A MODEL FOR PERFORMANCE INDICES IN OIL AND GAS INDUSTRIES

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ABSTRACT

Safety management is an act of entrenching some fundamental guideline, framework, processes, principles and measures to mitigate accidents such as injuries and other related consequences that may be caused using a facility or a product. Thus, the safety of any organization is a priority choice decision by any management to offer best safety system to all concerned. Obviously, safety management system comes with a very high premium and yet the implementation of safety precautions nose dive with little or no credibility has created unstable state within workforce. In this study, we introduce an experimental design model known as the Central Composite Design (CCD) with five coded levels architecture of four factors that would give a functional relationship with the proposed global method for adequate fitting of data as generated from the compiled questionnaire. But for the purpose of this study, the author focus more on the design model that can be implemented with computer application for a precaution model validation of the safety measures entrenched in Oil and Gas sector through the justification of data analysed from respondents. Safety management is complicated due to the complex "nature" of the workplace. Some of the safety factors that have been identified include risk management and site management, organizational complexity ratio and combinations of such factors connected to safety performance and the model as proposed has capacity to mitigate these excesses.

Keywords: Safety, Oil and Gas, Organization, Precaution, Hazard and incident

INTRODUCTION

The primary goal of effective safety programs is excellent performance. The desire to make this happen can only be seen from a committed organizational staff and management. Though, zero injuries can be seen as impossible because it takes collective will by management and staff members to adhere to every tenet of the organizational safety precaution. The procedural doctrine by well cautious staff would be to guide oneself from getting hurt so as improve work performance. Employees striving to be good corporate citizens and community members must employ best strategy to improve safety at work place. The amount of successes recorded by many companies is based on sustained excellent performance on safety management. Although, companies with strong safety programs and guidelines sometimes have lapses and this is because people make mistakes and equipment has capacity to malfunction unexpectedly. Naturally, human has instinct to foreseen and prevent possible hazard effects. Same goes to equipment designed with

appropriate guidelines with aim to maintain them correctly. On the same approach potential failures can be anticipated as well and prevented (He, et al., 2012). The end product of work ethics is centred conscious focus excellent safety performance, dedication and perseverance by stake holders such as the management and employees who take purposeful actions to implement, improve and sustain effective safety practices (Klein, 2021). It is established a well-articulated and planed safety management is of prime importance. Evidence from Agyekum *et al* (2022), Adebiyi (2020), Adebiyi *et al* (2018), Gong *et al*, (2021) and Rivera *et al* (2021), suggests that many organizations do not consider safety adequately.

Despite the success stories of manufacturing safety, organizations are still reluctant, perceiving it as cost increasing and time consuming. It is largely understood that to improve safety performance, attention needs to be given beyond the immediate working conditions and worker actions (Gambatese and Al-Omari, 2016; Edionwe and Mbegbu, 2022). Performance definition involves performing safety program necessities and systems to achieve program goals. These goals include avoidance of serious injuries and incidents. This also involves the use of other leading and lagging indicators to measure the functioning and effectiveness of safety amongst staff through activities that provides early warning. There are several matrix for warning health seekers because the medical professional routinely measure vital signs for early warning of potential health problems, it on this premise that appropriate metrics be created to monitor personnel overall injury to ensure safety program performance (Yousefi, *et al*., 2020).

The importance of this study which is to compare safety performance systems in organizations cannot therefore be over emphasized. Safety management is applying set of principles, framework, processes and measures to ensure performance with the aim to mitigate injuries and other related consequences that may be caused by using a facility or a product (Pickle *et al*., 2008; Najafi *et al*., 2011). Thus, the safety of any organization is a priority choice of any management decision to offer the best safety system to all concerned. Obviously, safety management system comes with a very high premium and yet the implementation of safety precautions nose dive with little or no credibility. In this study, we introduce an experimental design technique known as the Central Composite Design (CCD) with five coded levels and four factors that would give a functional relationship with the proposed global regression method for adequate fitting of the data as generated from the compiled questionnaire (Yeniay 2014). Thereafter, a single response optimization is performed to minimize the Squared Distance from Target (SDT). Lastly, a computer application will be applied for model validation on the regression method to further justify the results obtained from the predictive response for selected oil companies. Safety management is a complicated concept because work place is seen to be complex. Some of the work safety factors that have been identified include risk management and site management, organizational complexity and combinations of such factors to safety performance. From the various review there are accidents and injuries reported, hence making the traditional method far from solving the problem. Despite recent advances in technology, the presence of risks for workers has become an unresolved social problem. Companies recognize the necessity of mitigating risks posed to worker only after an accident has occurred (Wan and Birch, 2011; Mays *et al*., 2001).

Adebiyi *et al* (2018) developed a mathematical model for evaluating profitability of safety and health program in

tobacco industry in Nigeria. In their work, a cost function monetary savings/loss of accidents and health incidences preventions was developed. Accidents and health incidences for both pre safety period data and safety program period of data were adequately collected with four classes of accidents identified as fatal, serious, minor and trivial wounds with their costs determined as N2,455,750, N221,275, N26,780, and N2,000, respectively. Also, seven health incidences as captured were identified and this include hearing issues, back pain/ache, leg pain/ache, chest pain/ache, neck pain/ache, eye issue and headache with their costs determined as N18,176, N22,987, N8,354, N17,296, N33,305, N14,432 and N12,842, respectively. There are monetary savings for accident prevention and N40.1 million while about N9.7 million were seen to have lost on health incidences annually. The results showed that the safety program performance indices range from 5.78% in 2002. Akinyemi and Adebiyi (2019) in their work developed predictive models to evaluate runway safety investment strategies to predict the overall performance of the aviation system using System Dynamics stock and flow diagram. To aid the full actualization, an interactive computer program models was written in Java programming language. This was carried out through a set of dynamic equations for predicting several runway accidents, preventions, monetary savings/losses. The runway safety intervention effectiveness factor and level of budget implementation are the policy parameters for controlling the mechanism of a runway safety system. Important data were obtained from Federal Aviation Authority, Nigeria to help validate the models. Twenty-nine runway safety quantities were told to have been identified. The dynamic equations for several runway accident preventions and monetary savings/losses showed some exponential growth, while the number of runway accidents displays exponential decay (Shin *et al*., 2021). The results of the simulation run, showed no significant gaps between the former and real-life situations; hence, the models can serve as useful tools to effectively and efficiently manage the performance of the runway safety program.

METHODOLOGY

Software development methodology was the structured process used during this research work and reasons being that it is a framework that is used to structure, plan, and control the process development of an information system. In this study, we adopted the Waterfall development method. The waterfall method is a rigid linear model that consists of sequential phases (requirements, design, implementation, verification, maintenance) focusing on distinct goals that enable us to 100% complete a phase before the next phase began.

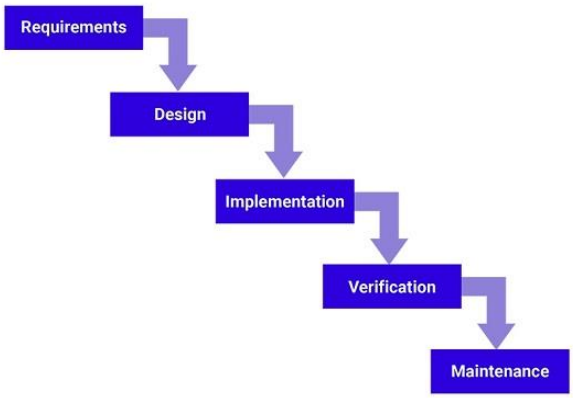

Figure 1: Waterfall model

The linear nature of the waterfall development method makes it easy to understand and manage projects with clear objectives and stable requirements.

Data Gathering

Questionnaire was developed to generate a quantitative primary data from staff of four (4) oil companies operating in Nigeria to answer the research questions. Two (2) of the four (4) oil companies are indigenous oil companies and the other two (2) are foreign oil companies operating in the shores of Nigeria. The staffs selected for this research were picked at random from

various departments of the companies (it was not limited to those staff working in safety department alone). They were assured that their names and the names of their companies will not be mentioned in this research work before some of them agreed to be part of the survey. The questionnaire consists of a set of restricted questions for respondent to make choices. The questions include company's safety: whether safety related training is provided for those working in hazardous environment, provision of safety equipment (personal protective equipment), whether managers discuss safety issues with workers on sight of operation and as well as whether workers in critically safer environment actually comply with safety regulations. The questionnaires consist of a five-point (Likert scale) in which the different options are assigned numerical value from 5 to 1. With the help of the questionnaires, relevant information concerning safety of work force in the oil and gas industry were gotten.

The Present System

For clarity on how the work should go a deeper analysis was made the present operation to understand its scope so as create a system that would best address the existing challenges. The process of safety management in the organizations selected for this study include the followings:

i. Workers undergo training on accident prevention and are provided with the required safety equipment.
ii. The companies have policies on safety in place. Their site managers usually encourage them to think safety during the performance of their duties.
iii. The companies also require employees to report directly to their immediate supervisor to file a report.
iv. Issues of safety are dealt with as soon as they occur.
v. Workers have site managers who are specialists in safety matters and give them regular briefings of safety in workplace.

Architecture of the Present System

The Gap Identified

During clear cut analysis on how the current system works this study was able to unravel gaps such as:

(1) That though the individual companies have safety department and support their staff with training and relevant workplace equipment (Personal Protection Equipment) to ensure their safety, information on safety issues are not reported to outside bodies such as the Organization for the regulation of safety practices in workplace.
(2) It is believed when safety issues are reported to such bodies, they will take a holistic approach by training and sharing ideas with other related companies on how best to handle such safety issues. Such bodies when fully informed about accident in different workplaces will collate such data and use it to the benefit to all the stakeholders in the various industries.

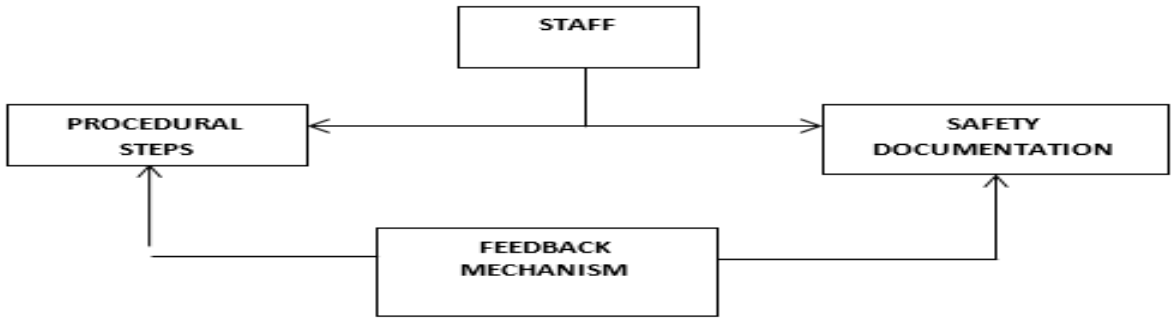

Figure 2. Architecture of the present system and it workings

In order to come up with a holistic approach that best address the challenges as seen from the reviewed literature and present system this study create a system that best handle the negative issues associated with the present system. The staff module represent the entire workforce of the organization and they are expected to carry out their job functions in line with the company's laid down procedures and policies. Having the understanding that "safety is everyone's business" the entire staff, visitors and contractors are expected to work safely in the company's premises. On the procedural steps, there are laid down procedures and policies that guide workers on how to carry out specific jobs in a particular environment. If a worker deviates from these procedures and policies in the course of executing his/her job, then is deemed to be working unsafely. The safety documentation is majorly about proper documentation and keeping of records, safety cannot be practice without documentation and record keeping. For instance, all jobs carried out in a company's premises are expected to be documented with the use of a PTW (Permit to Work) system. This permit to work is duly signed by those involved in the job as well as the safety officer on ground to ensure the job is done according to the company's policies and procedures. Furthermore, feedback mechanism as captured by the architecture is an independent, non-governmental, international organization that develops standards to ensure the quality, safety and efficiency of products, services and system in organizations known as ISO (International Organization for Standardization). It usually goes to inspect the safety practices, procedures, company policies and documentation of companies before they are standardized to be recognized internationally. Obtaining these standards give oil companies and as well as other companies an edge over peers in the business environment.

Problem with the Present System

One critical area as revealed by this study is that within the multinational organizations as sampled, safety is integrated in the day to day work environment and the method for recommendation and reporting safety issues is in-house affair. The degree to which each of the staff is involved in safety programs varies. Based on the aforementioned, there is no comparative analysis of how they performed individually as it concerns safety. Also safety is not usually reported outside the organization. Organizations concerned with safety do not have offices in these companies and it is the information the companies make available to such body that enables the said organization determine their level of compliance with safety matters. This situation makes it very difficult for the safety organization to determine the level of compliance on safety issues as well as aspects of safety that needs improvement. Without reliable data regarding to workplace hazards, it is difficult to effectively focus inspection and

compliance on the most hazardous workplaces.

The Proposed System

The proposed system is a web-based analysis of safety of multinational and national co-operations operating in oil and gas sector in Nigeria. Data was collected with the use of questionnaire which required the respondents to respond to safety issues. The data were analyzed and grouped together according to the performance of the various companies as it relates to accident reporting, provision of training, companies' policy on accident, provision of safety instructions by managers at the site of operation and workers compliance with safety precaution. The average performance of safety in the aforementioned areas were computed and inputted into a web application that has been designed to do comparative analysis of safety issues in the said companies. The comparison was based on the overall performance, performance in training, performance in provision of personal protective equipment, performance in workers compliance as well as performance on company's policy on safety. With the said web application, it is possible to determine which company performed best in all the various aspects of safety in the workplace. Information on accidents in workplace is very critical especially in the provision of training and equipment to forestall the reoccurrence of similar accidents in future. Every organization is bound to fulfill the compliance related to the health and safety of the employees and every individual associated with it. This is not specified to any particular industry, but some industries are at higher risk because of their sensitive production processes that involve risky tasks to be performed by the employees. Those organizations that do not comply with the regulations toward them by the state on health and safety are at higher risk compared with other organizations. This may result in loss of lives and health hazards to the people working there.

Oil and gas safety also hinge on the industry's resolve to support product stewardship to deliver safe products that champion safety. Implementing safety measures is just the beginning but monitoring safety improvements become quintessential to supplementing oil and gas safety management. Safety in Oil and Gas industries can be enhanced with the provision of appropriate data. This will enable the users of such information to be strategic in their planning and for the good image of the companies concerned. Where data is not available it becomes very difficult to plan and workers safety cannot be assured especially in Oil and Gas where safety precaution is very important.

Architecture of the proposed system

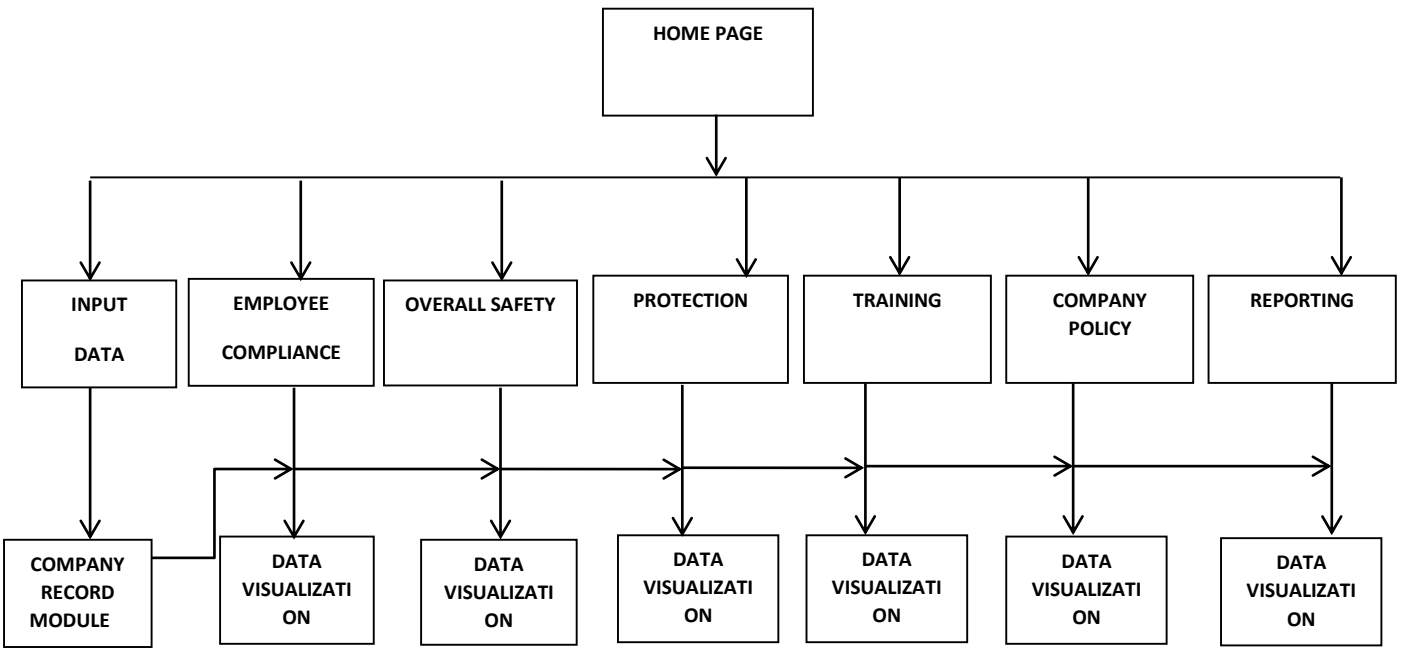

Figure 3**:** Architecture of the proposed system (Central Composite Design (CCD))

The system utilizes coherent attributes to functionally resolve all safety issues as it relates to hazardous state of human life, as life is considered one of the most precious gift that cannot be given by man except God. The designed architecture as seen in Figure 3 is an improvement model on the current method witnessed across oil and gas industries who have little on compliance effort towards safety precaution. When figure 3 model is compared with figure 2 it could be clearly understood the introduction of various modules that help capture all incidents that may arose when safety precaution is not complied with.

RESULT

Transformation of Data from Central Composite Design (CCD) to Response Surface Methodology (RSM) for the nonparametric regression techniques in RSM, the values of the explanatory variables are coded to lie between 0 and 1.

The data collected via a Central Composite Design (CCD) is transformed by a mathematical relation:

$$x_{new} = \frac{Min(x_{old}) - x_0}{(Min(x_{old}) - Max(x_{old}))} \quad (1)$$

where the transformed value is x_{new}, x_0 is the target value that needed to be transformed in the vector containing the old coded value, represented as x_{old} , $\mathrm{Min}(x_{old})$ and $Max(x_{old})$are the minimum and maximum values in the vector x_{old}respectively, see (He *et al*., (2012)).The natural or coded variables in Tables 3- 5 can be transformed to explanatory variables using equation below.

Target points for the four coded variables that needed to be transformed for location 4 are given below:

Target points $x_0: -1, 1, -1, 1; Min(x_{old}): -2, -2, -2, -2;\ Max(x_{old}): 2, 2, 2, 2$

$$x_{new} = \frac{Min(x_{old}) - x_0}{(Min(x_{old}) - Max(x_{old}))}$$

$$Explanatory\ variable\ x_1 :\ x_{41} = \frac{-2 - (-1)}{((-2) - (2))} = 0.2500$$

$$Explanatory\ variable x_2 :\ x_{42} = \frac{-2 - (1)}{((-2) - (2))} = 0.7500$$

$$Explanatory\ variable x_3 :\ x_{43} = \frac{-2 - (-1)}{((-2) - (2))} = 0.2500$$

$$Explanatory\ variable x_4 :\ x_{44} = \frac{-2 - (1)}{((-2) - (2))} = 0.7500$$

Target points needed to be transformed for location 23 under the coded variables are given below:

Target points x_0: $2, 0, 0, 0, 0; Min(x_{old})$: $-2, -2, -2, -2;\ Max(x_{old})$: $2, 2, 2, 2$

$$x_{new} = \frac{Min(x_{old}) - x_0}{\left(Min(x_{old}) - Max(x_{old})\right)}$$

$$Explanatory\ variable\ x_1 :\ x_{23,1} = \frac{-2-(2)}{((-2)-(2))} = 1.0000$$

$$Explanatory\ variable x_2 :\ x_{23,2} = \frac{-2-(0)}{((-2)-(2))} = 0.5000$$

$$Explanatory\ variable x_3 :\ x_{23,3} = \frac{-2-(0)}{((-2)-(2))} = 0.5000$$

$$Explanatory\ variable x_4 :\ x_{23,4} = \frac{-2-(0)}{((-2)-(2))} = 0.5000$$

Repeating the process up to location 30, then we obtain the entries for explanatory variables x_1 , x_2 , x_3 and x_4 respectively NPDC, IDSL, BGP and SHELL representing transformed RSM data that needed to lie between zero and one inclusively.

DISCUSSION

The current model for accident management as seen in figure 2 consist of training of workers, hazard control, ongoing worksite inspection, incident investigation, program administration review, emergency response planning and hazard identification. All these functions are done internally without the involvement of outside bodies who are users of accident information. Such outside bodies include organization of safety in work place. They have a great role to play in ensuring safety in a special way for workers because of the numerous data on safety at their disposal. A situation in which accident in work place is dealt with internally without bringing in other relevant stakeholders in accident management may not be very helpful for accident management in workplace**.** In the proposed model as stated in figure 3 accident management is dealt with both internally and externally by ensuring proper reporting of accident to the relevant stakeholders outside workplace. The users of such information have a role to play in monitoring to ensure compliance and training in order to guide against the reoccurrence of similar cases of accidents in workplace. This is the aspect that was not covered in the present model. In the present model, cases of safety reporting are dealt with internally without the involvement of the relevant stakeholders concerned with hazard management in workplace. The proposed model is a web base management system that help captured issues beyond the present system and it is believed that has brought about turnaround in the way incident cases would be handled moving forward.

In conclusion, Safety management is an act of entrenching some fundamental guideline, framework, processes, principles and measures to mitigate accidents, injuries and other related consequences at work place. This work has been able to demonstrates that safety of staff in any organization is a priority choice of any management decision to offer the best safety system that would best solve or stop it potential devastating effect on human. This work is a robust

platform created to mitigate or probably put an end to hazard associated with organization and thereafter create a good working environment for all staff within and outside the organization.

REFERENCES

Adebiyi, K. (2020) A Bi-Objective Modelling of Manufacturing Safety Programme Planning and Management.https://www.researchgate.net/publication/342533512_A_Bi-Objective_Modelling_of_Manufacturing_Safety_Programme_Planning_and_Management.

Adebiyi, K., Ajayeoba, A. O, OluwoleAkinolaAdunbarin, A. O. and WasiuRaheem, W. (2018).Modelling the Performance of Occupational Safety and Health in a Tobacco Manufacturing Industry in Nigeria.https://www.researchgate.net/publication/327399627_Modellingthe_Performance_of_Occupational_Safety_and_Health_in_a_Tobacco_Manufacturing_Industry_in_Nigeria

Agyekum, K., Simons,B. and Botchway, S. Y.(2022) Factors influencing the performance of safety programmes in the Ghanaian construction industry, ActaStructilia, 25(2), pp. 39-68. Available at: https://www.ajol.info/index.php/actas/article/view/180639.

Akinyemi, O. and Adebiyi, K. (2019). Development of System Dynamics Based Simulation Models for Runway Safety Planning. http://ijiepr.iust.ac.ir/article-1-854-en.pdf.

Edionwe, E. and Mbegbu, J. I. (2022) "Local Linear Regression and the problem of dimensionality: a remedial strategy via a new locally adaptive bandwidthsselector", *Journal of Applied Statistics,Vol.50, No. 6, pg. 1283 – 1309*

Gambatese, J. and Al-Omari, K. (2016). Degrees of connectivity: Systems model for upstream risk assessment and mitigation. https://pubmed.ncbi.nlm.nih.gov/26772820/

Gong, S., XinGao, X., Li, Z. and Chen, L.(2021). Developing a Dynamic Supervision Mechanism to Improve Construction Safety Investment Supervision Efficiency in China: Theoretical Simulation of Evolutionary Game Process.https://pubmed.ncbi.nlm.nih.gov/33808439/

He, Z., Zhu, P. E. and Park, S. H. (2012). A robust desirability function for multi-response surface optimization. European Journal of Operational Research, 221: 241-247. https://pubmed.ncbi.nlm.nih.gov/28454862/. https://pubmed.ncbi.nlm.nih.gov/33202768/

Klein, J. (2021). Factors That Impact Safety Performance: How to Achieve and Sustain Excellent Performance.https://www.abs-group.com/Knowledge-Center/Insights/Factors-That-Impact- Safety-Performance-How-to-Achieve-and-Sustain-Excellent-Performance-%5BPart-1%5D/

Mays, J. E., Birch, J. B. and Starnes, B. A. (2001). Model robust regression: Combining parametric,

Nonparametric and semi-parametric models. Journal of Nonparametric Statistics, 13: 245 - 277.

Najafi, S., Salmasnia, A. andKazemzadeh, R. B. (2011). Optimization of robust design for multiple response problem. Australian Journal of Basic and Applied Sciences, 5:1566 – 1577.

Osagie, M. S. U., Obahiagbon, K. O., Inyang, A. I., & Osagie, J. A. (2018). Digitalized responsive logical interface application. arXiv preprint arXiv:1805.05846.

Pickle, S. M., Robinson, T. J., Birch, J. B. and Anderson-Cook, C.M. (2008).“A semi-parametric model to robust parameter design.*Journal of Statistical Planning and Inference*, 138: 114-131.

Rivera, F. M., Mora-Serrano, J. and, Oñate, Eugenio. (2021). Factors Influencing Safety on Construction Projects (fSCPs): Types and Categories.https://www.sciencegate.app/document/10.1108/ecam-07-2020-0525.

Shin, J., Kim, Y. and Changhee Kim, C. (2021)The Perception of Occupational Safety and Health (OSH) Regulation and Innovation Efficiency in the Construction Industry: Evidence from South Korea. https://pubmed.ncbi.nlm.nih.gov/33673463/

Wan, W. and Birch, J. B. (2011). A semi-parametric technique for multi-response optimization. *Journal of Quality and Reliability Engineering International*, 27: 47-59.

Yeniay, O. (2014). Comparative study of algorithm for response surface optimization.*Journal of Mathematical and Computational Applications*, 19: 93 – 104.

Yousefi, Y., Karballaeezadeh, N. and Moazami, D. (2020).Improving Aviation Safety through Modeling Accident Risk Assessment of Runway.https://www.researchgate.net/publication/343788749_Improving_Aviation_Safety_through_Modeling_Accident_Risk_Assessment_of_Runway