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AN ANALYSIS OF CONSTRUCTION MATERIAL BATCHING BEHAVIOUR OF ARTISANS IN GHANA'S INFORMAL CONSTRUCTION SECTOR

Hedidor D[1] and Bondinuba F. K[2]

[1]Oboadaka L/A Junior High School
[2]Institute for Social Policy, Housing, Environment and Real Estate, School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University-UK.

ABSTRACT: *This study investigated construction materials-batching behaviour of artisans in the Ghana informal construction sector. The research was conducted in three major townships across three districts namely: Mepe/Battor in the Volta Region, Pokuase in the Eastern Region and Nsawam in the Eastern Region of Ghana. To achieve the study objectives, a quantitative data collection approach was adopted as the primary methodology for gathering data from the target population using cluster-sampling technique to select the sample population. The results showed that the Ghana informal construction sector paid scanty attention to the standard practices and procedures for constructing residential buildings. Reasons included inadequate levels of apprenticeship training to grow the skills and competence of artisans. Low-quality training duped apprentices into thinking that they were fully qualified when in reality they were not. Not only that, apprenticeship varied widely across construction trades and master craftsmen. Batching was generally eyeballed instead of being measured scientifically resulting in insufficient cement to aggregate ratio in cement blocks, concrete and mortar works. Also, cement and aggregate mixtures had high percentage of water. Weak cement blocks resulted in poor construction and weak buildings with rising moisture content in walls, leaking roofs, cracks and structural failure.*

KEYWORDS: Construction Material, Batching, Artisans, Informal Construction

INTRODUCTION

At the time of this study, the Ghana construction industry was made up of formal and informal sectors. The formal sector consisted of businesses that employed trained professionals such as architects, civil engineers, quantity surveyors, geotechnical engineers, electrical engineers and related skills. Formal sector businesses was regulated, monitored and taxed by the government while informal sector businesses were unregulated; they did not pay taxes and were typically run by informally trained artisans. Also unlike the formal sector, projects in the informal sector were implemented on incremental basis; project duration, cost and quality were unwritten. Clients' financial resources and master artisan determined the completion date and project quality. Projects undertaken in this sector typically include incremental housing, shops, fence walls and certain private institutional facilities. The informal sector of the construction industry was developing very fast because of the desire by individuals to own homes and the rising demand for rented properties.

The construction boom created numerous problems. Among them, construction without material and workmanship specifications, building planning permits or architectural, civil engineering and quantity surveying documentation. Buildings completed without these permits experienced rising moisture content in walls, leaking roofs, cracks and structural failure. Though these problems were commonplace, there was no systematic study of the nature of

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construction activities and material batching in the towns of Mepe/Battor, Nsawam, and Pokuase. The study sought to investigate the material measurement/batching behavior of artisans in the informal construction sector in the aforementioned townships.

LITERATURE REVIEW

Informal Sector

The Oxford Advanced Learner's Dictionary (OALD) defines the "informal sector" as "relaxed and friendly"; not following operational rules and regulations. Hart (1973) applied this definition to his study of the Frafra urban migrants in Ghana,

describing their business activities in the low-income economic sector. He found that most of the Frafras were "unskilled and illiterate". He concluded that various factors including price inflation and inadequate wages combined to produce a "high degree of informality in the income-generating activities of the sub-proletariat".

Uwakweh, (2000) examined the conceptual framework of construction-worker motivation in developing countries. He discussed various motivational strategies in the construction industry, arguing that if "we define motivation as the force that will drive an individual to engage in a behavior, then, our goal should be to determine the forces that will drive workers to perform". He concluded that reward or wage structures were one such compelling force. Chen, (2001) surveyed the movement of women in the informal sector worldwide. Reviewing the size, composition and movement of women in the in Sub-Saharan Africa and other parts of the world, he found that "virtually all of the female non-agricultural labor force is in the informal sector". He concluded that in most countries, there were more women in the informal sector than men. ILO, (2002) published a report on the factors shaping and reshaping the informal economy worldwide. Analyzing factors such as legal and institutional frameworks, employment, poverty and demographic factors and the informal economy, the report described the informal sector as the sum total of all income-earning activities outside of legally regulated enterprises. It found that informal sector in Sub-Saharan Africa was the largest concentration of informality worldwide, concluding that "contrary to earlier predictions, the informal economy has been growing rapidly in almost every corner of the globe, including industrialized countries – it can no longer be considered a temporary or residual phenomenon

Five years after the ILO report (Wells 2007), investigated informality in the construction sector in developing countries. He argued that the term 'informal economy' should examine the "conceptual whole of informality", taking into consideration the "production relationships and employment relationships". According to him, the concept was broad, emphasizing the 'unregulated' nature of economic activities where labour laws were rarely followed. He opined that, "a job is regarded as informal if it falls outside of the framework of labour regulation and therefore the holder doesn't enjoy any legal protection or entitlement to certain social benefits (annual leave, sick leave, etc.)". Potts (2008) examined the attitudinal changes toward the urban informal sector in the Sub-Saharan Africa. He discussed the sector dynamics and the role of African governments in promoting or discouraging the informal sector. He found that the majority of new urban jobs in Africa were in the informal sector, concluding that the informal sector contributed significantly to the continent's economy.

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Meagher (2010) investigated the identity economics of social networks and the informal economy in Nigeria by conducting comparative case studies of 14,000 small enterprises in Aba and Southern Nigeria. Analyzing current and historical statistical data, he found that the informal economy was at the heart of contemporary issues of economic governance and restructuring. She concluded that central governments could not ignore the importance of the informal sector's contribution to the national economy. Misati (2010) studied the role of the informal sector investments in Sub-Saharan Africa. Using system-GMM forecast techniques and informal market data created by the Heritage Foundation, he found that there was a positive correlation between economic investment and the informal sector. He argued that informal economy in sub-Saharan Africa "can be seen on the streets, sidewalks and back alleys of cities including petty traders, street vendors, small scale artisans and shoe shiners", concluding that the informal sector played a strong role in income and wealth generation. In a report commissioned by the Education for All Global Monitoring Report, Walther (2011) reviewed various studies on the informal sector in Sub-Saharan Africa. He found that many of the people working in the sector were informally trained and is some economies, the informal sector accounted for "90% of all labour market activities and jobs". He proposed various schemed for skill building including the "development of apprenticeship schemes adapted to the specific context of the agricultural and rural sector".

Informal Construction Sector

Rogerson (1988) studied the impact of economic recession on the informal sector in South Africa. Describing the construction industry as one of the largest employers of informal sector workforce, he argued stagnation in the formal sector precipitated informal sector expansion of the economy. He concluded that during recession "the growth of the informal sector may occur as a refuge from destitution but that the complexion of the informal economy will shift and be dominated by activities of a more 'socially unacceptable' nature

Well (2001) studied the informal construction sector in Kenya. Examining multi-story building ownership and labour management in the industry as well material purchases and capital formation, he found that there was close relationship between employees and building owners in the informal sector. He concluded that there was absence of regulation in terms of conditions of employment and the construction process of informal sector in the country. In the same year, Mlinga and Wells, (2001) investigated the collaboration between formal and informal enterprises in the construction sector in Tanzania. They found that the country's industry comprised a regulated formal and an unregulated informal sector. They concluded that the formal construction industry was one in which all the government regulations with regard to construction (licensing, registration, employment etc.) were adhered to, while in the informal construction industry, there was little or no regulatory compliance. Four years later, the triumvirate of Jewell, Flanagan and Catell, (2005) examined the effects of the informal sector on the construction industry worldwide. They found that a high percentage of construction work was done informally. For example, in developing economies informal construction accounted for 80% of employment at the time of the study, concluding that "The informal sector in construction is not well understood and difficult to measure and is thriving both in the developed and developing world".

In the following year, (Standing, 2011) explored the precariat or the new dangerous class. Defining some categories of informal workers as precariats (or people who did not identify themselves with any particular type of jobs), he argued that precariats were distinguishable from 'survivalist' informal workers like petty traders. He posited that precariats had much more

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to offer including qualifications, skills and experience in the labour market than the survivalist informal worker, but like the survivalist informal worker, the precariat also lacked labour rights.

Nature of Informal Construction in Ghana

The informal construction industry was pervasive throughout rural communities, urban and peril-urban areas of Ghana at the time of this study. Small and medium size (SME) businesses dominated this sector, employing between 2 to 4 people on casual basis. Wages ranging from 25ghc to 40ghc and 35ghc to 50ghc were paid in Mepe/Battor and Pokuase and Nsawam daily for a full day's work of 7 hours in 2016. According to the GLSS 6, 91% of young people working in construction were employed in the informal sector. Of those working in the sector, just under 29% were employees; 27% were apprentices and another 21% were casual workers. In 2013, the wage level reported by young people in the sector approximately $100 per month (GSS, 2014) or less than monthly earnings in mining ($210), health and social work ($152), transport and storage ($110) and agriculture ($144).

Artisan training

The artisanal apprenticeship system had long history. The system was first developed in the latter middle ages before it came to be supervised by craft guilds and town governments. A master craftsman was entitled to employ young people as an inexpensive form of labour in exchange for providing formal training in the craft. Most apprentices were males, but female apprentices were found in a number of crafts associated with embroidery, silk-weaving, sewing and cooking. Apprentices were typically ten to fifteen years of age and lived in the master craftsman's household. Most apprentices aspired to become master craftsmen themselves on completion of their contract usually a term of seven years.

Stretton, (1981) discussed the construction industry in Ethiopia, Kenya and Sri Lanka, comparing the industry in those countries with that of the Philippines. He found that there was no formal apprenticeship system in the Philippians. Instead, independent foremen and Pakiaos (subcontractors) conducted skill training for employees for no definite duration. As the trainees were often relatives of the trainers, no fee was charged. The system was referred to as "learning by doing". With piecemeal briefings from the trainer, the trainee learned as much as the trainer knew and was willing to share during the training period. Within the period of training, the trainee remained with one master craftsman, who determined when the trainee was competent enough to graduate from any particular grade. He concluded that artisans formed "the information network crucial to…the basis of skill acquisition and job recruitment within the industry". Ng'ethe, & Ndua, (1992) studied Jua Kali education, training and welfare of carpentry and metalwork in the Eastlands of Nairobi. They first demarcated the study area and systematically enumerated the metal work and carpentry establishments in the study areas with the help of research survey assistants. They noted the common apprenticeship system was one where masters in the various trades taught apprentices the way that they (masters) were taught with little or no infusion of new technology and new designs. They concluded that the system created virtually no new knowledge and limited the exposure of the apprentices and the quality of work that they could perform.

Abban and Quarshie (1993) explored the technical skills of apprentices and master mechanics. Discussing the apprenticeship training system, they found that training was carried out in phases. In phase one the novice was coached to perform menial tasks such as tidying up the

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work area or running errands. Phase two introduced tools, equipment and work materials. They concluded that though the training system was effective it was limited in scope and innovation. Boehm (1995) examined the role of apprenticeship in human resource development in small- and micro-enterprises in Africa. He analyzed knowledge transfer and tuition fee structures in the construction industry, noting that the apprenticeship system offered parents effective way of transferring skills or education directly to their children. He concluded because there was no published fee structure, sometimes the trainer received a fee but at other times the apprentice worked for reduced or no wages. Schwartz, (1999) investigated the working class in revolutionary France in relation to men's occupations. He discussed cottage industries, migrant and elite workers as well as apprenticeship practices in the country. He noted that apprenticeship was one of the oldest methods of training artisans, a practice that lasted from five to eight years under a "master craftsman" through an indenture agreement. He found that the industrial revolution and the economic burden on poor families reduced the popularity of long periods of apprenticeship. In comparison, he observed that the common practice in the 21st century, especially, in the informal sector was the abridged form of "on-site" training of artisans though the mode of operation, duration and intensity varied from place to place.

Muya et al (2003) discussed construction skills requirements in Zambia. Using structured interviews of construction workers in Lusaka, Copperbelt, Southern and Eastern Provinces, they gathered quantitative and qualitative data for analysis. They concluded that the "future effectiveness of the construction industry in Zambia depends on the quality of the workforce it educates and trains

Johanson and Adams, (2004) studied skills development in Sub-Saharan Africa. They reviewed the cost-effectiveness of publicly owned and managed technical and vocational education and training (TVET), discussing new developments in TVET especially nonfarm employment skills development. They found that apprentices learned trade-related skills such as how to handle tools and repair machines as well as general business management skills like sourcing, pricing, and contracting. They concluded that "trade associations can be instrumental in providing skills for the informal sector under certain conditions" such as clear understanding of the interest of potential participants. Frazer, (2006) investigated apprenticeship and human capital development in Ghana. Using the Ghana Living Standards Survey conducted between April 1998 and March 1999 and the results of the Ghanaian Manufacturing Enterprise Survey, he compared apprenticeship practices in various firms. He then developed models for apprenticeship training in Ghana, concluding that the nature of apprenticeship training in the country was sector-specific and often product-specific; apprentices might learn how to manufacture or repair only one item at a time.

The Joint Initiative on Priority Skills Acquisition (JIPSA, 2007) examined the accelerated and shared growth initiatives for South Africa. The initiative discussed the demand for artisans in Africa, particularly in South Africa. It found that the continent produced only 5,000 artisans per year. It concluded that Africa needed to train at least 12,500 artisans each year in order to meet industry demand by 2012. Walther (2008) studied the apprenticeship systems in West Africa specifically in Benin, Mali, Senegal and Togo. Using a multi-dimensional approach, he analyzed publications on post primary vocational training programs, interviewed a network of young African leaders and compared his findings with the apprenticeship system in East African countries. He concluded that there was a disappointing lack of apprenticeship reform in these countries except in Mail where reforms were introduced in 1997, enabling apprentices to spend 20% of their training time in the classroom and 80% in the field. Fitchett, (2009),

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studied skills development and job creation through small public buildings in South Africa. Analyzing the building of new clinics, hospitals, police stations and related social infrastructure in the Highveld region of the country, she argued in her doctoral dissertation that the construction sector was an important job creator. She reported that in terms of skills acquisition, the "Recognition of Prior Learning" (RPL) process was commendable for artisans certification with the appropriate grades, thus enabling them to function adequately in the construction industry. She recommended that artisan training should adapt "to the realities of communities where high unemployment prevents people from engaging in lengthy periods without a wage income".

Hilary, (2012) surveyed the apprenticeship systems and issues in G20 countries. In this ILO study, Hilary identified the success factors for quality apprentice programs. He noted that the best programs were those run by sector-based initiatives and private partnerships as well as programs combining "training with earnings, access to social protection and respect for labour rights". He concluded that training programs that paid apprentices also quickly introduced them to multiple skills and specialised tasks. Lerman (2013) presented a policy paper on the role of apprenticeship training on skills development in middle level occupations. He argued that countries that placed exclusive emphasis on college training only ended up with weaker human capital than those with a mixed strategy of college and apprenticeships programmes because adaptation to the requirements of the construction industry, which was a labour intensive industry in many countries, took long to achieve. He concluded that skills development through apprenticeships improved competency and knowledge in the execution of projects to international standards. Aivazova (2013) examined the role of role of apprenticeship in combating youth unemployment in Europe and the United States. He found that Germany is the only country with a successful long standing and very well developed apprenticeship system. He attributed Germany's apprenticeship success to the country's dual skills development system, opining that the dual education system law supported the close co-operation among the government, private firms and trade unions. The country's laws also strengthened and enabled apprentices to gain exposure and deep experience to meet the demands of work and increased prospects for good performance.

Trends in Ghana Artisans Training

Haan, (2002) investigated training programs in the Ghana informal sector. He discussed various types of training programs including vocational training for the informal sector, training for self-employment, apprenticeship training and related educational training programs in Kenya, Ghana, Tanzania, Uganda, Zambia and Zimbabwe. He also analyzed training policies and public and non-profit training providers. Interviewing government and non-government officials, he found that traditional apprenticeships in these countries were often family or community centered and included 'moral upbringing' as well as the transfer of practical skills. He concluded that, "information and communication technologies (ICTs)…hold a vast potential for training for the informal sector". Akyeampong, (2002) reviewed the vocationalization of secondary education in Ghana. He discussed the country's efforts in curriculum diversification since the enactment of the the vocationalization policy of the 1987 Education Reforms, arguing that although vocational programmes were intended to offer practical orientation to learners within a school-based setting, delivery conflicted with policy objectives. He concluded that vocationalization was popular and should be intensified.

In a similar study, Osei, (2004) reviewed the vocational or pre-vocational training programs in Ghana's 1987 junior secondary-school reforms. Using various types of interviews, he found

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that teachers failed to implement proposed integrated changes, concluding that vocationalization initiatives were not successful because they "were not clearly conceptualized". Botchie and Ahadzie (2004) investigated poverty reduction through skills development in Ghana. They reviewed various occupational skills training initiatives by interviewing managers of formal and informal programs throughout the country. They argued that apprentices lack of basic literacy and numeracy skills undermined the ability to develop core occupational competencies, concluding that the provision of training services by 'inexperienced staff" and lack of agency coordination duplicated efforts and created gaps in educational service delivery and occupational skills acquisition.

Palmer, (2005) examined the impact of informal and formal skills development on poverty reduction in Ghana. He reviewed the historical role of post-basic education and training (PBET), government poverty reduction strategies as well as the role of nongovernment providers of PBET. He found that vocational and technical education were linked to labour market demands, concluding that traditional apprenticeship training was responsible for some 80-90% of all skills development in Ghana, making apprenticeship training essential building blocks of the government's poverty-reduction strategy. Preddey, (2005) appraised the trends in skills development in rural Ghana. He profiled training providers in the country and discussed various types of training opportunities. He found that the National Vocational Training Institute coordinated various informal training activities including apprenticeships, standards, certification and labour-market monitoring. He concluded that "support for skills development in the informal economy…is virtually non-existent".

Palmer (2005) analyzed skills development in Ghana's informal sector. He discussed many training programs including the Technical Vocational Education and Training (TVET) programs, Ghana's Skills Development Strategy for the Informal Economy, on-the-job skills development in the informal economy, traditional apprenticeship training as well as trade-related and farm-related training. He found that micro-enterprise operators were trained by various training providers. He concluded that, "skills development interventions follow a top-down strategy, with programmes having little labour market relevance". King and Palmer (2007) reviewed the relationship between skills development and poverty reduction. After recounting the history of technical and vocational education and training (TVET), industrial and agricultural education, vocational education and training (VET) as well as poverty reduction initiatives, they found that while apprenticeships represented accessible training routes for the poor, high costs pushed essential training out of reach. They concluded that "left to the market, skills systems [tendered] to favour the non-poor".

Monk et al. (2008) conducted a survey of the apprenticeship system in Ghana. Using an urban-based household survey with detailed questions about earnings and training of public employees and self-employers, they found that apprentices made up nearly 25% of working-age Ghanaians and 28% of urban residents. Arguing that there was little research on apprenticeship as a form of skills training in the country, they concluded that 55% of the country's workforce was current or past apprentices compared with 17% who were vocationally trained at a school or training center. Akyeampong, (2010) reviewed 50 years of Ghana's educational progress and challenges. He reconstructed the country's educational initiatives from 1961 to 2007 and critiqued secondary and university education as well as technical and vocational training. He found that teacher shortages in TVET and learning-resource limitations, led to learner interest and quality reduction. He opined that the reasons for a lack of TVET relevance included incorrect assumptions about the labour market and lack

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of linkages between training providers and business owners. He concluded that though "access to all levels of education has improved significantly" skills training still were not yet able to fully support accelerated development. Akokye and Afrane, (2012) studied the processes, institutional dynamism and challenges of Ghana's apprenticeship training systems. Analyzing the results of 200 questionnaires distributed to auto mechanics, beauticians, hair stylists, textile, apparel and woodworkers, they found that nearly 33% of Junior High School and nearly 42% of Senior High School students dropped out of school. They concluded that "conscious effort must be made by all stakeholders to address the many bottlenecks to the growth and development of the apprenticeship system

Batching of Concrete and Mortar Materials

The materials for concrete and mortar production are typically stipulated in standards and specification manuals. Goldbeck and Gray (1968) studied methods of mixing concrete for strength, workability and durability. After examining the compression strength of structural and paving concrete, they concluded that concrete mixture should be engineered "to fit the available aggregates and the strength and durability requirements of the job". Neville and Brooks (1987) analyzed concrete technology. They discussed many aspects of cement technology including cement as a structural material, aggregate properties, water quality and the factors influencing the workability of fresh concrete, concluding that volume batching was a bad practice.

"The Concrete –Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier" published by the British Standards Institution (BSI) outlined the standards and specifications for mixing concrete. Specifically, the standard described the following types of concrete: designated concretes, designed concretes, prescribed concretes, standardized-prescribed concretes and proprietary concretes. According to BSI, the "the specifier of the concrete shall ensure that all the relevant requirements for concrete properties are included in the specification given to the producer". Olusola et al (2012), investigated the effect of batching methods on the fresh and hardened concrete properties. They discussed batching practices in the Nigerian construction industry and discovered that batching by volume was commonplace in the industry because site operatives found the process easier, simpler and faster. Noting that batching by mass was uncommon, they concluded that the compressive strength obtained from volume batching in a typical construction site in the country was almost likely be less than the target strength stipulated in the relevant standards and specifications.

Informal Sector Workmanship Quality

Workmanship, defined in the ISO 8402-1986 standard as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs", was a persistent problem in the Ghana construction industry. Baiden & Tuuli (2004) investigated the impact of quality control practices in sandcrete blocks. They analyzed construction-project defects and related activities including architectural drawings, specification, workmanship and "durability, aesthetic, performance or design". They noted that, *"defects and variations in construction products from standards is persistently a problem of concern in the construction industry in Ghana"*. They concluded that defective construction was typically due to "incompliance or lack of conformity with contract agreements. Kazaz & Birgonul (2005) studied the construction quality of mass housing projects in Turkey. Using a questionnaire survey containing 108 questions, they investigated the completed projects of the

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companies engaged building public houses for low and middle income groups. They found that poor workmanship was commonplace and that "households are not completely satisfied" by the quality of workmanship of these companies.

Wai Kiong & Sui Pheng (2005) investigated the defects at construction and occupancy stages of building projects in Singapore. Arguing that the limitations of construction inspections inhibited the types of defect that a building inspector could detect, the authors examined "differences among the defects that occurred during construction and 2 to 6 years after initial occupancy". They found that latent defects were almost never discovered during the construction stage. They also found that workmanship quality was influenced by lack of incentives, concluding that the majority of defects were due to "lack of knowledge, lack of information or lack of motivation" and "carelessness". Abdul Razak *et al*. (2010) conducted a benchmarking investigation of the status of the Malaysian construction industry. They examined the production processes used by Malaysian construction workers, key success factors, challenges, research and development, concluding that many construction projects in the country did not meet client satisfaction.

METHODOLOGY

To achieve the objectives of this study, quantitative data collection approach was adopted as the primary methodology for gathering data from the target population. The study population comprised construction artisans who were directly involved in the use and batching of construction materials such as cement, fine and coarse aggregates. According to Neuman, (2006), "questionnaire allows researchers to collect extensive amount of information such as demographic, behavioural habits, perceptions, opinions and attitudes from a wide range of respondents, and thus the findings become applicable to a population". To complement the questionnaire survey, the relevant literature on construction and the informal construction sector published in journals, textbooks and government documents were extensively reviewed. Prior to the questionnaires distribution, they were pretested on five artisans in the target population and on an expert who worked with informal construction artisans. After making the corrections suggested by the validators, 300 questions were hand delivered to randomly selected artisans in the study zones (Table 1). Since the target population was located in a wide geographical area; cluster-sampling technique was used to select the sample population. Out of the 300 questionnaires, 70 were distributed to artisans in Mepe/Battor, 120 at Pokuse and 110 at Nsawam.

The questionnaire comprised of six sections. Section A consisted of five closed-ended questions and one open-ended question about the respondent's skills set. Section B consisted of seven open-ended questions about project type undertaken by respondents, while Section C consisted of six open-ended questions about building materials and tools used on building projects. Section D consisted of another eight open-ended and four close-ended questions about material mensuration (batching). Section E consisted of five close-ended questions about building defects resulting from poor material mensuration skills of artisans while the final section F consisted of five open-ended and two close-ended questions about respondent's background. To facilitate follow up and boost return rate, contact cellphone numbers of the respondents were collected. Regular contact between the researcher and respondents was made until the completed questionnaires were returned. The responses were analyzed using simple percentages, and frequency tables and charts.

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Table 1: Questionnaire distribution and response rate by study zones

Study Zones	Frequency	Percentage (%)	# Questionnaire suitable for analysis	Percentage (%)
Mepe/Battor	70	23.33	67	25.97
Pokuase	120	40.00	97	37.60
Nsawam	110	36.67	94	36.43
Total	300	100	258	100

Source: Research questionnaire, 2016.

FINDINGS AND DISCUSSION

The issues discussed under this section were: respondents' background, respondents' skills training and types of building project undertaken by respondents. Other issues discussed were building materials and tools used on the selected building projects, mensuration (batching) techniques used in measuring building materials on site, and defects noticed during post construction audits. The questionnaire response rate was high. Out of the 300 questionnaires two hundred and fifty-eight (258) completed questionnaires were collected, yielding a response rate of 86%. Of these, forty-two (42) representing 14% contained no information or were incomplete and were not included in the results analysis. The following narrative highlighted the major findings.

Respondents' Information

This section briefly discussed the respondents' background to help generate confidence in the reliability of data collected and eventually in the findings of the study. Adinyira and Anokye (2013) opined that, "it is always important to have a fair idea of the respondents so as to situate the responses within context". Consequently, the relevant socio-demographic variables of respondents that this research covered included age, sex, level of education and trade expertise (occupational status).

The survey found that males dominated the construction sector in Mepe/Battor, Pokuase and Nsawam thus the sample was composed entirely of men, 100% n(258). The results agree with the work Eisenberg (1998). A survey of major employers by Mackenzie et al. (2000) also revealed a high level of skepticism about the recruitment of women in the construction industry and Mitullah and Wachira (2003) found in a similar study that males dominated the construction sector. They further reported that women's role on construction sites was limited to selling affordable food to workers. On the contrary, there was a large percentage of women in the Indian construction sector.

To ensure human capacity building in the construction industry, artisans needed to be continuously trained. The labor-intensive nature of construction work meant that the trainees needed to be millennials if trainers were to be productive. Accordingly, the respondents were asked to indicate their age. The age of the respondents were categorized in ten years-intervals in order to isolate the particular age range that produced the majority of the respondents. The respondents' ages ranged from 18 to 65 years with the majority being in the 26 year's brackets

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26.36%. Of this 5.04% were in the age bracket of up to 20, 25.19% of them were between 18 and 26 years, whilst 20.16% were between 32 to 44 years. Again, almost 10.85% of the respondents were over 60 years of age (Table 2).

Table 2: Age of Respondents

Age (years)	Frequency	Percentage (%)
Up to 20	13	5.04
20-30	68	26.36
30-40	65	25.19
40-50	52	20.16
50-60	32	12.40
60+	28	10.85
Total	258	100

The results showed that the labour force in the Ghana informal construction sector at the time of the study was aging; the respondents in the up-to-20-year group formed only 5.04% n(13). The difference between those in the 20 to 30 and 30 to 40 range was only 1.17% (3). This result could be attributed to the lack of interest in the building trades by country's rapidly increasing youthful population who were more interested in white collar jobs than physical labour. In the Mitullah and Wachira (2003) study already cited, the youngest construction worker was twenty-one years old, the eldest was 63. In general, the sector accommodated a relatively young work force; the majority of the workforce was below 45 years of age in Kenya.

The respondents were also asked to state their educational accomplishments. The results showed that 14.34% of the respondents had only primary education while 39.92% completed junior high and middle schools. About 32.56% attained vocational and technical education whilst 13.18% completed senior high school. In a similar study, Offei–Nyako *et al.,* (2014) reported that 68% of artisans in the Ghana construction industry had formal education up-to junior high school [Fig. 1]

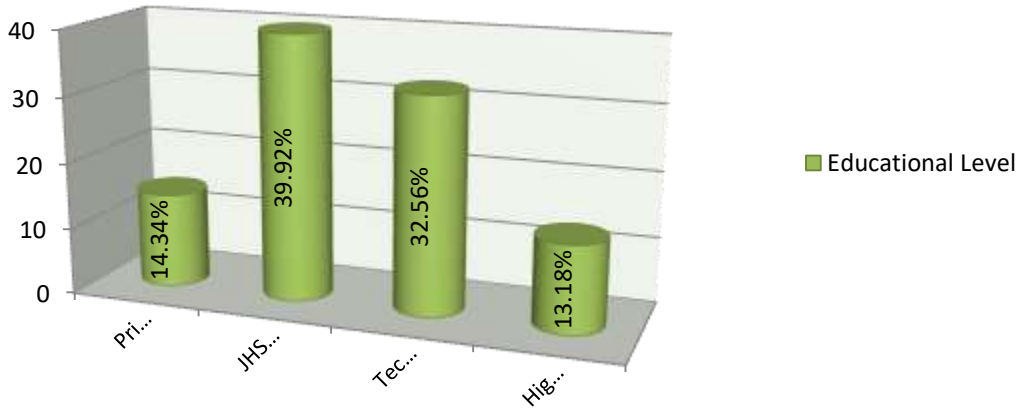

Fig 1: Artisans Educational Background

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In another study, Ng`ethe and Ndua, (1984) opined that workers within the informal economy were mainly individuals with comparatively low levels of education. However, the trend in both informal employment and low paying manual jobs changed since the beginning of the 1990s. This change perhaps could be attributed to the effect of Ghana's Free Compulsory and Universal Basic Education Programme (FCUBE) launched in 2005, aimed at making it mandatory for every Ghanaian to attain at least basic education (Ghana Ministry of Education, 2003). On the contrary, Wahab (2010) reported that 58.10% of artisans in the Nigeria construction industry were not educated; they passed through Trade Test Programme.

The respondents were also asked to describe their skill sets. The results from fig 2 showed that 43.41% of the respondents were skilled 36.05% of the respondents said they were semi-skilled while 20.54% said they were unskilled.

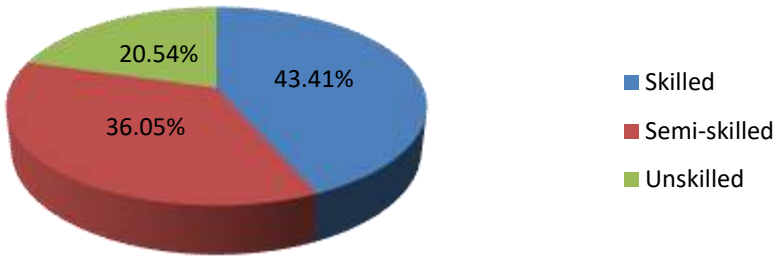

Figure 2: Skills type

It is evident from these numbers that there were more skilled artisans in the informal construction industry than semi-skilled and unskilled artisans. This result also coincides with the finding of Mitullah and Wachira, (2003) who found that majority (74%) of construction workers surveyed were skilled and 21% semi-skilled. They noted that the sample was biased towards skilled workers but the majority of the skilled tradesmen were masons, painters, plumbers or carpenter-Grade Twos.

In responding to the question about their occupational specializations, 37.21% of the respondents said they were block/brick layers. Plasterers constituted 28.29% with 14.73% being block manufacturers while others who were block/brick layers, either plasterers or block manufacturers constituted 19.77%. These numbers showed that the informal construction sector accommodated more block/brick layers than other specialties. In the view of one of the interviewees, block/brick laying was a more popular occupation than either plastering or block manufacturing. According to the interviewee, the general perception in the industry was that comparatively, block/brick laying was less demanding than plastering or block manufacturing. Besides, while a block/brick layers and plasters earned an average of 50ghc per 100 blocks, block manufacturers earned 10 ghc per one bag of cement respectively. In a study conducted by Wahab (2010) on stress management among artisans in the Nigerian construction industry, 33.70% of the respondents were bricklayers.

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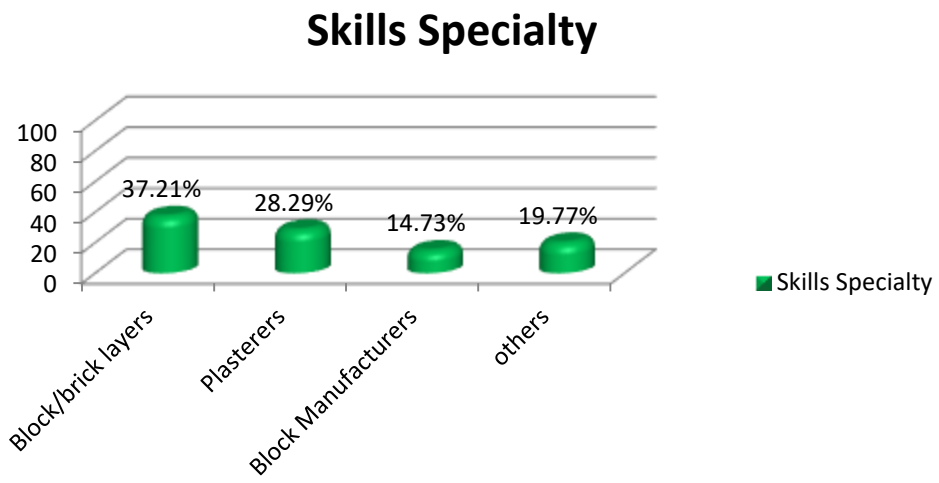

Figure 3: Artisans' skills specialty

The modes of artisanal training in the study areas identified by the survey were informal apprenticeship, vocational/technical training and on-the-job training as indicated in Table 3. The results showed that the majority of the respondents 63.18% had their artisanal/craft training through informal apprenticeship, 17.83% acquired their skills through formal apprenticeship training while 16.67% had their training through on-the-job training. The remaining 2.32% had their training through other unknown methods. The result showed that at the time of the study, the most popular apprenticeship training in Ghana was informal.

In an apprenticeship training, a master (trainer) transferred his knowledge informally to an apprentice (trainee). Keteku-Atiemo (2006) opined that there was a high tendency of a master artisan (trainer) transferring wrong or inadequate skills to an apprentice (trainee), who in turn transferred the wrong skills to others. The informal knowledge thus became widespread and common knowledge throughout the informal labour force. According to the author, the informal labour force was easily influenced by house-owners who wanted cheap labour and were willing sidestep building codes. Without properly structured, accredited and regulated apprenticeship training buildings would continue to be constructed with little regard to design requirements and specifications. This researcher found that many buildings in progress on the sites visited by the researcher were not properly set out. Finished ones had undulating plastered surfaces, cracked and crooked walls.

Lerman 2013 posited that countries that placed exclusive emphasis on college training only end up with weaker human capital than those with a mixed strategy of college and apprenticeships programmes because adaptation to the requirements of the construction industry, which was still a labour intensive industry in many countries, took long to achieve. Muya et al 2003 reported that the future effectiveness of the construction industry of any country depended on the quality and education of the workforce.

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Table 3: Means of Skills Acquisition

Response	Frequency	Percentage
Informal apprenticeship	163	63.18
Formal apprenticeship	46	17.83
On-the-job training	43	16.67
others	6	2.32

The respondents were asked to indicate the duration of their apprenticeship training. This question was to determine whether the artisans spent enough time in training in order to gain adequate proficiency to practice as an artisan. The results from table 4 indicated that 39.53% spent 3 years in training, 20.16% spent four years, and 13.18% spent 5 years while others 27.13% spent more than five years in their training. The result showed that the majority of the artisans who trained for 3 years were in the informal construction sector; indicating that perhaps 3 years was not long enough to gain professional level competence as an artisan.

Those who reported that they trained between five to six or more years indicated that learned practical skills for four years in addition to working one or two free years for their masters as thanksgiving. They added that the thanksgiving years helped them to gain deeper knowledge from their masters. Consequently, these artisans were able to read blueprints and transfer ideas accurately unto the ground.

Apprenticeship is one of the oldest methods of training artisans in construction skills. Schwartz, (1999) noted that in earlier centuries, informal apprentice training involved eight years of learning under a master craftsman through an indenture agreement. He argued that the industrial revolution and the economic burden on poor families reduced the popularity of long periods of apprenticeship. According to him, the common practice in the informal sector in the 21st century is an abridged form of on-site training of artisans; the mode of operation, duration and intensity varied from place to place.

Table 4: Duration of Training

Response	Frequency	Percentage
3 years	102	39.53
4 years	52	20.16
5 years	34	13.18
Others	70	27.13

Experience plays important roles in an artisan's construction operational excellence. Without well trained and experienced artisans, it would be difficult to produce quality workmanship. Mojahed and Aghazadeh (2008) reported that the skill level and experience of the workforce on site was the most important indicator of site productivity in the construction industry. Consequently, the respondents were asked to indicate their work experience as artisans since

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graduating from apprenticeship training. The results showed that 40.31% had up to 10 years' experience, 29.46% had between 10 to 20 years' experience and 15.89% had between 20 to 40 years' experience, 10.85% of the respondents had 40 to 50 years' experience while 3.49% had 50 plus years' experience, table 5.

Table 5: Respondents' experience

Response	Frequency	Percentage
Up to 10 years	104	40.31
10 - 20 years	76	29.46
20 – 40 years	41	15.89
40 – 50 years	28	10.85
50+	9	3.49

The above numbers showed that there were experienced artisans in the Ghana informal construction industry. This finding agrees with that of (Offei–Nyako *et al.*, 2014) who reported that the modal year-range of experienced artisans in the construction industry was between 6 to 10 years based on a frequency of 29 and representing 58% of the total number of respondents. Sherif et al (2014) reported that skill gaps in knowledge influenced productivity levels of workers; eventually contributing to poor workmanships due to in- experience.

The respondents were also asked to indicate whether they were training any apprentices at the time of the survey. The results from table 6 showed that 63.18% of the respondents were training apprentices, while 36.82 reported no apprentice-in-training. This result prompted further investigation. What kind of training did these apprentices receive since 63.18% of the trainers received their training through informal apprenticeship and 39.53% trained for only 3 years. Since the master artisans did not receive adequate training, they were likely to transfer the wrong skills to their apprentices, resulting in poor workmanship in the industry. According to Ogbeifun (2011) the informal sector adopted fragmented training depending on the relationship between trainees and independent foremen, regular team members or subcontractors. Abdul-Aziz, 2001 reported that the quality of training was compromised especially if the trainee was not a close relation of the trainer. Buys & Le Roux studied built-environment stakeholder perceptions of defects in the South African housing construction industry, isolating 'inadequate artisan skills' as the biggest factor leading to construction defects in houses with a mean value of 4.25.

Table 6: Training of apprentice

Response	Frequency	Percentage
Yes	163	63.18
No	95	36.82

The respondents were also asked to indicate the number of apprentice they have in training. The results from table 7 showed that 36.43% the respondents had four apprentices and 23.64%

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had 5 to 8 apprentices under training respectively. 17.05% of the respondents had apprentices while 22.87% other respondents had apprentices undergoing training. The result indicated that "half-cooked" construction artisans were churned out through the informal apprenticeship training system. Kaomaa and Muyab (2016) reported that artisans without good training backgrounds were the main reasons for the high frequency of poor construction workmanship in Zambia. They observed the majority of artisans hired in Zambia were those with no formal qualifications, who required close supervision to achieve intended results on construction sites; noting that the level of supervision needed to manage these types of workforce was very demanding.

Table 7: Number of Apprentice

Response	Frequency	Percentage=99.99
0-4	94	36.43
5-8	61	23.64
9-12	44	17.05
Others	59	22.87

Project Types

This section discussed the type of projects respondents typically worked on. The results showed that 66.67% of the respondents worked on residential incremental buildings, 9.30% on institutional buildings, and 7.36% on commercial buildings while 16.67% worked on mixed projects (table 8).

Table 8: Types of Project Undertaken

Response	Frequency	Percentage
Residential–incremental buildings	172	66.67
Institutional buildings	24	9.30
Commercial buildings	19	7.36
Others	43	16.67

The above numbers showed that the majority of informal construction sector artisans worked mainly on residential incremental construction projects.

The respondents were also asked to indicate the type of projects they were currently working on. The result showed that 70.16% of the respondents were working on residential incremental building projects 6.59% on institutional buildings, 12.79% on commercial building projects while 10.47% were working on mixed building projects. The results suggested that at the time of the study, there were more opportunities for artisans in the informal residential construction sector of the Ghana housing industry (table 9).

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Table 9: Current Projects

Response	Frequency	Percentage
Residential –incremental buildings	181	70.16
Institutional buildings	17	6.59
Commercial buildings	33	12.79
Others	27	10.47

The respondents were asked to indicate the specific services they performed in the projects they executed. The results showed that 53.88% of the respondents performed only block/brick laying services, 6.59% performed rendering and plastering service, 21.71% performed block-moulding services, 8.14% performed carpentry service while 9.68% of the respondents performed multiple services as shown in table 10.

Table 10: Jobs undertaken in the Projects

Response	Frequency	Percentage
Block/brick laying	139	53.88
Rendering/plastering	17	6.59
Block manufacturing	56	21.71
others	46	17.82

The respondents were asked to indicate their sources of obtaining construction jobs, table 11. The results showed that individual homeowners engaged 69.38% of the respondents, 13.95% obtained jobs from construction companies, 8.14% from NGOs. 1.94% from government agencies while 6.59% obtained jobs from various sources including private individuals. In the Ghana informal construction sector, employers did not typically demand company registration documents before making job offers; jobs offers were based on the recommendation of past employers. This situation was different in the formal construction sector where various documents were required including company registration certificates from the Registrar General's Department and construction classification certificate from Ministry of Water Resources, Works and Housing. This red tape coupled with cumbersome tendering processes accounted for the small number of respondents obtaining jobs from government agencies. Harvey (2000) also reported that most informal artisans often worked for building owners and private contractors as opposed to government agencies.

Table 11: Employer/Clients

Response	Frequency	Percentage
Private individuals	179	69.38
Company	36	13.95
NGO	21	8.14
Government	5	1.94
others	17	6.59

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The respondents were asked to indicate the source of obtaining project drawings. The results from table 12 showed that 23.64% of the respondents obtained project drawings from architects/civil engineers, 33.72% obtained project drawings from draughtsman, and 29.07% used self-sketched drawings while 13.57% used drawings from mixed sources. The low patronage of the services of architects/civil engineers could be attributed to the high cost of architectural services; sketched drawings cost nothing.

Table 12: Sources of Project Drawings

Response	Frequency	Percentage
Architects/Civil engineer	61	23.64
Draughtsman	87	33.72
Self-sketch	75	29.07
Others	35	13.57

The respondents were also asked whether they had access to detailed project drawings before commencing construction work. The results from table 13 showed that only 37.21% of the respondents reported that they had detail project drawings while an overwhelming majority, 62.79% did not. Detailed project drawings typically underpinned effective and efficient project delivery. Wang, Augenbroe and Sun (2014) reported in their study of energy efficient buildings in the USA that detailed construction design largely impacted heat resistance and air leakage properties of the building envelope.

Table 13: Detail Project Drawings

Response	Frequency	Percentage
Yes	96	37.21
No	162	62.79

The respondents were asked to indicate how they obtained detailed project information since clients did not provide detailed project drawings. The results showed that 50.39% of the respondents reported that they obtained project details from experience on previous projects, 33.7% from old project drawings while 15.89% obtained their project information detail from mixed sources as illustrated in table 14.

Table 14: Means of obtaining Project Information Detail

Response	Frequency	Percentage
Through experience	130	50.39
From old project drawings	87	33.72
Others	41	15.89

Building Materials and Tools

This section discussed the materials and tools used by artisans on informal construction sites. These materials and tools typically influenced the outcome of construction projects in terms of quality and duration. Consequently, the respondents were asked about the brand of cement used

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in mixing concrete and mortar. The results from table 15 showed that 37.98% of the respondents used Ghacem cement, 55.04% used Diamond cement, and 1.16% used Pozzolana cement while 5.81% of respondents used other brands of cement.

Table 15: Type of Cement used in mixing Concrete and mortar

Response	Frequency	Percentage=99.99
Ghacem cement	98	37.98
Diamond cement	142	55.04
Pozzolana cement	3	1.16
Others	15	5.81

The above numbers showed that Diamond cement brand was popular among the respondents. This might not necessary due to its strength but rather the prices since informal construction artisan do not conduct any form of test on their products. This can also be attributed to the price difference between Diamond cement (GH¢ 27.50) and other brands (GH¢ 28.5) and (GH¢ 30.5) as most informal clients prefer cheaper materials.

The artisans were also asked about where they obtained sand for mixing concrete and mortar. The results from table 16 showed that 25.96% of the respondents used river sand, 56.60% used sand from pits and 2.71% used sand obtained from quarry site while 14.73% used sand from mixed sources. The high preference for sand obtained from land is because of lack of fast flowing rivers, which have the capacity deposit soil along their banks as compared to the respondents who lived in close proximity to the Volta River, which has a large deposits of good quality sand. In Ghana quarry sand was commonly used by sandcrete block manufacturers. Observations from majority of the sites visited in Pokuase and Nsawam showed hips of sand mixed with tree roots and grasses as shown in the fig 4 below. Closer visual inspection revealed that there was high presence of clay content in the sand, suggesting that concrete produced with the sand was unlikely to meet the requisite structural standards. Ngugi, , Mutuku, and Gariy, (2014) conducted an experimental study on the effects of sand quality on compressive strength of concrete in Nairobi county and its environs in Kenya. They observed that the allowable minimum level of silt and clay content and organic impurities in sand being supplied in Nairobi and its environs is 4.8% and 0.106 ohms respectively. They concluded that beyond these limits then the resultant concrete will fail to meet the expected strength at 28 days age. It is therefore concluded that the presence of impurities in sand significantly contributed to reduction in compressive strength of concrete strengths which may lead to collapse of buildings if not addressed in the concrete design mix.

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Fig 4: Sample river sand from Mepe/Battor area as compared to pit from Pokuase and Nsawam

Table 16: Sources of sand for mixing concrete and mortar

Response	Frequency	Percentage
River sand	67	25.96
Sand from land	146	56.60
Sand obtained from quarry site	7	2.71
Others	38	14.73

The respondents were asked about the source of water for mixing concrete and mortar because water quality impacts concrete and mortar mixture and malleability. The results showed that 27.52% of the respondents used river water. 15.89% used pipe borne water, 22.09% used borehole water while 34.50% used water from mixed sources table 17. According to Chudley and Greeno (2004), water for concrete production should be clean and free from impurities. They reported that as water with impurities adversely affected concrete quality or strength, pond or river or canal or sea water was not good for concrete work; only water fit for drinking should be used for concrete works. This assertion meant that the majority of concrete and mortar works on informal construction sites that the present researcher visited did not meet standard concrete production requirement since majority of respondents used water from river sources.

Table 17: Sources of water for mixing concrete and mortar

Response	Frequency	Percentage
River water	71	27.52
Pipe borne water	41	15.89
Borehole water	57	22.09
Others	89	34.50

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The respondents were also asked about the source of coarse aggregate used in mixing concrete for their construction projects. The results showed that 40.31% obtained coarse aggregate from quarry site, 37.98% from hand broken suppliers; while 21.71% used oyster shells (table 18).

Table 18: Source of coarse aggregate

Response	Frequency	Percentage
Quarry	104	40.31
Hand broken from rock areas	98	37.98
From construction waste	Nil	Nil
Oyster shells	56	21.71

The above numbers showed that the use of construction waste aggregate was not common practice among informal construction sectors in this study. The use of oyster-shell aggregates was popular among the respondents from Mepe/Battor, located along the Volta River. Since introduction of cement block buildings, the use of oyster-shell aggregates were popular because they were super abundant. However, some respondents reported that the use of oyster shells in concrete was steadily being replaced by granite chippings that were easier to work with than oyster shells.

The respondents were asked about how they obtained materials supply. The results showed that 43.80% had materials supplied by clients, 31.39% from foremen and 19.38% from material suppliers while the remaining 5.43% obtained their material from commercial suppliers (table 19).

Table 19: Material Supplier

Response	Frequency	Percentage
Client	113	43.80
Foreman	81	31.39
Materials supplier	50	19.38
Others	14	5.43

The above results showed that in the informal construction areas covered by the study, clients bought materials for their workers though this was not a popular method of supplying construction materials. Wachira and Mittula (2003) found that, invariably 80% of building owners supplied materials for construction.

Construction work is typically executed using machinery and physical labour. Consequently, the respondents were asked about their construction equipment. The results showed that 5.81% used concrete mixer, 3.88% used poker vibrators, 1.94% used gauge box technique 65.89% used wheelbarrows 22.48% used multiple tools (table 20). All the respondents used head pans, spades/shovels, spirit levels, tape measures, builders' square, block hammer, lines and pins. It

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was important to know the range and types of equipment used by informal sector construction workers and how machinery impacted work quality. Many informal sector construction workers were unable to afford poker vibrators and concrete mixers which were typically rented by clients for specific tasks.

Table 20: Equipment normally used on site

Response	Frequency	Percentage
Concrete mixer	15	5.81
Vibrator	10	3.88
Gauge box	5	1.94
Wheelbarrow	170	65.89
Others	58	22.48

Batching of Materials

This section discussed the batching methods used by informal construction artisans in measuring materials on site. Consequently, the respondents were asked to indicate the batching methods they typically used on site (table 21). The results showed that the majority of the respondents 77.90% used volume-batching technique, 18.22% batched materials by weighing while 3.88% used multiple methods. Neville and Brooks (1987) asserted in a comprehensive study on concrete technology that volume batching was a bad practice. However, Olusola et al (2012) reported that volume batching was common practice in Nigeria construction sites because it was easier, simpler and faster compared to batching by mass. They found that the effect of batching methods on the compressive strength of concrete with mix proportion of 1:1:2, batched by mass was higher than concrete batched by volume at all water cement (w/c) ratio and for curing ages 7 to 28 days. Kellerman (2009) argued that when batching by volume, possible sources of error could lead to variation in the amount of aggregates in a specific volume. These errors often led to variations in the fresh and hardened properties of concrete against specified properties.

Table 21: Batching methods usually used on site

Response	**Frequency**	**Percentage**
Batching by volume	201	77.90
Batching by weight	47	18.22
Others	10	3.88

Batching tools were crucial in concrete and mortar works. As concrete and mortar production were specified in ratios, it was important for fine and coarse aggregate-part measurements to correspond with the cement volume. Consequently, the respondents were asked about the type of tools used in batching materials for concrete and mortar production. The results showed that only 7.36% of the respondents used gauge box in batching fine and coarse aggregates, 20.16 % used head pans, 41.86% used wheelbarrows while 30.62% used multiple tools (table) 22.

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Table 22: Tools used for Batching

Response	Frequency	Percentage
Gauge box	19	7.36
Head pans	52	20.16
Wheelbarrow	108	41.86
Others	79	30.62

The above result further showed that aggregate batching using wheelbarrows was popular among informal construction sector artisans at the time of the study. Large batching machinery or measuring equipment was not commonplace. Many sandcrete manufacturers, for example, typically eyeballed the quantity of sand used for making blocks indicating that there could be over batching with attendant implications for uneven block strength and bearing capacity.

Construction materials were specified and measured in ratios depending on the section or type of construction work. Consequently, the respondents were asked about the ratios used in batching various materials for concrete and mortar production. The results showed that none of the respondents used a concrete mix ratio of 1:1:2, 6.20% used 1:2:4 mix ratio, 59.30% used 1:3:6 mixed ratio while 34.50% used various ratios in mixing concrete (table 23). However, site visits revealed the use of a formula of 5-for-2 or five wheelbarrows of sand per two bags of cement with no specific measurement for the quantity of coarse aggregates.

Table 23: Concreting mixing ratio

Response	Frequency	Percentage
1:1:2	Nil	Nil
1:2:4	16	6.20
1:3:6	153	59.30
others	89	34.50

The respondents were asked about mortar mixing ratios. The results from table 24 showed that none of the respondents mixed mortar using 1:2 and 1:3 ratios, 41.47% used 1:4 ratio while the majority 58.53% used self-determined ratios. The last respondents reported that the quantity of sand used in mixing mortar depended on the quality of sand. The 5-for-2 formula was commonly used for sand extracted from quarries and 4-for-2 for riverbed sand. The respondents reported that riverbed sand had high clay content while quarry sand contained no clay. They used this ratio for both block laying and plastering. Since the majority of artisans did not use any prescribed ratios, the resultant mortar was likely to be more prone to rapid degradation. This was the case with many completed buildings in the areas surveyed.

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Table 24: Mortar mixing ratio

Response	Frequency	Percentage
1:2	Nil	Nil
1:3	Nil	Nil
1:4	107	41.47
others	151	58.53

The respondents were asked about the ratios used in mixing mortar for sandcrete block moulding. The results showed that both hand moulders and machine moulders did not follow any specific mixing ratios for block moulding. Typically in a block factory, one bag of cement was used to mould between thirty-five and forty-five blocks irrespective of block size. Hand moulders however reported using one bag of cement to mould twenty-five, thirty blocks or thirty-five blocks per cement bag depending of client request. Anosike and Oyebade (2011) investigated sandcrete blocks and quality management in the Nigeria building industry. They found that block manufacturers batched sand by volume using wheelbarrows. They noted that what was referred to as 'full' depended on who was in charge and hence the consistency of one batch differed markedly from another. Their finding indicated that 20% of the factories used specified mix ratio 1:8 cement to sand ratio and 80% use ratio 1:10. They concluded that 80% of the block manufacturers did not conform to the 1:8 cement/sand mix ratio specified by the NIS 87:2007 standard.

The respondents were also asked about how they determined the ratios for mixing concrete and mortar, block moulding and laying of sandcrete blocks. The results showed that 61.24% determined batching ratios from experience, 30.23% followed clients' instruction, while the rest 8.53% used either experience or followed clients' instruction (table 25). One interviewee explained that most artisans were not trained to work with published industry guidelines and specifications. Since the majority of the artisans were apprentices who did not receive formal training in concrete science and calculus they did not acquire professional batching skill sets. Inadequate training often led to both structural defect such as cracks and dampness. To reduce structural defect Goldbeck and Gray, (1968) recommended the application of appropriate mix proportion or a specified characteristic strength to ensure structural integrity.

Table 25: Batching Ratio Determination

Response	Frequency	Percentage
From specification document	Nil	Nil
From experience	158	61.24
By client's instruction	78	30.23
Others	22	8.53

Since structural integrity largely depended on the design and confirmed proportioning of materials, the respondents were asked about their batching knowledge and expertise. The results showed that only 29.07% knew the impact of batching on completed projects while 70.93% did not. The batching-ignorance of the majority of the artisans could be attributed to

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their informal training background. Informal apprenticeship training did not include materials properties and their apportionment.

The respondents were also asked about poor materials batching behaviour. The results from table 26 showed that 40.31% of the respondents reported cracked walls/floors, 35.27% reported dampness in walls/floors, 19.77%, reported plaster flakes while 4.65% reports related types of defects. The result confirmed that most structural defects could be traced to poor material proportioning or batching.

Table 26: Defects resulting from poor material measurement/batching

Response	Frequency	Percentage
Cracked walls/floors	104	40.31
Dampness of walls/floors	91	35.27
Flaking plasters	51	19.77
Others	12	4.65

The respondents were also asked about problems in applying batching techniques. The results showed that 64.73% of the respondents anticipated difficulties while 35.27% did not. Batching by weight was identified as the most challenging though most artisans did not own batching equipment. It was discovered during site visits that the majority of the artisans lacked simple tools such as vibrators, concrete mixers, mechanical rollers and concrete finishers.

The respondents were also asked about the impact of poor or inaccurate batching of material on the quality of construction. The results showed that 32.17% of the respondents reported that poor or inaccurate batching of materials resulted in poor concrete strength, mortar or blocks, 21.71% reported poor or inaccurate batching of materials resulted in delay in construction time, 40.31% reported lots of waste while 5.81% reported that such materials needed the expertise of experienced artisans (table 27). In the view of the majority of the respondents, the numerous wastes reported from construction sites were due to poor materials batching resulting in poor concrete/block strength.

Table 27: Possible effects of poor or inaccurate batching of material on quality of construction

Response	Frequency	Percentage
Poor strength of concrete or block	83	32.17
Delay in construction time	56	21.71
Results in a lot of waste	104	40.31
Required experienced artisan to work with such materials	15	5.81

The respondents were asked to indicate whether they occasionally worked with materials without any form of mensuration or batching criteria. The results showed that 39.53% reported

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working without mensuration or batching criteria while 60.47% did not. Working without mensuration or batching techniques was due to the fact that they did not fully understand the importance of mensuration or batching. This phenomenon was common practice among hand-block moulders in the small scale block manufacturing industry.

The respondents were asked about how frequently they mixed concrete, mortar or mould blocks without following batching rules. The results showed that 25.58% of the respondents reported that they mixed concrete, mortar or mould block "very often" without following batching rules, 25.20% reported they often followed the rules while 49.22% followed batching rules.

The respondents who said they did not follow batching rules were block manufacturers and quark artisans. These artisans did not train as artisans but worked with master artisans as labourers. However, even the respondents who reported following the rules provided no requested documentation.

Building Defects

This section discussed the impact of informal artisans' batching behaviour on completed building projects. The respondents were asked whether they conducted post construction audit or inspection on completed projects. The results showed that 36.43% of the respondents conducted post construction audit while 63.57% did not. Post construction audit or inspection was important in the construction industry. It helped to identify construction defects due to multiple factors such as poor workmanship or poor materials proportioning. Not only that, post construction inspection was standard practice in various countries including Hong Kong. In 2002, for example, the Environment, Transport and Works Bureau of Hong Kong's Special Administrative Region published an audit manual for the construction industry. The manual defined technical audits "as the methodical and independent investigation of specific processes and activities carried out by a person(s), with the aim of ascertaining whether the activities and processes and their consequent outcomes conform to set standards, have been executed efficiently and are appropriate to achieve set goals". Mwiya, (2009) affirmed the importance of post construction technical audits emphasizing that they should be an ongoing process during and after construction in Zambia.

The respondents were also asked to indicate whether they identified any form of defects during post construction inspection/technical audit. The results showed that 36.43% of the respondents discovered defects during post construction inspection, 35.11% identified various forms of defects while 64.89% did not. Respondents who conducted post construction inspected indicated that the audit was to increase operational excellence. To facilitate post construction audits, Garrand (2001) prepared a guide for defect detection, classifying building defects into various categories including defects in foundation and ground floor structures, external walls, roofs, internal walls and floors, above ground services, below ground drainage, and external works. The respondents were also asked to explain the causes of the defects noticed in the completed buildings. The results showed that 46.90%% of the respondents reported that they knew the causes while 53.10%% said they did not.

The respondents were also asked to indicate whether they received any further training since graduating from their apprenticeship training. The results from table 28 showed that 23.26% of the artisans received further training while 76.74% did not. Those who said they received further training were artisans who went through Technical/Vocational schools before

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practicing under a master artisan. Chan *et al*. (2006) stressed that the quality construction would be enhanced by increasing the capability of site labours through further training.

Table 28: Artisan's further training

Response	Frequency	Percentage
Yes	60	23.26
No	198	76.74

CONCLUSION

The findings of this study showed that the Ghana informal construction sector did not pay much attention to the standard practices and procedures for constructing residential buildings. Reasons included inadequate levels of apprenticeship training to grow the skills and competence of artisans. Though government training programmes offered flexible routes to build the skills and knowledge of artisans, apprenticeship programs offered by master craftsmen dominated the training-services market. Training services offered by a master craftsman was considered adequate in the past when long training periods were combined with one or two years free-practical work for the master craftsman following graduation. Economic burden on poor families however reduced the popularity and intensity of long periods of apprenticeship. Concomitant with short-training periods was the fact many master craftsmen were themselves ill-equipped to provide world-class, cutting-edge training. Low-quality training duped apprentices into thinking that they were fully qualified when in reality they were not. Not only that, apprenticeship varied widely across construction trades and master craftsmen.

The effects of artisan incompetence were devastating. Cement blocks and bricks made by informal sector artisans did not meet compressive-strength standard requirements. Batching was generally eyeballed instead of being measured scientifically resulting in insufficient cement to aggregate ratio in cement blocks. Also, Cement and aggregate mixtures had high percentage of water. Weak cement blocks resulted in poor construction and weak buildings with rising moisture content in walls, leaking roofs, cracks and structural failure. These defects were exacerbated by the fact that many buildings were completed without permits.

To reduce these problems, the Ghana Standards Authority and the Ministry of Water Resources, Works and Housing should establish an agency to monitor and regulate the quality and safety of cement blocks sold in the country as well as the output of the block-making industry. In addition, apprenticeship training programs should be given the same accreditation and related controls by the government to ensure that those training under traditional apprentice programs achieved the same or similar level of training as those who took more formal training in vocational schools and universities. Further work could analyze the impact of the aforementioned recommendations.

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