

Technology role in safety management of Iraqi construction projects

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Abstract. Iraqi construction industry is not away from high number of injuries and fatalities, to control this problem, Mobile Application Technologies (MATs), might offer a promising solution. Improved risk management will increase the productivity of the construction companies which might resulted in enhancing Iraqi national economy. This research addressed the most current used MATs in managing OSH in the construction projects, and highlighted the most benefits and limitations of using these technologies in the field of Iraqi construction projects. This aim achieved by conducting a comprehensive study of the related literature, by analysing a questionnaire response of 98 construction project managers, who are working in a small and medium sized company, BIM and WSDs were identified as the most current used MATs in the Iraqi construction projects, But with a low rate of occurrence about 25%. ‘Eliminate hazard during the design phase’ and ‘Help visualize hazard’ are the most two benefits of MATs with a rate of occurrence about 75%. However, ‘Extra costs associated with technology’, ‘Little or no government regulations for use’ are the most two limited factors of using MATs in OSH management in the Iraqi construction projects. In this research the suggestion for the future research has introduced.

1 Introduction

National incomes increased by manufacturing high performance constructions and vice versa. Public economic might be enhanced due to the improvement of construction industry, because of its key contributing of the national income and the global economy. Improved OSH management in the construction projects contribute effectively in enhancing production in the field of construction industry and this could enhance national economy.

However, every year thousands of construction workers injured and murdered all around the world, for example [1] reported about 970 site-work associated fatalities in the United States of America only in 2017. Annually 10 workers killed per 100,000 full-time employees of construction projects in developed countries such as the US and Canada. However, fatalities number in developing countries all around the world are even more than 3 to 4 times, due to work-related fatal accident as declared by International Labour of Organization (ILO) [2].

Workforce productivity will be affected if they faced any challenge, and this could lead to undesired economy outcomes. It is well known that the role of the mobile devices in the construction was limited to documents access and design viewing at the construction field.

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This draw market attention towards vast creation of mobile application solutions addressing both of management and design tools. Several of these applications have tools for evaluating safety at the construction field. The common factor among almost all safety related applications is the off-line feature which consider construction as a user environment, this off-line feature facilitate it is working in construction site where there is no availability of certain connection to the internet [3]. This feature means that enabling the off-line mode device collecting data and documenting reports. Data uploading starts by connecting to the stable internet connection, the uploaded data to the cloud-based database will be available for different construction parties of the construction projects [3].

Thus, construction companies in the developed countries, spared no efforts to improve OSH management, taking the advantages of the tremendous technology development, mobile application is a promising technology option to play a significant role in illuminating workforce hazard and controlling the relatively high number of accidents rates, during the implementation of construction projects [4].

[5] Many engineering safety methods and behavioural approaches have been followed over the last three decades to mitigate the relatively high accident numbers and to save the life of the construction workforce, and an increasement of safety precautions in the construction site and introducing the possible occurred hazard to the workers for improve their awareness about the hazard. [5] Studied the most used MAT_s by the USA, construction companies and Listed the most benefits, limitation and adopting factors of MAT_s in the USA, by conducted a questionnaire survey among construction safety managers and safety responsible personnel, who have a good experience in managing OSH for not less than 12 years. [5] concluded that MAT_s have a promising role in the OSH management in the field of the construction industry.

[6] stated that a by a continuously or a real-time observation of the construction hazards by using a robust method so called a computer vision (CV) technique, which could be to regarded as a real solution for improving OHS management in the construction projects.

[7] reported that mobile solutions have been under the focus of construction practitioners since 2015, Also, illustrated that in a conducted survey among 600 professionals from small and mid-sized construction companies, 80% of the participants believe that mobile application technology is a moderate or a high priority, particularly, in the term of enhancing collaboration, communication, OSH auditing and observations, moreover, [7] stated that to enhance information flow and management of at the construction sites, mobile management tools is gradually being developed by the software developers.

[8] developed an automatically model for identifying and illuminating work site hazards by categorizing the observed hazards and generating a prevention measure immediately to illuminate hazards from the design stage or to mitigate the observed hazards during the project implementation phase.

[9] studied the requirements of the smartphone's application to be widely used in the field of construction projects management, where the smartphone application model was designed after determining the requirements of the design, through the collection of the required data in a questionnaire among construction specialists, via an internet based survey among graduate students, who specialized in the construction project management, the laboratory designed model of application linked to a server taking into account the basic management concepts of the construction company, also they reported the effectiveness of utilizing mobile applications in increasing the productivity, by ensuring effective communication between all participants in the implementation of the construction project from contractors, stakeholders, project managers, designers and technicians supervising the implementation at the work site.

[10] highlighted building information modelling base mobile applications are examples of technology utilizing in improving the management of OSH of the workers which lead to enhancing productivity of the construction industry.

[11] reported that as a result of massive development of mobile technology, numerous information management safety relation applications have been offered in the markets, which have different type of safety improvement solutions. Four kinds of mobile safety application are presented at applications market, these kinds as shown in table1 are namely:

1. Project management mobile applications with related safety tools.
2. Safety inspecting or safety auditing mobile applications.
3. Specific safety related purpose applications.
4. Specific construction phase managing applications.

Table 1. Examples of the above mentioned four different types of safety related MTAs [11].

Types	Safety related mobile applications
1: Applications of cstruction project management with safety associated tools	bim+ Connect, Aconex, Procore Autodesk 360 Field, construction management software, PlanGrid, Trimble ProjectSight
2: Rating apps/ level inspection/ auditing or safety /measurement/	T3, InstaAudit, iAudit, Kotopro TR-mittaus iOSHA, Process Safety Management Auditing, Trimble Inspector.
3: A single specific purpose Applications	Safety Coach , iTriange, Dakota's EHS Pocket Guide, ChemAlert, Clinometer HD, SoundMeter, DMD Panorama, Tekla Field3D,
4: A specific construction phase or a work application meant	Daily Reports (concrete work), Concrete calculator, Raksamittari PRO, Fall PtD,

[11] Also, illustrated that in the application market the first type is the most common mobile applications, which could be utilized much more varied than other three types of the mobile applications. Moreover [11] showed that in some developed country such as Finland the most appreciated tool application seems to be safety auditing tool applications, for instance, Insta Audit mobile application which has been examined in Finland as an auditing tool. The third type of the applications which could be used for single specific purpose like guides for OHS management, measuring angles instruments. The fourth type safety related mobile applications is for single specific use or for controlling a construction phase, and producing safety related data for single work task, for example a daily reporter or concrete calculations data [11].

Construction site observation is an important factor of OHS management improvement, it means collecting safety related data form the workers and the management of the constructing site [12]. The collected information data in the information system are analyzed to control future accidents by educating personnel with a required actions and arrangements. The more accurate observation reports, produce safer work site environment, this could be achieved by following a system of rewarding on reporting accurate information in the observation and reporting processes and this motivate the employees [13]. Site worker actively participating and engaging in continuously monitoring and collecting safety related information which gradually improve OHS management level in the field of construction.

Figure 1 shows the management of safety observation process. Simply it starts by acknowledging and correcting the observation report at the site organization at the construction site in a weekly meeting between the site organization staff. Then at the organization of occupational safety the observation proposal improved, after improving the observation, they categorized and analyzed this observation information to produce a statistical data of the OHS management in the whole organization. And finally, the

information and required actions will be distributed back to the construction sites in form of a safety guideline packages [11].

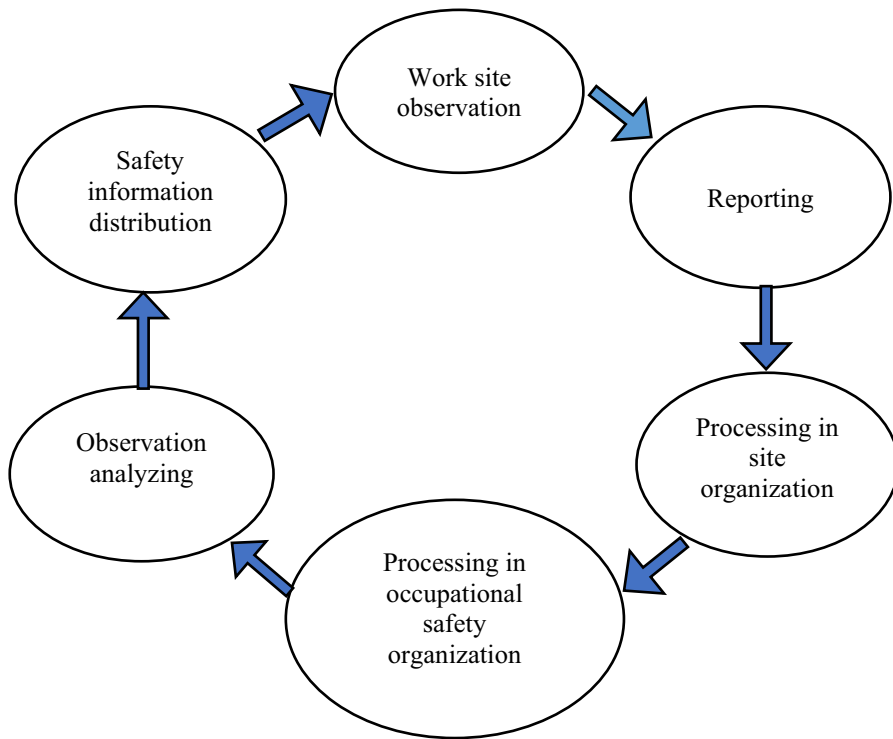


Fig. 1. Safety management observation process

Iraq as a developing country is witnessing a major progress, especially in the last three years in the reconstruction of cities liberated from terrorists, where thousands of small and medium-sized service projects were implemented. Construction safety management in Iraq suffer from the high-rate occurrence of construction accidents with increased number of injures and mortalities. This might be due to, the traditional method of managing OSH in Iraqi's construction projects. This OSH manging method is being followed by the majority of the construction projects implementing companies. Mostly, the role of the mobile technology is only limited to exchange e-mails and text messages.

Accordingly, his paper aimed to address the promising role of the mobile application in improving OHS management in the field of construction project. It aims of mitigating and reducing accidents to control the high number of injuries and fatalities in the field of construction industry in the developing countries, such as Iraq. Throughout presenting mobile application role in enhancing daily observation of safety environment, at the construction field, and highlighting its role in improving communication between the different parties of construction project, and also, by increasing the staff awareness toward OHS hazards might be support to achieve the aim of this research.

2 Research Methodology

To address the research objective in this paper, a multi-method approach was adopted in this research. The first approach involves a structure review and analysis of the accessible literature contents related to the topic of the research. The second approach includes a questionnaire survey among construction practitioners. The adopted methodology is presented in figure2.

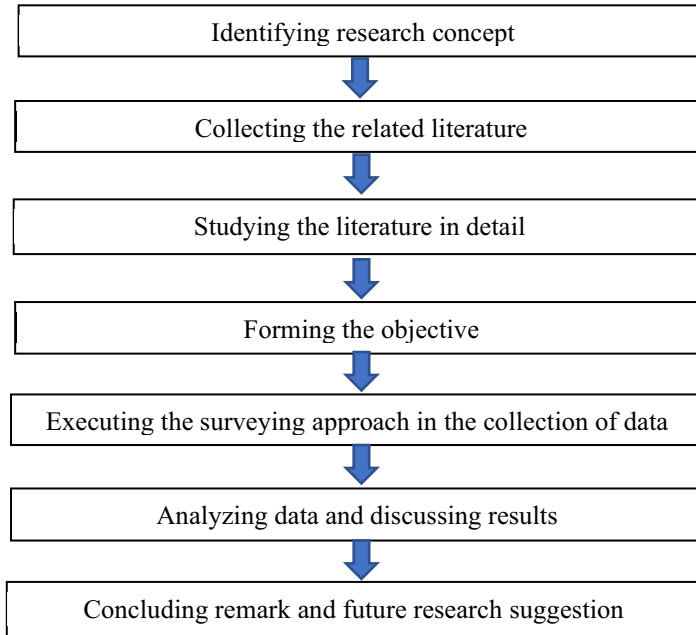


Fig. 2. Research methodology scheme.

To determine sample size of the survey and according to the statistical and probability requirements, the size of the sample was determined according to the equation #1 as stated by [5].

$$\text{Sample size} = \frac{z^2 * P * (1-p)}{c^2} \quad (1)$$

Where z = z-score responding to the level of confidence; $p(1-p)$ = variance of response; and c = margin error or interval of confidence. In this study z-score is =1.96, which represents 95% level of confidence. A 50% variance of response and a 90% confidence level were selected in line with previous study by [5,14].

By substituted all of the above-mentioned values in equation #1, the size of the sample must be more than 97 samples to be a large population representative. Therefore, the response of 100 participants of the survey were targeted by the researchers in the current study. An online survey was conducted by sending a survey sheet to 140 qualified construction project managers all around the country of Iraq including Kurdistan region, who are working in a public sectors and private construction companies with an experience of at least 10 years in the field of OHS management. It is worth to mention that, 98 participants were responded to the survey questions. This means that the response ratio was 70% in this survey.

3 Results

It is important to present well-known technology devices to the participants of the survey, to understand whether they familiar to these technologies, while they are managing OSH in their construction projects or not.

Table 2 shows the fact that they are commonly using these technologies but in different capacity. BIM is being used by the 25.51% of the participants in the current time and followed by WSDs with a rate of almost 23.47%, While MDO, LSL, RFID, DS, AI, and CNS, are (18.37, 16.33, 16.33, 13.27, 11.22, 11.22) % respectively, both AL and CNS devices are being used by about 11.22 % of the respondents, and both of VR and UAVs are being used by 10.2%. The less used technology devices, at the current time in managing OSH in the Iraqi construction projects, are PG by only 3.06 % of the total respondents.

Table 2. Currently used technologies in OSH management at the construction site. (N=98) [5]

S.N.	Current time used technology	Count (n)	% Rate= $\frac{n}{N} * 100$
1	Building Information Modelling (BIM)	25	25.51
2	Wearable Sensing Devices (WSDs)	23	23.47
3	Mobile Devices Onsite (MDO)	18	18.37
4	Laser Scanning and LiDAR (LSL)	16	16.33
5	Radio Frequency Identification (RFID)	16	16.33
6	Digital Signage (DS)	13	13.27
7	Artificial Intelligence (AI)	11	11.22
8	Camera Network Systems (CNS)	11	11.22
9	Virtual Reality (VR)	10	10.20
10	Unmanned Aerial Vehicles (UAVs)	10	10.20
11	Augmented Reality (AR)	9	9.18
12	Exoskeletons/Exosuits (EXO)	7	7.14
13	Robot and Automation (RA)	5	5.10
14	Quick Response Codes (QR)	5	5.10
15	Photogrammetry PG	3	3.06

To highlight the possible associated benefits and limitations with utilizing these technologies in the participants point of view, the researchers selected a list of possible benefits and limitations from the latest study published in May 2020 by [5], the reason behind this selection was to compare the results of this study to results published recently in the USA by [5] which addressed the benefits and limitations from the point of view of OSH manager practitioners all around the states. Table 3 and 4 lists the potential benefits and limitations, respectively. The participants number who agreed that a certain benefits and limitations is linked to a technology represented as the number of occurrences. However, rate of occurrence is the result of (dividing number of occurrence “n” to the total participants number “N=98”) multiplied by 100.

Table 3 shows that MAT_S benefits namely; “Eliminate hazard during the design phase”; “help visualize hazard”; “Enhances near miss reporting”; and “Improves workers awareness of hazard”, are the top four frequency as conferred by the participants. About half of the responses agreed that “improves safety inspections”, “Enhances safety planning” and “enhances injury reporting” were the benefits of the safety technology devices. However, other benefits like “help warn workers of workplace hazard” and “Isolate workers from hazard” had the less frequency and appeared at the bottom of the list as shown in table 3.

Table 3. Benefits of using technologies for OSH management. (N=98) [5]

S.N.	Benefits of safety and health technology devices	Number of Occurrence (n)	% Rate of Occurrence = $\frac{n}{N} * 100$
1	Eliminate hazard during the design phase	75	76.53
2	Help visualize hazard	74	75.51
3	Enhances near miss reporting	70	71.43
4	Improves workers awareness of hazard	65	66.33
5	Improves safety inspections	53	54.08
6	Enhances safety planning	49	50.00
7	Enhances injury reporting	45	45.92
8	Improves effectiveness of safety training	44	44.90
9	Enhances accident investigation	40	40.82
10	Enhances communication between workers	39	39.80
11	Help warn workers of workplace hazard	25	25.51
12	Isolate workers from hazard	25	25.51

Table 4 shows the respondents rate regarding the limitations associated with using technology in managing OSH in the construction projects. It shows the highest rate of 86.73% related to “Extra costs associated with technology” factor and followed by “Little or no government regulations for use” factor with a rate of 80.61%. “Workers may ignore prompts from devices” was another high-rated factor of 66.33%. Three factors “Required workers training may not be cost effective”, “No central system for managing data captured”, and “Data security is not guaranteed” were rated about 50%. This followed by other three factors “Privacy of workers personal data is not guaranteed”, “Little or no known standards for operation”, and “Decision to use varies with client” these factors were rated 38.78%, 33.67%, and 29.59% respectively. It is worth to mention that the less rated factor was 15.31% related to “Aging workforce is resistant to change” technology limitation factor.

Table 4. Limitations of using technologies for OSH management. (N=98) [5]

S.N.	Limitations of safety and health technology	Number of Occurrence (n)	% Rate of Occurrence = $\frac{n}{N} * 100$
1	Extra costs associated with technology	85	86.73
2	Little or no government regulations for use	79	80.61
3	Workers may ignore prompts from devices	65	66.33
4	Required workers training may not be cost effective	50	51.02
5	No central system for managing data captured	49	50.00
6	Data security is not guaranteed	47	47.96
7	Privacy of workers personal data is not guaranteed	38	38.78
8	Little or no known standards for operation	33	33.67
9	Decision to use varies with client	29	29.59
10	Aging workforce is resistant to change	15	15.31

4 Discussion

As a result of tremendous technological development, digital management has become an effective part of the management of all industries. The technological role in the management of construction projects remains under the level of ambition. As many published researches has confirmed, the United States of America has the second least use of technology in the field of construction industry [5]. However, there is a strong tendency to integrate technology into the construction industry to increase manufacturing efficiency and improve productivity [15]. Construction practitioners believed that OHS management in the construction projects could be enhanced by embracing mobile technologies. Similarly, practices of a sustainable construction are another highly increased demands in the field of construction industry [16]. Improved integration of mobile technology in managing OSH, might provide safer working environment [17]. Thus, in this paper benefits and limitation of mobile application technologies utilized in OHS management, has been recognized, to present the importance the benefits and limitations of mobile technologies to stakeholders and the project managers to encourage future adoption of this new method in OSH management.

Table 2 unveil the fact that just about quarter of Iraqi construction manager are using mobile application technologies (BIM and WSDs), and less than 20% are using the other technologies, this not often technology using in managing OSH in the Iraqi construction worksite might explains the high rate of injures and mortalities in the construction projects of Iraq. In comparison to the previous study have done in 2020 by [3], BIM and WSDs were the most used mobile technologies by the 102 respondents, who are in charge of managing OSH in their companies all around of the United Stated of America. Additionally, all the presented 15 mobile technologies in the same study by [3], were being used by more than 58% of the total respondents of the survey. In contrast, all the studied 15 technologies are being used by Iraqi construction managers, with a rate of occurrence ranging from (3.06-25.51) % of the total survey respondents. This difference is realistic and interpret the less utilizing of technologies in OSH management in the construction projects implemented in Iraq.

However, table 3 shows that the survey respondents have a good understating about the benefits of the technologies, used in OSH management, in the Iraqi construction projects, about 76.53% believe that 'Eliminate hazard during the design phase', 'Help visualise hazard', 'Enhances near miss reporting', 'Improves workers awareness of hazard', 'Improves safety inspections', and 'Enhances safety planning'. Similarly, in the USA more than 50% of the survey participants in [3] study, believed that the most benefits of mobile technology devices, used in the OSH management are namely; 'Improves workers awareness of hazard', 'Help warn workers of workplace hazard', 'Eliminate hazard during the design phase', and 'Help visualize hazard', these data show the good consistency and agreement between the survey participants in both the USA and Iraq about the benefits of using mobile technology applications in OSH management in the construction projects, particularly in 'Improves workers awareness of hazard', 'Eliminate hazard during the design phase', and 'Help visualize hazard'.

Table 4 shows a high rate of occurrence of limitations to the mobile technologies using in Iraq. Frequency of occurrence of the most limited factor; 'associated extra cost to the technology using' is the most limited factor of technology using in Iraq. Then factors; 'Little or no government regulations for use', 'Workers, may ignore prompts from devices', 'Required workers training may not be cost effective', 'Enhances safety planning', and "No central system for managing data captured' were selected by more than half of the

respondents with the rate of occurrence of (75.51, 71.43, 66.33, 54.08, and 50.00) % respectively. [3] reported that, the most limited factor of adopting mobile application technology in the USA is ‘Extra costs associated with technology’, with a moderate frequency of occurrence 47% of the 102 participants. This, might unveil the fact that an extra cost related mobile application technology using is the shared limited factor in both of the developed and developing countries but with different rate of occurrence.

5 Conclusions

This paper contributes not only in addressing the important role of mobile technology in OSH management in the construction industry, but also to control the annually high number of accidents, in the field of Iraqi construction projects. Due the complication of the construction industry, and also by following traditional method in managing OSH in implementing construction projects, high number of injuries and fatalities, reported every year in Iraqi construction projects [18], Thus, this research findings might offer the lawmaker and the different construction parties (Stakeholders, Designers, and project managers) a clear understanding about the necessity of the introducing the mobile application technology as an innovative technique. This could be achieved by issuing new laws and legalizations to achieve a high performance in managing OSH risk, and also by driving the construction companies towards more investing in OSH management and offering safety auditing and observing required tools with suitable tanning.

This study, offers benefits of using mobile technology in mitigating injuries and fatalities in the construction projects and found that the most important five factors are ‘Eliminate hazard during the design phase’, ‘Help visualize hazard’, ‘Enhances near miss reporting’, ‘Improves workers awareness of hazard’, and ‘Enhances safety planning’. These benefits found to be relatively similar to other studies have done recently in the USA.

Furthermore, this study highlighted many limitations to the mobile technologies using in Iraq. Frequency of occurrence of the most limited 5 factors are namely; ‘associated extra cost to the technology using’, ‘Little or no government regulations for use’, ‘Workers, may ignore prompts from devices’, ‘Required workers training may not be cost effective’, ‘Enhances safety planning’, and ‘No central system for managing data captured’ were selected by more than half of the respondents with the rate of occurrence of (76.53, 75.51, 71.43, 66.33, 54.08, and 50.00) % respectively.

However, in the USA, ‘Extra costs associated with technology’, is the most limited factor of using mobile application technology with a moderate frequency of occurrence 47% [3]. This, means that an extra cost related mobile application technology in OSH management is the most limited factor in the USA and Iraq, but with different rate of occurrence.

Finally, as the second most limited factor of technology using in OSH management in Iraq is a ‘Little or no government regulations for use’ factor, with frequency of occurrence 80.61%. this research concludes that, the lack of requiring legislation and laws to force construction companies to use modern methods, to reduce the relatively large number of injuries and fatalities in implementing construction projects in Iraq. It is worth to mention that, ranking factors which limited adopting of mobile application technologies in Iraq, could be an important variant for the future research.

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