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Development BIM Model to Manage the Demolition Waste in Iraqi Construction Projects

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Abstract

Demolition waste is an important topic in the construction industry, and as a result of demolishing old buildings, very large amounts of wastes are created and must be properly managed. The authors assumed that the building was demolished.The research aims to use the BIM model (Building Information Modeling) in demolition waste management because it provides reliable information for the decision-makers. The idea of the research was applied to the Deanship of Medicine College as a case study and was modeled using Revit software. Through modeling, the quantity takeoff is extracted for materials and by utilizing the ratios of field survey from a previous researcher, demolition waste was sorted. The results showed the process to calculate the volume of demolition for concrete and brick, as well as the process of sorting the demolition waste to (on-site reuse, reuse another site, recycle, and landfills). The authors found that through this research, the number of trucks required to transport demolition waste to its appropriate locations can be calculated.

Keyword: BIM, Demolition waste, Management.

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1. Introduction

Construction and demolition (C&D) waste are non-hazardous wastes that were generated as a result of activities through the new construction, renovation, and buildings demolition [1]. In general, large quantities of debris are generated as a result of the demolition of existing buildings, so the site engineers face great difficulty in calculating the volume of these materials accurately, what may affects the time and cost of the project [2]. Also, there are not many studies on the topic of demolition waste (DW) in the demolition phase [3]. In Iraq, the quantities of C&D waste are estimated at (700,000 tons) and constitute (39.7%) of the total annual solid waste volume in the year 2016 [4]. Consequently, engineers should focus on project planning, depend on resource determinants for increasing the effectiveness of schedules [5]. In the Arab world, some of the researchers studied in the demolition waste generated as a result of disasters from post-conflicts such as (Ali & Ezeah, 2017) [6] studied the waste in post-conflict in Libya and took into consideration the volume of accumulated waste and actions taken to deal it also suggested the framework to manage the waste but without using the BIM technique. In addition (Noaman &Alsaffar, 2019) [7] studied the accumulated waste in post-war in Mosul city (Iraq) through the field survey and studied the obstacles in the application of waste management in post-disaster, and suggested procedural method to manage the waste after the disaster. In recent years, there has been a lot of attention in improving construction sites by adopting modern technologies such as BIM [8], [9],[10]. This technique has the ability to model virtual environments that resemble a real work environment and help the safety manager to solve various problems in the early stage of a project [11], [12].

Also some of researcher study the demolition waste using BIM technique such as (Cheng & Ma, 2013) [13] who worked on developing the system based on BIM to estimate and plan the demolition and renovation waste (D&R) and through the system can be extracted the quantities of the waste such as (volume, and materials) and integrated this information to estimate the waste in details. Strategies of C&D waste consist of three main principles (reduce, reuse, and recycle) [14]. Hamidi et al., (2014) [15] the study investigated the application of BIM in providing reliable and accurate information required to cost also suggested three alternatives to manage the demolition waste and identify the required information to analyze each alternative. The authors in this research assume the building is fully demolished, and in addition, to develop the BIM model to manage the demolition waste by following these objectives below.

1. Introduction

- Calculates the quantities for each element in building through the BIM technique.
- Calculates the demolition volume for concrete and brick according to various equations.
- Uses the ratios of demolition waste through the field survey from previous researcher, and sorting the waste according to (reuse in the site, reuse in another site, recycle, and landfill).
- Calculates the number of trucks required to transfer the waste.

2. Research Methodology

This methodology consist of two parts, the first part is the theoretical part, and the second part called the experimental part as shown in Figure 1. the collection of data consist of BIM data and this data involves the adopting ratios of waste from field survey according to a previous local study, and the 3D model of case study (Deanship of Medicine College) at Diyala University campus using the Revit software (ver.2018).

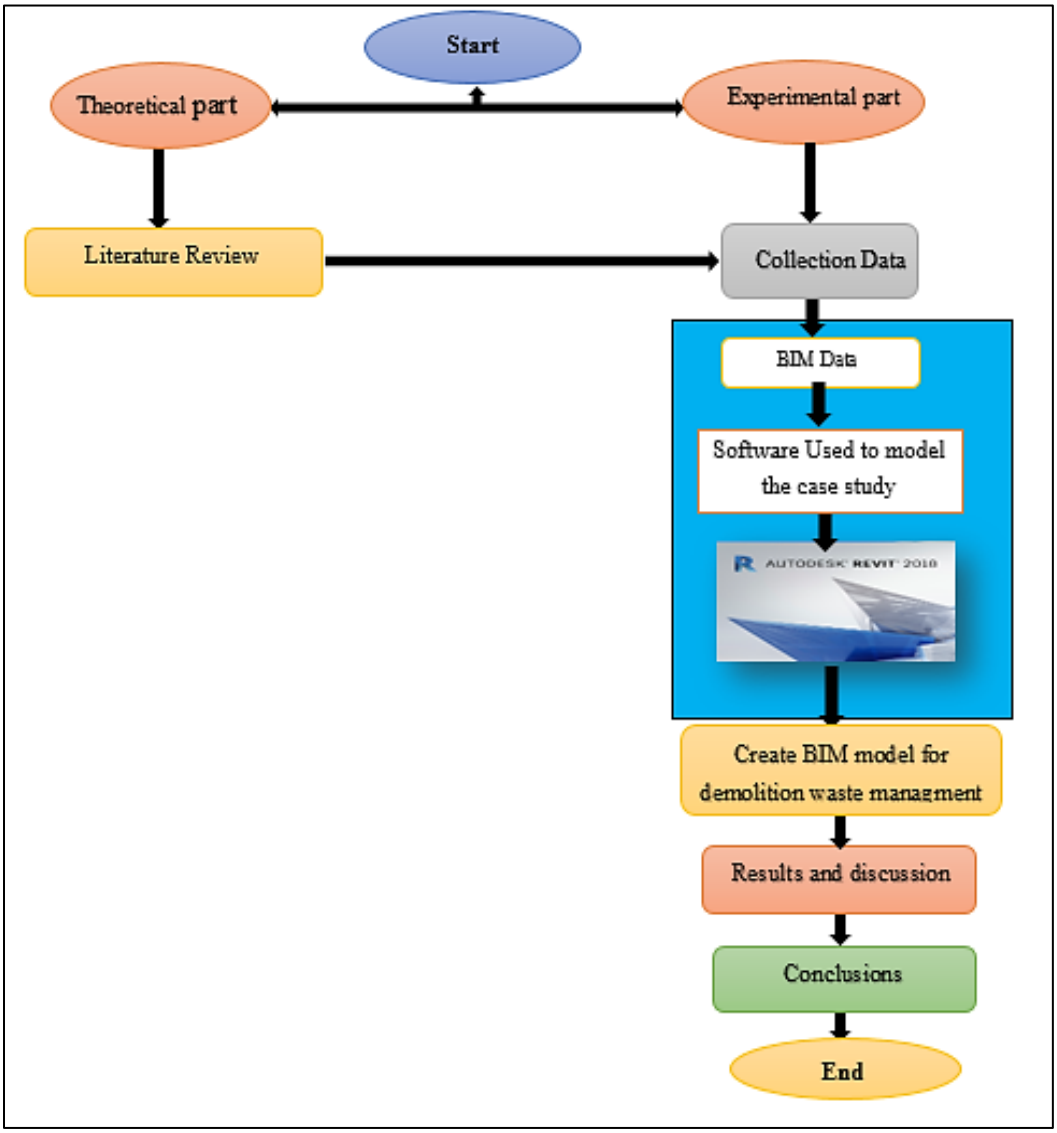

Fig (1). Clarifies the research plan (Researcher).

2.1 Experimental Study

The authors use the case study (Deanship of Medicine College) due to the presence of several dilapidated buildings in the Iraqi construction projects therefore, the authors need to study this topic. The authors relied on the 3D model of the Deanship of Medicine College from the previous local study [16], and the other reason to select this case study because of the designs are complete.

2.2 Case study (Deanship of Medicine College)

This project is one of the basic buildings of Medicine College. It consists of two floors, the ground floor, and the first floor. The total dimensions of this building is approximately (40.6 m * 42.6 m). The total height of building reach (11.6m). The height of the ground floor is (4m) and the height of the first floor is (3m). The 3D model was created for the Deanship of Medicine College in Revit software as shown in Figure 2 [16].

(2 a) (2 b)

Fig (2). Deanship of Medicine College at Diyala University

3. Results and Discussion

3.1 Estimation of Demolition Waste using BIM

The approach of BIM is used to manage demolition waste, and reduce the environment impacts. The authors clarified the quantity take off for each element in the projects.

3.1.1 Quantity Takeoff (Q.T.O)

The authors can calculate the quantity takeoff for each element in the project using the Revit software (ver.2018) as BIM tools. Quantity take off of the case study (Deanship of Medicine College) as shown in Table 1, and 2.

Table 1. Quantitites of concrete work for Deanship of Medicine College.

Item	Q (m^3)
Foundation	315.88
Columns	125.20
Beam	179.49
Slab	1805.43
Total concrete quantity ($V_{con.}$)	2426

Table 2. Quantitites of brickwork for Deanship of Medicine College.

Item	Q (m^3)
Brick	1284.05

3.1.2 Demolition Waste Volume

The reason for using ratios after disasters (wars) by a field survey from a previous local study is because the authors wanted to use the worst case in the demolition work, which is that the building is damaged to the maximum degree to calculate the minimum amount of what can be extracted from the demolition work and as these ratios apply to works of random demolition or comprehensive demolition, also the equations adopted from the previous researchers studied the (C&D) waste [17] , and [18]. The authors estimation of the accumulated concrete and brick waste using the following method:

Estimate based on quantities related to the construction database. Solis-Guzman has developed a model to estimate the volume waste of the building related to construction and demolition activities, and this model is based on four main parameters [17] , and [18] which are:

V_{ac}: apparent construction volume

V_{ad}: apparent demolished volume

V_{ar}: apparent wreckage waste volume

V_{ae}: apparent package waste volume

By following the equations below to calculate the demolition waste for each element in the project:

To calculate the apparent construction volume (V_{ac}) through the equation (1) by multiplying the quantities calculated from Revit software with the conversion ratio of the amount of item (i) in V_{ac}.

$V_{aci} = qi \times cci$ Eq (1), [15]

Where:

V_{aci}: apparent construction volume for the item (i) (m^3).

qi: The quantity of each item (i) in unit (m^3).

cci: The conversion ratio of the amount of item (i) in V_{aci} (m3/qi specific unit).

To calculate the apparent demolished waste volume (V_{ad}) through the equation (2) by multiplying the (V_{aci}) with the (ct_i) is the demolition factor or called Coefficient to transformation the V_{ac} to $V_{ad.}$

$V_{adi} = V_{aci} \times ct_i$ Eq (2), [17]

Where:

$V_{adi:}$ apparent demolition volume of item (i) in unit (m^3)

V_{ac}: apparent construction volume

ct_i: the demolition factor coefficient to transformation the V_{ac} to V_{ad} (Dimensionless).

There are several (ct_i) values can be illustrated below.

a) According to the [19], (ct_i) for each material type such as concrete, steel, wood, glass, cement, and masonry have a value of 1.1, 1.02, 1.05, 1.05, 1.1, and 1.1 respectively.

b) According to the [20] (ct_i) for the concrete work such as foundation, columns, beam, concrete wall, and slab have a value of 1.01, 1.15,1.25,1.18 and 1.20 respectively.

By Solís-Guzmán [17] statistically showed the value of the variables required to calculate the volume of the concrete and brickwork per 1 m^2 of the building area as shown in the Table 3, and 4.

Table 3. Estimation the volume of concrete waste for Deanship of Medicine College.

Item	q_i (m^3)	cci (m^3/m^3)	ct_i	V_{aci} (m^3)	V_{adi} (m^3)
Foundation	315.88	1	1.01	315.88	319.039
Columns	125.20	1	1.15	125.20	143.98
Beam	179.49	1	1.25	179.49	224.363
Slab	1805.43	1	1.20	1805.43	2166.516
				$\sum$ 2426	$\sum$ 2853.898
Total volume of concrete waste =					2853.898

Table 4. Estimation the volume of brick waste for Deanship of Medicine College.

Item	q_i (m^3)	cci (m^3/m^3)	ct_i	V_{aci} (m^3)	V_{adi} (m^3)
Brick	1284.05	1	1.1	1284.05	1412.455
Total volume of brick waste =					1412.455

The total volume of concrete demolition waste as shown in Table 3 equal to (2853.898 m^3) this volume is larger than the apparent construction volume of concrete that equals (2426 m^3). The reason for the increased demolition volume due to increasing the volume of voids as a result of concrete breakage. The purpose of calculating these results is that as a result of the process of demolishing dilapidated buildings, it For these reasons, the authors calculate the reusable volume, recyclable volume, and landfill volume as shown in Table 5. The benefits of this process to reduce costs, and reduce environmental impact from the gathering of this waste. results in accumulated waste in large quantities and the process of transferring it to landfills, it will produce enormous cost if assume the distance is large.

Table 5. Ratios (%) and the volume of concrete and brick waste

Item	Treatment of waste	Ratios (%) [20]	Volume (m^3)
Concrete	Reuse in site	<null>	<null>
	Recycle	44	1255.72
	Landfill	56	1598.183
Brick	Reuse in site	50	706.228
	Reuse in another site	<null>	<null>
	Recycle	50	706.228

Table 6. Estimation the number of trucks for Deanship of Medicine College.

Item	Treatment of waste	Volume (m^3)	Number of truck in eq(3)
Concrete	Reuse in site	<null>	<null>
	Recycle	1255.72	179
	Landfill	1598.183	228
Brick	Reuse in site	706.228	/
	Reuse in another site	<null>	<null>
	Recycle	706.228	101

The authors calculated the number of trucks that need it to transfer the demolition waste. Recycled concrete, as well as recycled bricks, can be moved to factories for crushing or using a special crusher on-site. In Table 6 the landfill concrete waste needs 228 trucks to transfer it to the landfill location. Reuse on the site do not need to calculate the number of trucks because of the reuse of the material on the same site.

3.2 Resource Management

Firstly, the authors need to calculate the number of trucks as shown in equation (3) also assume the truck capacity equal to (7 m^3), and other results clarified in Table 6

$$\text{Number of trucks} = \frac{\textbf{Volume of waste estimated}}{\textbf{truck capacity}} \quad \text{Eq (3)}$$

The demolition waste volume for concrete landfill equal (1598.183 m^3) number of trucks calculate below.

$$\text{Number of trucks of concrete landfill} = \frac{\mathbf{1598.183}}{\mathbf{7}} = 228$$

Conclusions

The authors study the topic of demolition waste management through using the BIM model. There are several conclusions, the most important:

1) The demolition waste volumes is larger than the apparent construction volume for concrete and brick
2) Most demolition wastes are transferred to landfills, and this affects the environment, time, and cost of the project, so they need to be sorted them to (reuse in the site, reuse in another site, recycle, and landfill) in order to comply with environmentally friendly options.
3) The authors calculated the number of trucks according to (reuse in another site, recycle, and landfill) in order to transfer the waste to the suitable locations.
4) They recommend in the future to use this method for analyzing the cost-benefit of the demolition waste using BIM application and also use this method to calculate the costs of loading and transporting of the wastes.

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