Journal of Materials Science Research and Reviews

Volume 10, Issue 2, Page 1-11, 2022; Article no.JMSRR.92714

Ascertaining the Level of Awareness of the Functional Uses of Geosynthetics among Construction Practitioners in the Construction Industry in Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Open Peer Review History:
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Original Research Article

Received: 27/08/2022
Accepted: 28/10/2022
Published: 07/11/2022

ABSTRACT

Whereas the strength properties, economic benefits, and comparative advantages the uses of geosynthetics have over traditional alternatives of soil improvement are known, little is known of studies that ascertain the level of awareness of the functional uses of geosynthetics among construction practitioners in Ghana. Thus, this current study seeks to establish the level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana. This cross-sectional study employed a structured questionnaire for data collection concerning the functional uses of nine (9) major categories of geosynthetics for civil engineering infrastructure. Data were analysed using frequency, percentage, mean, standard deviation, and one sample t-test. It was revealed that there was generally a low level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana. An overall mean score of 2.377 was recorded, less than the hypothesized mean

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of 3.5. Relatively, the level of awareness among construction practitioners regarding the functional uses of geopipes ranked 1st with a mean score of 4.057 whereas geofoams ranked 9th with a mean score of 1.796. Contrary to the view that geotextiles are the most known geosynthetics followed by geogrids, this study found out that in Ghana geopipes are the most known geosynthetics followed by geomembranes based on their functional uses for civil engineering infrastructure. Practically this study has established the level of awareness of the functional uses of geosynthetics in the construction industry in Ghana, specifically among construction practitioners such as civil engineers, construction engineers, construction technologists and building technologists. Theoretically, it has provided the basis for future studies on the functional uses of geosynthetics.

Keywords: Civil engineering; construction practitioners; geosynthetics; Ghana.

1. INTRODUCTION

Over the past decades, the use of geosynthetics as an integral part of civil engineering infrastructure has proven to be an environmentally friendly and more sustainable approach to improve the conditions of soil for civil engineering infrastructure compared with the traditional methods of improving soil conditions [1,2]. Civil engineering infrastructure is a collective term for the basic man-made systems, structures, projects and facilities that help society to function and maintain the environment [3]. They include roads, railways, buildings, tunnels, canals, dams, ponds, manholes, pipes, earth retaining structures, wastewater treatment systems, landfills, water supply systems, breakwaters, airfields, and utilities, among others [3]. Geosynthetics are planar products produced from polymeric materials and used with rock, soil, earth, or other geotechnical engineering-related material as an integral part of a man-made structure, project, or system [4]. The production and use of geosynthetics have the tendency of contributing to the realization of the sustainable development goal 12: responsible consumption and production, which among others encourages companies, especially large and transnational companies, to adopt sustainable practices in the procurement of civil engineering infrastructure, reducing waste generation substantially through prevention, reduction, recycling, and reuse [5].

Geosynthetics are in nine major categories based on their functional uses and applications: geonets, geocomposites, geogrids, geomembranes, geosynthetic clay liners, geofoams, geopipes, geotextiles and geocells [6,7]. Each category has specific functional uses for which it has been designed. However, they may be put to other functional uses based on the designer's considerations. The functional uses of geosynthetics include filtration, separation, drainage, containment, reinforcement, environmental protection, and provision of a fluid barrier [8,9].

Geosynthetic studies in the past have focused on some aspects of geosynthetics such as the continental level of usage of geosynthetics [9], properties of geosynthetics with a focus on some properties such as physical, degradation, structural, mechanical, and hydraulic properties [9], challenges to the use of geosynthetics [10], uses of geosynthetics in road construction [8], and comparative advantages the uses of geosynthetics have over traditional alternatives to soil improvement [11]. Though some studies in the past have also argued that globally, the low level of usage of geosynthetics has a relationship with the awareness of the functional uses of geosynthetics [6,10,12], little is known of country-specific studies that establish the level of awareness of the functional uses of geosynthetics for civil engineering infrastructure among construction practitioners. Moreso, none of the studies on geosynthetics has ever considered all nine categories of geosynthetics in a single study. Thus, the relevance of this current study as it seeks to establish the level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana. This study gives a more holistic view of the level of awareness of the functional uses of geosynthetics among construction practitioners as it considers all nine major categories of geosynthetics in a single study.

The specific objectives that governed this study were:

- To establish the level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana;

- To determine the relative level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana.

This Ghana study does not seek to oversimplify its findings to represent that of Africa or the globe due to the different dynamics and the composition of the construction industry across the globe. However, it offers lessons for countries like Nigeria, Burkina Faso, Angola, Malaysia, and South Africa; whose construction industry shares close resemblances with Ghana. It also provides the basis for future comparative studies on the level of awareness of construction practitioners on the functional uses of geosynthetics for civil engineering infrastructure, with a focus on Ghana and countries across the globe.

In this study, construction practitioners encapsulate practising civil engineers, construction engineers, construction technologists, building technologists, and consultants who are responsible for the design, construction and/or management of civil engineering infrastructure. Also, the functional uses of geosynthetics define the intended function(s) for which a geosynthetic was produced to serve, in addition to other secondary functions as specified by the designer or engineer [13]. Thus, in this study, the functional uses of geosynthetics are synonymous with the functions of geosynthetics. Awareness on the other hand is the knowledge construction practitioners possess or have about the functional uses of geosynthetics.

2. CATEGORIES AND FUNCTIONAL USES OF GEOSYNTHETICS FOR CIVIL ENGINEERING INFRASTRUCTURE

Every geosynthetic is made to serve primary functional uses [12] and [13]. However, beyond the primary functional uses, existing studies also inform that there are other functional uses for geosynthetics (secondary or other functional uses). For instance, according to [7] and [14], other functional uses of geotextiles include drainage, erosion control, and stabilization. According to [6] and [7], categories of geosynthetics, based on functional uses and applications, include geotextiles, geonets, geogrids, geomembranes, geosynthetic clay liners, geofoams, geopipes, geocomposites, and geocells [6,7].

2.1 Major Categories of Geosynthetics

2.1.1 Geotextiles

Geotextiles are permeable geosynthetic textile materials or fabrics used as an integral part of civil engineering infrastructure and are in contact with the soil, rock, earth, or any other geotechnical substance [4,8,15,16]. Geotextiles were found to be among the most well-known geosynthetics in the UK, India, USA, and Nigeria respectively by [6,10,17], and [18] based on their functional uses and applications as an integral part of civil engineering infrastructure. The primary functional uses of geotextiles include separation, filtration, drainage, erosion control, stabilization, and reinforcement [7,14]. Geotextiles function as reinforcement within the soil to improve the strength and deformation properties of unreinforced soil. They also function as a drain in soil, allowing fluid to flow through less permeable soil. Moreso, when geotextiles are used as a sand filter, they allow liquid to move through the soil and retain upstream soil particles [14]. Geotextiles also function as a separator when used to separate layers of the soil of different grades [14].

2.1.2 Geogrids

Geogrids are polymeric materials made by weaving, extrusion, or welding to form an opening aperture product of varying strain, strength, and load-carrying capability for soil reinforcement use [7]. Accordingly, [6] and [18] argued that geogrids are the second most known geosynthetics based on their functional uses and applications as an integral part of civil engineering infrastructure. Geogrids are manufactured primarily as a reinforcement or stabilizer material in addition to providing separation between soil and aggregate layers [8]. Geogrids could be used in the reinforcement of soil for steep slopes, walls, roadway and railway bases, and foundations, among others. They are also used for the stabilization of soil with low-bearing strength or high-water tables [7].

2.1.3 Geomembranes

Geomembranes are low-permeability or impermeable geosynthetic materials, used as an integral part of civil engineering infrastructure to reduce or prevent the flow of fluid through the soil [8]. They are commonly used as cut-offs and liners [8]. Geomembranes are also used as hydraulic barriers (an example is when used as canal lining), field seaming, and minimization of installation damage [8]. Geomembranes are used in combination with other geosynthetics as geocomposites for civil engineering infrastructure for enhanced effects [14]. An example is a geotextile-geomembrane geocomposite for civil engineering infrastructure such as waste landfills [14]. The combination improves the protection function of geomembranes as water barriers in waste landfill systems and avoids also frictional instability [14].

2.1.4 Geonets

Geonets or Geospacers are polymeric structures formed by a set of continuous parallel polymeric ribs at acute angles to one another, forming a net-like pattern [7,8]. In cases where chemical resistance is envisaged, geonets made from polyethylene and polypropylene polymers are highly recommendable [7,8]. They are functionally used for in-plane drainage of gases or liquids (especially leachates from landfill and mining projects) and filtration of sediments contained within these fluids [7,8]. Geonets are frequently laminated with geotextiles on one or both surfaces and are then referred to as drainage geocomposite [1,4].

2.1.5 Geofoams

A geofoam is a closed-cell, super-lightweight, rigid, plastic foam [9,19]. It is an extruded polystyrene (XPS) or expanded polystyrene (EPS) which is manufactured into large lightweight blocks [9,19]. Geofoam is functionally used to reduce settlement below embankments, provide sound and vibration damping, reduce lateral pressure on sub-structures, and reduce stresses on rigid buried conduits and related applications [9,19]. Primarily, geofoam provides a lightweight fill below a highway, bridge approach, bridge abutment, flood control levees, basement insulations, railways, embankment, and parking lot [9,19]. It also serves as new fills around culverts and pipelines to reduce the load over the base structure [9,19].

2.1.6 Geocells

Geocells are three-dimensional geosynthetic cellular structures made with novel polymeric alloy (NPA) or ultrasonically welded high-density polyethylene (HDPE) strips [1,19,20,21]. Geocells are expanded on-site to form a honeycomb-like structure which is then filled with soil, gravel, rock, or concrete. Geocells are also known as Cellular Confinement Systems (CCS) [21]. They are functionally used for soil stabilization on flat ground and steep slopes, channel protection, erosion control, road construction, landfills, landscaping, mining operations, structural reinforcement for load support and earth retention, protective linings for channels and hydraulic structures, providing support for static and dynamic loads on weak subgrade soil, and green infrastructure projects [1,21].

2.1.7 Geosynthetic clay liners

Geosynthetic clay liners consist of thin layers of bentonite clay sandwiched between two layers of geotextiles and bonded to a geomembrane [7]. Geosynthetic clay liners are used as hydraulic barriers for leachate, water, other liquids and even gases [7]. Geosynthetic clay liners are also used as a substitute for either compacted clay liners or geomembranes. They are also used in a composite manner to further improve traditional liner materials [7].

2.1.8 Geopipes

Geopipes are solid-wall or perforated polymeric pipes for the drainage of fluid (gases and liquids) [7]. They are primarily used for leachate collection and in instances of high compressive loads [7]. Geopipes are preferred for landfill usage as a means for the collection and quick drainage of the leachate to a sump, and removal system [7].

2.1.9 Geocomposites

Geocomposites are geosynthetics formed by a mixture of two or more geosynthetics such as geomembrane-geonet, geonet-geotextile, and geogrid-geotextile, among others [9]. The geosynthetic clay liner is an example of a geocomposite [9]. Primarily, functional uses of geocomposites include separation, reinforcement, drainage, filtration, stabilization, containment, and erosion control [22].

2.1.10 Functional uses of geosynthetics

Regarding the functional uses of geosynthetics, several views have been expressed in previous studies [8,9]. In literature, the functional uses of geosynthetics have been predominantly discussed under reinforcement, stabilization, erosion control, filtration, fill material, containment, drainage, and separation uses [8,9].

2.1.11 Containment

When geosynthetics are used as containment, they serve as barriers to fluid, landfill liners and covers, and general hydraulic applications including dams, surface impoundments and canals [9,23]. The categories of geosynthetics functionally used as containment are geomembranes, geosynthetic clay liners and some geocomposites [9,22]. When geosynthetic clay liners are used for hydraulic projects they provide a hydraulic barrier for water, leachate, or other liquids and even gases when it gets into contact with the fluid [9,22]. They are also used in highway construction, landfill construction, mining projects, and in canals as secondary containment [7]. Geomembranes aid in the prevention of contaminant diffusion in waste management [7]. Geomembranes serve as hydraulic barriers in ponds, transportation, tunnel, canal lining, and oil and gas applications [7].

2.1.12 Fill material

The category of geosynthetics used as fill material is geofoam [7]. When used as a fill material, geofoams reduce lateral pressures on retaining walls and stresses on underlying soil, abutments, or foundations [7].

2.1.13 Erosion control

Category of geosynthetics used for erosion control include geotextiles, geonets, geocells, geomembranes, and some geocomposites [9]. Geonets are used in foundation walls, landfills, and roads for erosion control [7]. Geocells are used for erosion control on steep slopes and offer protection to channels [7].

2.2 Stabilization

Categories of geosynthetics used for soil stabilization include geotextiles, geogrids, geocells, geonets and some geocomposites. Geotextiles are used in ensuring stability during saturation in the rainy season and conditions of sudden drawdown [9]. Geonets are used as stabilizers in foundation walls, landfills, roads, and asphalt concrete pavements [7]. 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 [2,7]. Geogrids offer soil stabilization in areas with high water table levels or low bearing strength where the laying of a foundation to carry heavy loads is critical [2,7].

2.2.1 Drainage

Geosynthetics for drainage purposes allow liquid to flow through it without losing the soil [9,17,22]. Categories of geosynthetics for drainage purposes include geopipes, geotextiles, geocells, geonets and some geocomposites [9,17,22]. Geonets are used to convey all types of fluids [7]. Geopipes are used to collect and drain leachates from landfill sites [7]. When geocells are used in highway construction, they aid in fixing water accumulation problems and the soil erosion problem that may arise [7].

2.2.2 Filtration

Categories of geosynthetics for filtration purposes include geonets, geotextiles, and some geocomposites [9,17, 22]. Geonets serve as filter media and prevent surrounding fills from clogging drainages [7,17].

2.2.3 Separation

Categories of geosynthetics used for separation include geonets, geocells, geotextiles, geofoams, and some geocomposites [7,17]. According to [9], separation is a primary function of geofoams and geocells applications as an integral part of civil engineering infrastructure.

2.2.4 Reinforcement

Categories of geosynthetics used as reinforcement include geonets, geogrids, geotextiles, geocells and some geocomposites [22]. 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 [7]. Geocells offer structural reinforcement for earth retention and load support when used for earth-retaining structures [7]. 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, their high tensile strength, and their high holding capacity [7].

3. METHODOLOGY

Due to the time relevance of the data for this current study, a cross-sectional study was adopted and a two-stage approach to research was employed. Firstly, a plethora of relevant literature was reviewed which aided in identifying the functional uses of geosynthetics as an integral part of civil engineering infrastructure. The second stage was the use of a structured questionnaire to solicit the views of construction practitioners on the functional uses of geosynthetics as an integral part of civil engineering infrastructure. The respondents included construction practitioners from 257 construction firms who belonged to the Association of Building and Civil Engineering Contractors of Ghana (ABCECG). This sampled size of construction firms was determined based on the principle that, according to [24], for a population of size around 1500, 20% should be sampled [24,25]. Thus, 20% of the population of 1282 construction firms registered with ABCECG was equivalent to 257 construction firms. The population size was obtained from the ABCECG secretariate and it was affirmed by [26]. ABCECG was chosen as the study population because it is the association for building and civil engineering contractors (construction firms) in Ghana with members in all the regions of Ghana. In each firm, information was solicited from construction practitioners within the field of civil engineering, construction engineering, construction technology, or building technology who have experience and/or knowledge of the uses of geosynthetics. In addition, views from five (5) construction industry consultants were purposively sought. Within each consulting firm, information was solicited from practitioners within the field of civil engineering, construction engineering, construction technology, or building technology who have knowledge and/or experience of the uses of geosynthetics. Thus, the views of 262 construction practitioners were sought regarding the uses of geosynthetics for civil engineering infrastructure. In this study, construction practitioners encapsulate construction practitioners with both consultants and contractors (construction firms).

In establishing the level of awareness of the functional uses of geosynthetics among construction practitioners, 31 statements regarding the functional uses of geosynthetics as an integral part of civil engineering infrastructure were presented to the construction practitioners. They were required to indicate the extent to which they agree with the statements based on their experience and/or knowledge, using a 5-point scale where (1) represents strongly disagree, (2) is disagree, (3) is neutral, (4) is agree, and (5) denotes strongly agree. Experience means work experience relating to geosynthetics or having worked in the construction industry for at least five years. Knowledge means having formal or informal information on the functional uses of geosynthetics as an integral part of civil engineering infrastructure.

A 100% response rate was recorded because the questionnaire was self-administered with the help of twenty (20) field workers from March 2022 to July 2022. Respondents spent at most 8 minutes on the survey, and further clarification was given when requested. Data were analysed using the standard deviation and the mean. Data were further analysed using one sample t-test. This helped in comparing the mean value of the respondents to the population/hypothesized mean to establish the level of statistical significance of the responses obtained from the research respondents. Accordingly, a hypothesized mean was set at 3.5 [27]. The significance level was also set at 95% in accordance with predictable risk levels [27]. Any significant (1-tailed) value (p-value) not exceeding 0.05 was considered statistically significant [27].

4. RESULTS AND DISCUSSION

The demographic characteristics of the respondents suggested a great level of work experience. This was an indication that the research respondents were informed and experience was brought to bear in response to the questions on the questionnaire. The percentage of male and female respondents reflected that the construction industry in Ghana was a male-dominated sector. Thus, the need to cautiously bridge the male-female ratio in the sector by supporting more females to read construction-related programmes.

From Tables 2a, 2b, and 2c, standard deviation values were largely below one (1.0). This was an indication that there was consensus in the views expressed by the research respondents. Thus, responses were reliable and accurate. Moreso, all the p-value for the one-tailed test from Tables 2a, 2b, and 2c, indicated a strong statistical significance of the data collected. All, the p-values of the t-test were 0.000.

Table 3 presents the outcome of the level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana based on their experience and/or knowledge. It was revealed that there was generally a low level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana. An overall mean score of 2.377 was recorded, less than the hypothesized/population mean of 3.5. Specifically, the results indicated that apart from geopipes which recorded a mean score of 4.057, all the other categories of geosynthetics recorded mean scores that were lower than the population/hypothesized mean of 3.5. This was an indication that there was generally a low level of awareness regarding the functional uses of geosynthetics among construction practitioners in Ghana. This confirmed the argument by [6,10,12] and [18] that there was a generally low level of awareness among civil engineering practitioners regarding the functional uses and applications of geosynthetics as an integral part of civil engineering infrastructure. However, this current study in Ghana has further revealed that a low level of awareness of the functional uses of geosynthetics as an integral part of civil engineering infrastructure was not only limited to civil engineering practitioners, but construction practitioners such as building technologists, construction technologists, and construction engineers in Ghana. Thus, the approach to address this low level of awareness of the uses of geosynthetics should look beyond civil engineering practitioners. It should be centred on construction practitioners in general.

Furthermore, this study unraveled that relatively, the level of awareness of the functional uses of geopipes among construction practitioners ranked 1st with a mean score of 4.057 according to Table 3. This contrasted the view of [10], [12] and [18] that geomembranes and geotextiles were the most known in terms of functional uses and applications. It was also an indication that the level of awareness of geosynthetics among construction practitioners differed from one country to another. Hence, Ghana's case contrasted with that of the UK, Nigeria, and the USA as revealed by [6,10], and [18] respectively.

Table 1. Respondents' demographic characteristics

Main variables	Specific variables	Frequency(N)	Percentage (%)
Job role of respondents	Civil engineer	112	42.75
	Construction Technologist	35	13.36
	Building Technologist	85	32.44
	Construction Engineer	25	9.54
	Consultant	5	1.91
	Total	262	100
Working experience in Ghana	5 years	40	15.27
	6 to 10 years	43	16.41
	11 to 15 years	42	16.03
	16 to 20 years	79	30.15
	Above 20 years	58	22.14
	Total	262	100
Gender	Male	247	94.27
	Female	15	5.73
	Total	262	100

Table 2a. Level of awareness of the functional uses of geosynthetics among construction practitioners

Functional uses of geosynthetics	Mean	Mean score ranking	Standard deviation	Sig(1-tailed)	Statistical significance
Geotextiles	**2.770**				
Geotextiles are used for soil separation	4.2061	1st	0.65761	0.000	Yes
Geotextiles can be used for soil filtration	3.7328	2nd	0.79099	0.000	Yes
Geotextiles functions as a filter media	2.4618	3rd	0. 71951	0.000	Yes
Geotextiles can be used as soil stabilizers	2.3321	4th	0.58758	0.000	Yes
Geotextiles are useful for soil drainage	2.2824	5th	0.57101	0.000	Yes

Functional uses of geosynthetics	Mean	Mean score ranking	Standard deviation	Sig(1-tailed)	Statistical significance
Geotextiles are useful for erosion control	2.2748	6th	0. .55438	0.000	Yes
Geotextiles serve as a reinforcement for soil	2.1031	7th	0. 73296	0.000	Yes
Geomembranes	**3.105**				
Geomembranes function as containment to prevent ground pollution	3.9198	1st	0.77637	0.000	Yes
Geomembranes are useful for erosion control	2.2901	2nd	0.56715	0.000	Yes
Geogrids	**2.185**				
Geogrids serve as a reinforcement for soil	2.6641	1st	1.01037	0.000	Yes
Geogrids serve as soil stabilizers	1.7061	2nd	0. .72812	0.000	Yes

Table 2b. Level of awareness of the functional uses of geosynthetics among construction practitioners

Functional uses of geosynthetics	Mean	Mean score ranking	Standard deviation	Significant (1-tailed test)	Remarks Significant (1-tailed test)
Geonets	**1.957**				
Geonets could function as a filter media	2.0878	1st	0.85541	0.000	Yes
Geonets are useful for erosion control	1.9542	2nd	0.85646	0.000	Yes
Geonets serve drainage purposes in soil	1.9084	3rd	0.96649	0.000	Yes
Geonets function as soil stabilizers	1.8779	4th	1.03962	0.000	Yes
Geofoams	**1.796**				
Geofoams serve as fill material	1.8206	1st	0.98372	0.000	Yes
Geofoams are used for soil separation	1.7710	2nd	1.00241	0.000	Yes
Geosynthetic clay liners	**1.897**				
Geosynthetic clay liners serve as containment of fluid to prevent ground pollution	1.8969	1st	1.04353	0.000	Yes

Ranked 2nd was geomembranes with a mean score of 3.105. This confirmed [10], [12] and [18] that geomembranes were known in terms of functional uses and applications. Among the two functional uses of geomembranes, geomembranes function as containment to prevent ground pollution with a mean score of 3.9198 ranked 1st whereas geomembranes are useful for erosion control with a mean score of 2.2901 ranked 2nd according to Table 2a. This implied that sensitizations geared towards improving the level of awareness among construction practitioners, regarding the functional uses of geomembranes as an integral part of civil engineering infrastructure, should prioritize geomembranes are useful for erosion control.

The 3rd ranked was geotextiles with a mean score of 2.770 according to Table 3. This supported [17] that geotextile was one of the major categories of geosynthetics whose functional uses and applications were commonly known. Geotextiles had seven functional uses out of which geotextiles are used for soil separation with a mean score of 4.2061 ranked 1st whereas geotextiles serve as a reinforcement to soil with a mean score of 2.1031 ranked 7th (Table 2a). Apart from the functions, geotextiles are used for soil separation and geotextiles can be used for soil filtration, that recorded mean scores greater than the hypothesized mean of 3.5 for this study, all the remaining five functional uses of geotextiles recorded mean scores less than 3.5. This implied that there was generally a low level of awareness of the functional uses of geotextiles as an integral part of civil engineering infrastructure among construction practitioners in Ghana. Hence, any effort to improve the level of awareness of construction practitioners regarding the functional uses of geotextiles should prioritize the functional uses that record mean scores below the hypothesized mean of 3.5 such as, geotextiles serve as a reinforcement for soil and geotextiles are useful for erosion control, among others (Tables 2a, 2b, 2c and 3).

Moreso, the awareness level of construction practitioners on the functional uses of geogrids with a mean score of 2.185 ranked 4th. This was followed by geonets with a mean score of 1.957 ranking 5th, and geosynthetic clay liners with a mean score of 1.897 ranking 6th. Geocells recorded a mean score of 1.816 and ranked 7th whereas geocomposites obtained a mean score of 1.809 and ranked 8th. According to [10,12] and [18], geogrids, geonets, geosynthetic clay liners, geocells and geocomposites are among the major categories of geosynthetics whose functional uses and applications are known. However, it is the relative level of knowledge that varied in this Ghana study.

The least ranked geosynthetic was geofoams with a mean score of 1.796 and ranking 9th. This supported [9] and [19] that geofoams were among the known major categories of geosynthetics though it was relatively the least known geosynthetic in Ghana among

Table 2c. Level of awareness of the functional uses of geosynthetics among construction practitioners

Functional uses of geosynthetics	Mean	Mean score ranking	Standard deviation	Significant (1-tailed test)	Remarks Significant (1-tailed test)
Geocells	**1.816**				
Geocells separate soil	2.1832	1st	1.08491	0.000	Yes
Geocells stabilize soil	1.8092	2nd	0.87638	0.000	Yes
Geocells reinforce soil	1.7557	3rd	0.99879	0.000	Yes
Geocells are useful for erosion control	1.5153	4th	0. .72036	0.000	Yes
Geocomposites	**1.809**				
Geocomposites are useful for soil separation	2.1374	1st	0.90469	0.000	Yes
Geocomposites are useful for soil stabilization	2.0382	2nd	1.14312	0.000	Yes
Geocomposites are useful for soil reinforcement	1.9427	3rd	1.10752	0.000	Yes
Geocomposites are useful for fluid containment	1.8931	4th	0.97676	0.000	Yes
Geocomposites serve as filtration media	1.8702	5th	1.03869	0.000	Yes
Geocomposites are useful for soil drainage	1.7176	6th	0.82374	0.000	Yes
Geocomposites are useful fill materials	1.5878	7th	0.67660	0.000	Yes
Geocomposites are useful for erosion control	1.2863	8th	0.45288	0.000	Yes
Geopipes	**4.057**				
Geopipes are useful for soil drainage	4.0573	1st	0.67846	0.000	Yes

construction practitioners. The two functional uses of geofoams comprised: geofoams serve as fill material with a mean of 1.8206 which ranked 1st and geofoams are used for soil separation with a mean score of 1.7710 which ranked 2nd.

Table 3. Mean score ranking of the level of awareness of the functional uses of geosynthetics among construction practitioners

Geosynthetic(s)	Mean score	Ranking
Geopipes	4.057	1st
Geomembranes	3.105	2nd
Geotextiles	2.770	3rd
Geogrids	2.185	4th
Geonets	1.957	5th
Geosynthetic clay liners	1.897	6th
Geocells	1.816	7th
Geocomposites	1.809	8th
Geofoams	1.796	9th
Overall mean score	**2.377**	

5. CONCLUSIONS

This current study sought to establish the level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana. The study concluded that there was generally a low level of awareness of the functional suses of geosynthetics among construction practitioners in the construction industry in Ghana. Relatively, awareness level among construction practitioners regarding the functional uses of geopipes ranked 1st with a mean score of 4.057 whereas geofoams ranked 9th with a mean score of 1.796. Contrary to the view being held in previous studies that geotextiles were the most known geosynthetics followed by geogrids, based on their functional uses and applications, this study found out that in Ghana geopipes were the most known geosynthetics followed by geomembranes based on their functional uses. This affirmed the argument that the level of awareness of the functional uses and applications of geosynthetics was industry or country-specific.

This study had empirically made known that the low level of awareness of the functional uses of geosynthetics was not peculiar to civil engineering practitioners but, also to construction practitioners like construction engineers, construction technologists, and building technologists. Thus, efforts aimed at addressing this low level of awareness of the functional uses of geosynthetics should include all construction practitioners in the construction industry in Ghana. The findings of this study have the tendency of informing policymakers in policy-making relating to the functional uses and applications of geosynthetics. Practically it has established the level of awareness of the functional uses of geosynthetics among construction practitioners in the construction industry in Ghana, especially among construction practitioners such as civil engineers, construction engineers, construction technologists and building technologists. Again, the study contributed to the existing literature on geosynthetics usage and served as the basis for future studies on the functional uses of geosynthetics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/92714