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EARTHQUAKE RISK: THE OPINION OF GHANAIAN LOCAL ARTISANS

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Abstract

Natural disasters have numerous impacts on national economies and can have significant impact on the sustainability of long-term development and a country's productive performance economy. A field survey was conducted between 2012 and 2013 to assess how Ghanaians of all works of life view risk associated with earthquake disaster. This paper particularly focuses on the earthquake risk perception of artisanal masons or so called "one-man contractors", who form the group responsible for the construction of a large percentage of residential and informal buildings in the country. It provides an analysis of their seismic risk perception, and how such a perception is associated with demographic and socioeconomic variables. Furthermore, it analyses how their risk perception affects their behavior towards mitigation actions. The results of the study point to seismic risk perception behavior being greatly influenced by respondents' demographic and socioeconomic characteristics, whereas mitigation actions also depend strongly on respondents' demographic and socioeconomic status. It was noted from the study that the earthquake education is lacking and is a critical factor that needs to be addressed in the Ghanaian society. The findings will help Ghanaian local government authorities develop targeted policies earmarked at seismic risk disaster reduction, particularly for the sprawling urban centres.

Keywords: Local Artisans; Earthquake disaster; Seismic risk; Mitigation action; Risk perception

1. Introduction

Natural disasters have had major catastrophic impacts on national economies with consequential bearing on log-time sustainable development and productive performance. Studies have shown that most deaths from earthquakes result from unsafe structures, and most often it is the economically disadvantaged and marginalized in society that bear most of these consequences. Earthquake fatalities are exacerbated by faulty construction practices, collapse of unsafe structures and buildings, ground instability, etc. Disastrous earthquakes result not only in large number of injuries and fatalities but also huge economic losses, and this typically occurs when hazards and vulnerability meet [1, 2]. In this regard, the extent of devastation becomes immeasurable when earthquakes hit urban areas having densely populated settlements. For instance, in 2008, the Sichuan earthquake caused thousands of deaths and over $150 billion in economic losses [3]. Likewise, the 2010 Haiti earthquake killed more than a quarter of million people and resulted in losses of over $14 billion [3]. On the other hand, impacts in sparsely populated settlements are generally minimal as was the case of the New Madrid earthquakes of 1811 and 1812, respectively [4].

Although earthquake science has advanced significantly in the last decades, the precise prediction of earthquake occurrence still remains a challenge. Many surveys have indicated that people are generally aware of the risks posed by earthquakes but have fatalistic attitudes towards them [5]. Generally, it is accepted that proper planning can help mitigate against the disastrous effects of earthquakes [1]. Governments at both the national and local level, as well as individuals, can take measures to minimize or cope with the impact of earthquakes. Such measures could include: retrofitting buildings to make them perform better under seismic conditions, properly securing non-structural elements in buildings, drawing up a family disaster plan, etc. [2].

In Ghana, houses are predominantly built with reinforced concrete and masonry blocks. These structures are typically heavy are noted to have caused pronounced injurious effects on occupants in past earthquakes. [6]. Due to the high cost involved in hiring building engineers and professionals, local artisanal masons, or so called “one man contractors”, typically construct a significant number of residential houses and semi-commercial buildings in Ghana. Consequently, in studying seismic risk perception and seismic safety, their critical role cannot be ignored. In 2010, data published by Ghana Statistical Service (GSS) indicated that the construction industry together with real estate services was a noticeable contributor to the country’s GDP [7]. It is thus, imperative that buildings are constructed with optimum safety features in order to reduce the number of casualties, and the level of catastrophe caused by earthquakes, as well as the economic and social loss to communities.

Generally, it has been shown time and time again that strong non-engineered affordable houses resistant to impacts of earthquakes can be constructed if appropriate materials, techniques and technologies are selected and used [1]. However, it is noted that people are normally ignorant of the appropriate measures and techniques need to use to build properly. Furthermore, the important need to for the retrofitting of existing vulnerable houses also is not recognized as it should be [5].

Based on the above discussion, the primary object of this paper is to explore the seismic risk perception of local artisans (masons) or “one-man contractors” in Ghana, who are directly involved in site inspection and housing construction. The results of this study will help inform government and civil society on the current status of earthquake risk perception among this grouping, and also help to identify critical measures that should be taken to enhance seismic safety in the country in general.

2. Historical Seismicity

Ghana is located on the Southeastern margin of the West Africa craton, distant from the major earthquake zones that mark the present day lithospheric plate boundaries [8]. Fortunately, most African nations are not classified as earthquake prone regions as their occurrences are infrequent and largely confined to sparsely populated regions [1]. This is agreement with recent available seismic data which indicates that almost nearly all countries

in West Africa have experienced earthquake at one point in time in this century [9]. Notwithstanding the infrequency of occurrence of earthquakes in West Africa, a number of major and minor earthquakes have struck the Ghana in the past. In recent times, earth tremors of magnitudes up to Magnitude 5 on the Richter scale have been recorded. Ghana, has, however, recorded of damaging earthquake dating as far back as 1615, with the last three major events occurring in 1862, 1906 and 1939, respectively [8]. Interestingly, the region of high seismicity in the country is located near the capital, Accra, which has the highest population density in the country, and also is the most highly industrialized. As discussed earlier this points to a region of high seismic risk due to the convergence of both increased seismicity and high disaster vulnerability.

Fig. 1 – Upper part of a house that collapsed in the 1939 Accra M6.5 earthquake

Based on the above, it is therefore significant for Ghana to examine the earthquake risk of its earthquake-threatened urban centres, and in particular to assess the level of exposure of buildings and infrastructure to the potential impacts of earthquake disaster. This will help provide input for decision-makers to provide targeted mitigation actions that can help reduce the level of the country's seismic risk exposure. To a large extent, the damage caused by earthquakes is directly proportional to the level of knowledge, planning, and the degree of safety measures implemented by the people. In this regard, according Allotey et al. [6], other countries with earthquake-threatened capitals like Accra, such as Nepal and Ecuador are doing better than Ghana.

3. Methodology

3.1 Data collection and coding

Survey questionnaires were administered to local artisans (masons) in Southern Ghana with the aim of evaluating respondents' perception on disaster risk in the housing construction industry, and by extension, the entire construction industry. The data was collected over a period of four (4) months from 2012 to 2013 using the paper-and-pencil self-administered questionnaire technique. The developed questionnaire was divided into five (5) main sections namely: demographic and socioeconomic characteristics, earthquake knowledge and experience, risk perception, mitigation actions, and general safety consciousness. The simple random sampling survey approach was used for the selection of respondents for questionnaire administration. This approach facilitated better monitoring and quality control as well as placing a high response burden on the respondents.

Questionnaires collected from the field that were used for the analysis numbered three hundred and ninety eight (398). Interim analysis and memoing were performed on some qualitative responses [10, 11] and these were subsequently coded together with quantitative responses for further analysis by SPSS [12, 13].

3.2 Statistical data analysis

Data collected from the survey were analyzed with the SPSS statistical software, Version 20. General data descriptive analysis including frequency analysis, cross-tabulations, etc. were conducted. In addition, correlation analysis was performed with cross-tabulations to elicit the combined distribution of variables. This was followed by Chi-square analysis and statistical independence testing between the variables. SPSS made statistical analysis results more accessible and enhanced convenient use of the data. The Chi-square tests of independence allowed for the determination as to whether given variables were independent of each other, or whether there was a pattern of dependence existing between them.

Cross-tabulations (with chi-square analysis) was used to determine whether there were statistically significant differences between the correlated variables. A 95% level of confidence was used for the chi-square assessment.

4. Results and Discussion

4.1 Demographic and socio-economic characteristics of respondents

Table 1 shown below provides the general frequency statistics for the attributes of respondents. From the table, majority of the respondents were found within the urban centres of Accra and Kumasi. However, when one considers the Greater Accra Metropolitan Area (GAMA) that includes Accra, Ga West and Ga East, then it can be noted that over 50% of the respondents are from the GAMA area. The table also shows that a majority of the respondents are within the 18 – 45 age bracket, which is typically the prime working age of most artisans in Ghana. In addition, most the respondents are noted to only have completed basic school (i.e., Junior Secondary School, JSS), with a sizeable fraction also completing high school (i.e., Senior Secondary School, SSS).

Considering socio-economic level of their location of residence and their personal economic status, it was found that most of the respondents considered their place of habitation to be within the moderate to high socio-economic class. This seemed somehow at variance with the economic status indicator, which measured their perceived economic status to be within the low – moderate economic class. The variance between these two indicators could be characteristic of Ghanaian urban centres, which have a marked mixture of different socio-economic classes living within a general area. This is generally unlike other places in the world, where there is a clear distinction between very well planned and clean communities with high social standing, and other poorly planned and unmaintained communities.

4.2 Risk perception and mitigation behaviour

Table 2 presents the frequency statistics for various indicators that measure the seismic risk perception of masons. The table shows that most of the masons surveyed consider the buildings they build for their clients to have a general very low to moderate earthquake safety rating. This is quite interesting since one could argue that the masons (one-man contractors) are the experts and should be quite confident of the safety of the houses they build. This is against the backdrop that the table shows that over half of the respondents believe that houses can be designed and constructed well to provide enhanced seismic safety. This therefore points to the artisanal masons being somehow aware of the fact that the buildings they put up are not strong enough. This could be due to a knowledge on their part that the construction methods they use are sub-standard, which could result from lack of training on how to building well, or a knowledge of the fact that their clients would not be willing to pay the right price for “strong buildings”. In this regard, Table 3 also shows that a predominant number of the masons note that they use both drawings and experience to build for their clients. A significant number also note

that they only build with drawings for their clients. If most buildings being built by the artisanal masons are designed, it is surprising that the masons consider the buildings they build not to be strong enough. The use of drawings to build is corroborated by the indicator that measures whether the buildings masons build have permits. This indicator shows that most of the respondents state that the buildings they build have permits. A building can only be given a permit if the required design drawings and documents have been approved by the municipal/metropolitan authorities; such buildings therefore have the required design drawings [14].

Table 1 – Attributes of Respondents

Indicator	Classes	Frequency	Percentage
Metropolis	Accra	130	33
	Ga West	72	18.3
	Ga East	14	3.4
	Kumasi	120	30.5
	Obuasi	58	14.7
Age	<=18	18	4.5
	18-30	156	39.3
	31-45	172	43.3
	46-60	51	12.8
Education	None	12	3.1
	Primary	78	20
	JSS	193	49.5
	SSS/Diploma	103	26.4
	BSc/BA	4	1
Socio-economic level of place of living	Very High	18	4.7
	High	196	50.9
	Moderate	144	37.4
	Low	24	6.2
	Very Low	3	0.8
Personal economic status	Very Low	13	4.7
	Low	285	73.6
	Moderate	84	21.7
	High	4	1
	Very High	1	0.3

Table 2 – Risk Perception

Indicators	Classes	Frequency	Percentage
Safety level of buildings built by Masons	Very Low	92	23.5
	Low	117	29.8
	Moderate	106	27
	High	52	13.3
	Very High	25	6.4
Buildings can be designed and constructed to give assurance of seismic safety	Yes I believe	230	58.7
	No Assurance	11	2.8
	Difficult to say	50	12.8

In contrast with the above discourse, the Table 3 also shows that most masons believe that following the laid down building permit procedure results in enhanced building safety. However, this enhanced safety does not seem to reflect in an increased confidence in the seismic safety of the buildings they build for their clients. As previously noted, this could be due to they knowing that they use sub-standard construction techniques,

although the building designs are well prepared, or just perceived ignorance on their part in regards to what they need to do to make the buildings they build safer.

Further to the above, most of the masons noted their strong interest in gaining more knowledge on how to build safer buildings, and were of the view that with the resources available in the country, not enough was being done in regards to earthquake education and awareness creation. This issue is of critical importance and points to the urgent need for a strong targeted earthquake education and awareness campaign. In this regard, the Ghana Earthquake Society (GhES) that is currently in its formative stage, and seeks to serve as the umbrella organization for earthquake professionals in Ghana, has to consider earthquake awareness creation as one of its critical tasks.

Finally, Table 3 provides a response by the masons to the amount of money they would be willing to spend on retrofitting their own buildings to make them more seismically safe. A large proportion of the respondents note that they are willing to spend US$500 or less, however, almost 50% state that they cannot spend more than US$50. Noting that when it comes to construction, US$50 cannot do much, this response shows that among the various domestic issues needing attention, the respondents do not really consider the need for seismic retrofitting as that important. This is particularly significant since these same masons have noted that the buildings they build for people are not that strong, even though they know it is possible to build strong buildings. This inferred observation points to the lack of "real true" understanding on the part of the masons of the level of risk faced. This in part could be due to the noted lack of effective earthquake education and awareness, and also on the perception of limited likelihood of a destructive earthquake event occurring any time soon.

Table 3 – Mitigation Actions

Indicators	Classes	Frequency	Percentage
Do building Masons build have building permits?	All do	35	9.3
	Most do	143	37.9
	Some do	141	37.4
	Most do not	58	15.4
Masons build with drawings or experience?	With drawings	146	37.2
	Solely experience	37	9.4
	Both but more experience	209	53.3
Following permit process enhances building safety?	Does nothing	16	6
	A bit	29	10.8
	Average	54	20.1
	Quite a lot	169	63.1
Interest in learning more about quake-resistant buildings	Very low	9	2.3
	Low	27	6.8
	Moderate	41	10.4
	High	179	45.3
	Very high	139	35.2
Money willing to be spent on seismic retrofitting of buildings (***in GH¢: 2GH¢ = 1 US$***)	<=100	105	45.7
	1000	89	38.7
	10000	35	15.2
	100000	1	0.4
Think enough resources being spent on earthquake education and awareness?	Yes	69	17
	No	231	57
	Somehow	37	9.1

4.4 Correlation between risk perception and demographic & socio-economic characteristics

Table 4 – Correlation matrix between risk perception and demographic and socio-economic levels

	Perceived safety level of buildings built by masons			
	Level of education	Number of kids	Socio-economic level of metropolis	Economic status of respondents
Pearson correlation	45.846	57.387	39.251	32.739
Significance (2-tailed)	0.000	0.000	0.001	0.008
N	398	398	398	398

* Correlation is significant at the 0.05 level (2-tailed)

Considering the correlation between risk perception and demographic and socio-economic levels, Table 4 shows that at the 5% significant level, correlation between risk perception and level of education ($p = 0.000$), number of kids ($p = 0.000$) and socio-economic levels of the metropolis ($p = 0.000$) in which the respondents live was noted to be statistically significant. Surprisingly, the economic status ($p = 0.008$) of the respondents was noted not to have a strong correlation with perceived building safety. Thus, the perceived low-moderate level of building safety cannot be said to vary more significantly with economic status, but rather an across board general perception. On the other hand, the table shows that the area where a respondent lives correlate well with the respondent's perceived building safety. Not much direct inference can be drawn from this, however, it can be speculated that the observed correlation could be due to the risk perception of the masons being influenced by the high socio-economic levels of their neighbours and the clients they build for them. This assertion is based on the premise that people living in high socio-economic areas have a higher risk perceptibility [15].

Table 4 shows a significant correlation between risk perception and education level. This seems to be counter-intuitive since it points to the low – average level of education impacting on the observed low-moderate perceived level of building safety. However, one can also explain this observation by noting that their low – average education level makes them less confident of their work, and for that matter, not too sure about the strength of the buildings they put up. Assuming this assertion to be true, increased earthquake education and awareness would be a critical factor in making the masons more confident about the strength of the buildings they put up. This is against the backdrop that a majority of them have noted their interest in learning more about earthquake-resistant construction.

Finally, Table 4 also notes a strong correlation between the low-moderate perception of building safety and the number of kids a respondent has at home. In general terms, there is no direct reason why such a correlation should exist. However, when one considers the fact that being a parent generally makes one more protective of his/her children, it could be inferred that this latent inherent risk aversion, makes the respondents generally a bit more cautious than necessary.

4.5 Correlation between risk perception and mitigation action

Table 5 – Correlation matrix between risk perception and mitigation actions

	Perceived safety level of buildings built by masons		
	Do buildings built have permits	Do you build with drawings/experience	Enough resources/ awareness
Pearson correlation	97.427	30.155	23.552
Significance (2-tailed)	0.000	0.000	0.003
N	398	398	398

* Correlation is significant at the 0.05 level (2-tailed)

Table 5 shows the correlation between respondent's perceived safety level of buildings they put up for their clients and various mitigation factors/actions. As earlier discussed, the table shows that at 5% level of significant, there is correlation between low-moderate perceived level of building safety and buildings that are built with permits. This reinforces the assertion arrived at in the previous section pointing to the low perceived safety of buildings built by masons, although they have the relevant permits. This means that although masons consider the permitting process helpful to the enhancement of building safety, they do not perceive this factor to be strongly deterministic enough to ensure their perceived level of safety required in the case of an earthquake event. This contrasting inference is also corroborated by the significant correlation that exists between the low level of perceived safety and the significant portion of buildings that are constructed by the masons with design drawings. The perceived lack of enhanced seismic safety of buildings built by masons can thus be attributed more to their appreciation of the level of their own construction practices.

From the table, the consideration that not enough resources is being made available for earthquake education and awareness is seen to also significantly correlate with lack of perceived building safety. This shows that the masons in one way or the other, consider increased earthquake education and awareness to be important in regards to building seismic safety.

5. Conclusions

This paper explored the seismic risk perception of local artisans (masons) or "one-man contractors" in Ghana, who are directly involved in building construction, i.e., mainly residential building construction. This is part of a larger study on the assessment of the overall earthquake risk perception of the Ghanaian society.

Among others, the following important observations were made from the study:

- The artisanal masons are generally aware that the buildings they put up are not strong enough to withstand the effects of a possible future earthquake event, although they consider that it is possible to build strong buildings that can potentially withstand the effects of a future earthquake event. The reason for this could in part be due to the knowledge on their part that the construction methods they use are sub-standard.
- Most of the masons considered that not enough resources available in the country were being allocated to earthquake education and awareness creation. Most of them also noted their strong interest in gaining more knowledge on how to build safer earthquake-resistant buildings. This observation provides an appreciation of what civil society groupings such as the newly formed Ghana Earthquake Society (GhES), which seeks to serve as the umbrella organization for earthquake professionals in Ghana, should focus their attention on.
- Almost 50% of respondents noted that they would not be willing to spend more than US$50 on retrofitting their homes. Noting this to be a considerably small amount, and considering the fact masons are involved in the construction business and should know this, points to the lack of a real understanding on the part of the masons of the level of earthquake risk faced.

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