD and Revit quantity survey is due to several factors: (1) calculating concrete elements using Revit is more accurate than using AutoCAD because Revit enables users to calculate concrete quantities after subtracting the voids in which steel bars are placed, so Revit results are more accurate and less than AutoCAD results; (2) using Revit helps to calculate quantities of irregular shapes accurately in comparison to AutoCAD results; (3) using Revit by making (join order), helps to calculate quantities of irregular shapes accurately in comparison to AutoCAD results. As a result, utilizing Revit to conduct a concrete elements quantity survey is more accurate, efficient, and economic than using the traditional method (AutoCAD). For a variety of reasons, there is a difference between steel reinforcement waste generated using traditional methods and using BIM. Prefabrication is the primary and most important reason for adopting BIM to reduce steel reinforcement waste. The prefabrication approach reduces cutting waste while minimizing time and effort. Another major benefit is the reduction of rework, since BIM helps in the accurate implementation of each element with the necessary materials to achieve client satisfaction, as well as the elimination of waste. Additionally, using BIM in implementation helps in determining the proper workflow, which helps in ordering the proper quantities of materials (steel reinforcement) required, thereby solving the problem of steel storage on site for long periods of time, which leads to theft, deterioration, or rust. Based on current concrete and steel reinforcement pricing, and with concrete and steel reinforcement costs of 1200 LE and 14,000 LE, respectively, the total cost of concrete and steel for each project is as indicated in Figure (9). The percentage of cost reduction achieved by AutoCAD and BIM is also demonstrated.

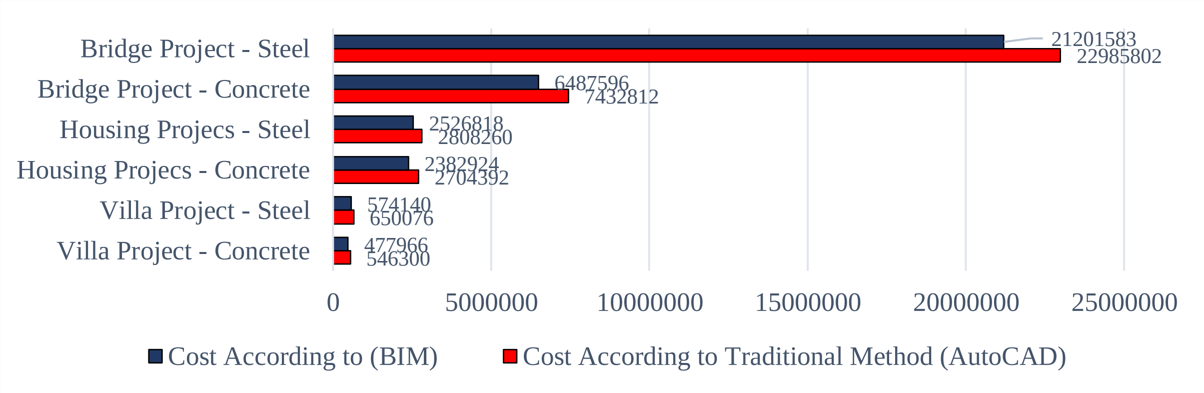

FIG. 9: The total cost of concrete and steel for each project

4.2.3 BIM Practical Case Study (HESHAM BARAKAT BRIDGE)

This case study will be thoroughly discussed. When comparing the quantities of concrete and steel reinforcement in AutoCAD and Revit, there is a difference in the values. As a result of the previous case studies, it has been determined that adopting BIM is extremely successful and may reduce RC material waste at the quantity survey stage. However, it should be observed that BIM may be used to optimize RC material waste for reasons other than quantity survey. To demonstrate the relevance of using BIM in infrastructure projects, the practical evaluation of these factors will be focused on the "Hesham Barakat Bridge" case study.

Building information modelling technology is one of the most recent technologies to arise in recent years, as it enables the implementation of projects in a virtual world before beginning the implementation of the project in reality, thereby reducing expected problems and obstacles and assisting in the timely resolution of these problems, thereby reducing the total time and cost of the project. Because the best approach to integrate all project participants (owner, consultant, and contractor) is to utilize building information modelling technology, building information modelling is the ideal approach for such urgent projects that require accuracy and speed in implementation. Revit, Navisworks, Infraworks 360, and BIM 360 Docs were used in this research.

At first, Using Revit Structure to extract quantity survey lists accurately and faster than the traditional method is initially difficult owing to the existence of several complex shapes, which made it impossible to calculate quantities using the traditional method. Figure (10) shows an example of a complex shape that is properly predicted using Revit structure. Then, throughout the project's execution, we need an executive position to monitor daily project work, which is required by the customer. As a result, one of the best ways to accomplish this task is to use the Navisworks program, where the project schedule and 3D model are entered into the program to create a 4D simulation, from which a daily report showing the progress of the project's work is extracted with links to the three-dimensional model, as shown in Figure (11).

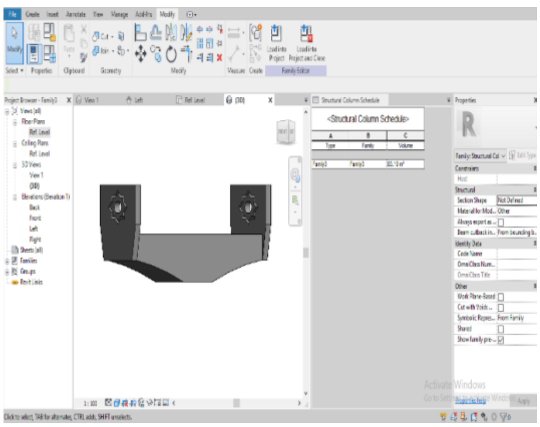

FIG. 10: An example of an accurate quantity survey of a complex shape

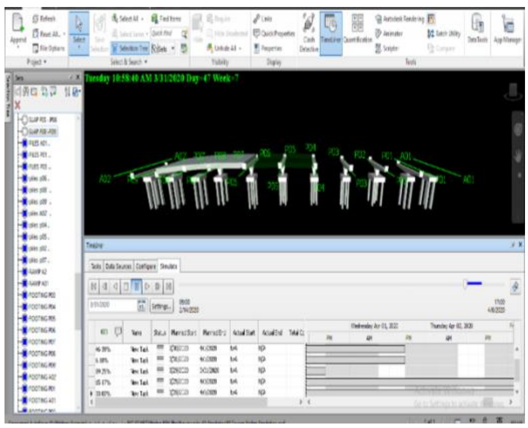

FIG. 11: Insert time schedule with the 3D model to make 4D simulation

Then we move on to the next step, which is to use Autodesk Infraworks 360, which is one of the most important program for infrastructure projects because it helps to create a profile for roads and bridges, as well as count quantities, measure land topography, determine excavation and backfilling quantities, and link them. Because the drainage networks are included in the 3D model, it is possible to extract conflicts more quickly and correctly. The method is illustrated in Figures 12 and 13.

In this case study, the final step in implementing BIM is to use the BIM 360 Docs cloud. Because all project documents are stored in a single cloud and all project participants from all disciplines may handle these documents according to the permissions defined by the Project Admin, BIM 360 DOCS is the ideal solution to connect all project stakeholders. All project drawings are placed and divided into folders, and if any modifications are required, an issue is made with this modification and assigned to the competent person, and BIM 360 DOCS reads the various versions of the project panels and extracts the elements that have been added, deleted, or modified. And one of the most important points that must be highlighted is the BIM 360 Submittals Workflow, which ensures that the panels are sent to the consultant, who ensures that they reach the competent authority for review and adds notes from the consultant, saving time and effort and reducing errors so that all panels are reviewed and resent to the contractor to make the necessary adjustments. Because the BIM 360 DOCS does not allow for signatures on the plates, the plates are printed and given to the consultant with an official letter to accept the final submittal once the consultant has made the appropriate revisions to the plates. Figures 14 and 15 show how BIM 360 Docs may be used.

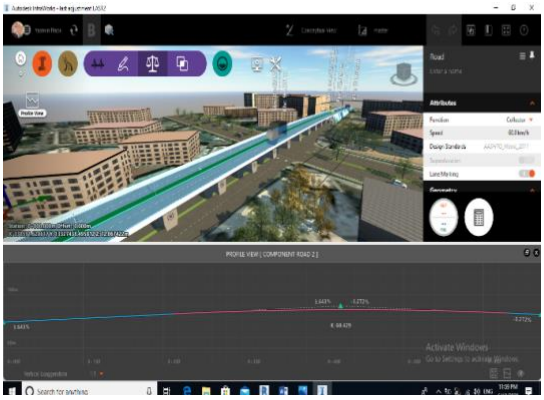

FIG. 12: Making profile using infraworks 360

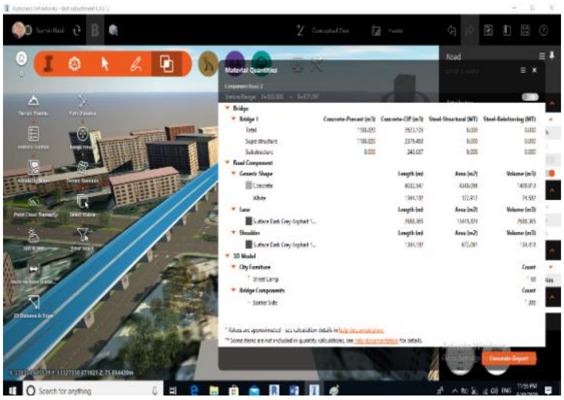

FIG. 13: Quantity survey using infraworks 360

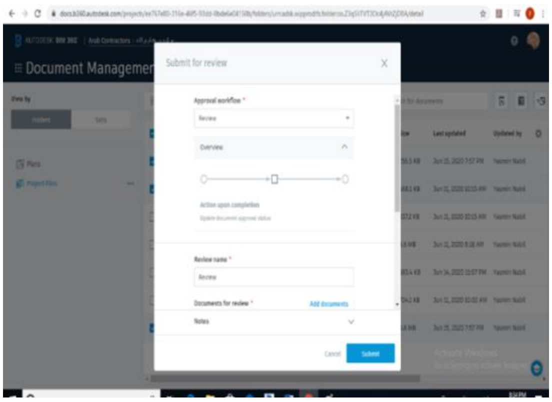

FIG 14: Compare between drawing's versions to find the difference

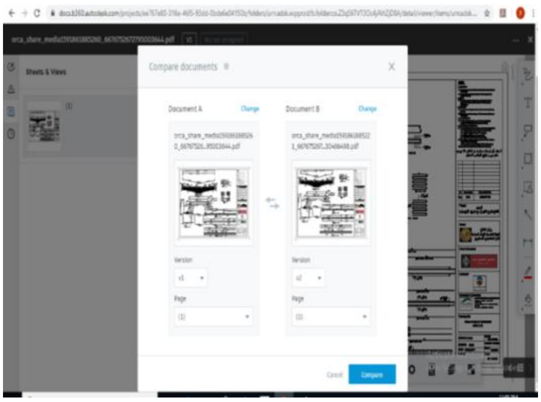

FIG 15: Submittals workflow on BIM 360 Docs

Since a result of the preceding case studies, it is shown that adopting BIM is more successful and cost-efficient than traditional methods, as it aids in the resolution of a variety of issues prior to and during construction, such as clash detection, material storage, and material ordering. Although BIM is not widely used in Egypt, engineers must be familiar with it because it will be a required requirement for implementing projects in the future.

5. CONCLUSION

This research is to establish the significance of building information modelling (BIM) in construction projects. The study's main goal is to demonstrate the value of BIM in the construction industry. According to the results of the questionnaire analysis, approximately 41% believe that BIM can minimize project costs compared to the traditional method, with a range of 16% –20%. Furthermore, it is found that the percentage of differences in reinforced concrete quantity survey between using traditional methods (AutoCAD) and Revit is 44% with a range of 11% to 15%, about 46% thought BIM eliminates design errors with a percentage of 21% to 25% and about 51% thought BIM helps reduce rework with a percentage of 21% to 25%. Also, from case studies it is found that utilizing Revit to conduct a concrete elements quantity survey is more accurate, efficient, and economic than using the traditional method (AutoCAD). Calculating concrete elements using Revit is more accurate than using AutoCAD, using Revit helps to calculate quantities of irregular shapes accurately in comparison to AutoCAD. Also, Prefabrication is the most significant reason for minimizing steel reinforcement waste using the BIM method and finally, the impact of utilizing the BIM technique appears on project cost, and it is discovered that BIM reduce project cost. Although BIM is extremely successful, it is not employed in a wide variety of circumstances so, engineers must consequently be educated about BIM implementation in order to be qualified to work with BIM.

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