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Factors affecting the quality of construction of unique buildings in Nigeria

Ogidan, Olamipe Timothy

[1] Moscow State University of Civil Engineering, Moscow, Russian Federation; ogidanot@mgsu.ru
Correspondence:* email ogidano@gmail.com; contact phone +79857382089

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Abstract:

The object of research is construction of unique buildings in Nigeria. The population is growing, but there is no more land for construction. This circumstance necessitates the construction of high-rise buildings, rather than traditional buildings. The construction industry in Nigeria is quite a chaotic environment through all the stages involved. Developing countries encounter difficulties in the management of construction projects and processes. **Method**. Experts responded to questionnaires ranking the factors from least important to most important on a 5-point scale. The experts had to have completed at least university education (Bachelor's). Kendall's coefficient of concordance (W) was used to measure the agreement between the expert opinions. Pearson's chi-squared test was used to test the significance of Kendall's W by determining the existence of a relationship between the opinions. **Results**. The results of the research showed a significant amount of agreement in the ranking of the experts, especially in the most important factors. Factors directly connected to materials were observed to affect construction projects in the Nigerian environment the most. Labour and type of contract also have significant impact of the success of projects in Nigeria.

1 Introduction

The development, progress and completion of any construction project can be influenced by the factors and risks involved in the construction environment, also by the technology of its production. The construction process is a complex, nonlinear and dynamic phenomenon that may exists on the edge of chaos sometimes. Therefore, the construction projects are rich in plan failure, delays and cost overruns more than in successes. The design and construction process consists of linear path from the initial concept of the project until its occupancy. The project develops through the stages on step at a time till it arrives to be successfully delivered. These stages are design, bidding stage, pre-construction, procurement, construction, and post-construction [1]. The system-technical linking of all participants and subsystems of the organization of construction production for system analysis and evaluation of the quality of construction and installation works should significantly increase the reliability of the operation of facilities under construction based on the use of modern information and computing technologies [2]. Organizational and technological and managerial decisions allow the building project to be considered as the unity of individual organizational and managerial factors interacting with each other, with a certain degree of influence on the final result [3, 4].

Population growth and territorial land mass deficit is leading to a trend in development of high–rise construction in the Lagos megalopolis. Baranov argues the lack of territory for construction, as well as the incredible population growth in economically developed cities are the main causes of such a trend [5]. The government of Lagos State in Nigeria is currently working with developers to build a new city on reclaimed land from the Atlantic Ocean. Integration of new materials and modern technologies permits a decrease is cost of residential building construction [6]. The requirement for quality construction varies over time depending on the technical and economic capabilities of the environment. Quality is as essential as cost and time, relevant for the life cycle of a projects in general, particularly for construction projects. The quality of construction is considered from a system engineering point of view [7, 8]. Construction is a very chaotic process, requiring systemization to organize and optimize the process involved. The Nigerian construction industry is under systemized. The immensely relaxed preparation and adoption of planning documents can be associated with the harmonization of local planning documents with the law and the harmonization of lower-level plans with higher plans within the period defined by law [9]. There is a problem of harmonization of international standards with local to establish the general requirements for building construction [10].

Developing counties often encounter difficulties in organizing the construction process, especially high-rise buildings [11]. This results in cost and time overrun from the design stage to the post-construction stage. Many factors increase the risk of an unsuccessful unique building project in such economies [12]. However, prioritization of organization and qualified expertise has proven to improve the construction process in developing economies like Singapore, United Arab Emirates and many more. The risks involved in construction of unique buildings in developing economies have not been extensively researched. Most of the readily available research have been carried out in developed countries with very distinctive economic, financial, and technological edge. Walker grouped the factors into cultural, economic, financial, infrastructure, institutional, legal, political, sociological and technological. Navon argued that a control system is vital to identify factors affecting construction [13 – 17]. It is necessary to identify the parameters of organizational and technological solutions at the construction stage with low performance indicators and make recommendations to improve them to the required level [18 – 20]. However, many researchers have proposed a development of management tools and techniques specific to the developing economy project environment.

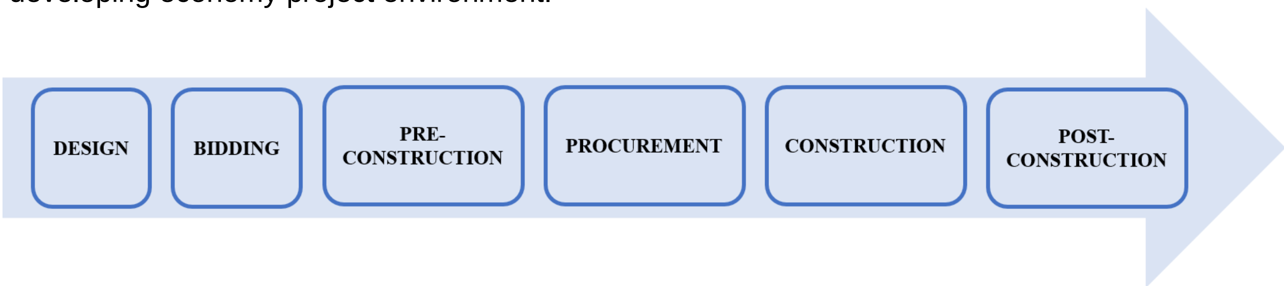

Fig. 1 – Stages of construction project

The goal of this research is to define the main factors affecting construction of unique buildings in Nigeria. The tasks required are: 1) determine factors affecting the success of construction projects in Nigeria; 2) carry out a survey on the extent of effect of the factors; 3) statistical analysis of the concordance and agreement between the experts in the survey; 4) determine the most and least effective factors.

2 Materials and Methods

The goal of the method was defined to determine the ranks of the factors affecting construction projects in the case of Nigeria, otherwise stated as in the project environment of Nigeria. The study of the degree of influence of factors affecting the quality of construction production was carried out by the method of a priori ranking. A questionnaire survey was conducted based on the previous findings of P.O. Akanni et al [13]. A list of factors affecting the quality of construction at each stage of their production based on the literature data was compiled. 28 of 29 factors were selected to be ranked by the experts. The experts were asked to rate the factors according to the degree of their influence on the final construction product [21], in the case of Nigeria. A construction product is defined as a completed construction of buildings and other structures, as well as their complexes [22].

According to authors Zagorskaya and Lapidus [23], It is not possible to calculate the required number of experts required to rank more than 31 factors due to the limitations of the Chi tabular values. The minimum number of experts adopted in this way determines the sufficiency of the sample size for the application of the Pearson criterion (provides statistical significance). As shown in figure 1, the minimum number of experts required for 28 factors is 4. Hence, the condition is being satisfied to further carry out the research.

The weight contribution of each factor was assessed by the magnitude of the rank place assigned to it by the expert. A total of 7 experts were interviewed, including: 1 Doctor of Technical Sciences, 1 PhD holder of Technical sciences and experienced professionals in the construction industry. Table 1 shows the demographic data of the experts. It is worth noting that the academics are experts in the field of construction with at least 10 years of experience. Also, indicated below is the highest awarded degree of the expert. Therefore, if an expert holds a master's degree, the bachelor's degree is neglected. In the same manner, holders of a PhD degree were grouped according to the PhD rather than the master's degree.

An online survey using Google forms was formulated. The purpose of the questionnaire was to identify the important factors influencing the construction of buildings with a height of at least 100 m in Nigeria. According to the Russian Unified Standards popularly transliterated to GOST in the Russian Federation, a building whose height is not below 100 meters is a unique building [24] as opposed to the undefined status of a skyscraper according to modern sources. Modern literature classifies a skyscraper as a building with at least 100 meters or 150 meters in height.

Table 1. Demographic data of experts

Academic Background		
Parameter	Number	Percentage
Bachelor's degree	1	14.3
Master's degree	4	57.1
PhD holder	1	14.3
Doctor of Technical Sciences	1	14.3
Professional expertise in construction		
< 5 years	2	28.6
5-10 years	2	28.6
10-20 years	2	28.6
20-30 years	1	14.3

Project performance indicators like materials consumption, cost, labor productivity, schedule, quality or waste are used in determining the performance of projects [12, 16 – 18]. The factors chosen for the purpose of the research are as follows: x_1 – inflation rate, x_2 – inadequate working capital, x_3 – unexpected prices (labour), x_4 – unexpected prices (materials), x_5 – access to capital, x_6 – shortage of labour, x_7 – shortage of plants/equipment, x_8 – importation of materials/equipment, x_9 – labour strikes, x_{10} – late delivery of materials/equipment, x_{11} – governmental instability, x_{12} – political agitation, x_{13} – policy instability, x_{14} – legislation, x_{15} – election, x_{16} – planning regulation, x_{17} – contract, x_{18} – attitude of judiciary, x_{19} – civil conflicts, x_{20} – beliefs/customs, x_{21} – hidden obstruction, x_{22} – access to social amenities, x_{23} – literacy, x_{24} – climatic/weather condition, x_{25} – natural disaster, x_{26} – site conditions, x_{27} – geology, x_{28} – high water table.

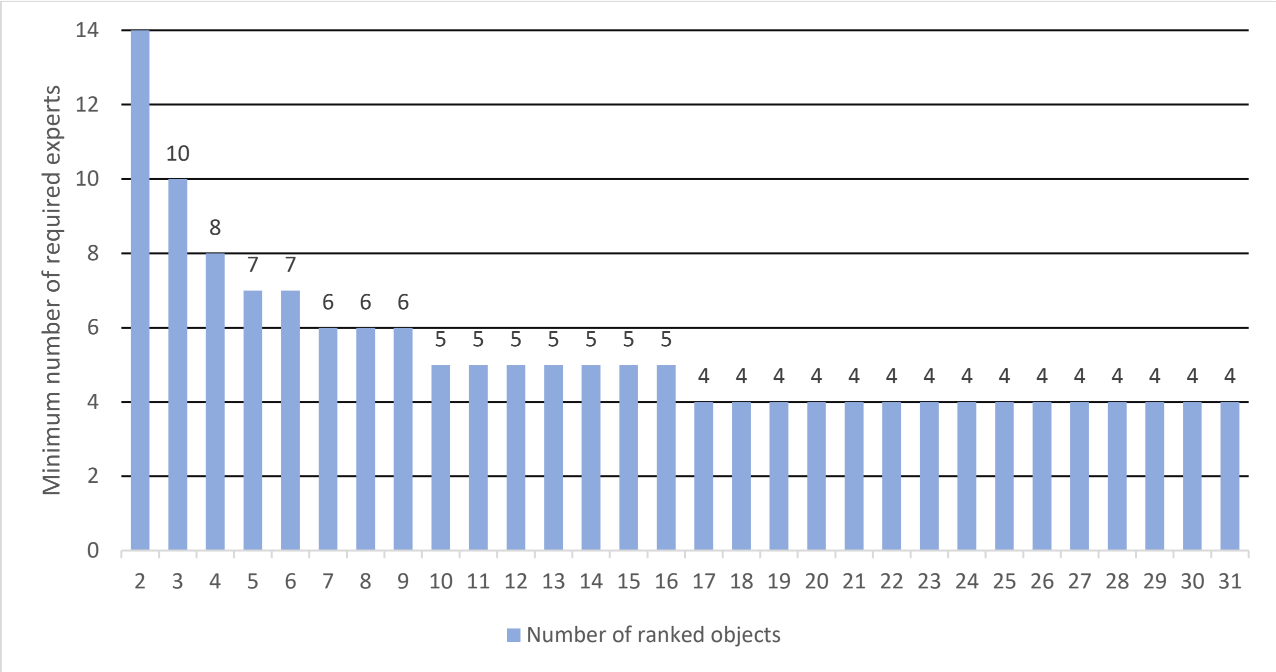

Fig. 2. Minimum number of experts for a priori ranking of various number of objects

A priori ranking of factors is performed, based on the results from the questionnaire survey, which allows the identification of the most significant factors and filters out factors that have an insignificant effect on the construction project. Multicriteria decision analysis (MCDA) techniques such as the Analytic Hierarchy Process (AHP) offer a way to systematically evaluate and integrate stakeholder opinion in order to set priorities and make decisions [25].

The algorithm as proposed by Zagorskaya and Lapidus [23] in their paper starts with defining the type of data to be analyzed. For the purpose of this research, the categorical variable has been assigned to the data. determining the minimum required number of experts to rank the factors. The minimum number required to go further in the research is 4. To minimize the number of expert opinions to be evaluated further in the research, a Spearman analysis was carried out to compare the correlation between the rankings of each expert. The correlation coefficient of ranks is calculated as shown below in equation 1:

$$\rho = 1 - \frac{6\Sigma d^2}{n(n-1)} \tag{1}$$

Experts A and C with the least field experience were filtered out of the matrix to achieve a more 'expert' opinion. Table 2 shows the Spearman correlation between the ranked factors.

Table 2. Spearman correlation analysis

Expert	A	B	C	D	E	F	G
A	1,000	0,063	0,032	0,402	-0,090	0,284	0,003
B	0,063	1,000	0,392	0,310	0,594	0,493	0,614
C	0,032	0,392	1,000	0,098	0,249	0,146	0,163
D	0,402	0,310	0,098	1,000	0,254	0,456	0,449
E	-0,090	0,594	0,249	0,254	1,000	0,231	0,484
F	0,284	0,493	0,146	0,456	0,231	1,000	0,564
G	0,003	0,614	0,163	0,449	0,484	0,564	1,000
∑	1,693	3,466	2,080	2,969	2,723	3,174	3,278

The results of the questionnaire survey depicted in the a priori ranking matrix in table 3.

Table 3. A priori ranking matrix of expert opinions for each factor

Expert / Factor	B	D	E	F	G	$\sum Ri$	$\bar{R}$	$(R-\bar{R})^2$	S
x_1	20	6	25	15	20	86	54,18	1012,60	27926,11
x_2	9	6	3	15	1	34		407,17	
x_3	24	6	25	5	20	80		666,75	
x_4	1	1	3	5	1	11		1864,39	
x_5	1	1	3	15	1	21		1100,82	
x_6	9	1	1	5	1	17		1382,25	
x_7	1	6	3	1	20	31		537,25	
x_8	20	1	17	1	13	52		4,75	
x_9	9	1	3	15	20	48		38,17	
x_{10}	1	6	3	1	1	12		1779,03	
x_{11}	20	6	1	15	13	55		0,67	
x_{12}	9	26	17	15	25	92		1430,46	
x_{13}	9	21	17	15	20	82		774,03	
x_{14}	9	6	17	5	1	38		261,75	
x_{15}	20	26	17	28	25	116		3821,89	
x_{16}	9	21	3	5	1	39		230,39	
x_{17}	1	13	3	1	1	19		1237,53	
x_{18}	9	13	3	15	13	53		1,39	
x_{19}	24	21	3	15	13	76		476,17	
x_{20}	28	26	17	15	28	114		3578,60	
x_{21}	24	13	28	15	13	93		1507,10	
x_{22}	24	24	25	15	25	113		3459,96	
x_{23}	9	24	3	15	13	64		96,46	
x_{24}	9	13	17	5	1	45		84,25	
x_{25}	1	13	3	5	1	23		972,10	
x_{26}	1	13	3	5	13	35		367,82	
x_{27}	9	13	3	5	1	31		537,25	
x_{28}	1	13	17	5	1	37		295,10	
H_j	1944	1014	3264	3234	2196				

$\Sigma_{j=1}^{m} T_j = 11652$

After the survey, the degree of consistency of expert opinions is assessed by calculating the Kendall coefficient of concordance (W).

$$W = \frac{12 * \sum_{i=1}^{k} \Delta_i^2}{m^2 * (k^3 - k) - mT} \quad (2)$$

where Δ_i^2 – sum of squared deviations *i-th* factor;
m – number of judges (experts);
k – number of ranked factors;
T – correction factor for tied ranks.

The evaluation of its significance is carried out using Pearson's χ^2-criterion, determined by the formula:

$$\chi^2 = m * (k-1) * W \quad (3)$$

where W – Kendall's coefficient of concordance;
m – number of judges (experts);
k – number of ranked factors.

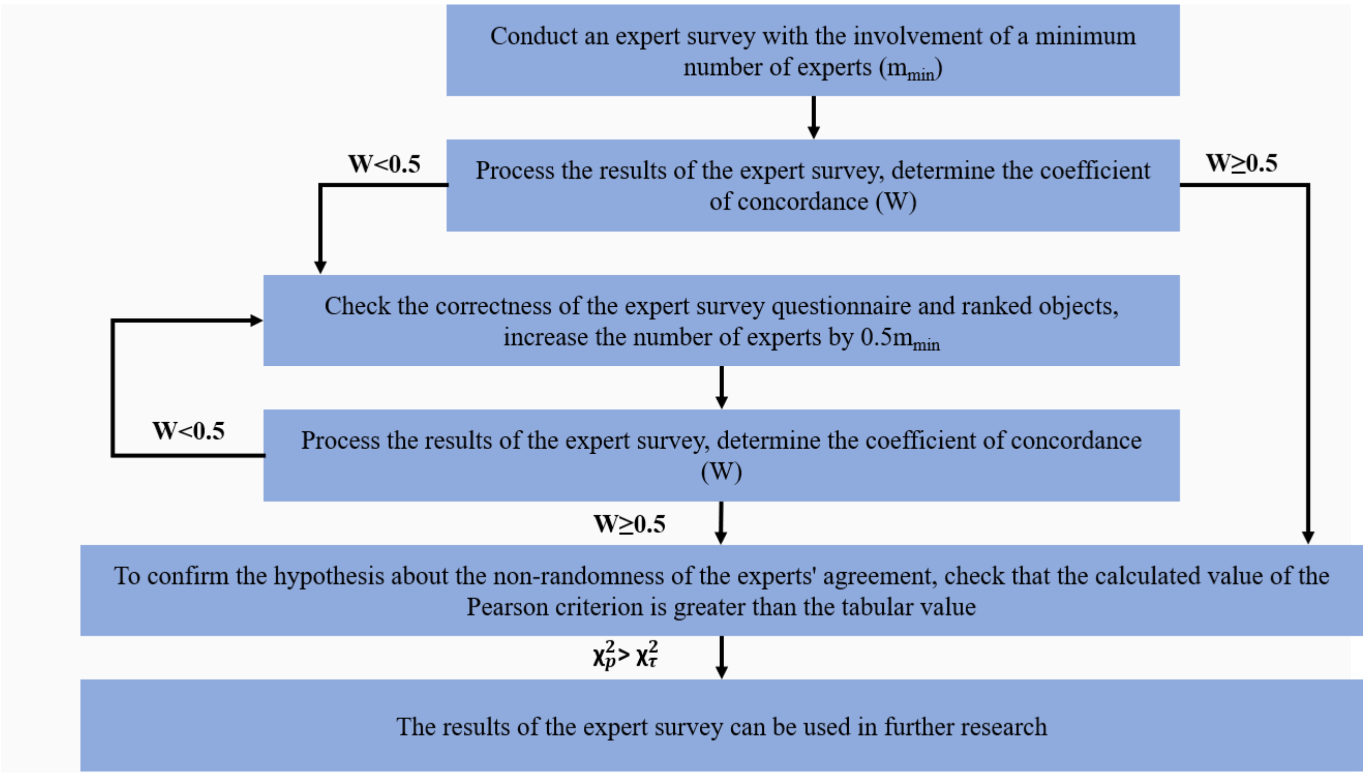

Fig. 3. Recommended algorithm for conducting an expert survey with a priori ranking

The hypothesis of the agreement of the opinions of the interviewed experts is considered to be perfectly positive if the coefficient significantly tends to 1 [26, 27]. The hypothesis of non-randomness of expert agreement is satisfied if the calculated value of the Pearson criterion is greater than the tabular value, that is if the following inequality holds:

$$\chi_\rho^2 > \chi_\tau^2 \quad (4)$$

where χ_p^2 – calculated value of Pearson's criterion;
χ_τ^2 – tabular value of Pearson's criterion.

A significant coefficient of concordance allows to draw an average a priori rank diagram in coordinates: y-axis – the inverse sum of ranks; x-axis – ranked factors. The smaller the sum of the ranks of this factor, the higher its place in the diagram.

3 Results and Discussion

The results of the degree of consistency of expert opinions after determining Kendall's coefficient of concordance according to equation 2 showed significant consistency. The result was greater than the recommended 0.5.

$$W = \frac{12 * \sum_{i=1}^{k} \Delta_i^2}{m^2 * (k^3 - k) - mT} = 0.68 \quad (5)$$

With a concordance coefficient W ≥ 0.5, as is the case in our research, the hypothesis of non-randomness of expert agreement is tested. The evaluation of its significance, also called the significance test, was carried out using Pearson's χ^2-criterion as shown in equation 3.

$$\chi^2 = m * (k - 1) * W = 92.36 \quad (6)$$

The comparison between the tabular value of Pearson's criterion with a 95% confidence level (α = 0.05) and degree of freedom of 27 is given as 40.11. Since $\chi_p^2 = 92.36 > \chi_\tau^2 = 40.11$, it can be assumed that the expert opinions are in agreement.

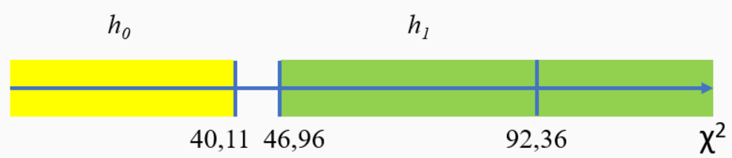

Fig. 4. Graphical representation of Pearson's significance test

The empirical value $\chi^2 = 92.36$ of falls into the critical region, hence, it supports the motion to reject the null hypothesis. The concordance coefficient is significantly closer to one than it is to zero ($p < 0.05$), therefore there is a sufficient amount of consistency in expert opinions evaluating the surveyed factors.

A diagram of ranks of the expert opinions is drawn as shown in fig. 4. Factors 4 – *unexpected rise in the price of construction materials*, 10 – *late delivery of materials and or equipment*, 6 – *shortage of labour* and 17 – *type of contract* showed the most significant effect on construction projects in Nigeria. On the other hand, 15 – *election*, 20 – *beliefs/customs*, 22 – *access to social amenities*, 21 – *hidden obstruction*, 12 – *political agitation* showed the least significant effect under the same conditions.

Expert B ranked the factors unexpected rise in the price of materials, access to capital, shortage of plants/equipment, late delivery of materials/equipment, type of contract, natural disaster, site condition, high water table as the most important. Expert D ranked the factors unexpected rise in the price of materials, access to capital, shortage of labour, importation of materials/equipment and labour strikes as the most important. Expert E ranked the factors shortage of labour and government instability as the most important. Expert F ranked the factors shortage of plants/equipment, importation of materials/equipment, late delivery of materials/equipment and type of contract as the most important. Expert G ranked the factors inadequate working capital, unexpected rise in the price of materials, access to capital, shortage of labour, late delivery of materials/equipment, legislation, planning regulation, type of contract, climatic/weather condition, natural disaster, geology, high water table as the most important. Unexpected rise in the price of materials, access to capital, late delivery of materials/equipment, type of contract and shortage of labour were most regularly ranked as the highest. This may be due to the unstable economy in the country and lack of infrastructure to produce domestic materials and equipment. It is worth mentioning that Nigeria possesses an affluence of natural resources necessary for construction. Also, the lack of proper management skills may play a vital role in the risk of unsuccessful projects in the Nigerian conditions.

During the survey, no expert took the opportunity update the list of factors affecting the construction production of buildings and structures in Nigeria, which indicates its completeness of the list. However, this could also be a result of the lack of exposure to previous research.

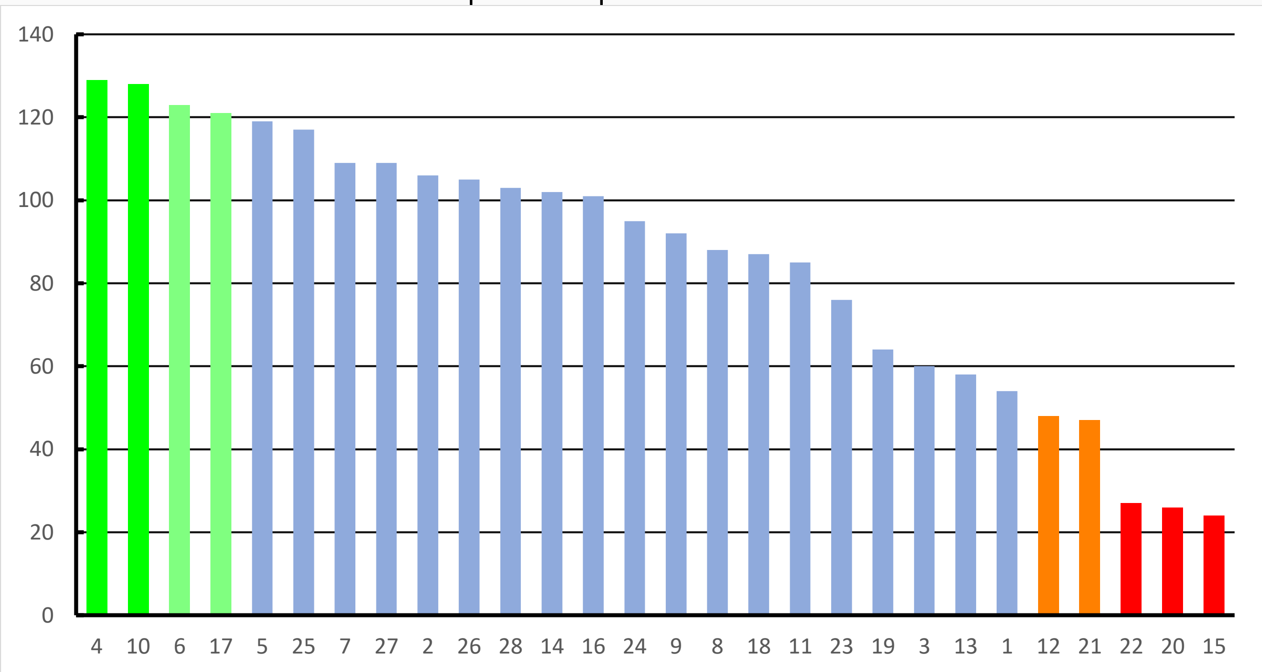

Fig. 5. Rank diagram of expert opinion

During the survey, no expert took the opportunity update the list of factors affecting the construction production of buildings and structures in Nigeria, which indicates its completeness of the list. However, this could also be a result of the lack of exposure to previous research.

Expert B and G ranked beliefs and customs as the least important. Expert D ranked political agitation, election, beliefs and customs, access to social amenities, literacy as the least important. This was the only expert to assign factors (political agitation, election, beliefs and customs) a rank of zero which suggests that they have no effect on construction projects in Nigeria. Expert E ranked election as the least important. Expert F ranked election as the least important. Overall, the experts ranked beliefs and customs and elections as the having little to no effect on construction projects in the Nigerian environment. This could be related to absence of elections during the period of research.

The rank diagram of expert opinion supports the opinion of each of the experts as shown in fig. 4 that unexpected rise in the price of materials, late delivery of materials/equipment, type of contract and shortage of labour. Similarly, elections, beliefs and customs and access to social amenities is in conformation with the opinion of each expert.

4 Conclusions

1. The factors affecting construction projects in Nigeria were studied. 28 factors were chosen.
2. The Kendall's coefficient of concordance, W was greater than 0.5. There was agreement among the expert opinions.
3. Unexpected rise in the price of materials, late delivery of materials/equipment, type of contract and shortage of labour were identified as the leading factors affecting construction in Nigeria.
4. Elections, beliefs and customs and access to social amenities were identified as the least risky factors to achieve a successful construction project in Nigeria.
5. A priori ranking was sufficient to determine the most important factors.
6. It is necessary to carry out further research on how the factors affect project parameters like cost, duration and quality.

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