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MODELLING ACCIDENT PREVENTIVE MEASURES: A DUAL-PHASE STRUCTURAL EQUATION APPROACH

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ABSTRACT

Accident is viewed by all as an ill event that takes place on the building construction site, having a consequential effect on its victims. However, averting this incidence is a possibility, which should be glimpsed beyond the proximal preventive measures. Consequent upon a catalogue of accidents occurring on building construction site, the study aimed at developing a model for the prevention of accident on the building construction site. In achieving this, a non-random sampling was adopted to select the study participants in responding to the research questionnaires. Consequently, three hundred and eighty-four self-administered questionnaires were analysed descriptively, while structural equation modelling (AMOS version 22) was used in developing a valid model to eliminate the occurrence of accident on the building construction site. Moreover, fourteen (14) well-experienced construction stakeholders were purposively selected for interview, with the transcripts analysed using NVivo software. The outcome of the survey revealed that the construction stakeholders (client, consultant, contractor, health and safety agency) have major roles to play in the prevention of accident on the building construction site, as 17 and 23 preventive measures were found to be significant at the preconstruction stage and during the construction stage respectively. The twenty-four (24) experts across the construction fields that were contacted for the validation of the developed accident prevention model agreed to its validity. Conclusively, the dual-phase accident prevention model becomes important to enable the stakeholders to be aware of their individual's safety roles during the preconstruction and construction stages.

Keywords: accident prevention, construction industry, preventive measures, structural equation model, construction stakeholders.

1. INTRODUCTION

Operating on an accident-free building site is a possibility, while it requires a process. This is achieved through the implementation of preventive measures, as the measures are put in place by the right individuals, that is, construction stakeholders (client, consultant, contractor, health and safety agency). Accident-free (zero-accident) building site, in reality, is achievable but the common practice is the formulation and enforcement of accident prevention strategies. However, by research (quantitative and qualitative), such strategies cut across both the preconstruction phase and construction phase, of which attention is focussed on Construction (Design and management) regulations of the United Kingdom [1] to underpin this study. Going by definition, accident prevention is a conglomeration of procedures of control that makes an organisation to exert corrective measures and correction commitment for averting the events that give rise to an accident on the building site. Moreover, understanding the issues related to accident is traceable to Herbert Williams Heinrich of 1930s (an accident theorist), who published a book on 'Industrial Accident Prevention'. The book is found to have prepared a solid ground for the understanding of the cure of accident; as having the knowledge of the causes of accident serves as a precursor to the development of preventive measures [2, 3, 4]. However, illustration was given by [5] in the domino theory by relating accident to five metaphorical dominos, where accidents are known to be caused by unsafe acts or conditions of people engaged in site activities. Nevertheless, the possibility of prevention of accident comes through the removal of these acts or conditions. Each domino represents an event, and an effort being put up to prevent the falling of one domino on another is regarded as prevention, of which the effective implementation of this effort will have accident prevented, as depicted in Figure 1.

Figure 1. Possibility of Accident Prevention

Moreover, past researches on accident prevention (6, 7, 8] gave a generic approach towards accident preventive measures in achieving a zero-accident on the site, which serve as guides for this study. Moreover, it is being reported by [9] that the first age of accident prevention was in relation to the technical measures in giving machinery a guard, preventing fire and explosions as well as preventing structures from experiencing collapse. This move lasted until 1950s, with an attendant realisation that technical risk assessment and technical preventive measures were insufficient in accident prevention drive. Departing from this was the second age of accident prevention with emphasis on the interaction between man and machine, commonly regarded as the socio-technical accident prevention concept. Thereafter, dissatisfaction set in by 1980s, with the conception that issues related to H&S could be tackled with the simple method of linking the individual to technology. Consequently, this metamorphosed into the third age involving the conglomeration of man, machine, environment, organisation and society, as shown in Table 1. Hence, for a successful and workable preventive measure, the management systems cannot be side-tracked.

Table 1. Age of Safety and Accident Prevention Concept

Age level	**Accident prevention concept**	**Machine**	**Man**	**Environment**	**Organisation**	**Society**
First age (Before 1950)	Technical	■				
Second age (1950-1980)	Socio-technical	■	■			
Third age (1980 till date)	Socio-cultural	■	■	■	■	■

Adapted from [9]

2. LITERATURE REVIEW

2.1 Accident Prevention Process (APP): The Preventive Measures

A focus on experiencing zero-accident is the best option for ensuring safety of construction workers. This is achieved when all construction–related preventive measures are put in place on the building construction site. Besides, accident is said to have been prevented in its entirety when construction is accident-free and operations are carried out safely by construction operatives. Going on the line of explanation, prevention of accidents (PoA) encompasses identifying and eliminating the causes of accident prior its occurrence. However, reaction to accident is predominantly practised by site supervisors, meaning that, they investigate accident in order to determine what caused the accident. This is followed by executing some corrective actions to prevent reoccurrence. This process only assists in eliminating future accidents from a specific cause, as confirmed by [10], who said that the prevention of BCS accident always entails the prediction of future accidents, and such prediction which must be based on effective knowledge about past accidents. Therefore, deeper efforts will be put in place in considering the precautionary measures against accident both at the preconstruction and construction phases of building development, with a focus on the duties of the construction stakeholders. However, the CDM regulations of 2015 have provided a foundation for the prevention of accident thus; i) accident prevention at the preconstruction stage (PCS), and ii) accident prevention during the construction stage (TCS). These two stages are discussed next.

2.1.1 Accident Prevention at the Preconstruction Stage

Preconstruction phase of any project contains all the activities to be embarked upon before the commencement of any practical construction on the building construction site (BCS). With regards to [11], "preconstruction phase means any period of time during which design or preparatory work is carried out for a project". This incorporates the conceptual, design and the planning stages [12] that are embarked upon by all the parties (client, designer, and contractor) involved in construction. However, the degree of their involvement differs. For instance, conceptualisation of the project may exempt the involvement of the contractor, while his involvement as well in the design level is unsolicited, except such project is design and build. Hence, the collective efforts (responses) of the construction stakeholders are indispensable in order to have the occurrence of BCS accidents mitigated. Against this backdrop, the construction stakeholders in this study are the clients, consultants, contractors and the H&S agency. Nevertheless, the consideration of the above mentioned stakeholders is in line with the studies of [4, 13, 14] who emphasise the importance of the involvement of these construction stakeholders and the H&S government agency as the major controllers of accident on BCS. These measures are discussed next, while Figure 2 shows the involvement of the stakeholders at the preconstruction stage.

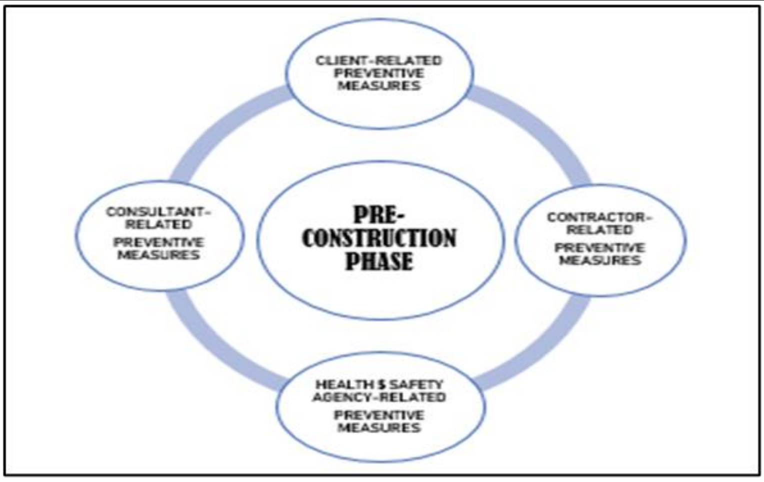

Figure 2: Stakeholders' Involvement in Accident Prevention at Preconstruction Stage

(i) Client-related preventive measures: These include sourcing for fund with the intention to adequately budget for safety issues [15, 16], timely appointment of competent professionals [17], involvement of safety expert during the design process [18], and acquisition of land with safe ground conditions and topography [19]. Additionally, allowing sufficient time for designers to produce building designs that are safe to build, and ensuring that all safety related information about the site is communicated to the consultants and to other necessary person(s) are further preventive measures in relation to the client [1]. Others are ensuring that contract is awarded to contractors with good safety records [20], giving notice to the H&S Agency on the commencement of project for the benefit of site inspection and monitoring [1], making sure that investigation of site is carried out to ascertain the potential hazards before the commencement of site works, and ensuring that adequate time is given to the contractor for effective project planning so that work does not begin until safety and health plan is fully developed.

(ii) Consultant-related preventive measures: These measures include rendering advice to client on safety cost and the appointment of safety officer, hazards identification, incorporation of components, designing of well layout of workplace, specification of quality materials, production of complete working drawings, inclusion of sufficient safety fund in the contract bill, quality time spent on design, and prequalification of contractors. Some of these measures, and how their neglect has been responsible for accident on the BCS are echoed in the studies of [18, 21-28].

(iii) Contractor-related preventive measures: The measures in relation to the contractor at the preconstruction stage include making sure the client is aware of his safety related duties to enable him carry out his responsibilities [1], preparation of safety plan and stating objectives of safety policy [29] to be implemented during progress of work, involvement in investigation of site to ascertain the potential hazards before the commencement of site work, and making adequate plans towards procurement of all safety related items. Equally, for the necessity of the preparation of method statements in prevention of accident, [30] indicates that the method statements should form part of the contents of the H&S file submitted to the client.

(iv) Health and safety agency-related preventive measures: The H&S agency is a representative of the government. Being an agent of the government, the body is in the best position in getting the government advised on issue related to safety. Most contractors possess no interest in submitting themselves to compliance with safety regulations, and this is not far-fetched from monetary issue. Safety-related programmes (training, orientation, meeting, committee, campaign, etc.) are not conducted in most contracting organisations, and this is not unconnected with finance. However, by establishing the importance of safety programmes [29, 31], being a move to get accident prevented on the site, the H&S agency can prepare a proposal and get it forwarded to the government on the need to make incentives available to the contractor for implementation of safety programmes for their workers. A clue is taken from the American Society of Safety Engineers whose roles are inclusive of the need to enable government make available incentive measures (monetary or non-monetary) to the organisations that are willing to conduct safety programmes for their workers. Moreover, [32] equally stress the need for the government to offer incentives [29] to firms that willingly carry out H&S management system. Nevertheless, the safety programme should be comprehensively carried out [29] and constantly implemented [33], of which the submission of [34] cannot be brushed aside, who declare that the conduct of H&S management system by organisations brings the frequency of accidents into minimal. Such programmes, according to the authors, create room for higher awareness of H&S issues and responsibilities as well as help highlighting the impact of poor H&S standards on organizational performance. Additionally, part of the preventive measures in respect to the H&S Agency is offering advice to the government on issue related to safety policies and regulations, as [33] reveals the conspicuous absence of policy guidelines on safety precaution in the under-studied industries. Safety policy forms the bedrock of all other safety activities on the BCS. It is, however, embarrassing and disheartening to see that OHS statutory regulations are defective and inadequate in most developing economies [34]. The building code still remains a valid document being relied upon by most construction professionals in the prevention of accident on building site, precisely Nigeria, whereas the contractors being blamed for not complying with H/S regulations on site [35] is linked to the fact that regulations guiding the H&S are not adequately in place.

2.1.2 Accident Prevention During Construction Stage

Achieving an accident-free site goes beyond the implementation of preventive measures at the preconstruction stage (distal) but extends to the construction phase (primal) where major preventive strategies are essential. The four parties are of importance in the implementation of such measures, which are discussed next, while Figure 3 shows the stakeholders' involvement.

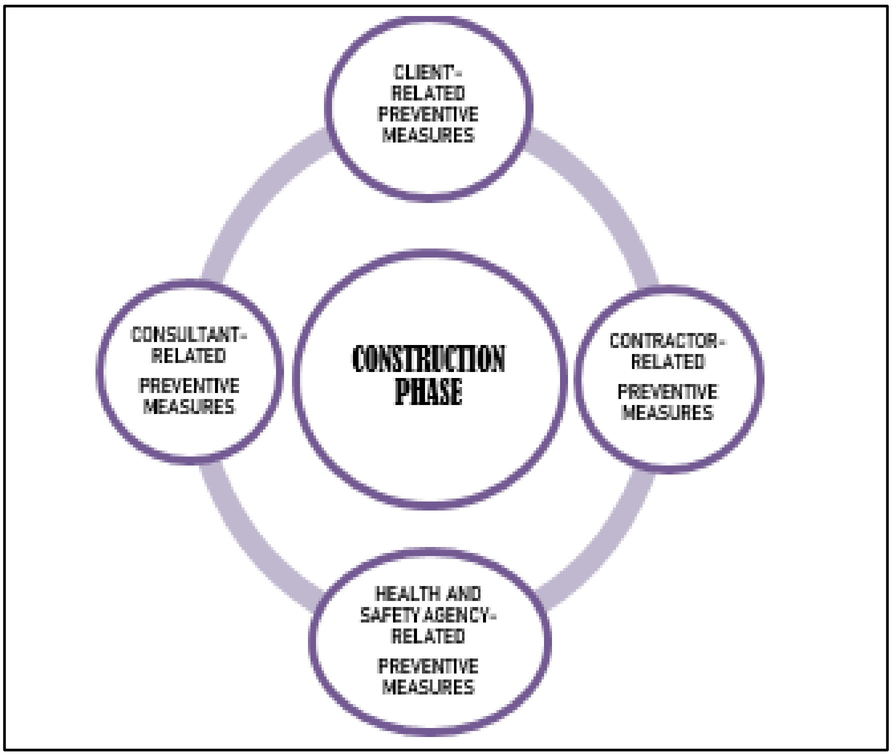

Figure 3: Stakeholders' Involvement in Accident Prevention during Construction Stage

(i) Client-related preventive measures: In addition to the preventive measures put up at the preconstruction stage, the project owner has some other measures to implement during the construction stage with a plight to give a farewell message to accident occurrence. These are inclusive of ensuring that safety incentive [36] is given to the workers by the contractor, involvement of client's representative in supervision, and reduction of time pressure on the contractor during progress of work, as [16] see time pressure as an agent of accident on BCS, while [37] describe hasty construction as a causal factor of accident. In addition, ensuring that the contractor implements safety programmes [8], participation in safety committee [9], ensuring regular site inspection, and prompt release of fund to the contractor for the purchase of safety items are other preventive measures against the occurrence of accident.

(ii) Consultant-related preventive measures: Multifarious accident preventive measures having a link with the consultants during the construction stage are inclusive of participation in safety-related programmes and monitoring of contractor's implementation of safety policy, of which [14] declares that if works are not carried out safely as indicated in the safety policy or plan such contractor can be stopped. In addition, ensuring that the contractor organises safety training for employees, and the preparation of safety file at completion of work for safety of workers during maintenance of building [1, 30] are other preventive measures to be implemented by the consultant. Further preventive measures include playing a supervisory role particularly in high-risk work [29], involvement in site inspection to ascertain the provision and usage of safe equipment [62], ensuring the engagement of a safety officer on site by the contractors before commencement of work [38] and ensuring that the contractor fulfils all necessary safety requirements before issuing interim payment certificate.

(iii) Contractor-related preventive measures: Setting up safety committee [38, 39, 41], the use of appropriate tools for a specific task [40], conducting safety meeting [20, 43], engagement of adequate competent supervisor [44], rewarding worker of good safety records [45], effective communication, training of workers and supervisors, enforcement of safety regulations, regularly maintained equipment, provision of adequate safety items [40, 46, 47], inspection [48] of work environment, housekeeping [6, 49] and fencing for safety are all considered to be necessary on the BCS for accident prevention. Moreover, the provision of medical facilities [50] and workers' welfare package, adequate working platforms and railings, and involvement of trained workers in hazards identification are scholarly recommended accident preventive measures. Moreover, the availability of safe accommodation [9, 51] and timely resolution of conflict [52] among workers as well as giving opportunity for prayer [53] at stipulated time cannot be jettisoned in the drive to have accident prevented on the site. However, prayer becomes essential following the fact that some accidents do take place on BCS as an act of God, while it is known that some workers are prone to accident. It will, then, take the intervention of God to prevent such workers form falling victim of accident occurrence.

(iv) Health and safety agency-related preventive measures: These include advising the government on the followings: the need to provide incentives to the contractors for implementation of safety programmes for their employees; the policies/regulations governing H&S; and the need to empower the agency by adequately providing fund for monitoring and inspecting construction sites. Moreover, the involvement of H&S officials in the building plans approval process, staging safety campaign and orientation programme to create safety awareness and the employment of adequate number of qualified H&S professionals saddled with the responsibility of site monitoring and inspections are the H&S Agency preventive measures that can be implemented at this stage.

3. MATERIAL AND METHODS

Non-probability sampling approach was adopted to select the research respondents, and chosen from the south-western states of Nigeria. The administered questionnaire consisted of the demographic information of the study respondents, coupled with the preventive measures (items of the constructs) categorised according to the duties of the stakeholders. The questionnaire for the preventive measures was based on 5-point Likert scale and calibrated thus: 1 = unimportant, 2 = less important, 3 = neutral, 4 = important, 5 = highly important. This was in line with [54, 55, 56], but with little modifications. Moreover, collection of data was done through self-administered questionnaires, but prior to the administration of the questionnaires, a pilot study (using construction experts) was carried out, resulting in an acceptable Cronbach's alpha values, as indicated hereafter. Also, the inputs of the construction experts were considerably put into use to enrich the questionnaire. In achieving the purpose of the study, the target population included client organisations/project managers, consultants, contractors, safety practitioners and craftsmen, with three hundred and eighty-four correctly filled, valid and usable questionnaires based on the recommended upper limit of [57]. The questionnaires were administered through physical contact and e-mails in the South-western states of Nigeria, being the scope of the study. The missing data were treated and replaced using the SPSS software. Besides, the respondents were drawn from both the contracting and consultancy sectors. In the analysis, exploratory factor analysis using the SPSS version 22 software was employed in establishing the structure of the measurement models, classifying the items into eight factors, while the Kaiser-Meyer-Olkin (KMO) as well as the Bartlett's test of sphericity was engaged in confirming the instrument validity by assessing the sample adequacy and multivariate normality of the study variables. Moreover, the structural equation modelling (SEM) further validated the measurement models through the use of AMOS software by establishing satisfactory goodness-of-fit (GFI) indices of the variables of the study.

4. RESULTS AND DISCUSSION

4.1 Demographic Information

In the achievement of accident-free building site, the retrieved questionnaire comprised of the responses from the client, consultant, contractor, health and safety officer and the artisan. The demographic information of the respondents, as shown in Table 2, indicated that they all possess the experiences needed in giving positive and correct responses to the administered questions, with the following information: The state of operation: Ondo/Ekiti (42.2%), Oyo/Osun (31.5%) and Lagos/Ogun (26.3%). Areas of specialisation: Client (18.5%), Consultant (31.5%), Contractor (36.2%), Safety (5.5%) and Craftsman (8.3%). Years of experience indicate 1-5 years (38.8%), 6-10 years (26.3%), 11-15 years (15.4%), 15 years and above (19.5%). Regarding qualifications, ND (18.8%), HND (27.3%), BSc/B.Tech (21.6%), PGD (8.6%), MSc/M.Tech (14.1%) and PhD (2.1%).

Table 2. Demographic Information of Respondents

Demographic Criteria	Classification	Frequency	Percentage (%)
State of Operation	Ondo/Ekiti	162	42.2
	Oyo/Osun	121	31.5
	Lagos/Ogun	101	26.3
Years of Experience	1-5	149	38.8
	6-10	101	26.3

	11-15	59	15.4
	Above 15	75	19.5
Highest Academic Qualification	ND	72	18.8
	HND	105	27.3
	BSc/B.Tech	83	21.6
	PGD	33	8.6
	MSc/M.Tech	54	14.1
	PhD	8	2.1
	Others	29	7.6
Area of Specialisation	Client	71	18.5
	Consultant	121	31.5
	Contractor	139	36.2
	Safety	21	5.5
	Craftsman	32	8.3

4.2 Accident Preventive Measures

Eight significant constructs were developed viz; Client-related preventive measures, consultant-related preventive measures, contractor-related preventive measures, and health and safety-related preventive measures at both the preconstruction and during construction phases. The following eight codes were ascribed respectively to the constructs: CLP (10 items), CSP (10 items), CTP (5 items), HASP (6 items), CLC (7 items), CSC (8 items), CTC (18 items), and HASC (5 items), altogether making 69 constructs. At the preconstruction stage, the client-related preventive measures are: Sourcing for fund (CLP1), timely appointment (CLP2), safety expert in design (CLP3), acquisition of safe land (CLP4), sufficient time for designers (CLP5), communication of safety information (CLP6), contract award (CLP7), notification on work commencement (CLP8), site investigation (CLP9) and sufficient time for project planning (CLP10). The consultant-related preventive measures contain: Advice to client on cost (CSP1), appointing safety officer (CSP2), hazards identification (CSP3), incorporation of safe components (CSP4), layout of workplace (CSP5), specification of quality materials (CSP6), complete working drawings (CSP7), sufficient safety fund in contract (CSP8), quality time spent on design (CSP9) and prequalification of contractors. In relation to contractor-related preventive measures, they comprise of: Client awareness of responsibilities (CTP1), preparation of safety plan (CTP2), potential hazards identification (CTP3), method statement prepared (CTP4) and adequate plans for procurement (CTP5). As for the health and safety-related preventive measures, they are: Advising government on incentives (HASP1), advising government on safety policies (HASP2), advising government on fund (HASP3), involvement of safety officials (HASP4), safety campaign and orientation (HASP5) and adequate qualified H&S Experts (HASP6). Moreover, at the construction stage, the client-related preventive measures are: Ensuring safety incentive by contractor (CLC1), involving client's representative (CLC2), reduction of time pressure (CLC3), ensuring contractor implement safety (CLC4), participation in safety committee (CLC5), ensuring regular site inspection (CLC6) and prompt release of fund (CLC7). The consultant-related preventive measures include: Participation in safety programmes (CSP1), monitors contractor's safety policy (CSP2), ensuring contractor organises training (CSP3), preparation of safety file (CSP4), playing a supervisory role in risky work (CSP5), involvement in site inspection (CSP6), ensuring engagement of safety officer (CSP7) and ensuring fulfilment of safety requirements (CSP8). In reference to the contractor-related preventive measures, they contain: Setting up safety committee (CTC1), conducting safety meeting (CTC2), adequate competent supervisor (CTC3), rewarding worker with good records (CTC4), effective communication (CTC5), training of workers and supervisors (CTC6), enforcement of safety regulations (CTC7), regularly maintained equipment (CTC8), provision of adequate safety items (CTC9), inspection of work environment (CTC10), housekeeping (CTC11), fencing for safety (CTC12), medical facilities and workers welfare (CTC13), adequate working platforms, and railings (CTC14), trained workers in hazards identification (CTC15), safe accommodation (CTC16), ensuring timely resolution of conflict (CTC17) and opportunity for prayer (CTC18). Finally, in reference to the health and safety-related preventive measures, they comprise of: Ensuring competent supervisors (HASC1), training, workshops and seminars (HASC2), site inspection and monitoring (HASC3), office accessibility to contractors (HASC4) and accident records and investigation (HASC).

4.3 Exploratory Factor Analysis (EFA)

Prior the EFA was the determination of the mean scores (MS) and the standard deviations (SD) of the 69 preventive measures, which had the lowest MS of 3.64 and highest being 4.17, while the SD had a minimum value of 0.953 and

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the highest being 1.224. This confirmed the significance of all the items, but based on the responses of the respondents. Exploratory Factor Analysis (EFA) connotes one of the approaches used in the analysis of individual influences of all the items that make up a construct. However, regarding the testing of the EFA, sample size is commonly a determining factor in the valley of decision, either to drop or accept an item. The occasion where an item is dropped, it indicates that such an item is less than the threshold value [58]. The authors suggest several factor loadings, but with the characteristics of this study, factor loadings with a value of 0.70 were considered appropriate. Consequently, factor loadings above this value were considerably accepted and used for the computation of the CFA and the structural model. Moreover, principal component extraction via promax rotation was adopted in achieving the relevant eight factors (components). For the suitability of the sample, Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were carried out and shown as Table 3. Following the EFA, 57 items out of the 69 items derived from literature were found to be above the 0.70 factor loading cut-off. The deleted items (12NOS) that could not measure up to the 0.70 cut-off threshold included CLP3, CLP5, CLP8, CSP5, CTP3, HASP6, CLC2, CLC4, CTC7, CTC17 and HASC4.

Table 3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.977
Bartlett's Test of Sphericity	Approx. chi-Square	22421.368
	df	2346
	Sig.	.000

The value is an acceptable one, being above the accepted minimum of 0.5, while the Barlett's test of sphericity is significant ($p < 0.05$).

4.4 Reliability of Instrument and Confirmatory Analysis

Reliability test was carried out via Cronbach's alpha, while the values obtained for each construct included: CLP (.906), CSP (.931), CTP (.880), HASP (.903), CLC (.889), CSC (.927), CTC (.959) and HASC (.882), indicating that the level of significance was high enough and they all met up with the requirement [59]. This indicated that the proposed model would enable stakeholders to know the appropriate accident preventive measures to mitigate against the occurrence of accidents on the site. However, confirmatory factor analyses were carried out on the constructs in order to establish the goodness of fit of the models. The initial model of every construct was carried out, but where the initial model could not reach the acceptable requirement such construct was subjected to adjustment (revision) to produce a better model fit. Moreover, the modus operandi involved in respect to achieving a fitted model was to be sure that every factor loading equalled to (=) or above (>) 0.6 [60], indicating that factor loading less than 0.6 was unquestionably expunged at confirmatory level. Therefore, Figure 2 shows the initial CFA carried out on one of the constructs, which as a result of want of space it is a representative of initial CFAs done for other constructs, while Figure 3 depicts the initial and modified CFA models of all the preventive measures, with the summary of all the CFAs shown in Table 4. The conditions for acceptance of the model is to see that the modification indices, such as Goodness of Fit Index (GFI), Tucker Lewis Index (TLI), Comparative Fit Index (CFI), and Normed Fit Index (NFI) are higher than 0.90 (>0.9). The Chi-square's ratio (chi-sq) as well as the Degree of freedom (df) must not be higher than 5.0, that is, Chisq/df $\leq$ 5.0. In addition, the Root Mean Score Error Approximation (RMSEA) should cleave to a lower value of 0.08, that is, $\leq$ 0.08. The situation where a revised or adjusted model is needed is where the initial CFA, the hypothesised model and the structural equation models (SEM) could not fulfil the minimum requirement of the modification indices [59, 61].

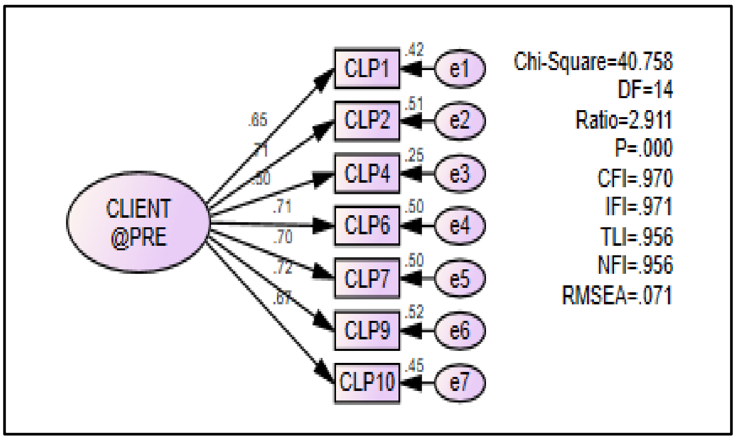
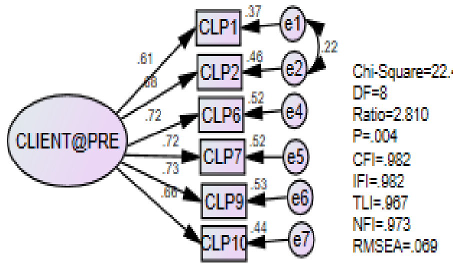
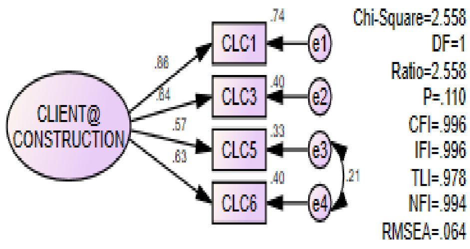


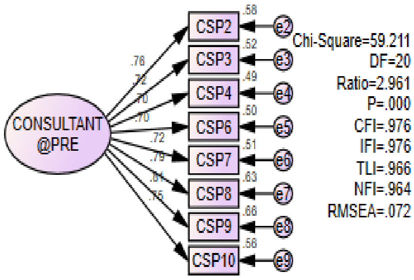
Figure 2. Initial CFA of client-related preventive measures.



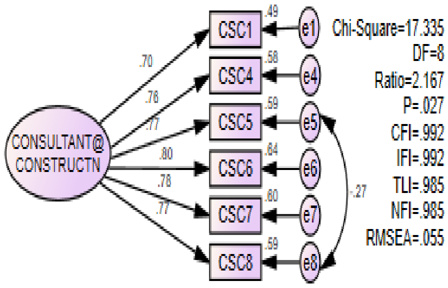
Revised CFA of client-related preventive measures at PCS



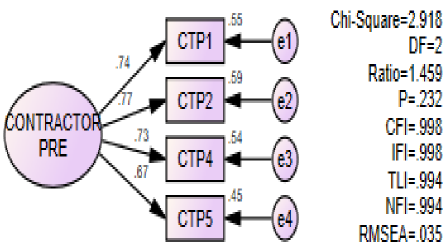
Revised CFA of client-related preventive measures at TCS



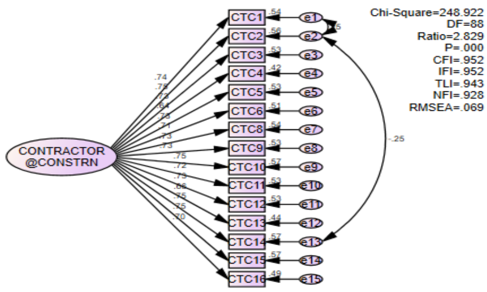
Revised CFA of consultant-related preventive measures at PCS



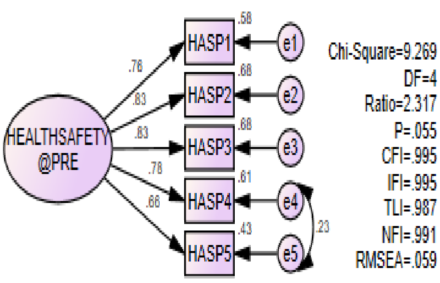
Revised CFA of consultant-related preventive measures at TCS



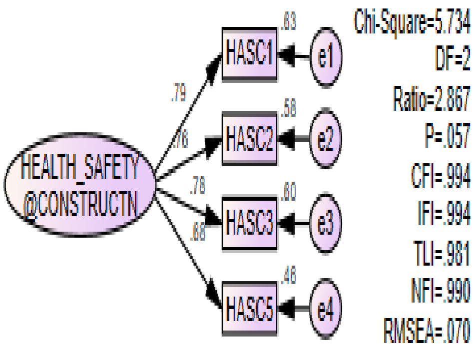
(Initial and revised CFA of contractor-related preventive measures at PCS



Revised CFA of contractor-related preventive measures at TCS



Revised CFA of H&S agency-related preventive measures at PCS



Initial and Revised CFA of H&S agency-related preventive measures at TCS

Figure 3: Initial and Modified CFA Models of all Preventive Measures at both Stages

Table 4: Summary of the Model Fitness Indices

Description	Process	Chisq	Df	Ratio	P-Value	CFI	IFI	TLI	NFI	RMSEA
Client at Preconstruction	Initial	40.758	14	2.911	.000	.970	.971	.956	.956	.071
	Adjusted	22.482	8	2.810	.004	.982	.982	.967	.973	.069
Consultant at Preconstruction	Initial	100.012	27	3.704	.000	.961	.961	.948	.948	.084
	Adjusted	59.211	20	2.961	.000	.976	.976	.966	.964	.072

Contractor at Preconstruction	Initial	2.918	2	1.459	.232	.998	.998	.994	.994	.035
	Adjusted	No Modification								
Health and Safety at Preconstruction	Initial	22.979	5	4.596	.000	.982	.982	.963	.977	.097
	Adjusted	9.269	4	2.317	.055	.995	.995	.987	.991	.059
Client at Construction	Initial	12.087	2	6.043	.002	.976	.976	.928	.972	.115
	Adjusted	2.558	1	2.558	.110	.996	.996	.978	.994	.064
Consultant at Construction	Initial	135.330	20	6.767	.000	.937	.937	.911	.927	.123
	Adjusted	17.335	8	2.167	.027	.992	.992	.985	.985	.055
Contractor at Construction	Initial	343.107	104	3.299	.000	.933	.933	.922	.907	.077
	Adjusted	248.922	88	2.829	.000	.952	.952	.943	.928	.069
Health and Safety at Construction	Initial	5.734	2	2.867	.057	.994	.994	.981	.990	.070
	Adjusted	No Modification								

Moreover, effort was made to establish the relationship of all the constructs of accident preventive measures. This became necessary in order to establish the inter-correlation among the constructs so as to enable the researcher confirm the validity and reliability of the constructs of the model. Consequently, Figure 4 shows the model of relationship among the constructs of accident preventive measures, while the result of the validity is contained in Table 5. In addition, the measurement model contains eight constructs that are inter-correlated, and having 57 items across the constructs, with the measurement error shown on each item. In addition, the factor loadings (FL), inter-factor correlation and the goodness of fit indices were considered in the course of validating the model. Based on the responses of the respondents the factor loadings above 0.6 were analysed.

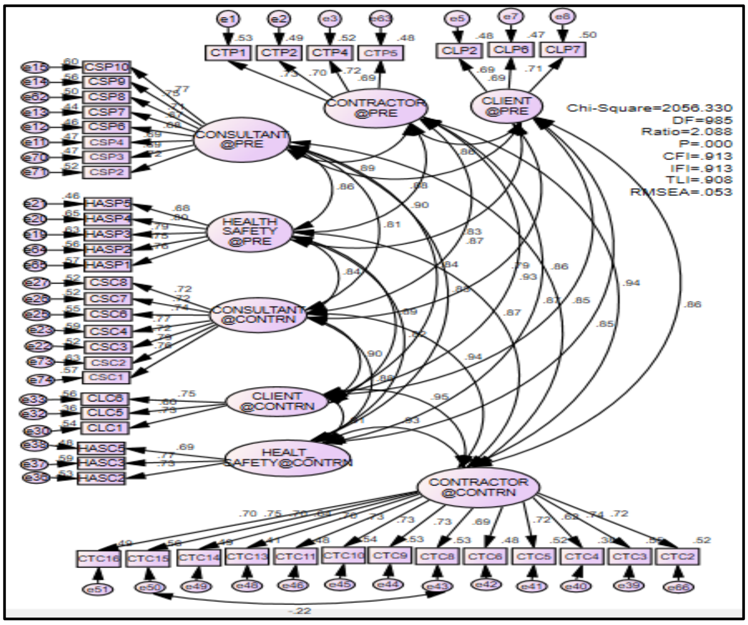


Figure 4: Modified Model of Relationship among the Constructs of Accident Preventive Measures (First order measurement model).

Table 5: Validity of Model of Relationship among Constructs

S/N	Constructs	Composite Reliability	AVE
1	CLP	.74	.48
2	CSP	.89	.50
3	CTP	.80	.50
4	HASP	.87	.57
5	CLC	.74	.49
6	CSC	.90	.56
7	CTC	.93	.50
8	HASC	.77	.53

In addition, in testing the relationship between the first order and the second order measurement models, SEM (Structural equation model) was used to achieve this. However, with the results of the test of the second-order model shown in Figure 5, it implied that the outcomes of the structural model were also found to have met the acceptable thresholds of the statistical parameters in literature for a model fit. Consequently, the values obtained for the modified model are: The Chi-square = 1634.662, the df = 733, Ratio = 2.230, CFI = .912, IFI = .912, TLI = .906 and RMSEA = .057. Moreover, at the development of structural equation model 40 items (preventive measures) were found to be significant which are indicated in the model (Figure 5).

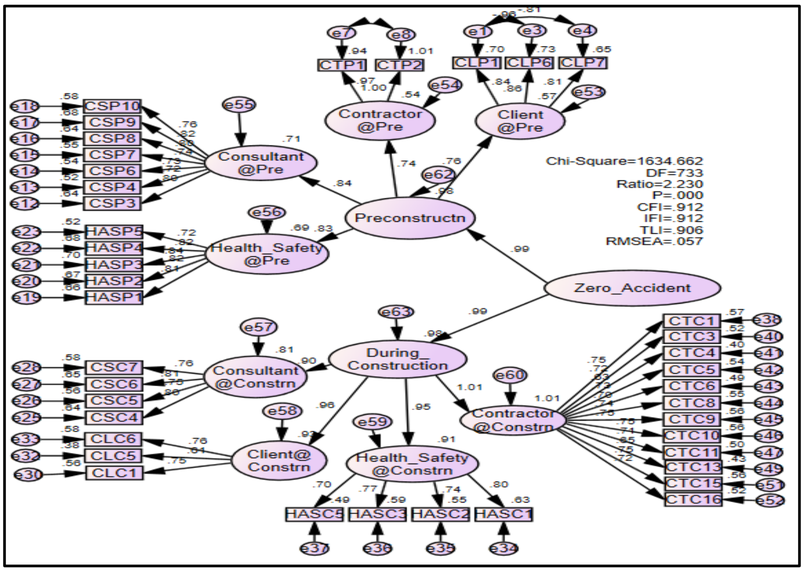


Figure 5: Modified Structural Equation Model of Accident Preventive Measures (Second order measurement model)

4.5 Triangulation of quantitative and qualitative results

Mixed methods approach was adopted in arriving at the results of the study. The results are summarised and indicated in Figure 6. The first column contains the significant preventive measures at the PCS, the second column comprises the same but at TCS. Depicted in the figure are the findings of the study during the questionnaire survey. The third column contains the findings of the interview conducted for the experts with emphasis on the preventive measures at the PCS, while column four contains the preventive measures at TCS. Findings reveal a high level of corroboration between the responses of the research respondents during questionnaire survey and that of the experts during the interview session.

Findings from Literature			
Safety fund [15, 46 55]; Communication of safety information [1]; Client awareness [1]; Hazards identification [53]; Contract award to contractor of good safety record [14, 20, 29, 50]; Safety plan [16]; Regulations [67]; Compliance and enforcement [34]; Safety incentives and rewards [32, 36]; Campaign and orientation [62, 63]; Training [38]; Safety committee [9, 29, 43]; Site inspection and monitoring [9, 44]; Safety in design [22]; Safety officials in design [18]; Supervision [29, 44, 52]; Safety officers site involvement [18]; Equipment maintenance [65, 66]; PPE [46, 47, 58]; Safety file [30]; Housekeeping [6, 49]; Medical and welfare facilities [50, 64].			
Questionnaire Findings (Summary)		**Interview Findings (Summary)**	
Preconstruction Phase	Construction Phase	Preconstruction Phase	Construction Phase
Safety fund	Safety file	Safety advice	Accident investigation
Communication	Safety committee	Competent professionals	Communication
Contract to safety contractor	Site inspection and monitoring	Safety in design	Competent supervisor
Safety in design	Safety incentives an rewards	Safety fund	Safety regulations compliance
Quality time on design	Supervision	Education and training	Conflict resolution
Client awareness	Safety officers employed	Hazard identification	Usage of safe materials
Safety plan	Communication	Client awareness	Safety fund released

Safety incentives	Training, workshops etc.	Method statement	House keeping
Safety officials in design	Equipment maintenance	Safety plan	Medical facilities
Safety campaign and orientation	Accident records and investigation	Safe materials specification	PPE
	Housekeeping	Site investigation	Safety incentives
	Medical facilities		Safety meeting
	Safe working platforms		Safety committee
	Hazard identification		Supervision
	Adequate PPE		

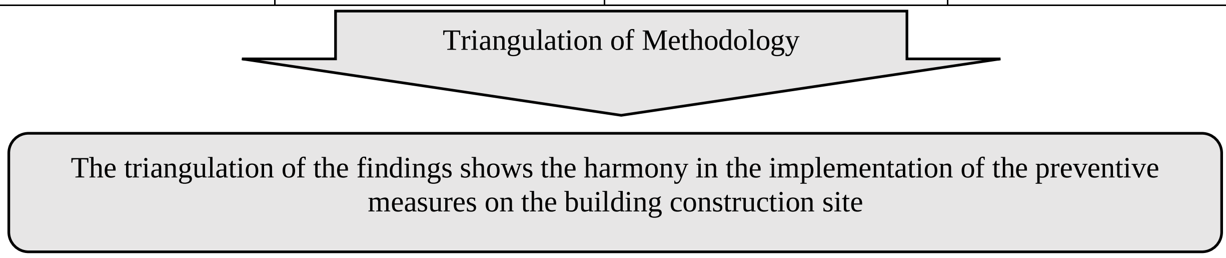


Figure 6: Triangulated research findings

4.6 Model Validation

Consequent upon the development of the model as shown in Figure 5, the model was further positively validated by experienced construction professionals, purposively chosen across the country (Nigeria). The experts possessed high level of experiences of not less than fifteen years in the construction-related fields, while the under listed indicators were demanded from them.

1. Validity and appropriateness of the model in preventing accident.
2. The model serves as a guide for construction professionals and other stakeholders in prevention of accident on building construction site.
3. Comprehension of the model.
4. The necessity for Health and safety regulations and enforcement as a requirement for the successful implementation of the accident preventive model.
5. Model depicts the processes involved in carrying out an accident prevention study.
6. Further steps to be taken to enhance the implementation of the model.
7. Additional suggestion on how the model can be improved upon.

Regarding indicator number one, all the twenty-four experts (100%) responded positively by indicating “yes”. For indicator number two, twenty-three (23) representing 95.8% agreed to this fact by indicating “yes”, while only 4.2% indicated “no”. Moreover, in relation to indicator number three, all the experts (100%) indicated “yes”. Indicator number four gained the agreement of 91.7% of the experts. The last indicator attracted 21 experts showing that 87.5% indicated “yes”, while 3 (12.5%) indicated “no”. The summary of their responses is presented in Table 6. However, the suggestions proposed by the experts have been effected in the improvement of the model.

Table 6. Overall Model Assessment

Attributes of the Model	**Yes**		**No**		**Unsure**	
	f	**%**	**f**	**%**	**f**	**%**
Appropriateness of the model in prevention of accident	24	100	-	-	-	-
The model as a guide for construction professionals in prevention of accident	23	95.8	1	4.2	-	-
Understanding the model	24	100	-	-	-	-
Implementation of model through H&S regulations and enforcement.	22	91.7	1	4.2	1	4.2
Processes involved in carrying out accident prevention	21	87.5	3	12.5	-	-

Consequent upon the assessment given by the experts, it is found that the model is valid and appropriate for PoA. Beyond any other proof, it serves as a guide for professionals in enforcing safety. Besides, it is understandable enough, even to a lay man, while the H&S regulations and enforcement are seen as the yardsticks for the implementation of the model. Moreover, the processes involved in carrying out accident prevention are clearly shown. Conclusively, to the experts, the model was found useful for the prevention of accident at the building site. Moreover, shown below is the dual-phase accident prevention model for the building construction industry.

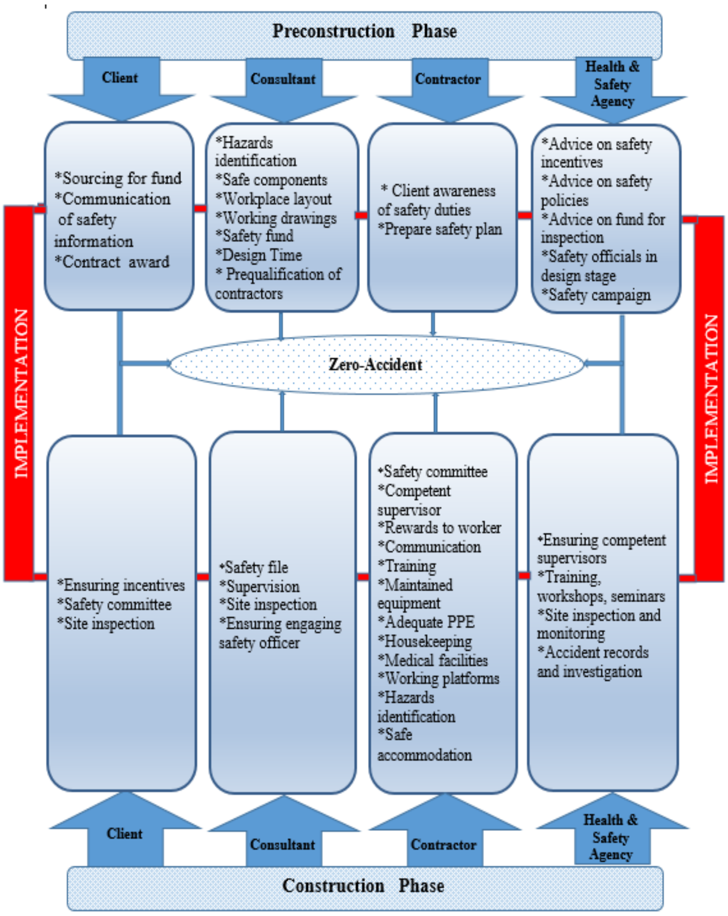


Figure 7: Dual-Phase Accident Prevention Model (DAP-Model)

Furthermore, it is imperative to develop a model to prevent the accidents that are occurring on the BCS in Nigeria so as to achieve an accident-free site. In the application of the model, it is essential that each stakeholder is aware of his responsibilities as defined in the model, coupled with the fact that the regulations governing the H&S in Nigeria are enforced. The usage of the model spans through the briefing and planning stages (preconstruction) as well as the construction stage, consequent upon the composition of UK CDM regulations, which forms the basis of the preventive measures as shown in the figure. Besides, the various measures covering the two stages are embedded in the model. However, the client, consultant, contractor and H&S agency (shaded with sky blue colour) have duties to perform at both stages (as indicated in the boxes), while the red colour indicates the implementation of the measures. "Zero-Accident" is achieved when the four stakeholders have implemented the preventive measures as contained in the model. Moreover, the measures are underpinned by the findings from both the quantitative and the qualitative processes. There is, therefore, much assurance that the right implementation of the model will make accident occurrence on the BCS a forgotten issue.

5. CONCLUSION

The final outcome of the research was the development of a model, with a content of the tasks of the duty holders (construction stakeholders) in the prevention of BCS accident, as model is glimpsed to be the most suitable way of studying the circumstances surrounding occupational accident. More so, it is viewed to be a theoretical way of possessing knowledge of a concept or idea, thus representing diverse ways of approaching complex issues. The participation of major stakeholders is imperative during the identified dual-stage of construction in the drive to achieve a zero-accident at the building site. However, this research can further be elaborated by considering a critical analysis of the involvement of construction stakeholders in the prevention of accident on the BCS as well as testing the implementation of the developed model on the building construction sites.

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