Original Research Article

AN ASSESSMENT OF THE KNOWLEDGE LEVEL IN GEOSYNTHETICS AMONG FRESH GRADUATES IN CIVIL ENGINEERING AND ALLIED PROGRAMMES IN GHANA

ABSTRACT

Whereas the knowledge level in geosynthetics among fresh graduates with a bachelor's degree in civil engineering is known to be generally low in developed countries such as the UK and the USA; there is a lack of country-specific studies that establish the knowledge level in geosynthetics among fresh graduates with a bachelor's degree in civil engineering in developing countries. Thus, this current study seeks to establish the knowledge level of fresh graduates with a bachelor's degree in civil engineering and allied programmes in Ghana on the types and primary functions of geosynthetics. Structured questionnaire aided in data collection. Data were analysed using frequency, percentage, mean, standard deviation, and one sample t-test. The study revealed that there was generally a low knowledge level regarding the types and functions of geosynthetics among fresh graduates with bachelor's degree in civil engineering and allied programmes in Ghana. However, Ghana's case is of great concern as the fresh graduates were only knowledgeable in 3 out of the 9 types of geosynthetics and 4 out of the 10 primary functions of geosynthetics. The uniqueness of the study lies in the fact that it empirically established the knowledge level of fresh graduates in civil engineering, building technology and construction technology and management programmes at the bachelor's level on the types and primary functions of geosynthetics which hitherto was not in existence. The study will inform the review of the existing curriculum for building technology, civil engineering, and construction technology and management programmes at the bachelor's level to include adequate content on geosynthetics. Again, the study contributes to the existing literature on geosynthetics and forms the basis for future studies in geosynthetics.

Keywords: Building, Civil Infrastructure, Geosynthetics, Ghana, and Technology.

INTRODUCTION

Although geosynthetic-based solutions are gradually gaining acceptance and use within the construction industry across the globe (Oginni & Dada, 2021; Ministry of Textile, 2013), with geosynthetics like geotextiles and geomembranes being the most known followed by geogrids in countries like India, USA and the UK (Raja, 2011; Ministry of Textiles, 2013; GSI, 2013); the growth in its applications has been constrained by the little or lack of knowledge in geosynthetics among fresh graduates with bachelor's degree in civil engineering (GSI, 2015), and/or allied programmes (Adewumi, 2018). This is chiefly a result of the inadequate or lack of content on geosynthetics in civil engineering and allied programmes at the bachelor's level (GSI, 2015; Raja, 2011). Whereas the knowledge level in geosynthetics among fresh graduates with a bachelor's degree in civil engineering from developed countries, specifically the UK and the US, is known to be generally low (GSI, 2015; Raja, 2011); there is a lack of country-specific study that has assessed the knowledge level in geosynthetics among fresh graduates with a bachelor's degree in civil engineering and allied programmes from developing countries. Thus, this current study is relevant as it seeks to establish the knowledge level of fresh graduates with a bachelor's degree in civil engineering and allied programmes in Ghana on the types and primary functions of geosynthetics. Ghana was chosen for the study because its academic programmes share close characteristics with that of many developing countries. Though the researcher does not seek to generalize the findings of this study in Ghana to represent that of developing countries, it offers fruitful lessons for developing countries like Nigeria, South Africa, Algeria, Malaysia, and Burkina Faso. In Ghana, studies on geosynthetics have considered the underlying constraints to the use of geosynthetics among construction practitioners (Somiah et al., 2022), the extent of application of geosynthetics to civil infrastructure projects (Somiah et al., 2022), among others. What is not known is the knowledge level in geosynthetics of fresh graduates with a bachelor's degree in civil engineering and allied programmes. Thus, this current study which focuses on Ghana addresses the lack of literature that assessed the knowledge level of fresh graduates with a bachelor's degree in civil engineering and allied programmes on the types and primary functions of geosynthetics. The allied programmes that were considered in addition to civil engineering in this study were construction technology and management, and building technology. This was because these programmes, like the civil engineering programme, involve aspects of structural engineering, construction management, geotechnical engineering, environmental engineering, water resource engineering, transportation engineering and hydraulic engineering. Thus, knowledge of geosynthetics is essential for the training and career development of fresh graduates with a bachelor's degree in civil engineering and allied programmes (see GSI, 2015). The study considered both fresh graduates from public and private universities who graduated within the 2021/2022 academic year and were yet to find a job. Fresh graduates were students who successfully completed their programme of study and were awarded Bachelor of Science (BSc), Bachelor of Technology (BTech), or Bachelor of Engineering (BEng) in civil engineering, construction technology and management, or building technology during the 2021/2022 academic year and were yet to find jobs. The aim of the study was to establish the knowledge level of fresh graduates with a bachelor's degree in civil engineering and allied programmes in Ghana on the types and primary functions of geosynthetics.

The specific objectives that guided the study were:

- to establish the knowledge level of fresh graduates with a bachelor's degree in civil engineering and allied programmes in Ghana on the types of geosynthetics,
- to establish the knowledge level of fresh graduates with a bachelor's degree in civil engineering and allied programmes in Ghana on the primary functions of geosynthetics.

TYPES AND PRIMARY FUNCTIONS OF GEOSYNTHETICS

Geosynthetics are planar products produced from polymeric materials and used with rock, soil, earth, or other geotechnical engineering-related materials as an integral part of man-made structures, projects, or systems (ASTM, 1994; Somiah et al., 2022). Geosynthetics are mostly made (usually a combination of polymers) from synthetic polymers of polypropylene, polyester, polyethylene, or polyamide (Agrawal, 2011; Narejo, 2016). However, there are other emerging polymers that are also used in the production of geosynthetics like Polyvinyl chloride (PVC), nylon (Agrawal, 2011),and cellulose which is a polymer that occurs naturally and is based on glucose as the monomer (Mohan & Nair, 2021). The primary functions of geosynthetics include filtration, separation, drainage, reinforcement, environmental protection, and provision of a fluid barrier (Koerner et al., 2012; Ziegler, 2017; Somiah et al., 2022). Prior to the advent of polymer for geosynthetics, natural geosynthetics were in use though rare (Agrawal, 2011; Narejo, 2016).

However, the fundamental problem with natural geosynthetics, using natural materials such as wood, cotton, jute, among others to stabilize, reinforced, and filter, among other primary functions of geosynthetics, was the biodegradation that occurs from microorganisms in the soil when buried in the environment(Agrawal, 2011; Narejo, 2016). Nevertheless, with the advent of polymers, a much more stable material became available that could last for centuries even in harsh environmental conditions when properly formulated (Agrawal, 2011; Narejo, 2016). Other benefits of integrating geosynthetics into man-made structures include a reduction in the use of natural materials in improving the conditions of soil (Raja, 2011; Pinho-Lopes, 2018), comparative cost advantage, physical strength properties, mechanical strength properties, and time efficiency in the delivery of civil infrastructure (Raja, 2011; Elragi, 2000; Khan & Singh, 2020; Wu et al., 2020; Christoforidou et al., 2021). In recent times, intelligent geosynthetics have been developed which makes it possible to monitor the performance of geosynthetics after its application (Ziegler, 2017). These are geosynthetics with integrated chips and sensors for measuring strains, temperature and other environmental conditions (Ziegler, 2017). For example, for landfill sealing systems with intelligent geosynthetics (eg intelligent geomembranes), the electro-resistive sensors in the intelligent geomembrane detect possible leakage in the vicinity of the geomembrane (Ziegler, 2017). There is also, another group of intelligent geosynthetics that integrates polymer optical fibres (POF) into the geosynthetics. For instance, for a dam structure that integrates intelligent geosynthetics, the geosynthetic enables continuous observation of the deformations so that at the beginning of the collapse of the dam, a warning is given in advance and people can be timely evacuated to a safer place (Ziegler, 2017).

A plethora of studies have suggested nine (9) main types of geosynthetics (ASTM, 1994; Christoforidou, et al., 2021; Ait, 2021) namely: geotextiles, geonets, geogrids, geomembrane, geosynthetic clay liners, geofoams, geopipes, geocomposites, and geocells (Qamhia & Tutumluer, 2021; The Constructor, 2022). Each of the types has a wide range of primary functions. The primary functions of a geosynthetic are the intended use for which a particular geosynthetic was manufactured (Somiah et al., 2022).

Primary functions of geosynthetics

The primary functions of geosynthetics have been predominantly discussed under reinforcement, stabilization, erosion control, filtration, fill material, containment, drainage, separation, and protection (Ministry of Textile, 2013; Khan & Singh, 2020; Oginni & Dada, 2021), and sometimes fluid conveyor (The Constructor, 2022).

Reinforcement

The object of using geosynthetics as a reinforcement to soil is to reinforce the weak soil or subgrade (Ministry of Textile, 2013), strengthen the soil surface and improve the stability of the soil, especially slopes (Ministry of Textile, 2013). Additionally, it prevents water from pervading the slope and regulates infiltration that occurs during precipitation (Ministry of Textile, 2013). Types of geosynthetics used as reinforcement include geonets, geogrids, geotextiles, geocells and some geocomposites (Koerner, 2012). These geosynthetics are good in tension and thus complement the soil which is good in compression to serve its structural purposes when used as an integral part of civil engineering infrastructure (The Constructor, 2022). Geocells offer structural reinforcement for earth retention and load support when used for earth-retaining structures (The Constructor, 2022). Geogrids are normally used to reinforce the sub-base of roads, as well as retaining walls or other structures such as dams due to their ability to redistribute load over a wider area due to their high tensile strength, and high holding capacity (The Constructor, 2022).

Soil Stabilization

Categories of geosynthetics used for soil stabilization include geotextiles, geogrids, geocells, geonets and some geocomposites (Oginni & Dada, 2021; Somiah et al. 2022). Geotextiles are used in ensuring stability during saturation in the rainy season and conditions of sudden drawdown (Oginni & Dada, 2021). Geonets are used as stabilizers in foundation walls, landfills, and roads, asphalt concrete pavements (The Constructor, 2022). Geocells are used for soil stabilization on steep slopes and flat grounds. Geogrids are used to stabilize the subgrade for the construction of embankments in railways and highways. Geogrids offer soil stabilization in areas with high water table levels or low bearing strength where laying of foundations to carry heavy loads is critical (Macharia, 2019; The Constructor, 2022).

Erosion control

Category of geosynthetics used for erosion control include geotextiles, geonets, geocells, geomembranes, and some geocomposites (Oginni & Dada, 2021). Geonets are used in foundation walls, landfills, and roads for erosion control (The Constructor, 2022). Geocells are used for erosion control on steep slopes and offer protection to channels (The Constructor, 2022).

Containment

When geosynthetics are used as containment, they serve as barriers to fluid, landfill liners and covers, and general hydraulic applications including dams, tunnels, surface impoundments and canals (liquid or/and gases) (Pilarczyk, 2000; Oginni & Dada, 2021). The category of geosynthetics used as containment are geomembranes, geosynthetic clay liners and some geocomposites (Koerner, 2012; Oginni & Dada, 2021).

Fill material

The type of geosynthetics used as fill material is the geofoam. When used as a fill material, geofoams reduce lateral pressures on retaining walls and stresses on underlying soils, abutments, or foundations (The Constructor, 2022). Geofoams are used as fill around culverts and pipes (Somiah et al., 2022).

Drainage

Geosynthetics for drainage purposes allow liquid to flow through it without losing the soil. Categories of geosynthetics for drainage purposes include geopipes, geotextiles, geocells, geonets and some geocomposites (Koerner, 2012; Oginni & Dada, 2021). Geonets are used to convey all types of fluids. Geopipes are used to collect and drain leachates from landfill sites (The Constructor, 2022). When geocells are used in highway construction, they aid in fixing the water accumulation problem and the soil erosion problem that may arise.

Filtration

The object of using geosynthetics for filtration is to retain soil while allowing the passage of water (Ministry of Textile, 2013). Thus, such geosynthetics should be permeable for functional use (Ministry of Textile, 2013).Types of geosynthetics for filtration purposes include geonets, geotextiles, and some geocomposites (Koerner, 2012; Oginni & Dada, 2021). Geonets serve as filter media and prevent surrounding fills from clogging drainages (The Constructor, 2022).

Separation

Separation serves as a medium between the different layers of soil which absorbs the load in the form of tension and prevents change in the alignment of the soil layers (Ministry of Textile, 2013). The object of separation by Geosynthetics is to prevent a well-defined material from penetrating the sub-grade or the poor soil (Ministry of Textile, 2013).Geosynthetics used as separators should have good puncture/tear resistance properties to avert the loss of layered aggregates or soil into the underlying soil or subsoil, upward pumping of subsoil, maintains the porosity of different layers of the soil and eliminates contamination (Ministry of Textile, 2013). Types of geosynthetics used for separation include Geonets, geocells, geotextiles, geofoams, and some geocomposites (The Constructor, 2022). According to Oginni and Dada (2021), separation is a primary function of geofoams and geocells use.

Protection

Geosynthetics used for protection serve as cushioning and protection membranes (Ministry of Textile, 2013). Such geosynthetics are useful for landfill and waste containment from puncture due to sharp stones or stress (Ministry of Textile, 2013).

Fluid conveyor

The geosynthetics that function as a fluid conveyor are the geopipes, specifically the ones that are not perforated (The Constructor, 2022). They are used to convey liquids (leachates) to sumps or for safe disposal (The Constructor, 2022). It has been also applied in the transportation of oil and gas (The Constructor, 2022)

Table 1.A matrix of types and primary functions of geosynthetics in previous studies

Geosynthetics	Separation	Filtration	Containment	Drainage	Reinforcement	Stabilization	Fill material	Erosion control	Protection	Fluid Conveyor
Geotextiles	X	X		x	x	X		x		
Geomembranes			X					x	x	
Geogrids					x	X				
Geonets or geospacers		x		x		X		x		
Geofoams	X						x			
Geosynthetic clay liners			X							
Geocells	X				x	X		x		
Geocomposites	X	x	X	x	x	x	x	x	x	
Geopipes				x						x

METHODOLOGY

This quantitative study employed a two-stage approach to research. In the first stage related literature was reviewed to identify the types and primary functions of geosynthetics. The second stage was the use of a structured questionnaire to solicit the views of fresh graduates with a bachelor's degree in civil engineering and allied programmes in Ghana on the types and primary functions of geosynthetics. The fresh graduates considered were graduates who had their graduation within the 2021/2022 academic year. Also, among fresh graduates, only those who were yet to find job were considered for the study. The essence is to avoid inclusion of the views of fresh graduates who have gained some level of exposure or experience in geosynthetics after graduation. Since there was not in existence database from which data on this category of fresh graduates could be sampled, this study conveniently used 109 fresh graduates from public and private universities in Ghana, with Bachelor of Science (BSc), Bachelor of Technology (BTech) and Bachelor of Engineering (BEng) degrees in civil engineering, construction technology, construction technology and management or building technology. The respondents were reached by snowballing.

The study used a 5-point scale, where (1) represented strongly disagree, (2) was disagree, (3) was neutral, (4) was agree, and (5) denoted strongly agree in measuring the responses from the research respondents. In all, the respondents were to indicate their extent of agreement regarding nineteen (19) statements of the types and primary functions of geosynthetics. Out of the 19 statements on geosynthetics, nine (9) related to the types of geosynthetics and ten (10) were on the primary functions of geosynthetics. The respondents were reached via email and WhatsApp. They were requested to complete the questions on the Google forms relating to the types and primary functions of geosynthetics as well as the demographic characteristics of the respondents. The responses were extracted onto IBM SPSS Version 22 software for analysis. Data were analysed using the standard deviation and the mean. One sample t-test was further used in analysing the data which aided in comparing the mean value of the respondents to the population/hypothesized mean to ascertain the level of statistical significance of the responses obtained from the research respondents. Accordingly, a hypothesized mean was set at 3.5 (see Somiah et al., 2022). The significance level was also set at 95% in accordance with predictable risk levels (see Somiah et al., 2022). Any significant (1-tailed) value (p-value) not exceeding 0.05 was considered statistically significant (see Somiah et al., 2020).

RESULTS AND DISCUSSIONS

Table 2. Respondents' demographic characteristics

Main variables	**Specific variables**	**Frequency(N)**	**Percentage (%)**
Programme of study	Civil Engineering	67	61.47
	Building Technology	22	20.18
	Construction Technology and Management	20	18.35
	Total	109	100

University	Public	94	86.24
	Private	15	13.76
	Total	109	100
Gender	Male	101	92.66
	Female	8	7.34
	Total	109	100

The demographic characteristics revealed that 61.47% of the respondents were fresh graduates with a bachelor's degree in Civil Engineering, 20.18% had a bachelor's degree in Building Technology and 18.35% obtained qualification in Construction Technology and Management. Thus, the responses were dominated by civil engineering. The percentage of male and female respondents only reflected that engineering and technology in Ghana has been a male-dominated discipline and there was the need to cautiously bridge the male-female ratio in engineering and technology programmes.

Table 3. Knowledge level of fresh graduates on types of geosynthetics

SN	Types of geosynthetics	Mean	Mean score ranking	Standard deviation	Sig(1-tailed)	Statistical significance
1	Geomembranes	2.36	1st	0. 62	0.00	Yes
2	Geopipes	2.12	2nd	0.49	0.00	Yes
3	Geotextiles	1.70	3rd	0.17	0.00	Yes
	Overall mean score	2.06				

From Table 3, standard deviation values were all below one (1.0). This was an indication that there was consensus in the data collected from the research respondents and thus, variability in the views expressed by the respondents was insignificant (Somiah et al., 2022). Therefore, responses were reliable and accurate. Moreso, all the p-values for the one-tailed test from Table 3, indicated a strong statistical significance of the data collected. All, the t-test p-values were 0.000.

Generally, the results showed that the graduates were only knowledgeable in only three (3) out of the nine main types of geosynthetics identified from the literature review. This translated into an overall mean score 2.06, less than the hypothesized mean of value of 3.5. This confirms the argument by GSI (2015) that the knowledge level in geosynthetics is generally low among fresh graduates in civil engineering at the bachelor's level, specifically in the USA. However, this study in Ghana has further revealed that the low knowledge level in geosynthetics is not only associated with fresh graduates in civil engineering at the bachelor's level but is also inclusive of graduates in allied civil engineering programmes like construction technology and management, and building technology programmes.

Relatively, the knowledge level in geomembranes among the fresh graduates ranked 1^{st} with a mean score of 2.36. This is consistent with the assertion by Adewumi (2018) that geomembranes are the most known geosynthetics. Geopipes with a mean score of 2.12 ranked 2^{nd}.It is peculiar to this study in Ghana that geopipes are among the three most known geosynthetics among fresh graduates in civil engineering and allied programmes. This, contrasts the opinion by the Adewumi (2018) and Oginni and Dada (2021) which found geomembranes, geotextiles and geogrids to be the three most known geosynthetics. Lastly, geotextiles with a mean score of 1.70 ranked 3^{rd}.This supports the argument by the Ministry of Textiles (2013) that geotextiles are well known geosynthetics.

Table 4. Knowledge level of fresh graduates on types of geosynthetics

SN	Primary functions of geosynthetics	Mean	Mean score ranking	Standard deviation	Sig(1-tailed)	Statistical significance
1	Geosynthetics function as separating media	2.36	1^{st}	0.62	0.00	Yes
2	Geosynthetics function as filter media	2.12	2^{nd}	0.49	0.00	Yes
3	Geosynthetics function as containment to prevent ground pollution	1.29	3^{rd}	0.78	0.00	Yes
4	Geosynthetics are useful for drainage purposes	1.17	4^{th}	0.56	0.00	Yes
	Overall mean score	1.74				

From Table 4, standard deviation values were all below one (1.0) indicating consensus exist in the views of the respondents (Somiah et al., 2022). Therefore, responses were reliable and accurate. Moreso, all the p-values for the one-tailed test from Table 4, suggested a strong statistical significance of the data collected. All the p-values of the t-test were 0.000.

The knowledge level of the fresh graduates regarding the function of geosynthetics was generally low. An overall mean score of 1.74 was obtained, thus less than the hypothesised mean of 3.5. Hence, this confirms the view of GSI (2015) that the knowledge level of fresh graduates in civil engineering at the bachelor's level on geosynthetics is low. Peculiar to this study in Ghana is that fresh graduates were only knowledgeable in four (4) out of the ten (10) primary functions of geosynthetics identified from the literature review. Specifically, geosynthetics function as separating media with a mean score of 2.36 ranked 1^{st}. According to the Ministry of Textile (2013) and Oginni and Dada (2021), a function of geosynthetics is serving as separating media for layered soil. Geosynthetics function as filter media obtained a mean score of 2.12 and ranked 2^{nd}.This supports the study by The Constructor (2022) who found the functional use of geosynthetics to be filteration.Acording to The Constructor (2022) when geosynthetics serve as filter media they prevent surrounding fills from clogging drainages (The Constructor, 2022).Geosynthetics function as containment to prevent ground pollution with a mean score of 1.29 emerged the 3^{rd} knowlegdeable area among the fresh graduates.This supports the revealation by Pilarczyk (2000) Oginni and Dada (2021) that containment is a function of geosynthetics. Lastly, geosynthetics are useful for drainage purposes with a mean score of 1.17

ranked 4th .According to Koerner (2012) and Oginni and Dada (2021) drainage is a function of geosynthetics.When geosynthetics function as grainage they aid in draining sub-soil as well the coyenace of fluid.However, the coveyance function is at times separated from the drainage functions in some literature with an example being The Constructor (2022).

CONCLUSIONS

This study sought to establish the knowledge level of fresh graduates with a bachelor's degree in civil engineering or allied programmes in Ghana on the types and primary functions of geosynthetics. An overall mean score of 2.06 and 1.74 were recorded regarding the types and primary functions of geosynthetics respectively; less than the hypothesized mean of 3.5. Thus affirming the generally low knowledge level among fresh graduates regarding the types and primary functions of geosynthetics. However, the Ghana's case is of great concern as fresh graduates were only knowledgeable in 3 out of the 9 types of geosynthetics and 4 out of the 10 functions of geosynthetics. Moreso, this study in Ghana revealed that low knowledge level is not only associated to fresh graduates in civil engineering at the bachelor's level as reported in previous studies but also fresh graduates in building technology and construction technology and management programmes exhibited low knowledge levels in the types and primary functions of geosynthetics. The uniqueness of the study lies in the fact that it empirically established the knowledge level of fresh graduates in civil engineering, building technology and construction technology and management on the types and primary functions of geosynthetics which hitherto were not in existence. The study will inform the review of the existing curriculum for building technology, civil engineering construction technology and management programmes at the bachelor's level to include adequate content on geosynthetics which has been an environmentally friendly approach to improving the conditions of weak soil for civil infrastructure purposes. Again, the study contributes to the existing literature on geosynthetics usage and forms the basis for future studies in geosynthetics, especially on the knowledge level of graduating students.

The study recommends the review of the existing curriculum for building technology, civil engineering construction technology and management programmes at the bachelor's level to include geosynthetics. The government should partner with institutions of higher learning in Ghana to develop the capacity of Lecturers in the delivery of geosynthetics content in curriculum building technology, civil engineering construction technology and management programmes. Also, this study recommends the inclusion of a stand-alone course in geosynthetics engineering within the curriculum being run by public and private universities in Ghana in civil engineering, building technology and construction technology and management at the bachelor's level to enhance the knowledge levels of fresh graduates in geosynthetics in the long term. In the short term knowledge of geosynthetics could incorporate into geotechnical engineering, construction materials or ground engineering to enhance the knowledge of fresh graduates. A future study that proposes an ideal content for geosynthetics engineering for inclusion in civil engineering, building technology and construction technology and management programmes will be a novelty.

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