International Journal of GEOMATE, Dec., 2018 Vol.15, Issue 52, pp.53 - 61
Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2018.52.33934
ISSN: 2186-2982 (Print), 2186-2990 (Online), Japan

KASHWANI RISK ASSESSMENT: NEW APPROACH FOR OIL AND CONSTRUCTION INDUSTRIES

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Received: 29 May. 2018, Revised: 28 Jun. 2018, Accepted: 05 Oct. 2018

ABSTRACT: The aim of this study is to provide an integrated framework that can optimize the implementation of the safety engineering system through the usage of a risk assessment. Current safety studies in oil & gas and construction exposed the presently weak areas in the risk assessment application thereby aiding the selection of the framework inputs in this research. There are three main sections employed as filters during the hazard identification stage in which each one of them has specific criteria. Such a focus will facilitate avoiding the kind generalizations practiced in most risk assessment sessions to cover all the possible scenarios that can occur with the existing hazards. Each group has three standards that should clarify the identified hazard, its dimension and interaction mechanism with the wanted construction activity. Following this full examination, a regular risk assessment procedure is carried out where risk estimation and evaluation will be conducted. At the same time, risk monitoring will be involved in the all steps to facilitate a healthy communication between the parties, especially the management and end-users.

Keywords: Safety Engineering, Construction, Risk assessment, Integrated Framework

1. INTRODUCTION

Safety engineering system is an integrated system in which all its processes are connected together in some way. According to Kaplan [1], it can be agreed that risk assessment is the most vital in the safety engineering system process where the decision-making step is usually related to the findings of the risk assessment. To clarify, the process sequence of risk assessment is to identify, assess the potential hazard, implement the controls, whether engineering controls or administrative controls and then apply the recovery plan. Therefore, risk assessment process can be divided into four main actions: identify, assess, control and recover where these actions are directly related and can be highly affected by external and internal factors [2]. For example, in risk identification stage, if the collected information about the hazard is not accurate and enough, a faulty analysis may be conducted in the risk analysis stage resulting in a lack of implementation towards risk assessment [3]. According to Aven & Vineem [4], even with risk assessment development, there are many potential accidents in the oil and gas industry due to the implementation problem that leads to an inadequate risk assessment. In order to reduce and control these likelihoods, risk assessment should be implemented in a professional manner. Many scholars believe that the inadequacy of risk assessment could be due to the deficiency in risk assessment process elements.

Risk and hazard identification is the first step in the risk assessment process that is used in the oil and gas industry to identify the possible hazards that may be associated with a certain job. Schroeder and Kaclson [5] mention that risk identification is the most important step in the risk assessment process in the oil and gas sector because adequate risk identification generally includes; lesson learned, the current status of risk assessment methods and HSE plan. The main goal of risk and hazard identification is to expose all the hidden hazards and provide a first response or mitigation plan to control the potential risks. The importance of risk identification lies in the way of its implementation that affects the next process in risk assessment. This is due to the fact that risk identification findings represent the first inputs for the whole risk assessment process.

Reviews and analyses of the lesson learned, the current status of risk assessment and HSE plan in the risk identification stage would help in obtaining a better risk breakdown structure and that will strengthen risk identification implementation. Risk categories that are used in the oil and gas industry are; technical support, procurement and materials, startup & operations, field execution & logistics and organization and communications [6].

Kerzner explains [6] that the inadequate risk identification in these categories will lead to weakness in applying risk assessment in the construction stage. As such, many oil and gas construction companies make sure to conduct Task Risk assessment (TRA) for any coming project. In (TRA) mechanism, the hazards are identified for different phases of the project and preliminary prevention plans or control measures are provided accordingly which lead to more accurate implementation [7]. There is a number of methods and approaches that used for risk identification other than the TRA such as HAZID, HAZOP, and etc, but according to Chapman [8], any method is used for risk identification purposes should include five important steps to be effective and implementable. Chapman suggests that the effective risk and hazard identification process should include the following steps. The first step, knowledge acquisition, the overall objectives for the project should be reviewed with respect to the project parameters such as cost, timeline, and planning. Moreover, an integrated assessment and examination for the general hazards that threaten the project should be identified and discussed.

After that, the second step is the Selection of the representative's team. For example, the hidden hazard is one of the main threats that affect risk identification mechanism in implementing risk assessment goals. To avoid that, Chapman [9], believes that the team who participate in the identification and assessment of the risks facing the project should have people from the core business such as construction people where this will help expose hazards that are hidden to the senior management and engineers working in the offices.

The third step is the presentation of the project process. Chapman says that it is necessary for risk identification members to go over the project process to increase their awareness about the project which will develop their ability to identify the hazards for each phase of the project.

According to Wideman [10], the identification step (the fourth one) is more like the breakdown process where each has its own way and system for utilizing the identification concept. However, the author says that for each method there are limitations that may determine how suitable the method is in regard to a certain activity in the project. Therefore, it is important for the representative team to have full knowledge of the capabilities of the used risk identification. In the last step, Verification is used to obtain the assessment acceptance from the representative team towards risks and their sources, and the likelihood of occurrence and impact.

Risk identification is not only about answering the questions of when, where, why, and how, the risk may be identified, one needs to determine risk factors, risk probabilities, and providing preliminary risk response plan when ich would result in having a better implementation of risk identification in the field [11]. Moreover, ISO 17776, [12] that is tailored for the Petroleum and natural gas industries, includes the sidelines on tools and techniques for hazard identification and risk assessment, as well as the Center for Chemical Process Safety [13] both recommend the following risk identification methodologies: Preliminary Hazard Analysis (PHA), Hazard and Operability Study (HAZOP), Hazard Identification checklist (HAZID), Environmental Issues Identification (ENVID) and ―what if analysis.

2. RISK ASSESSMENT CHALLENGES

Many scholars believe that the main reason for risk assessment implementation, the issue is due to the weakness and gaps in risk legislation, in which risk assessment process needs to be controlled in a systematic way with respite ect to the roles and responsibilities of each involved party. For example, Johnson [14] states that risk assessment is a process and performance-based approach and it is highly attached to the safety regulation in the heavy industries. The author says that, by having effective limitations and requirements in the risk regulation, enhanced standards would be legislated, that leads to better safety practices in the industries. Moreover, Hale [15] supports this idea, stating that safety regulation is a dynamic process that consists of the following steps: Plan-Do-Check-Act (PDCA) cycle and to have a high quality of implementation towards risk assessment, two things should exist in the regulation; monitoring and management of change (flexibility).

Hale defines monitoring as a rule follower where it is more like an active procedure for the whole risk assessment process. In the risk assessment monitoring, the purpose of this stage is to know the status of the project of concern in terms of the safety performance. This can be measured through daily, weekly, monthly and annual risk reports, where all working capitals, availability of the resource, and financial projections should be mentioned alongside with compliance, violation, and deviation of the current project. Burke et al., [16] mention that the existing monitoring system in the oil and gas industry needs to be restructured due to the inadequacy level. The authors say that the self-reporting system has a lack of transparency which causes a lack of implementation for the whole risk assessment. The author uses an example the oil spill accidents that frequently happen in Grand Bank Eastern Canada which affect the biodiversity life in there. This supports the idea of Hale that weak monitoring can indicate the existence of different issues such as inadequate behavioral safety, but the effective monitoring can point out the challenges that risk regulation is facing especially in the planning phase in the oil and gas industry. In addition, many scholars believe that auditing can be a good method for monitoring in oil construction. It is clear that the purpose of reviewing the audit system is to determine the level of compliance towards risk assessment regulations. According to Wang & Li [17], the audit is a very effective indicator for determining external and internal factors that affect risk regulation system. The author explains that the audit is usually conducted against the whole system of the organization. It requires reviewing a lot of documents that contain different risk regulations. The authors add that audit findings can develop and improve regulations for risk assessment which will result in better implementation of safety performance in the organization. Moreover, according to Wu & Li [18], auditing can be a very good monitoring for ensuring regulatory compliance. For example, many contractors show full compliance for regulation prior awarding their contracts and during the early stage of construction, but after proceeding for a while with construction activities, the compliance towards the regulation decreases because of insufficient audit frequency and follow up.

However, other researchers believe that reporting is the key to overcome all the organizational deficiencies that may affect the risk assessment implementation. According to Bridges, [19] Near Misses are the best indicators to evaluate the risk assessment implementation. Near Miss can be defined as an unplanned sequence of events that could have caused harm if conditions were different or are allowed to progress, but did not in this instance [20]. In the oil and gas industry, Near Misses should be investigated to help identify the root causes. This would assist the company in understanding the defects in their HSE system. Since Near Miss Incidents have common causes to affect work procedures, response to the root causes of the Near Miss will eliminate the root causes of the accident. This highlights the importance of the Near Miss investigation as it is vital in preventing accidents due to the fact that generally Near Misses share root causes with accidents.

Gordon [21] believes that while technical and organizational factors can have a major impact on the safety and risk assessment in the oil and gas industry, personal factor have an even greater impact on influencing safety and risk assessment. This is due to the fact that the human factor is the main medium of interaction with other operating factors such as technical and organizational factors. The integrity of the human factors and their interaction will help ensure a better risk assessment implementation. French and Geller [22] believe that in order to guarantee the stability of the human factors, it is necessary to create a safety culture in the organization itself. The authors claim that management should publish the safety culture between the employees through different activities such as regular inspection and auditing, awareness campaigns, training for competence assurance, positive promotion policy, and open communication.

According to Beatrice [23] negative attitude displayed by management influence the organization‘s safety implementation, creating a blaming culture in the work environment. Beatrice mentions that management should promote a positive work culture. That is, they must accept employees as human instead of creating a blaming culture that may affect the trust and the openness of the relationship between the management and construction employees. This would create a blame-free culture that encourages employees to sustain good practices, such as reporting near misses, identifying hazards, and making a recommendation. Gennard and Judge [24], however, believe that even if the management wants to foster a free-blame culture, the change should start from the individual level. To do so, challenges and barriers should be examined as most barriers arise from Behavioral Based Safety (BBS) such as educational barriers. Deming [25] who is considered one of the pioneers in safety engineering, believes that laborers with poor education usually do not prioritize safety which leads to productivity pressure from their seniors. Deming suggests that besides the proper training to maintain the competence level, laborers should be educated about the principle methods and implementation strategies of safety in the construction stage. This would grant laborers with a full spectrum of the importance of safety performance in their construction duties, which would, in turn, help them transition from knowledge-based behavior to skill-based behavior.

3. KASHWANI RISK ASSESSMENT

This study strives to optimize the safety performance at construction projects in the oil & gas and construction industries through the implementation of risk assessment. As can be gleaned from the literature review, many scholars elucidate their struggles with current applications of risk assessment and the needs for an integrated approach. The aim of this research is to involve all vital and contributable areas that can cause an accident as immediate or root source. Technical, procedural, and behavioral aspects were investigated with respect to the external and internal attributes that play a critical role in the oil and gas industry as shown in Fig1. Pervious risk assessment frameworks could not provide an integrated perspective to identify the full scope of the hazards at the construction site.

Kashwani Risk Assessment		
Procedural	Technical	Behavioral
Operation procedures	Functional analysis	Organization factor
Safety and health procedures	Failure Modes	Work Environment factor
Communication procedures	Maintenance strategy	Employee Behavior

Fig 1 Kashwani Risk assessment Framework Concept

3.1 Procedural section

3.1.1 Operation procedures

It is important to highlight the operational procedures that will be used in the construction task for all the employees who are participating in it. The first step is to indicate the manuals which the procedures are taken from them to help the job performers in identifying the main technical references. According to Hale and Borys [26] providing these manuals during the risk assessment, entices a social motivation for the end-users to explore the procedural concepts and gain more technical information that can enhance their competence skills. Furthermore, having written procedures with manual reference offers a clear and precise summary of the execution of a complex construction task whilst also providing supervision for the workers on site [27, 28].

It is critical to define the entire process that should be followed in order to achieve the main goals of the construction activity, including steps, materials, time, and equipment [29]. However, many scholars suggest reviewing the manuals to select the required process so as to enhance the construction target that may rely on the experience and the history of previous jobs for a similar activity. Often, it is required to change or modify the described process in the manuals due to the job nature difference from one location to another thereby necessitating the use of individual ability to learn. The modified process should be within the international standards acceptable range limit, without major violations to specifications that can lead to safety defects at the execution phase. Additionally, the process analysis needs to check the feasibility of applying the defined process with the available resources and start contacting the procurement department in case of shortages of materials.

3.1.2 Safety and health procedures

Many of the HSE engineers capture the written procedures and embed them as safety measures in their integrity plan without any consideration for job performer academic background which may require more clarity and simplicity. To illustrate this, the safety and health procedures can be simplified by adding some drawing and figures that can be more understandable for laborers who have the language barrier issue. This can be displayed through separate posters that can be hanged on different spots of the construction location. Moreover, it is suggested for the safety engineers to explain these procedures by giving examples from the previous lesson learned which shows the importance of studying and analyzing the earlier incidents for the same wanted activity. However, one should always remember that the main goal of clarity and simple step is to enhance the compliance and not compromise or provide shortcuts against safety performance. Having multiple and different contractors on the same site can be another challenge in this stage where each construction company has their own safety system. As such, it is extremely vital to explain and utilize the same safety measures for the all the workers whether they form the client or contractor companies thereby helping the laborers to focus at one system to follow. Using a checklist is another method that can provide clarity and simplicity concept in a suitable technique in the construction field. For instance, before conducting any construction activity, the end user should fill the safety measure checklist that illustrates the job procedures and then he/she submits it to the main supervisor.

3.1.3 Communication procedures

The absence of oriented communication in many of the construction organizations is because they lack a clear communication procedure that involves all organization activities e.g. maintenance, materials supply, and construction. The usual practice, which is followed, explains and embeds communication briefly without mentioning the people and channels. For that, most of the risk assessment sheets do not provide any kind of communication information even for emergency cases. As such, this framework will enhance and fill the communication gaps by providing a scheme that answers the three major questions; what, who, and how. The visibility of these three pillars of communication can eliminate the different barriers that may occur during exchanging information as shown in Fig. 2. This helps to ensure the success of communication in the entire construction project.

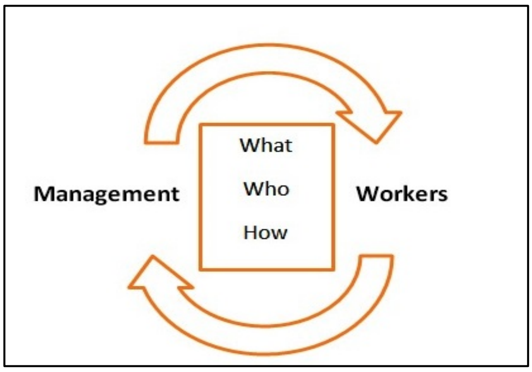

Fig 2 Communication Process

3.1 Technical section

3.2.1 Functional analysis

This framework presents integration between construction safety and systems engineering through functional analysis that explains the equipment parts and their utilities. This would help fill the gap in the questionnaire, especially in the machinery and equipment failures. There are several scholars who strongly believe that there is a lack of technical examination for the current automotive safety technology at the construction site [30]. This is due to the nature of the heavy equipment with their numerous parts which act as potential hazards for users and the surrounding environment. As observed in the questionnaire, the workers lacking a higher education background are often unable to deal with construction equipment in a safe manner. Furthermore, the construction organization does not have sufficient technical courses for their staff. For that, having functional analysis in the risk assessment will guarantee the awareness and control of work equipment to prevent any accident or injury. Furthermore, rapid advances in technology often make constant updating of their procedures difficult for organizations. In this framework, the functional analysis for the construction equipment will be divided into four main categories as shown in Fig. 3. These four aspects will enhance the proactive safety performance for the users. For example, the verity of scholars suggests using material analysis to determine the performance of the materials under elevated temperature [31].

3.2.2 Failure Modes

Lin et al., [32] believe that examining the functional analysis of the equipment is one of the vital approaches to prevent equipment failure in the workplace. However, the authors refer to the Murphy‘s Law concept i.e. anything that can go wrong, will go wrong, and for that control and mitigation plans should be involved in the risk assessment stage. In this framework, a forward logic method will be used where all the possible failure modes scenarios are defined.

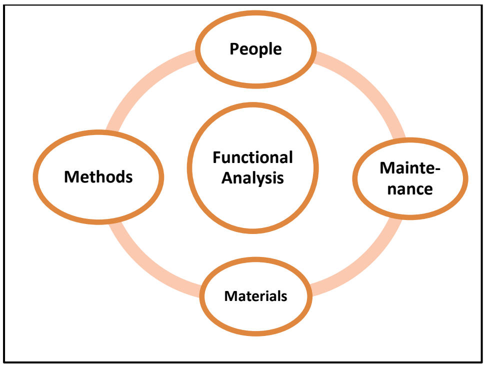

Fig 3 Communication Process

Definitions of the causes will help shape the failure effects that may occur during the construction works, but it is far more practical for employees, especially end users, to apply monitoring practices. Monitoring the failure effects are divided into two main categories: people, and the environment. Pinto et al., [33] believe that supervision of these two factors is the last barrier layer in failure modes prevention. Applying this concept to the pipeline rupture, supervision practices to site environment can help the safety engineers to have more knowledge regarding the soil mechanics at the site. For example, soil reinforcement can be applied in the offshore site as an immediate action to strengthen the ground to have better resistance against runoff and sedimentation.

Detecting the failure mode is the chief goal of the failure mode analysis where forward logic is employed to analyze the technical system and improve the safety performance during design and construction stages. According to Liu et al., [34] using this sequence of evaluation can aid the designers and safety engineers in understanding the dynamic between equipment/machinery and construction job. This integrated view helps identify all potential hazards that may lead to failure. As such, estimating the hazard and its severity and putting prevention safety barriers is the major key in this stage. That is to say, in the first stage (Defining the failure mode), it shapes the frequent failure modes and their immediate root causes.

3.2.3 Maintenance strategy

Many construction professionals believe in the need of involving the maintenance strategy in the risk assessment of the project. For instance, Hung et al., [35] believe that three maintenance strategies;

predictive, prevention, and reactive should be applied for each construction. That is, traditional maintenance strategies may not achieve the production and safety goals because they are designed to perform before or after equipment breakdown. Such a superficial understanding of the role of maintenance strategy prompts management to make questionable decisions that translate into accidents at the construction site. As such, a new methodology will be introduced in this framework which involves border dimensions of the maintenance strategy, such as audit and leadership.

3.3 Behavioral section

According to Garrett and Teizer [36] that the difference between human factors and behavioral analysis in construction safety depends mainly on the worker beliefs. Garrett and Teizer illustrate that human factors are more associated with factors affecting the individual performance e.g. training and equipment usage. In on another hand, the behavioral section strives to examine all the attributes that influence the worker beliefs which can be developed into attitude and then to constant behavior. Behavioral safety is the most important prevention barrier at a construction site. However, most safety professionals settle on the challenges that associate with the implementation process. These challenges can contribute due to internal or external reasons. For example, from the questionnaire, the external factors that affect the behavioral safety performance for the employees can be classified into three categories: employee capacity, organization, and work environment. According to Clark [37] all these factors are related to each other and to have an efficient BBS program at the workplace, it is vital to implement an approach that continues to link these areas together. This explains the three themes, i.e. safety competence, welfare plan, and behavior analysis, in this research framework. Understanding the interactions mechanism between these three points is a key challenge that top management should address in order to foster a healthy safety culture at their sites. Fig. 4 clarifies the mainstream of the interactions between these behavioral safety aspects where the ultimate goal is to promote a healthy safety culture at the workplace.

3.3.1 Organization factor

Organization factors play a critical role in the Applied Behavioral Analysis (ABA), comprising of significant features such as supervision, leadership and etc. However, scholars such Zohar and Luria [38] believe that behavioral organization factors have a direct effect on worker competence. For example, most oil and gas organizations provide only the basic safety courses for their staff, usually at the beginning of their tenure. Evaluating the training matrix of the employee, especially for the workers at the site, is extremely important to determine the level of their safety competence and how it could improve in the future. Due to the complexity of the oil and gas industry, most workers complain about other organizational factors that may affect their safety competence as the questionnaire display in this study. For instance, workload, poor visibility of management, and blaming culture can disturb the worker safety competence even if he/she has received adequate technical training course.

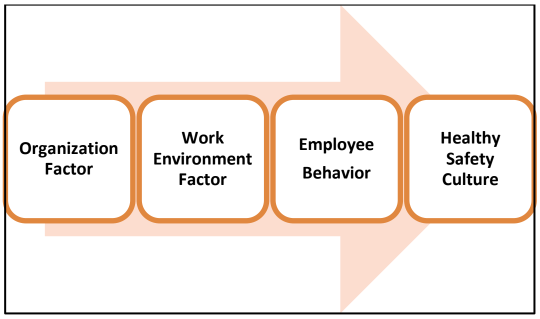

Fig 4 Behavioral safety elements interaction

As a result, senior management should deliver healthy organization factors that motivate end-users to augment their safety competence through initiatives such as safety bonus and supervision care. Langford et al., [39] suggest several practices for the organization to enforce safety attitude at the workplace. For instance, having joint safety training between safety supervisors and workers at the site strengthens the safety culture in the long-run. Additionally, the authors believe that organizations should establish a clear policy illustrating how any worker has the right to refuse a task that he/she has not been trained in. The commitment of the organization towards these healthy practices will build a perspective that the company cares about the workers ‘personal safety and is more willing to cooperate.

3.3.2 Work Environment factor

Construction workers need acceptable rest, washing facilities and food. To ensure the behavioral safety of the worker, the welfare plan should reach beyond these basic requirements. According to Harris and McCaffer [40] welfare is one of the most serious hidden work environment behavioral factors that cause a vulnerability in the workers ‘technical skills. For example, several health and physical issues often appear due to a poor welfare plan for workers at the site. When welfare services quality declines at the site, the end-users lose the incentive to be creative and give innovative feedbacks to improve the safety system implementation. This framework highlights that an ineffective utilization of working environment factors has an equal effect on the managerial and field activities. This should encourage the organization to gain a wider perspective about the impact of an informed welfare plan that establishes a safety culture in their current and future projects. Emerging welfare plan in the risk assessment as an essential element within all other technical ones, increase the chance to have more suitable work environment factors for the labors at the site. That is, analyzing technical activities highlights the kind of services the employee needs to safely perform the required job. For instance, most pipeline construction projects require able-bodied laborers who are able to perform the different activities, such as bending and lifting. Here, the risk assessment will help the top management and project supervisor select younger labors for these activities and assign older ones for other jobs at the site. Moreover, involving a welfare plan in the risk assessment provides the asset engineers with a better idea in the layout of welfare facilities that need to be installed, such as heating facilities during cold weather.

Wong et al., [41] support the importance of having an integrated welfare plan that runs parallel to the technical work at the construction site. However, the authors encourage the most industrial organization to conduct a separate risk assessment after the welfare resources installation to avoid any incident that may occur during the operation phase. For example, several incidents occurred in the construction projects due to incorrect storing of cylinders in non-ventilated places outside the workers ‘accommodation.

3.3.3 Employee Behavior

Many authors support the concept of how employee behavior is highly related with other behavioral external factors in which shape it as the last barrier of behavior safety. As such, the organization should avoid focusing solely upon analyzing the worker safety behavior without considering the organization and work environment factors. To attain a meaningful evaluation of the worker, indicators from both management commitment and work environment ought to be monitored in a continuous manner. Selecting the indicators is the key obstacle that an organization needs to cross in order to ensure they have a fair monitoring system. Management commitment is a vital indicator of the organization behavioral safety since it can exceed beyond establishing policy and procedures. For example, management commitment is the essential element of creating a supervisory and supportive environment at the construction site. When an end-user feels that his/her management prioritizes his or her personal safety over productivity, the communication transparency will increase in the organization. At this point, tracking the behavioral analysis of the employee in the daily activities will be easier. That is, the more emphases from senior staff, the more oriented supervision toward worker behavioral safety is applied as result of management activities e.g. manager‘s visits to the site, managers-workers and open discussion.

Other scholars encourage worker involvement as one of the main behavioral indicators in the behavioral analysis system. Management should be more willing to provide active and passive control to end-users. For example, workers can participate and contribute in the decision making of safety policy and procedures. As such, more individuals will gain an appreciation for the safety behavioral and its importance, eventually shaping a healthy safety culture at the construction site. Understanding and applying these new indicators will help the organization utilize an update in the industry. For instance, organizations use a performance mentality to analyze the worker behavior at the site. Such a mentality is propagated by the idea that unsafe behavior is fundamentally linked to workplace accidents records and scenarios. As such, accident data is considered the key indicator of judgment. This framework analyzes the effort put forth by management as part of employee behavior. The reason behind this focus is that employee behavior influences the technical skills of the workers. That is, most behavioral safety incidents at the construction site come from experienced workers who required revived several pieces of training by their management. However, concurrently, management often fails to stress the role of behavioral safety at the workplace. To attain a safety culture at the workplace, an integrated examination of the employee behavior should be conducted. This will aid safety engineers to understand the root causes of unsafe practices, instead of focusing only on the act-doer and the required disciplinary actions.

4. CONCLUSION

This study provides a new perspective towards optimizing the implementation of safety engineering system. Academics, scholars, and construction professionals suggest using an integrated mechanism to enhance the safety implementation at the site. The essential mechanism was delivered in this research by providing an integrated Framework as shown in Fig.1, which illustrates how to fill current safety implementation gaps. However, as with any research, there were constraints affecting research methodology. There is also a lack of previous risk evaluation studies that cover the safety performance implementation in the construction phase of the oil and gas industry [42]. In case of availability of earlier studies that provide critical analysis or numerical models, this would help the research to cover this topic from a different perspective.

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