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CHALLENGES AND EFFECTS OF CLIMATE CHANGE ON CONSTRUCTION SITES TOWARDS EFFECTIVE SITE MANAGEMENT SKILLS IN ADAMAWA STATE, NIGERIA

By

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ABSTRACT

The major purpose of this study is to determine the effects of climate change on construction site, the challenges to overcome, and the effective skills needed to overcome the challenges. The design of the study is descriptive survey. The populations for the study are civil engineers, Structural engineers, Professional and nonprofessional experienced builders (the Sites managers and lecturers). The population were grouped into two groups; i. the civil engineers, Structural engineers and professional builders. and nonprofessional site Managers. ii, lecturers in building related trades such as architecture, structural engineers builders and quantity surveyors formed the second group. The total number of the population is 135. 135 questionnaires were distributed and collect back immediately after responded to, representing hundred percent. Two Lecturers from Adamawa State Polytechnic and two experience site managers validated the instrument. The data collected was analyzed using Mean, Standard deviation. The finding of the study revealed that climate change post challenges to the site managers, affects site management activities such as focusing, designs implementation and schedules of material supply there for affect the cost, time and the quality of the final product (building).

KEYWORDS:

Climate, Change, Weather, Management, Construction, Site and Managers



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Introduction

Climate change is universally figured as the major factor affecting the glow as well as the building environment. Abubakar (2018) defined climate change that occurred on the earth planet and attributed it to direct and indirect human activities. He further observed that within a comparable time periods, Climate change is usually caused by frequent rainfall and extreme dry season. Abubakar explained, hundred years ago, people worldwide began burning more coal for transportations. Burning fissile fuels releases carbon dioxides in atmosphere this additional greenhouse gases have caused earth to warm more than it has in the past, Gardinal (2009), in his contributions stated that change is more likely to increase the challenges of properties development and the need for more training for site managers in building industries..

The effect of climate change on nations economic cannot be over emphasized. The United Nation Scientific Cultural Organization (2008) stated that climate change affects the ecosystem as it create desertification and serious flooding. thus increases the risk and cost associated with purchase and supply of the needed materials. Akinola, Afuye, and Osho (2023), stated that the chemical changes weathering of the soul, temperature and humidity levels rise. This may result in metal structures Corrosion leading to the building collapse being experienced in Nigeria and other cloud. Metal structures such as roof, reinforce concrete are likely affected. Voh (2012) stated that an abnormal and extreme heat wave killed 2005, and at least 1,300 people died as a result of hurricane Katrina which is causing an estimated 35 billion dollar economic damage (Innovest, 2012)

Bell and Ogunsammi (2012), observed that the unstable condition of climate alters the expected period set for the project. This is because it becomes difficult to predict the weather. Sometimes design execution much difficult matter and therefore cost much expensive proposed (Apagu and, 2013). Climate change makes site management very challenging, making forecasting weather, cost of materials, and duration of the construction very difficult because of the changes and interruptions that occur especially in planning hiring and storing and scheduling of jobs.

Ordering or supply of materials can sometimes, be disrupted by either of the elements of weather and climate charge for instances rainfall can stop the supply or storage of cement. Accesses road to the site, storage facilities if not well constructed, the excessive rain, wind or heat both can disrupt transporting materials to the site. The project manager will be able to know where and when relevant materials may be released for use on other projects. All these should be known in advance. This information will permit the effective use of all resources.

Building Standard of Nigeria (BSN), 2008 listed the benefits of Site management;

- Enable unproductive time of both human and plants to be minimized if not totally eradicated.
- Facilitates checking of types or materials required, time required etc by which work progress can be measured
- Aids the firms by being a future working apparatus of work method which is efficient. It also exposes difficulties likely to occur in the future and facilitates re-organization to overcome such problems in future.
- Provides faster and more efficient construction, reducing on-cost and general overheads and
- The overall results in due course are reflected in more accurate and keener estimating.(pp12).

Bello and Ogunsammi (2012) presented some site management' skills affected by climate charge

1. Materials forecasting

2. Materials processing or requisitions

Ordering, Loading, transportation and off-loading of materials/equipment. (pp. 34). Nilsonetal further stated that these functions are co-ordinated while the type of loading determines the method of lifting; some manual control will still be required. for mechanical handling;- Understanding the situation at site, discussing the form of packaging beforehand and controlling the sequence of the transportation/deliveries, using the right equipment for lifting or loading Adopting firm control of all operation, storage of materials protection security and forecasting the overall Programme. In their observation Bello and Ogunsammi (2012) stated in their study that the site manager should have control plan which includes: Recording of delivery to site, Installation of plant on site, Maintenance and services, Repairs and overhauls and Ensuring operators are briefed. (pp. 6)

The built environments usually supervised by site managers were supposed to be the safest. It is expected that during the construction process the site Manager skillfully addressed all challenges that may occur during and after the construction processes. The built environment not only provides shelter and safe place to the occupants but comfort as well. Well-built structure should be able to withstand both internal and external challenges; these could either be imposed or superimposed. Balami, Soji, Usman and Adaji,(2023) observed that buildings from design should be equipped with all that are needed to stand the challenges it may be subjected to the imposed or superimposed.

Recent events have shown that build environments are no longer safe because of the incidences of defacing of the structures, cracks, and even collapse of the structures resulting to lose of lives and consequently economic challenges or lost. Example of these occurrences is the collapsed of buildings on construction, in Lagos killing the owner, the workers, and hawkers who were in the building during the incident. These incidences bring untold hardship to the family members. Studies were carried out on the causes of Building cracking, defacing and even the collapses. Little or no studies were done on the effect of climate change on the materials used for building the structures and the new effective skills needed by the site Managers, brought into play by the new challenges of climate change. The studies so far made on the effect of climate change on built environment do not seem to have addressed the effective skills needed by the Managers of the construction site. Climate change might have brought with it new challenges and require new skills to effectively handle them. These and other reasons justify the need to carry out this study in other to identify these challenges and new effective skills needed by construction site Managers, to effectively tackle the effects of climate change on the built environment by construction site Managers.

The following purposes of the study includes to; Determine the challenges of Climate change on construction site, Determine the effects of climate change on construction site, and Determine the new effective skills needed by construction site managers. Three research questions were asked; what are the challenges of Climate change on construction site? What are the effects of climate change on construction site? What are the new skills needed for effective site management? The findings of the study also have the following significances; help the site managers in managing their site. The challenges climate change would be known to site managers therefore equipped themselves with the new skills needed. That affects site management activities if made known to the managers and the contractors can be avoided. They will be able to take all necessary measures to alleviate any of the effects on site. The most important significant of the study is that it will provide a comprehensive

developed and up to date knowledge of site management activities that are usually affected by climate change. Climate change effects on construction site activities such as excavation, blinding, communication and placing of concrete can be avoided by simple forecasting in to weather. Other environmental issues that affect construction site management can be avoided when the outcome of this study is made public by publishing the study.

Operations on Site

Ekop, RintipIdongesit, and Ebiloma, (2023) stated that the contribution of the construction industry to global warming is of great environmental concern. They stated that this due to the quest for adequate concrete production, leading to the production and application of chemical admixtures which compounds the environmental impact challenges. Bello and Ogunsammi, (2012) explained that when plant is delivered to the site the time and date of delivering must be recorded. The installation and dismantling period should also be noted. Registers of any maintenance and overhauls should also be noted. Statutory inspection like that of Excavation of foundation trench should be properly inspected by the site managers to ensure they have been done to appropriate standards. "The need for an assessment of risk with regard to the support excavation and protection of people within the excavation is contained in the construction (health, safety and welfare) regulations 1996. Site managers must-ensure that as rule whenever working height is approaching 1.5m or above, working platform should be provided for the workers to ensure the job can be carried out in a safe and easy manner. Upon completion of work the working platforms should be dismantled and neatly stored. Koni and Tabunk (2010) stated that site manager should be able to delegate registration. Registration is an act of parliament. In most cases government brings in Acts to deal with some national or social need, or possible change Bello and Ogunsammi, (2012), observed that buildings from design should be equipped with all that are needed to stand the challenges, it may be subjected to the imposed or superimposed.

Safety of Building Environment

Recent events according to Gardinal, (2009), have shown that build environments are no longer safe because of the incidences of defacing of the structures, cracks, and even collapse of the structures resulting to lose of lives and consequently economic challenges or lost. Example of these occurrences is the collapsed of building on construction, in Lagos killing the owner, the workers, and hawkers who were in the building during the incident Africa Independent Television (AIT), (2022). These incidences bring untold hardship to the family members. Studies were carried out on the causes of Building cracking, defacing and even the collapses. Little or no studies were done on the effect of climate change on the materials used for building the structures and the new effective skills needed by the site Managers, brought into play by the new challenges of climate change. The studies so far made on the effect of climate change on built environment do not seem to address the effective skills needed by the Managers of the construction site. Climate change might have brought it new challenges and require new skills to effectively handle them. These and other reasons justify the need to carry out this study in other to identify these challenges and new effective skills needed by construction site Managers, to effectively tackle the effects of climate change on the built environment by construction site Managers.

Effects of Climate Change

Bello and Ogunsammi (2012) stated that effect of climate change affects site management schedules and plant. The opinions of the lecturers and that of the site managers agreed as there was no

difference in their opinions. The opinions of the respondents agreed with that of Bello Ogunsammi in which they stated that excessive rainfall affects construction activities. Bello and Ogunsammi further explained that when plant is delivered to the site the time and date of delivering must be recorded. The installation and dismantling period should also be noted. Registers of any maintenance and overhauls should also be noted. Statutory inspection like that of Excavation of foundation trench should be properly inspected by the site managers to ensure they have been done to appropriate standards. The need for an assessment of risk with regard to the support excavation and protection of people within the excavation is contained in the construction (health, safety and welfare) regulations 1996. Site managers must ensure that as a rule whenever working height is approaching 1.5m or above, working platform should be provided for the workers to ensure the job can be carried out in a safe and easy manner. Upon completion of work the working platforms should be dismantled and neatly stored.

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Construction industry worldwide is facing challenges due to global warming as a result of climate change. In optimizing the performance, durability and sustainability of concrete structures many research have been made on concrete additives to improve its adaptability. Green concrete is an environmentally friendly alternative to conventional concrete, utilizing recycled or industrial by products as partial replacements for traditional constituents. Balami, Soji, Usman, and Adaji, (2023), observed that by reducing cement content, incorporating supplementary cementations materials and utilizing recycled aggregates, green concrete reduces carbon emission, conserves natural resources and minimizes waste. In his words Gardinal (2009) in Balami et al (2023), stated that cement and concrete are widely used in construction industries due to their versatility, durability, and cost effectiveness. It is a common knowledge cement, is the primary binding agent or material is responsible for strength and stability of concrete. The combination of cement aggregates (sand and gravels), and water offers excellent structural properties such as durability, fire resistance and to some extent chemical resistance. Soil bearing strength is key information required in design of either

shallow or deep foundations. This information is gotten with more difficulties and sometime with errors due to climate change challenges which made soil becoming weaker due to increase in the soil water content, therefore affecting soil mechanics consequently its bearing capacity. This and other factors have resulted to foundations failure and collapse of structures (buildings). Ayegba, Adejumo, and Amadi, (2023), observed that bearing capacity equation originally proposed by Terzaghi, (1943) requires the effective shear strength parameter, unit cohesion (c) and angle of shearing resistance (ϕ) (i.e. effective Stress Approach, SSA) assuming drained condition in terms of pore water. Lack of standard construction materials has necessitated the search for local alternatives. In tropical and subtropical areas, lateritic soils rich in aluminum, iron appear as surface soil deposits formed from physical and chemical weathering of pre-existing rocks. In most areas in Nigeria laterites, serve as foundation materials in construction of civil engineering works without due consideration to their geotechnical behavior and site performance, mostly these accounts for unstable highway sectors in Nigeria as observed by Ayegba, et al, (2023),

Methodology

The design employed for this study is the descriptive survey research method and stratify Interview Instruments. Area of the study is Adamawa, Taraba, Gombi and Bauchi States. These states were purposely selected because they have almost the same weather/climate. These states are located at the north east region of Nigeria. The states are located between the latitudes and 800N and 1000N and Longitude 11.50E and 13.50E. the state has a population of about 3, 106,585 (Adamawa State Government, 2007).

Population of the Study

The populations for this study are civil engineers, structural engineers, professional builders and lecturers and nonprofessional site managers. The population was grouped into two groups. The civil engineers, Structural engineers and professional and nonprofessionals Builders with experiences in site management formed group one. Lecturers in civil engineering, structural engineering and Building Technology departments in all tertiary institutions and Universities within the study area formed group two. The population of the study included 135 building related trade lecturers from the Polytechnics within the states and professional engineers in building related fields, managing construction sites: The population breakdown is as presented below:

Lecturers in building related trades	70
Professionals/ Engineers on Site Management	65
Total	135

Instrument for Data Collection

Instrument for data collection is designed questionnaire. The instrument will be developed by using information obtained from the reviewed related literature. Physical observations was also used, structured interview items will be used to collect some data from the managers on the site and measuring equipment such as Testo 405-v1 (05604053) pocket-sized thermal anemometer with telescopic air velocity stick also a camera was used to take pictures of the structures on going and those affected or collapse. It was structured into a Four Likert Scale, with the following response categories and their assigned numerical values as

Strongly Accepted	-	4
Accepted	-	3
Rejected	-	2
Strongly Rejected	-	1

Procedure for Data Collection

Data collection will be started by distribution of questionnaires; the researcher will distribute the questionnaires to the respondents and collected them back after responded to by the respondents. For effective administration and collection of the questionnaires the researcher will distributed the questionnaires Waite and collect them from the respondents when responded to. Ninety five (95) questionnaires will be distributed to all the ninety five (95). After the questionnaires are collected and the date analyzed the researcher go back to the sites and interview the site manager using the Interview Instrument (II) designed by the researcher. The data collected from the questionnaire instrument and that of the Interview Instrument are sougthed out then annualized. The data collected was analyzed using Analysis of Variances (ANOVA). Mean, and Standard Deviation were also used.

Results

The results were presented according to the research questions asked.

Research question one: What are the challenges of climate change on construction site?

Table One (1): Opinions of the Site Managers and Building Related Trades Lecturers, on the Challenges of Climate Change on Construction Site.

SN	Items	X_{SM}	S_{SM}	X_{BRL}	S_{BRL}	X_{YM}	X_{BRL}	S_{SM}	S_{BRL}	RMRK
1.	Decline in the size of Artic Sea	4.45	0.35	4.52	0.63	4.54		0.54		Accepted
2.	Increase in Ocean heat	3.25	0.34	4.39	0.62	4.24		0.49		Accepted
3.	Increase in Ocean Air Temperature	4.92	0.46	4.34	0.57	4.86		0.49		Accepted
4.	Rise in Sea Surface temperature	4.24	0.40	4.32	0.62	4.30		0.49		Accepted
5.	Humidity Increase	4.32	0.43	4.38	0.61	4.32		0.52		Accepted
6.	Increase in Land Air Temperature	4.38	0.44	4.24	0.58	4.34		0.51		Accepted
7.	Earlier Melting of snow	4.31	0.42	3.93	0.53	4.12		0.49		Accepted
8.	Irregularities in rainfall Pattern	4.63	0.43	3.98	0.54	4.27		0.48		Accepted
9.	Flood	3.84	0.38	4.05	0.54	3.93		0.47		Accepted

10.	Sub-standard Construction Materials in Market	2.05	0.35	2.56	2.56	3.76	0.45	Rejected
Grand Mean		4.85	0.42	4.25	0.57	4.43	0.49	Accepted

($X_{SM}S_{SM}$) Site Managers' Mean and Standard Deviation
 ($X_{BRL}S_{BRL}$) Building Related Trade Lecturers' Mean and Standard Deviation

Table 1 revealed that all the suggested items except item one rejected were accepted as challenges on site. The changes on climate make it difficult for the soil Mechanics to be stable therefore making it impossible to accurately determined the bearing capacity of soil on which the Building is being erected. Due to floods, places that were upland, in the pass become water lock weakening the soil bearing capacity. Rainfall makes it difficult to correctly forecast whether there is going to be rain or not, thereby affect the supply and work plan on the site. These effects of climate change and more post challenge to site managers.

The earlier melting of snow or ice, the raising temperature, the increase in humidity, changes in the chemical contents of the soil, were accepted as affecting materials such as cement and re-enforcement irons used in construction. These could lead to collapse of the structure (Building).

Research question two: What are the effects of Climate Change on Construction Site?

Table (2): Opinion of Site Managers and Building Related Trade Lecturers on the Effects of Climate Change on Construction Site

S/ N	Items	X_{SM}	S_{SM}	X_{BRL}	S_{BRL}	$X_{YM}X_{BRL}$	$S_{SM}S_{BRL}$	RMRK
1.	Desertification leading to serious flooding	3.93	0.30	4.00	0.55	3.96	0.42	Accepted
2.	Increase in the risk and lost associated with embarking on construction project	3.82	0.36	4.26	0.59	4.04	0.47	Accepted
3.	Increases the chemical weathering of concrete structures, as temperature and humidity level rise.	4.68	0.46	4.40	0.60	4.54	0.53	Accepted
4.	Metal structures and cosmetic damage in concrete.....	3.44	0.34	3.55	0.49	3.49	0.41	Accepted
5.	Corrosion in metal structures such as roofs is likely to increase	4.38	0.21	4.21	0.58	4.29	0.50	Accepted
6.	Abnormal and extreme heat wave results to the staff falls sick affecting staffing	4.01	0.39	4.40	0.60	4.21	0.49	Accepted

7.	Affect the expected period and amount set for the project	4.13	0.40	3.98	0.55	4.05	0.47	Accepted
8.	Difficulty in predicting what will be later	3.81	0.37	3.68	0.51	3.74	0.44	Accepted
9.	Forecasting the weather very difficult	4.68	0.42	4.39	0.62	4.63	0.54	Accepted
10.	Affects the cost of materials	3.72	0.37	3.83	0.53	3.73	0.46	Accepted
11.	Affects the duration of the construction causing increase in the cost of labour	3.45	0.35	3.65	0.56	3.58	0.42	Accepted
12.	Causing changes in planning, hiring plants, storage and scheduling of jobs	3.37	0.37	3.82	0.51	3.71	0.54	Accepted
13.	Affect ordering and supply of materials	3.92	0.35	3.77	0.73	3.62	0.44	Accepted
14.	Organization of site becomes very difficult	3.94	0.33	4.67	0.54	3.89	0.43	Accepted
Grand Mean		3.99	0.37	4.17	0.48	3.25	0.46	Accepted

(X_{BRL} , S_{BRL}) Site Managers' Mean and Standard Deviation

(S_{SM} , S_{BRL}) Building Related Trade Lecturers' Mean and Standard Deviation

Table 2 shows that all the suggested items as having effects of climate change affecting them. This shows that the site manager accepted items 1 and 14 as being affected by climate change. So also the lecturers accepted the effects as caused by climate change.

Items: 4, 8, 10, 11, 12 and 13 were accepted by means of less than four (4) while items 1, 3, 5, 6 and 10 were accepted by both managers and lecturers with means above four (4).

While items, 1, 2, 7, and 14 were accepted by both managers and lecturers with different means. Managers accepted items 1, 2, and 14 with mean above three (3) while lecturers accepted the same with mean above four (4). Item eight (8) was accepted by managers with a mean above (4) while the lecturers accepted the item eight (8) with a mean of 3.98.

Research Question 3: What are the effective skills needed by construction site managers to overcome the challenges and effects of climate change on construction site?

Table Three (3): Opinions of the Site Managers and Building Related Trades Lecturers, on the Suggested Effective Skills needed by Construction Site Managers

SN	Items	X_{SM}	S_{SM}	X_{BRL}	S_{BRL}	$X_{YM}X_{BRL}$	$S_{SM}S_{BRL}$	RMRK
1.	Weather forecasting	4.00	0.45	4.00	0.59	4.00	0.49	Accepted
2.	Materials forecasting	4.00	0.45	3.00	0.62	3.50	0.57	Accepted
3.	Order, Supply and Storage of Materials	4.00	0.45	3.50	0.62	3.50	0.51	Accepted
4.	Loading, Transporting and off-loading of Materials & Equipment	4.00	0.45	3.05	0.59	3.50	0.52	Accepted
5.	Ability to report accurately progress made	3.00	0.38	3.07	0.54	3.04	0.46	Accepted
6.	Valuing Days Work	4.00	0.45	4.00	0.61	4.00	0.49	Accepted
7.	Preparation of variation.....	4.00	0.46	4.00	0.66	4.10	0.56	Accepted
8.	Keeping time book and materials lob book	4.00	0.45	4.00	0.63	4.00	0.52	Accepted
9.	Recording of delivery to site	3.00	0.44	4.00	0.59	3.50	0.52	Accepted
10.	Installation of plant on site	2.00	0.22	1.10	0.38	1.51	0.91	Rejected
11.	Maintenance and Services of Equipment	2.10	0.28	2.01	0.60	2.04	0.44	Rejected
12.	Repairs and overhauling plants/Equipment	2.31	0.29	2.24	0.71	2.25	0.45	Rejected
13.	Preparing operator's briefs	4.00	0.47	3.10	0.65	3.50	0.51	Accepted
Grand Mean		4.85	0.42	4.25	0.57	4.43	0.49	Accepted

($X_{SM}S_{SM}$) Site Managers' Mean and Standard Deviation

($X_{BRL}S_{BRL}$) Building Related Trade Lecturers' Mean and Standard Deviation

Table 3 shows that items 1, 6, 7 and 8 were strongly accepted by both site Manager (SM) and Building Related Trade Lecturers (BRL). Items; 3, and 13 were strongly accepted by sm only while items 9 was strongly accepted by BRL only. Item 5 was accepted by both the sm and the BRL. Items: 10, 11, and 12 were rejected both the SM and the BRL. These out-come shows that if the sites Managers are equipped with the strongly accepted and accepted skills the challenges of the construction site management can significantly reduce if not totally overcome

Summary

The study was a survey design that makes use of an instrument (questionnaire) to collect data on the Effects and Challenges of Climate Change on Construction Sites and Effective Site Management Skills. The design of the study was designed to survey the opinions of the lecturers and site managers on the Challenges, Effects of Climate Change on Construction Sites and Effective Site Management Skills. Three research questions were asked. The structured questionnaire items were designed for both building related technology lecturers and construction site managers. All the seventy (70) lecturers and sixty five (65) site managers were used. The questionnaire items were subjected to face and content test using Richardson formula (K-RU). All the building related technology lecturers in Adamawa State Polytechnic Yola were used. The questionnaires were administered directly by the researcher to the lecturers and the construction sites managers. The questionnaires were collected back immediately after responded to by the one hundred and thirty five respondents. The one hundred and thirty five questionnaires were all collected back by the researcher. This represents hundred per cent collection.

Challenges such as; increase in temperature, flash floods, irregularities in rainfall pattern, sub-standard construction materials in the market unstable cost of materials, and persistent devaluing of naira. The challenges have made scheduling and reporting of work progress very combatant. Sometime what was planned to finish with in one day could take two to three days because of unforeseen circumstances such as; rain flood, high temperature and more.

Effects were also identified which are; decertification leading to serious flooding, increase in the risk and lost associated with embarking on construction project, increase in chemical weathering of concrete structures as temperature and humidity level rise, corrosion in metal structure such as roofs are likely to increase, abnormal and extreme heat wave resulting to the falls sick affecting staffing.it also have effect on the expected period and amount set for the project, difficulties in predicting what will be later and make forecasting the weather very difficult and a lot more.

The data were analyzed using Mean and Standard Deviation. The results indicated that the challenges post by climate change can be overcome by equipping site managers with more effective site management skills. Some of the site management skills advocated include loading and off-loading skills, storage, plant maintenance, rescheduling of planned work, Reporting work progress and safety measures on sites.

Conclusion

This study was done to determine the challenges of climate change post to the site managers, effects of climate change on both site and the operations on the sites. The study also looks at the needed new skills to overcome challenges that come with climate change. Climate change was seen to have advert effect on the cost of construction. Making weather focus very difficult and there by resulting to waist of man hours and material, increase in the cost hiring plants and storage facilities. New skills were advocated for. Knowledge of soil mechanics by site managers were agreed to be necessary.

Recommendations

The following recommendations were made base on the findings of the study: The site

- i. Managers should be retrained on the effects and challenges of climate change on construction site management.
- ii. Institutions of learning that train technologist and engineers should make site management a compulsory course to be included in the list of courses to be study by their students.
- iii. The industries especially the construction industries should be able to provide all the necessary instruments needed by the site managers to enable them manage their sites effectively.

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