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HAZARD ASSESSMENT OF SELECTED ENGINEERING PROJECTS IN THE NIGER DELTA REGION OF NIGERIA

Ferdinand Emeka Harrison and Ebigenibo Genuine Saturday

Mechanical Engineering Department, University of Port Harcourt, Rivers State

Abstract

Hazard assessment of selected engineering projects in the Niger Delta region of Nigerian was carried out in this work. The approach adopted in this research was both descriptive and analytical survey design. The study attempts to estimate the hazard levels / consequence levels of various hazard factors which are often associated with selected engineering projects in construction, oil and gas companies in the Niger Delta region of Nigeria. The instruments for data collection employed involve the administration of questionnaires, interviews and observations. Engineering departments in engineering organizations in Rivers, Bayelsa and Delta States constitute bulk of the area of survey. Total of Sixty (60) practitioners in engineering projects with varied years of experience in the industry were selected to respond to questionnaires. Descriptive data analysis technique was used as an approach to explain the results obtained. From total of sixty questionnaires (60) sent out to engineering practitioners forty-two (42) were returned at the time of this analysis. The investigation shows hazard assessment in engineering projects as a complex and difficult process. The study identified that hazard varies from one organization to the other. Out of six hazard factors identified, economic and financial hazards, technical hazards and commercial hazards were the most potent with hazard levels of (87.25%), (85.50%) and (78.75%) respectively. The study revealed that hazard assessment should be viewed as an ongoing process, which needs continual monitoring, planning and modification as the needs evolve.

Keywords: Consequence levels, Descriptive and analytical survey design, Hazard assessment, Hazard factors, Hazard levels.

INTRODUCTION

Engineering projects are fickle and fraught with varying risk. In recent times, much attention and focus on risk assessment have been experienced. It has become evidently clear that there is need for a holistic framework to effectively identify, assess, and efficiently manage risk in engineering practice. Project Management Institute (PMI) has underscored a qualitative approach where risk assessment is mostly associated with mathematical models and analytical tools. Though PMI studied and showcased the qualitative, quantitative, and semi-quantitative attributes of risks, this continuous study shows the wholeness of risk assessment in the implementation of engineering projects, policies and programmes [1]. The need therefore arises to carry out a comprehensive hazard assessment associated with a particular engineering project so as to provide the needed information to forestall failure of the project. A project can be stated as a specific event or activity with a specific starting and an ending point [2]. Hazard is potentially a source of harm and/or adverse health effect on a person or persons. “Hazard” and “Risk “are often used interchangeably. Workers of construction sites are, generally, exposed to an excessive risk of being injured at work [3]. Pungvongsanuraks et al (2010) [4] elicited that construction industry is unique and complex. Every engineering project involves hazard, in which proper management of the hazard can save time, money and guarantee quality. Hazard can occur at any point in a project and it is essential that they are identified, assessed, monitored and controlled appropriately and effectively.

The outcome or variability need not be exactly predictable for any given product or output, but the probability of outcome or loss must be capable of being established for a large number of cases or observations. Hazard therefore prevails when the chances for the occurrence of an event can for instance be said to be 50/50) or 60/40) or 80/20 That is, there are multiple possible outcomes for each alternative and a value or probability of occurrence can be attached to each outcome [5]. If the probability that a prediction will turn out to be wrong is also a hazard; a high probability that this prediction will prove to be considerably in error implies a high hazard while, if the probability of substantial divergence is low implies a small hazard [6]. In his book, world of business, Stenhoff [7], noted that insurance is not the best solution to cope with any hazards even if business and individuals firms could ensure themselves against all possible danger, the cost would be prohibitive. And some hazards are not insurable in the first place. There have been various ways hazards are cope with however, no method is guaranteed that the damages, losses and injuries in all cases is avoidable.

Project hazard is the hazard identified during the planning, evaluation and appraisal of the project in view, with tools like hazard identification (HAZID) and hazard operation (HAZOP). They are technically designed out. While Post-project hazard can be defined as the hazards that are established after project execution and the clean-up of the project site/environment. They are usually operational such as lifting chemical risks and logistics, etc. for which management systems and procedures and should be put in place. We have witnessed several cases of abandoned engineering projects and poorly unfulfilled project works in Nigeria, leading to economic waste and sabotage. This is so because in majority of these projects, time has not been taken to assess the varied systemic hazards associated with them nor adequate contingency plans made to alleviate or reduce them when they occur. For instance a project may fail due to contractor’s incompetence or lack of contingency plans to cater for shortage of project working materials or price variations. These ugly circumstances of losing time and value in projects could be mitigated or avoided if adequate thought and planning as regards the hazard assessment of a particular project go into the conceptualization of these projects. To overcome these problems, the need for a proper hazard assessment and contingency plan of the engineering project is very imperative.

Common factors that will lead to the occurrence of hazard are identified and summarized by Suresh [8] as fol1ows:

i. Unclear Goals and Objectives.
ii. Complexity of technical solutions.
iii. Use of new/innovation technology.
iv. Logistic (Materials shortage and procurements)
v. Lack of project visibility.
vi. Loss when new project fails.
vii. Equipment loss during transit.
viii. Material failures.

ix. Lack of resource planning
x. Communication gaps

Hazard assessment is required for strategic management, planning and control of project thereby enabling the organization to achieve its corporate goals. Enlightenment and creation of awareness of factors of hazard in engineering projects and the implored method of control will be the contribution of the study to project owners and contractors. Hazard and Risk assessment plays an important role in disaster risk management. Existing multi-hazard risk assessment models are often qualitative or semi-quantitative in nature and used for comparative study of regional risk levels [9].

Hazard management is an essential knowledge and common to engineering profession and is so important as to guarantee the success of any particular engineering endeavour. Safety in engineering construction sites is needed so as to reduce the risk of injury during work. Safety is also seen as one of the highly prioritized factors affecting the image of the project manager and the organization [10]. High rate of accidents occurs in the construction industry than in the other manufacturing sector [11]. Hazard is defined as a risk, danger or a chance of injury or loss, a factor, person or thing likely to cause loss or danger or incur the chance of unfortunate consequences of doing something [12]. Hazards common in the oil and gas industry has been identified and ways of preventing such hazards has also been advocated in several works [13-16]. Also, hazards pertaining to the construction industry have been of concern to several researchers. The common hazards in the construction industry, their causes and prevention have thus been severally studied [17-20]. Most of the studies do not consider projects in the Niger Delta region of Nigeria which terrain may likely contribute to hazards in both the construction as well as the oil and gas industry.

Hazard identification technique is also effective for traditional brownfield projects and green field developments or modifications as well as offshore or onshore plants. The diverse types of project will lead to a variation in the quality of information that is needed. Whenever new technology is involved hazard is always associated with a project. The implications of failure heavily weighs on project and the required gain has to be very significant for the hazard to attractive. It is particularly important that the consequences of failure or delay in the procurement of the new technology should be fully accounted for in the project execution plan. Also, a project under execution may be obsolete with time due to technological developments. Audit and reviews should be used to assess the impact of hazard, which are balanced by the potential gains the project has accrued. The assessment of hazards in research bears these issues in mind.

METHODOLOGY

Research Design and Study Area

Descriptive and analytical approaches are adopted in this work. The study attempts to estimate the hazard levels of various hazard factors which are often associated with selected engineering projects in construction, oil and gas in Niger Delta region and with the basic research design to be employed in this survey involve the administration of questionnaires, interviews, observations, and collection of data.

Generally, the research ascertained the impact of hazard factors in selected engineering project in construction, oil and gas in selected industries in Niger Delta delivery alongside the identification of the hazard factors and their various hazard levels.

Sample Size and Sampling Techniques
For the purpose of this study, projects and engineering departments in engineering organizations in Bayelsa and Delta states constitute bulk of the area of survey site. Also, all projects executed in Port Harcourt where the researcher had contacts with project engineers, managers, and consultants were used. Practitioners in engineering projects with varied years of experience in the industry and varied organizations in Niger Delta ranging from five to twelve years of experience were selected to respond to questionnaires.

Data Collection Technique
Primary data were obtained from interviews and questionnaires that were administered. The questionnaire used for data collection is presented in Table 1. It is similar to the questionnaire used in Ref [21].

Methods of Data Analysis
The analysis of data carried out is to establish the level of hazard of various identified hazard factors in the engineering project and also evaluate the effect of these variables as they are impacted on projects in terms of the quality, cost and project delivery period. The measurement of the effect of hazard factor and variables responsible for any likely deviations to the project aims and objectives were done through tabulations, percentages and the use of clear charts. Descriptive technique will be used as an approach to explain the results obtained. The analysis of the data was done by weight-scaling method. Specifically, the practitioners weigh and assess the hazard identified in terms of the level of hazard, relative consequences if hazard occur and the project objective affected mostly.

Table 1: Questionnaire for data generation

Hazard Characterization	**Hazard levels**				**Consequences**				**Effects**		
	A				B				C		
Hazard weightings	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**
1. Technical Hazard Items											
i. Subsurface uncertainties											
ii. Use of new technology											
iii. Complexity of technical solution											
iv. Material defect and failure											
v. Loss when new project fails											
vi. Procurement logistics											
2. Commercial Hazard Items											
i. Contractors Hazard											
ii. Changes in contracting policy											
iii. Loss of customer to competition											
3. Economic and Financial Hazard Items											
i. Material price variation											
ii. Currency fluctuation											
iii. General inflation											
iv. Funding hazard											
4. Social-Political Hazard Items											

KEY

A. RISK LEVEL

1. Negligible hazard
2. Low hazard
3. Significant hazard
4. High hazard

B. CONSEQUENCE LEVEL

1. Negligible consequence
2. Low consequence
3. Significant consequence
4. High consequence

C. EFFECTS ON PROJECTS

1. Cost implications
2. Project delivery period
3. Quality

i. Labour market fluctuations												
ii. Changes in contracting policy												
iii. Loss of customer to competition												
5. Legal Hazard Item												
i. Violation of regulation												
6. Stakeholders Hazard Items												
i. Changes in requirement												
ii. Hidden Agenda												

The hazard level, consequences and the parameters most affected are sought as in columns A, B and C. The hazard items are characterized into 6 groups. With a number of item (s) in each group.

In column A:, we have the hazard level assessment as weighed by the practitioners. The weighing Levels are:

1 = Negligible hazard
2 = Low hazard
3 = Significant hazard
4 = High hazard

From the questionnaire, all individual assessment of the respondents for the various hazard items were collated using this scale. The total weight or assessment is obtained by summing the respondent weights. That is, total weight A_T is,

$$A_T = A_1 + A_{2.} + \ \dots + A_n \qquad (1)$$

where subscripts $1, 2, \dots, n$ identified the various respondents and A is the weight assessed by the practitioner. The mean weight and the percentage weight are calculated using Equations (2) and (3) respectively,

$$\text{Mean weight}, \bar{A} = \frac{Total\ weight}{Number\ of\ respondents} \qquad (2)$$

$$\text{Percentage weight, A \%} = \frac{\text{mean weight}}{4} \times 100 \qquad (3)$$

This percentage weight gives the average hazard level of the respondents and equally indicates the level of importance.

Column B contains the consequence level assessment of the hazard by practitioner. The weighing scales are:

1 = Negligible consequence
2 = Low consequence
3 = Significant consequence
4 = High consequence

Similarly, the total assessment or weights for consequence level of hazard items were obtained by summing the respondent's weight, i.e.

$$Total\ weight\ , B = B_1 + B_{2.} + \cdots + B_n \qquad (4)$$

Where the subscripts 1, 2, …, .n indicates the various respondents and B is the weight assessed by the practitioner.

The mean weight, $\overline{B} = \frac{\text{Total weight}}{\text{Number of respondents}}$ (5)

$Percentage\ weight,\ B\,\% = \frac{\text{mean weight}}{\text{maxi mum score (four)}} \times 100$ (6)

This percentage weight gives the average consequence level of the respondents and equally indicates the level of importance.

Column C indicates the most affected project objectives, where
1 = Cost implications
2 = project delivery period, and
3 = quality

The respondents indicate the most affected project objective if a particular hazard occurs by ticking either of the numbers 1, 2 or 3 in the last row of the questionnaire.

RESULTS AND DISCUSSION

The results obtained were from analyzing responses to the questionnaire given to project practitioners. Table 2 shows the respondents and their years of experience.

Table 2: Respondents with years of experience

Years of Experience	No. of Respondents	% Respondents
2	5	11.90
4	7	16.67
6.5	11	26.19
12	10	23.80
16.5	5	11.90
20.5	4	9.52
Total	**42**	**100**

The hazard level of the various factors in the project is shown in Table 3, the hazard factor consequences levels are shown in Table 4 while the project objectives mostly affected by the different hazard factors are shown in Table 5.

Table 3: Hazard Level of various hazard factors in engineering project

S/N	Hazard Factor	Hazard level (average of mean weights)	Percentage weight (%)
1	Technical Hazards	3.42/4	85.50
2	Commercial Hazards	3.15/4	78.75
3	Economical/Financial Hazards	3.49/4	87.25
4	Social/Political Hazards	1.91/4	47.75
5	Legal Hazards	1.67/4	41.75
6	Shareholders Hazards	2.29/4	57.25

Table 4: Hazard factors consequences level

S/N	Hazard Factor Consequence	Consequence Level (Average of Mean Weights, B)	Percentage (%)
1	Technical Hazards	3.16/4	79.00

2	Commercial Hazards	2.87/4	71.75
3	Economical/Financial Hazards	3.50/4	87.50
4	Social/Political Hazards	2.20/4	55.00
5	Legal Hazards	2.14/4	53.50
6	Shareholders Hazards	2.63/4	65.75

Table 5: Hazard factor effects on engineering projects

S/N	Hazard Factor	Project Objective Mostly Affected
1	Technical Hazards	Quality and Cost
2	Social/Political Hazards	Delivery schedule and cost
3	Economical/Financial Hazards	Cost of execution
4	Commercial Hazards	Delivery schedule
5	Shareholders Hazards	Cost, quality and delivery
6	Legal Hazards	Delivery schedule

The different hazard factor items for each hazards factor and their hazard levels and consequences are shown in Tables 6 to 10; that of legal hazard is not shown separately .because it has only one item which hazard level and consequences is same as those shown in Tables 3 and 4 respectively.

Table 6: Technical hazard factors items, their hazard levels and consequences

S/N	Hazard Factor Items	Hazard Level, %	Consequence level, %
1	Subsurface uncertainties	88.4	73.5
2	Use of new technology	96.2	87.5
3	Complexity of technical solution	85.8	77.5
4	Material defect and failure	76.6	73.7
5	Loss when new project fails	97.9	95.3
6	Procurement logistics	77	67.3

Table 7: Commercial hazard factor items, their hazard levels and consequence

S/N	Hazard Factor Items	Hazard Level, %	Consequence level, %
1	Contractors Hazard	91	89.6
2	Changes in contracting policy	66	47.5
3	Loss of customer to competition	84	82

Table 8: Economic and financial hazard items and their hazard levels and consequences

S/N	Hazard Factor Items	Hazard Level, %	Consequence level, %
1	Material price variation	95.4	93.9
2	Currency fluctuation	88.7	84.8
3	General inflation	87.5	92
4	Funding hazard	83	84.8

Table 9: Social-Political Hazard Items and their hazard levels and consequences

S/N	Hazard Factor Items	Hazard Level, %	Consequence level, %
1	Labour market fluctuations	59.4	40.4
2	Changes in contracting policy	47	49

3	Loss of customer to competition	39.8	75.4

Table 10: Stakeholders hazard items and their hazard levels and consequences

S/N	Hazard Factor Items	Hazard Level, %	Consequence level, %
1	Changes in requirement	68	87.7
2	Hidden Agenda	49.8	47.2

The technical hazards and the economic/financial hazards have the highest hazard level as well as consequence eve. Leal hazard has the lowest hazard level and lowest consequence level as well. This is similar to the risk analysis results obtained in Ref [21]. Unlike the risk analysis results obtained in Ref [21] where the hazard level for each risk factor is always greater than the consequence level, the results of the hazard analysis in this work shows that for some hazard factors, the hazard level is greater than the consequence level while for others, the consequence level is greater than the hazard level. Figure 1 shows this occurrence.

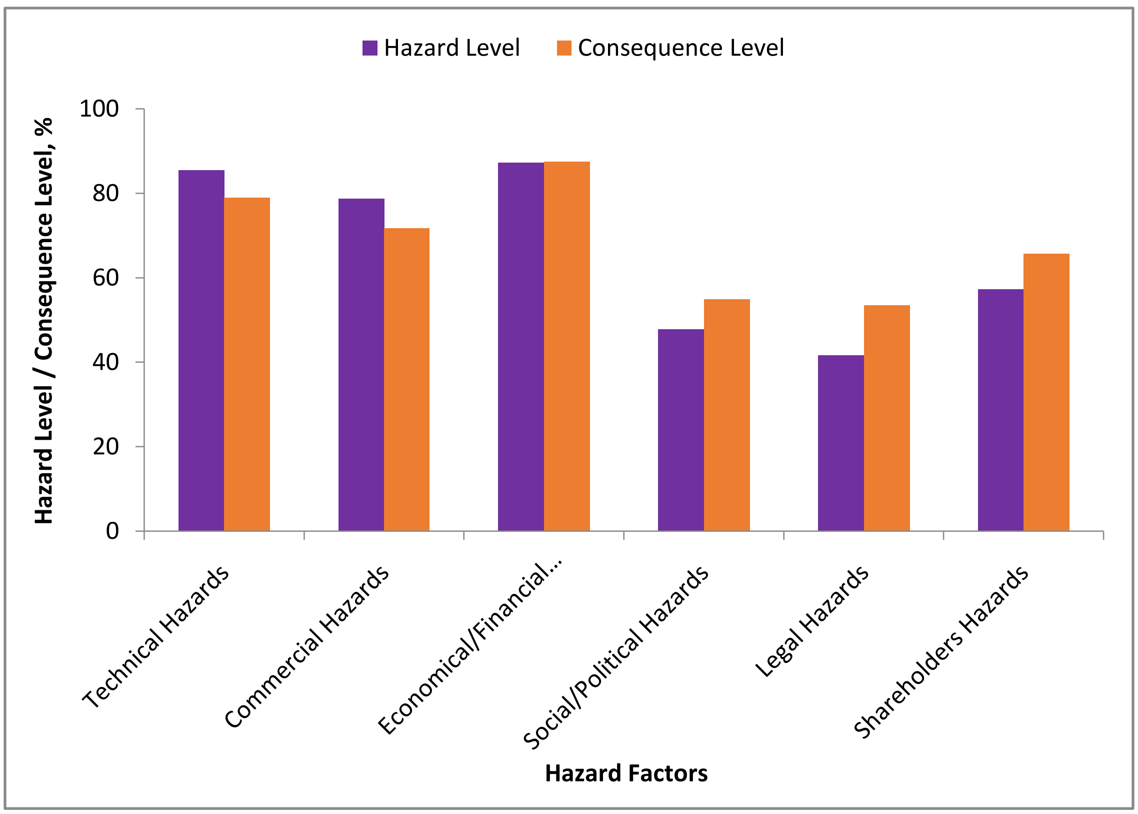

Figure 1: Average percentage hazard level and consequence level of the various hazard factors

CONCLUSIONS

The study identifies the need for control and hazard assessment in engineering projects which indicate that the problem of hazard assessment in construction/engineering project execution has its root in the attitude of the personnel/professional running the engineering projects. The investigation identified that economic/financial hazards (87.25%), technical hazards (85.50%)

and commercial hazards (78.75%) were recorded as hazards of high level. The aim of every project advancers is the realization of the project within the planed estimated schedule of the project in terms of quality, cost and time. To achieve these objectives it will require the adoption of adequate control module and hazard assessment at the time of execution of the project linked with greater discipline on the part of the project execution practitioners to stay within his estimates from inception of the project to completion. However, hazard assessment in any engineering projects is a difficult and complex process, which varies from one organization to another. It should be viewed as an ongoing process, which needs continual planning, monitoring and modification as the needs arises.

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