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Construction Waste and its Distribution in Iraq: An Ample Review

Maytham Kadhim Obaid[1]*, Ismail Abdul Rahman[1], Intidhar Jabir Idan[2] and Sasitharan Nagapan[1]

[1]Faculty of Civil Engineering and Environment
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Malaysia; abuthar210@gmail.com
[2]Department of Environmental Engineering, Faculty of Engineering, University of Babylon, Babylon, Iraq

Abstract

Because of the economic evolution and advancement of the construction industry observed by many countries, the critical requirement for utilizing contemporary potentials in it is to construct taller and deeper buildings. On the other hand, the problems that rise with the similar capacity is the generation of millions of tons of construction waste each year. Such generation of construction waste causing many landfilling and environment problems in the world. Through the last few decades, the rapid development of construction industry has been also observed in Iraq. Such rapid development causes huge amount of construction waste also and causing not only landfilling problems but also effects to environment. In this research work, review has been taken to emphasize on construction waste. Almost 51 latest and critical research papers and web blogs has been reviewed. On the basis of reviewed literature in this research work, it is observed that no any standards have been set for disposing off the construction waste at Government level. Also, many non-government companies are working to construct proper lands for disposing off the construction waste. But still, the union of Iraqi Contractors and Engineer League must symposium on construction waste and designed better plans to manage waste and disposing off construction debris.

Keywords: Amount and Distribution, Construction Waste, Construction Waste Management, Construction Waste types, Sources

1. Introduction

The progression in construction activities in the course of recent decades has brought about a parallel increment in the quantity of generating construction waste. This development, combined with deficiencies in landfill space, especially in urban zones, has turned out to be a difficult stress or to the environment[1,2]. The construction industry shows an important job in improving the worth of the built environment, but its activities also influence on the extensive environment in various means, including waste generation. Presently, world cities generate around 1.3 billion tons of construction waste every year. This quantity is relied upon to increment to 2.2 billion tons by 2025. Waste generation amounts will further than double over the next twenty years in developing countries[3]. This signifies a momentous growth in per capita waste generation proportions from 1.2 to 1.42 kg per person per day in the following fifteen years. Nonetheless, worldwide averages are extensive approximations merely as proportions differ noticeably by region, country, city, and even within cities. According to the European Commission statics, the total volume of Construction and Demolition (C&D) waste produced in 2008 was about 890 million tons[4]. In developed countries, reusing of C&DW waste is controlled by law and policy such that the reusing proportions have extreme exceeded 90 %. In Australia, nearly 90 % of such waste was reused[5], Japan's reusing rate is 99.5 % in 2012[6] and Singapore has revealed the maximum reusing proportion of 99.9 %[7]. Malaysia's C&DW retrieval proportion observed at not as much of as 50%[8]. In Iraq there are a few previous studies on waste management in construction projects, like[9–11] focused on estimate the volume of (C&D) in construction sites. Though the activity has now move in a decay stage, because of the economic recession and the variation in the construction progression, difficulties instigated by such waste, or reasonably, by its supervision essentials to be addressed and considered in depth[12].

Higher growth in population, rapid growth in economic, increasing discretely earnings and different clashes has directed to deteriorating waste management challenges in Iraq. Iraq is expected to generate 31,000 tons of solid waste along with construction waste each day by per capita waste generation surpassing 1.4 kg per day. Additionally, many illegal landfills for dumping of the waste including C&D waste reported and shown in Figure 1[13] and Table 1[14]. Rapid increment in waste generation is setting great tension on Iraqi waste management organizations which have deeply smashed following years of clash and mismanagement. Without present day and productive waste dealing with and transfer framework the majority of the wastes are arranged in unapproved landfills crosswise over Iraq, with almost no apprehension for both environment and human health. Impulsive fires, groundwater pollution, surface water contamination and higher amount of greenhouse gas emissions have been the symbols of Iraqi landfills[13].

Table 1 shows total 597 landfills until 2017, having 163 unapproved and 73 approved environmentally in the year 2015, but the trend decline trend in 2017 as compared to year 2016 for the approved and unapproved landfills. This is alarming situation to worsen the management of the waste in Iraq. However, for regular and non-regular transformational stations, the situation is different and showing an improvement for the waste management. It is mainly because of the lack of studies, research and developing coding standards related to the environmentally cleaning services sector to develop a sound waste management mechanism, also the geographical area of the cities and their horizontal extension, which is not commensurate with what exists from effort equipment and workers.

Iraq is a developing country and threatened by the construction waste challenges which have led to an illegitimate waste that causing environmental pollution and, moreover, increases the project budget. Design, transportation, materials handling and storage are most important influential exercises in construction waste generation[15,16]. These exercises would exhaust time and energy without enhancing the customer, in this manner, causing in construction materials waste, interruption in project finishing time and performance of ineffective operations. All these challenge can aggravate if not addressed appropriately so in this work, the detailed review study on construction waste in Iraq is presented. In this review work, many latest and critical research papers and official and non-official web blogs were also reviewed to provide up-to-date information related to the subjected area. Construction waste, its types, sources of it, its waste and distribution presented and argued in an up-to-best manner in this review work. On the basis of reviewed stuff in this work, some conclusions and suggestions also presented but more than that some future studies also found which can be beneficial to the beginners in this subjected area.

2. Solid Waste

Solid waste is a comprehensive expression which contains the undesirable or unusable solid materials obtained from industrial, residential and commercial exercises in a particular zone. Solid waste can be categorized as per its source (construction domestic, commercial, industrial and institutional); as per impending of exposure from it (radioactive, flammable, toxic, non-toxic, infectious, etc.); also as per solid waste substances (glass, plastic paper, organic material, metal, etc.)[17]. However; there are different types of solid waste[18] as shown in Figure 2:

- Organic waste: waste from preparation of food, market places, etc.
- Combustibles: paper, wood, dried leaves, packaging for relief items, etc.
- Non-combustibles: metal, tin cans, bottles, stones, etc.
- Ashes/dust: residue from fires used for cooking.
- Bulky waste: tree branches, tiers, etc.
- Dead animals: carcasses of domestic animals and livestock.
- Hazardous waste: oil, battery acid, medical waste.
- Construction waste: roofing, rubble, broken concrete, etc.

Table 1. Environmental Statistics for Iraq - Municipal Services 2015, 2016, 2017[14]

No. of Landfill	Year	Environm-entally Approved	Environmental-ly Unapproved	Regular Transformational Stations	Non-Regular Transformer Stations	Random Dump Locations
236	2015	73	163	30	78	235
156	2016	112	44	42	23	34
205	2017	57	148	59	23	53

Figure 1. Illegal dumped of waste including C&D waste [13].

Iraq with a population more than 32 Million in 2013 generated 31,000 tons per day of solid waste[19]. Baghdad is considered the capital city with a population density about 7 million and generated more than 2.5 Million Tons of solid waste annually[19]. As per[20,21] wastes generation, types and sources in Iraq as shown in Table 2.

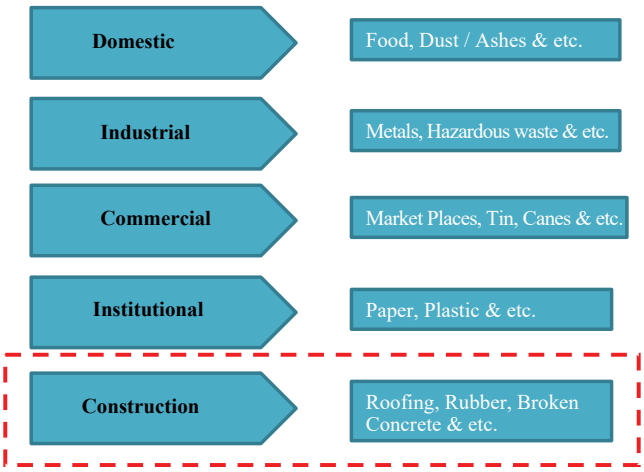

Figure 2. Solid waste classification [18].

3. Construction Waste

Construction waste have no any general definition and can be discussed in broad spectrum as Ortiz et al., 2010 defined it as whichever material or by-product of humanoid or industrial operation that has no particular value[22], such definition was also supported by[23]. Also Llatas, defined the construction waste is the general word referred to any material yields from construction places, demolition of structures, or of a combination of both[24]. As per[25] constructions waste is characterized as the contrast between the esteem and amount of materials acquired and the amount of material utilized as indicated and precisely. Construction waste have no any general definition and can be discussed in broad spectrum as Ortiz et al., 2010 defined it as whichever material or by-product of humanoid or industrial operation that has no particular value[22,26,27]. In other words, it is defined as "any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client"[28]. Moreover, a clear comprehension about

Table 2. Wastes generation, types and sources in Iraq[20,21]

Type	Source	Waste Components
Waste from House	Buildings and Houses	Food, Plastics, Cardboard, Leather, Textiles, Wood, Glass, Garden Waste, Ash, Metals, Electronic Devices, Special Waste, Oils, Batteries, Hazardous Waste, Tires.
Waste from Industries	Small and Medium Manufacturing industries, power plants, chemical plants.	Food stuffs, Destruction waste, Household waste products, Packaging, Construction waste, Non-standard products,
Waste from Commercial Area	Hotels, stores, markets, restaurants, office buildings	Cardboard, Paper, Wood, Plastic, Glass, Food residues, Metals
Waste from Institutes	Government Buildings, Schools, Prisons,	Same as in waste from commercial area
Waste from Hospitals	Hospitals, Health Care Centers, medical clinics, maternity centers	Non-Toxic waste containing of food and paper
Waste from Construction	Ongoing construction, restoration sites, road repair, destruction of buildings	Concrete, Metals, Wood
Waste from Municipal Activities	Water treatment sites, parks, Street cleaning, beaches etc.	Street cleaning, garden waste, recreational and parks areas waste.
Waste from Agricultural	Dairy plants, Orchards, waste of animal slaughter, farms	Agricultural waste and musty food

the construction waste conception, it is compulsory to classify the types of construction waste in unlike perceptions.

Construction waste is a combination of extra materials produced through new construction, repair, and destruction of structures, bridges, roads, and entire further works linked to civil engineering[29–31].

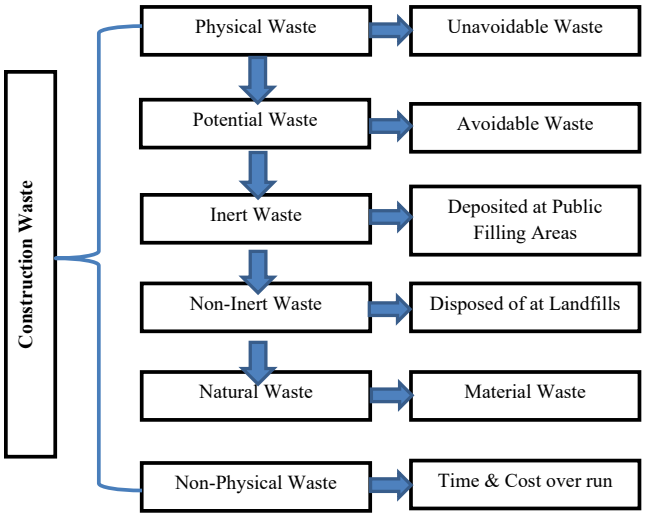

Figure 3. Construction waste classifications.

4. Classification of Construction Waste

As per[32] constructions waste mainly categorized into two different groups: physical and non-physical wastes. While as per[25] the essential types of construction waste are natural, potential, inert, non-inert and physical wastes. However, in this work, the types of construction waste are discussed below and summarized in Figure 3.

4.1 Physical Construction Waste

It is defined as "the waste which originates from construction, renovation and demolition actions including land excavation, civil and building construction, site clearance, roadwork, and building demolition and renovation"[33,34]. In simple definition, physical waste is acknowledged as the waste which can be detected practically at project site area. Physical waste contains enervation of construction materials, as they are irreparably broken and missing[35,36]. However; physical construction waste always transported from the project site to landfills[37,38]. On the other hand, it is categorized into 3-sub-groups: additional material loss, equipment operational time and man-hour overproduction[39].

4.2 Non-Physical Construction Waste

Usually non-physical waste contains both time and cost overruns as its major forms and normally produced during construction activities. Work disturbances, waiting periods, deferments in execution and getting work authorizations, reworks and conductance of preventable works are major kinds of wastage of time[37]. While, cost overrun is considered as "cost increase" or "budget overrun". Cost overrun includes unexpected costs experienced in excess of the budgeted amounts[40]. Numerous authors have stated that both time and cost wastes can lead to the generation of waste material[38]. As like, Memon et.al stated that "non-physical waste includes undesired activities, which can cause the physical waste, such as rework, and unnecessary material movements"[41].

5. Source of Construction Waste Generation

Construction waste has the following sources: overproduction, transportation, movement, substitution, inventories, waiting time, processing, production of defective products and others[25,42–45].

6. Amount of C&D waste

As per the Central Statistics Organization (CSO) for 2016, 2017 and 2018, the C&D waste and total solid waste generated for 2015, 2016 and 2017 are extracted as in Table 4.

These percentages of C&D waste over the total solid waste for the cities of Iraq are presented in Figures 4–6.

7. Construction Waste and their Distribution

For construction waste we mean waste from construction. They are solid waste, demolition, construction, extension, repair, demolition of buildings, buildings, roads, bridges, sewage outlets such as asphalt, concrete, brick, wood, glass, aluminum, iron, packaging, pipe insulation, wires. These wastes differ in structure, but the benefits of their reduction and reuse as well as recycling, if possible, for new applications gives additional efficiency.

Following quite a while of strife and global endorses a great part of the key common framework inside Iraq has fallen into deterioration, prompting an extensive

Table 3. Illustrates those sources attached with their descriptions[25,42–45]

Source	Description
Overproduction	Represented by excessive quantities of materials to be produced than the intended / required quantity which results in man-hours, materials and equipment wastage.
Transportation	Referred to the movements of construction materials in site. This type caused by lack of materials control when transported due to usage of improper equipment and depraved situations of sequences adopted in site resulted from lack of planning.
Movement	Related to unnecessary movements displaced by labors in construction site. This type resulted from poor arrangement of works, ineffective work methods or inadequate equipment used.
Substitution	Referred to substitution of intended materials by expensive ones, employ qualified labors or sophisticated equipment for simple works.
Inventories	Concerned with unnecessary / exaggerated inventories of construction materials that would be transformed to waste due to inadequate storage conditions, deterioration, theft & vandalism.
Waiting time	Represented by the idle time spent by the labors gang / equipment due to lack of materials flow and synchronism
Processing	Referred to the nature of activity that consumes the intended materials which could be reduced to its lowest rates by changing the technology adopted.
Production of defective products	Correlated to waste caused by the non-compliance of the final product / activity with the intended specification / quality. This might result from lack of planning and control, deficiency of incorporation between design and production, poor qualification of the team work, etc.
Others	Any other waste which dissimilar to the earlier defined wastes like: vandalism, burglary, accidents, inclement weather, etc.

Table 4. C&D waste generated between 2015, 2016 and 2017[14]

City	2015		2016		2017	
	C&D waste (ton / year)	Total waste (ton / year)	C&D waste (ton / year)	Total waste (ton / day)	C&D waste (ton / year)	Total waste (ton / day)
Baghdad Center	583,890.5	4,118,259	3,500.8	3,838,237.4	59,766.4	2,522,159.9
Outskirts of Baghdad	15,001.5	321,273	95,201	634,245	117,424	680,777
Karbala	214,255	563,633	436,950.4	867,130.8	331,769.6	794,741.4
Babil	73,182.5	347,298	356,308.2	785,437.2	186,884.8	575,874,8
Salah al-din	22,520.5	269,480	462,321	825,806	823,911.5	1,556,554
Maysan	126,472.5	645,284	93,568	430,123	46,364	401,919
Muthanna	184,982	348,977	179,220.8	357,869.8	60,435.2	219,077.2
Wasit	61,320	364,015	232,194	606,506	219,078	539,544
Qadisiyah	134,247	452,345	167,080	579,244	236,712	554,659
Diyala	26,243.5	354,306	85,128	409,928	74,223.2	440,158.2
Anbar	not- recorded	not- recorded	not-recorded	not-recorded	2,073,483	2,954,364
Kirkuk	7,482.5	377,155	99,297.6	385,298.67	86,412.8	384,420.8
Dhi Qar	6,0663	226,997	80,924.8	620,201.8	95,707	701,822.5
Najaf	285,101.5	902,098	341,587.7	895,451.2	490,947	1,168,301
Ninewa	not- recorded	not recorded	not-recorded	Not-recorded	3,210,299.4	3,899,283.8
Basrah	433,547	1,647,647	2,120,484	3,310,214	2,249,905.6	3,276,539.6

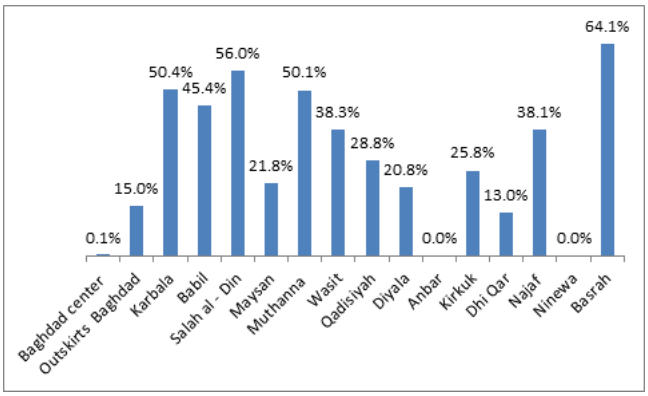

Figure 4. Percentage of C&D waste compared to total waste of each city in Iraq for 2015.

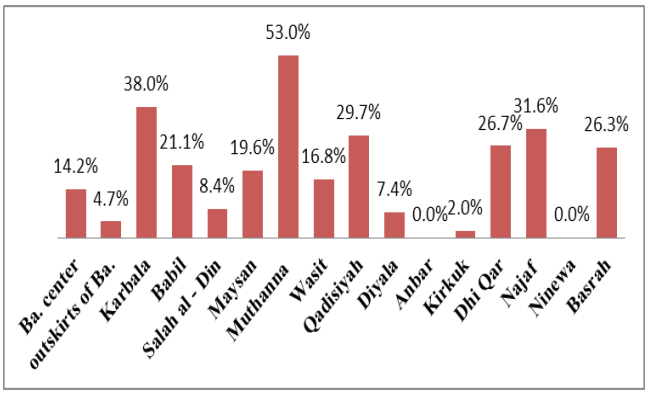

Figure 5. Percentage of C&D waste compared to total waste of each city in Iraq for 2016.

decrease in the arrangement of fundamental and basic civil administrations. This is especially valid for waste and asset the executive's benefits that have seen long stretch of under development and deterioration[46]. In an outcome to such scenario in Iraq, a National Solid Waste Management Plan (NSWMP) was introduced in 2007, to get ready for the vital improvement of all parts of waste administration in the nation over the coming 20 years. Such NSWMP plan for Iraq was developed by association of international waste management experts. The plan contains the suggestions for improvement and which clarifies the foundation for choices[13]. However; the majorly principles of NSWMP in Iraq are précised as[46]: Proximately principles and self-sufficiency, sustainable development, precautionary principles, producer responsibility, polluter pays principle, waste hierarchy and best practicable environmental option.

Generally, plan explains that 33 environmentally engineered landfills will be constructed in Iraq having 600 million m3 capacity in all 18 governorates in Iraq by 2027.

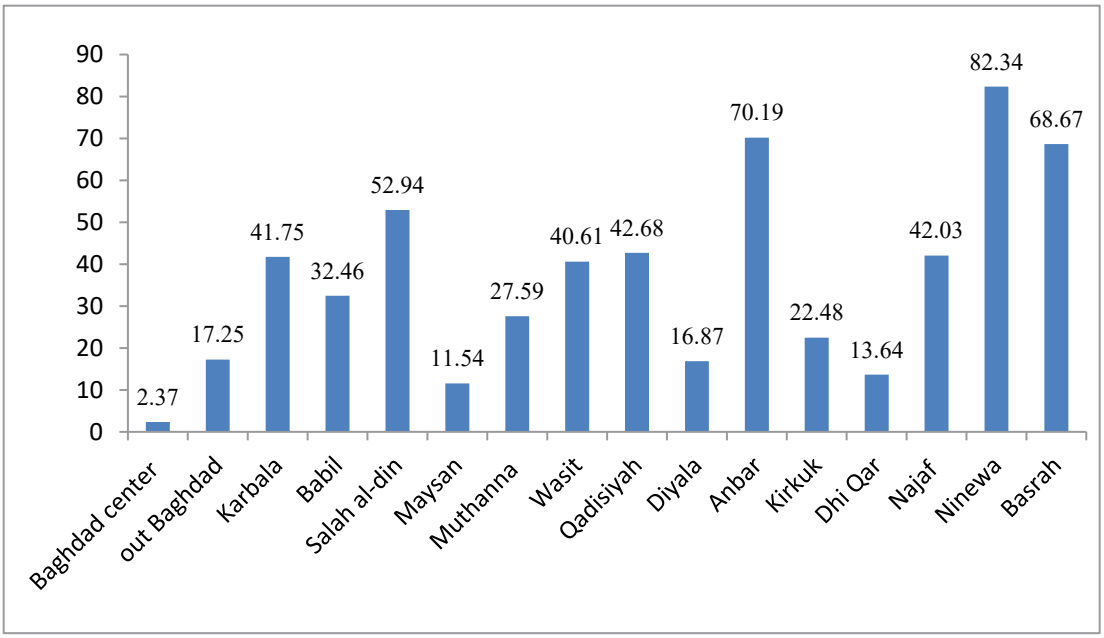

Figure 6. Percentage of C&D waste compared to total waste of each city in Iraq for 2017.

The plan also emphasis on the collection, transportation, disposable, recycling and reuses system[47]. In Iraq, Kirkuk was the first city to get productive outcomes from solid waste management program. Such solid-waste management program was initiated by the foreign funded agencies in 2005 to discover an environmentally harmless solution to the city's debris collection and disposal problem. This landfill is expanded on 48-acre and is located 10 miles south of Kirkuk. Furthermore, it has a predictable lifespan of 10–12 years and will achieve the both U.S. Environmental Protection Agency and European Union Landfill Directive standards[48]. Basra is the second city of Iraq where the first landfill was constructed as per international environmental standards. This landfill was fully funded from international aid. Solid waste management program in Basra was established by UNICEF and it will not only renovate proficient waste gathering organisms in the city but will also establish familiar "recycling schools" which helps in promoting environmental responsiveness in in the public in the city by initiation a movement to instruct the people about effective waste dumping procedures. UNICEF also developed Erbil's solid waste management master plan through the aid from the European Union. Finally, the solid waste management master plan for Dohuk Governorate was developed and finalized in June-2011 with the funding from UNICEF.

8. Conclusion

This research work is about reviewing the C&D waste in Iraq. In this review work, we; the authors review the latest and most critical research work related to the Iraq about subjected area. Furthermore; we highlighted the current challenges and problems due to C&D waste and in continuous to it, briefly explain the C&D waste, its types, sources and distribution in the Iraq. However; on the basis of review stuff in this research work we concluded that the construction materials waste has been considered as a main challenge in the construction industry which has significant effects on both of the proficiency of the industry and on the environmental effect of the construction developments. The construction industry is a significant component in overall economy. Also, the construction waste increase in the same proportion with the increment in the construction industry. Besides to it, less importance to waste reduction and poor management procedure led to generation of massive quantity of construction material waste. Furthermore, project cost deviancy and illegitimate landfill dumping are main difficulties in Iraqi construction industry, these problems are closely associated to construction waste[32]. Inadequate labors experience, resident engineer and technical staff and existence of several mistakes during project execution are considered as major causes beyond the high rates

generated in privately construction projects[27]. The actual waste percentages of construction materials at the local scale at Karbala are more than the restrictions fixed by the Iraqi Ministry of Housing and Construction[49]. Local contracting companies don't appear to be alarmed about material waste hence they don't apply a systematic control of material usage[50]. Also there is no system applied in construction projects in Iraq for managing waste. The ways of dealing with types of waste generated in the construction projects of Iraq, are different according to nature of generated materials[51].

In continuation to the conclusion of the research work, to understand the crucial importance for reducing the construction waste, we wish to express some recommendations for the Iraq Government and Non-Government sectors as: all the concerned Government Ministries related to Housing and Building, Planning and Environment for setting up the regulations to minimize the construction waste, following the international rules for eco-environmentally and proper dispose-off the construction waste. Also, the Union of Iraqi Contractors to conduct symposiums to raise contractors' awareness using modern appropriate measures to lower down materials waste in the construction sites. In the last, the Iraqi Engineers League must have conducted symposiums to raise the awareness of the professional teams (designers, procurement committees, and site planning engineers) in the dilemma of construction material waste.

9. Future Studies

Construction waste is continually increasing due to everlasting need of new building and infrastructure development projects. This has developed one of the foremost environmental complications all over the world. As per the European Union Waste Strategy, construction waste is considered as one of the urgency waste streams. The construction industry shows important part in growth of economic and social advancement of the Iraq. But, construction industry also is fronting serious difficulties in the shape of construction waste generation and requires severe consideration and in seriousness to solve this problem. To solve such difficulties and challenges, the more important phase is to recognize the construction waste problem, reasons for generation and the effects of construction waste. A little research work on construction waste in Iraq is focused on quantifying the amount of the waste generated. However, it is still required to more work on this area and to identify the factors and causes which are contributing to the waste generation. On the basis of reviewed literature in this work, we wish to work out more to find the factors and check the contributions of such factors to the construction waste. Also, discover the remedies for reducing the influences of such factors for generating construction waste. Furthermore; the awareness must be spread through proper stream channels to the concerned for reducing the construction waste. Above than that, the authorities must design a waste management plan suitable for the execution environment in Iraqi construction sites and develop a waste disposal data system because of the acute demerit in the construction waste data base at local scale.

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