Developing Structural and Civil Engineering (SCE) Curriculum in sub-Sahara African Nations on the Foundation of the Developed Nations, in Training, Practices and Technology – Nigeria as Case Study

Article history
Received
11 September 2023
Received in revised form
3 October 2023
Accepted
7 October 2023
Published online
23 December 2023

Christopher A. Fapohunda[a*], Adekunle O. Abioye[b], and Oluwatoyin E. Osanyinlokun[c]

[a]Department of Civil Engineering, Federal University Oye-Ekiti, Nigeria
[b,c]Deparment of Civil Engineering, Bamidele Olumilua University of Education, Science and Technology, Ikere-Ekiti, Nigeria
** christopher.fapohunda@fuoye.edu.ng*

Abstract

The training and practice of structural and civil engineering (SCE) education in developing nations, especially the sub-Sahara African nations, are not as robust and dynamic when compared to what are operating in the developed Nations of the World. Available resources in the public domain show strong evidence of a sustained fundamental link of SCE training and practice of the developed nations to the classical training of the ancient Caesar's Rome. This paper looks into the training and practice of structural and civil engineering about 2000 years ago in the imperial Caesar's Rome. The data used were collected from the information available from the public domain. The results showed that: (i) the curriculum for SCE education was very wide and deep and it is in partnership with the State (ii) the training together with the attendant skill development program/schemes began early at Roman home, (iii) SCE is deeply connected to Latin and Greek languages, and (iv) a heavy dependence on classical philosophical studies existed. It is thus concluded that the curriculum for SCE engineering in developing nations be tied to these foundations.

Keywords: Caesar, Civil engineering, Curriculum Education, Nigeria, Practice, Sudan, Sub-sahara Africa, Training.

Introduction

The structural and civil engineering (SCE) and technology capabilities of developed nations continue to advance robustly and to be a major driver of the economies of those nations. The same cannot be said of the developing nations especially sub-Sahara Africa where there is a lot of expectations from Nigeria to take the leadership role. But sadly, this has not been. While many foreign companies are daily making major inroads into Nigeria's construction industry, the same cannot be said of a Nigerian company winning a major construction job in another country. The situation seemed to be so bad that Nigeria now imports technicians and artisans. This is a result of a wrong policy by the Nigerian Government that phased out trade centres without putting in place appropriate commensurate institutions. This trend has not escaped the notice of the Council for the Regulation of Engineering in the Country (COREN) and has described the scenario as shameful (COREN, 2021). In an attempt to resolve this, it is thus necessary to look beyond the surface and try to find out if Nigeria SCE engineering industries are operating from the same foundation as those of the developed nations, especially the United States of America (USA) and the United Kingdom (UK). It is an open fact, and it is well documented that SCE training and practice in the USA, UK, and European countries are founded on principles and practices that dated into the ancient Rome, especially the Caesar's era (Bianco, 2023). These nations, as former colonies of the Roman Empire, inherited massive SCE works and other structures that are still standing and functioning. It is very glaring that these nations have not only held firmly to and sustained the principles from which these structures emerged, but have also continued to draw inspiration from these inherited structures. Further, these Caesar-era Roman structures have become the subject of study for Engineers and materials scientists (Fox, 2021). The influence of Roman structural themes on modern-day structural constructions is glaring, as many structural forms like domes, vaults, arches, and many others, that are being used in structures were developed by the Romans over two thousand years ago. In addition, the wordings in the ICE and ASCE, as will be shown later in this work, contained expressions that are deeply rooted in

Fapohunda, C. A., Abioye, A. O., and Osanyinlokun, O. E., (2023) Developing Structural and Civil Engineering (SCE) Curriculum in sub-Sahara Africa Nations on the Foundation of the Developed Nations, in Training, Practices and Technology – Nigeria as Case Study, *ASEAN Journal of Engineering Education*, 7(2), 17-27.

Caesar's time. In the field of SCE, the strategies for selection of the materials and the methodology to produce mortar have remained substantially unchanged not even with the introduction of the ordinary Portland cement (D'Ambrosio, 2015).

Problem Statement

The structural and civil engineering education in Sub-Saharan African countries seemed to lag behind that of their counterpart in the developing Nations. Many approaches have been proffered as ways to improve engineering education, especially in the sub-Sahara African nations including, increased funding, welfare for teachers, arrest of brain drain, and so on. Lately, the encouragement of STEM education has also become an added strategy to improve engineering education (Gladstone et al., 2022). All these are noble ideas. But are these ideas built on the correct foundation? According to Goldberg and Somerville (2016), continuous improvement will require a cultural attitude and commitment with the attendant humility to admit that learning from outside our community enhances such improvement. In this case, improvement from the learning schemes founded on ancient Rome SCE principles and practices cannot even be considered as an outsider to the African nations. As noted by Bianco (2023), Roman architecture and the building science of the time are an integral part of today's heritage; and belong to all. Structural engineering practices in sub-Saharan African nations should connect to and maintain a firm grip on this foundation. Thus the purpose of this paper is to underscore the need of sub-Sahara African nations, especially Nigeria, for the development of structural and civil Engineering (SCE) curriculum on the foundation of Caesar's Rome of classical times in terms of educational training, practices, and technology. The time frame considered spanned the times of Julius and his Son, Augustus Caesar when the Roman engineering feat reached a sublime height. The primary source of information about structural engineering and construction works of the time is Emperor Caesar's Engineer, Vitruvius, described as the Chief Engineer of the civilized World (Bruner, 2007). Vitruvius treatise *De Architectura Libri Decem* (Ten Books on Architecture), written after 2. B.C (Fapohunda, 2023a and Fapohunda, 2023b), is a seminal comprehensive work that is a revelation of the structural engineering history and theories of the Classical Roman antiquity. It was a publication that was addressed to Augustus Caesar, the Emperor of Rome (and to the Roman world at the time, which included the whole of Africa) that has survived to the present day.

Some definitions

It is necessary to study the two Greek words that combined to form the word "architecture", so that the thought behind it can be grasped. This word is according to equation 1.

$$\text{architecture} = \text{archẹ} + \text{tekton} \quad \textbf{(1)}$$

This is expedient so that the full depth and expanse of the meaning, in the classical imperial period can be captured, as we progress in the curriculum development. The first word "*arche"*, in the language of the period means the governmental authority or position or a Principality or the State Personified; and the person sitting on it was called "archon" (Prince) to whom all the people owed subjection and into whose hands the power of overall governmental administration fell and who also has the power to punish evil doers (Paul, 2014a). This was the person of both Julius and Augustus Caesar at the time. The second word "*tekton*" means simply a builder or to construct. This word is elastically wide and deep in the treatise of Vitruvius. For example, a builder can build with concrete, stone, wood, glass, bricks, gold, silver, iron, bronze, and so on. Also, what a builder builds is many and diverse in the treatise of Vitruvius. It could be housing of all types for different people, or temples of Gods, palaces, towns, cities, towers, bridges, water-carriers (aqueducts), sewage systems, water-supply systems for a city/town, construction machines, military equipment, institutional structures, roads, and ships (military and merchant ships) so on. All these and many more are included in the Vitruvius concept of building. Each of these types of constructions, no doubt, will require different structural systems, different construction techniques, different construction materials, different safety measures, different technical associations, different administrative styles, and so on. All these happened to be the war times and peace-time activities of both Julius and Augustus Caesar, and Vitruvius was there, as their *numero uno* Engineer. In addition, a builder can build for their own citizens (or *civilis* in Latin, the root of the word "civilians") or for strangers. Those who are bound together by the common defence, legislature, and temple are regarded as citizens in the understanding of the time. Both Julius and Augustus Caesar built structures for their own citizens (or *civilis*) as their Prince (*arche*). It is then understandable that Vitruvius directed his work to Augustus Caesar, who as the Prince of Roman citizenship, represented the Roman state at the time, and thus the "Prince-Builder". The "arche" and "tekton" Equation 1 can now be interpreted to mean:

$$\text{architecture} = \text{arche} + \text{tekton} =$$

$$\text{Prince-Builder/ Civil Engineer/ Citizens Engineer} \quad (2)$$

Thus, Prince-builder or Civil engineer (ing) – within the context of citizenship engineer (ing) - will be used interchangeably in this work and this is our mindset; and hence-forth used as to the scope of

structural engineering in the attempt to link its curriculum development to its imperial Roman roots and foundation. Structural engineering, in our view, is wider than civil engineering (which history tells, is the engineering after peace was established). This is because structural engineering was behind the war time structures wars were fought at the time to establish peace. Structural and Civil engineering are thus linked to the persons who established peace. This was Augustus Caesar at the time (Houston, 2016 and Augustus, 2021). That is not to say that the authors are advocating a career in the military as a prerequisite for the practice of structural engineering. Rather, it is to be understood in the philosophical sense. According to Keener (1993), philosophers used to describe their conflict with wicked and bad ideas (or actions, conduct, etc.) or principles as wrestling in an athletic contest or a war. What are used in this conflict, according to him, are virtues – listed in Table 2 and not fists or missiles, or any violent means. Structural and civil engineers will have to deploy all these virtues to solve multifaceted human problems in the practice of the profession. This is the equivalent of the modern-day recognition of the need for the development of "soft skills" or interpersonal skills, or such phrases among engineers.

Methodology

(i) Sources of Information

The approach adopted for this work is to gather all available information in the public domain around the time frame under reference. This information, obtained from internet sources, Universities repositories, textbooks, commentaries, and so on, dealt with numerous construction projects. Also, political events that generated construction activities of the time, of which structural engineering was pivotal, were studied and analysed. But the primary source of information is the Morgan's translation of the Ten Books on Architecture by Vitruvius (1914). All others are supportive. The materials collected from the public domain for the purpose of this work were grouped and analyzed around four themes on the basis of relevance to aim of the study. These are: (i) preparatory and early education, (ii) Basic Education (iii) Post-basic Education (iv) the content of the curriculum.

Results and Discussion

(i) Preparatory Education and Early Education

The substance of the Roman curriculum up to the high school level is presented in Table 1. It can be seen in Table 1 that training of Roman children began at home with an emphasis on behaviour, behaviour with respect to the Roman Constitution and to participate in the worship of the Gods for peace sake of all men. Thus, it was the parental duty at home, to lay s solid foundation for their children for the development of Roman character, Roman Faith, and to be submissive to the concept of the Divine or Providence. The practical expression of this faith and concept produces some elements that are essential to the formation of Roman character. These elements were expanded by Barrow (1953) and Miliken (1958), and it is presented in the original Latin words in Table 2. The issue of moral or character as foundational to education is also recognized by the Nigerian Education Research and Development Council (NERDC, 2013).

The syllabus for Nigerians according to section 2 of the National Policy on Education released by NERDC (2013) is presented in Table 3. From observing Table 1 and Table 3, it can be deducted that the three divisions of stages of education are approximately similar. It can be observed from the comparison of both Tables that while the Roman placed the responsibility of early education of children squarely at home, the Nigerian counterpart placed it squarely in the hands of private operators. The substance of education at home is with reference to the development of good character and the study of Roman law (or in modern terms, the Constitution) and divine appreciation. That is, familiarity with the Constitution started early at home for Roman citizens. The Constitution was and still is what is common to all the citizens. In Nigeria, this is not so. Not many people have it, not to say able to comprehend it for the purpose of practicing it. The importance of this early instruction on Constitutional matters resulted in what is later known as Jurisprudent developed by the Jurists, which is to be part of the curriculum for Civil engineers recommended by Vitruvius as will be observed later (Table 4). In his Institutes, Justinian (2023) summarized the Roman jurisprudence as to live honestly, to injure no one, and to give everyone his due. To injure none is the whole goal of structural engineering in all ramifications. From this *maxim* arose many construction laws that are used in developed Nations, which govern the construction process, construction safety and performance as well serve as a basis for apportioning construction risks (Bruner, 2007).

Table 1: Expected Syllabus content up to High School (Milliken, 1958)

S/No	Stages	Some of the contents of the Syllabus
1	Early years home-training (less than 7 years old)	• Education and Training in - Discreet behaviour - Modesty in speech - Respectful behaviour - Roman Law, summarized as " to live honestly, to injure no one and to give everyone his due" (Justinian, 2023) - In home-based Roman Religion meant to procure the "Peace of the God" to mankind.
2	Elementary school (7 – 12 years old)	• Great attention paid to reading and writing in Latin and Greek • Training in Arithmetic • Training of memory through learning by heart Greek and Latin prose and poetry
3	High school (12 – 19 years old)	Training and education in the followings: • Grammar (in Greek and Latin) • Dialectic (the art of critical enquiry by discussion) • Geometry • Astronomy • Music • Medicine • Civil engineering • Public speaking

Table 2: Character development (Barrow, 1953 and Miliken, 1958)

	Latin Words	Description
1	*Pietas*	The proper submission to all the established institutions, and a sense of duty to the immortal Gods and one's parents, that is, the habit of obedience to divine authority
2	*Simplicitas*	This is the quality in a man to sees things clearly and see them as they are, that is, keeping one's feet planted firmly on the ground
3	*Frugalitas*	To have simple tastes
4	*Gravitas*	Serious sense of responsibility which made even the smallest affairs of life seem too things too great to be trifled with
5	*Humanitas*	Respect for human personality and relationship. A sense of the dignity of one's own human personality, which is unique and which must be cared for and developed to the full, ... and the recognition of the personality of others and their right to care for their own personalities, . . . and this recognition implies self-restraint. Respect for human personalities and relationships
6	*Virtus*	Manliness and energy
7	*Disciplina*	The training (at home and public) which produces steadiness of character
8	*Industria*	Hard work
9	*Constantia*	Firmness of purpose , . . tenacity of purpose
10	*Clementia*	The willingness to forgo one's rights for common goals
11	*Comitas*	Good humour
12	*Libertas*	Maintenance of freedom of individual
13	*Fidas*	Respect for pledged words and the expressed intention
14	*Mores*	Holding fast to what has been handed down as containing accumulated wisdom, which no moment or man can supply

It is difficult to practice structural/civil engineering in an unstable environment where there is no stable human character, stable institutional and good legal framework that guides relations amongst citizens at every contact encountered in all human endeavours during practice be it the government at all levels, or government agencies, or institutions, individuals, and so on. It is also noteworthy in Table 1 that the development of peace issues, as essential component of human personality formed part of early years of education, and this training resided at the average Roman home. Inclusion of the concept of peace issues at the early stage of human development, inadvertently prepared the framework of peace and harmony that are necessary for the practice of SCE A structural and civil engineer needs a lot of skills in the art of practical peace-making to manage the diversity of human natures in forms of character, conduct, cultures, ethnicity, belief, legal systems, citizenship, etc., that must be resolved; first to create enabling working environment for peace and harmony, and secondly for safe and sound structural judgement during the whole period of the construction work. However, peace issues, ultimately fall under the jurisdiction of the statesmen who are empowered to punish violators of public or societal peace, which was a sin-qua-non for the practice of civil engineering. Placing the early educational development of Nigerian citizens in the hands of private operators, with no guidance or basis (as the Roman counterpart anchored Roman Law), and with no well-developed character sets as in Table 2 (as for the Roman), portend danger to the society. Nigerians trained by private operators who are unknown and amorphous and subject to the whims of just any wind of doctrine, cannot produce the stable and resilient character as well as peaceful disposition required to practice structural engineering in the long run.

(ii) Basic Education

The elementary school in ancient times, from Table 1, is approximately equal to Nigeria's basic education as can be seen in Table 3. The substance of the curriculum for elementary school in the classical times is basically arithmetic and language studies in Latin and Greek literature poetry, history, oratory, and so on. Although the concept of what constitutes arithmetic may have varied in terminology over times, the centrality of the study of Latin and Greek languages to the Basic education in the times under reference is unmistakable. The centrality of a common language in a community as a vehicle of growth, development and specially building activities for civilization, was recognized a long time ago. Moses (2014) document showed that, but for the intervention of the Divinity in ancient times, the whole humanity would have succeeded in their efforts to build a city and a tower that was to reach the Heavens because of the common language at the time. The present stage of human civilisation seemed to be firmly established on the taught-forms and though-precepts that were either Latin or Greek or both combined together. While the classical Greek language is today's language of universal learning and education; Latin, the language of the Romans is the medium of Caesar's imperial law (constitution), and still the basis of several national legislations (Bianco, 2023). Nigeria basic education also recognizes the importance of Languages by including a minimum of 3 (three) languages, namely English language, French language, and one Nigerian; as well as Arabic language which is optional. The inclusion of these languages was well-intended but may not provide the necessary link to the language of classical Caesar's times on which structural and civil engineering practices were founded. The link is necessary to gain access to resources that is necessary for robustness and dynamism in the practice of the profession so as to make meaningful contributions to human development.

(iii) Post-Basic Education

The contents of the curriculum of post-basic education by NERDC (2013) are shown in Table 3. This is approximately equivalent to the High school in Caesar's Rome of the 1st century as shown in Table 1. The NERDC (2013) contents contain five (blocks) and within each block are courses. The courses in the first block are compulsory and five other subjects are to be added in other blocks. In the technology block, there is building construction. Building construction here, using the language of Caesar's time was simply Civil engineering as earlier adverted to. In Caesar's time, the scope of activities of Civil engineering, according to Augustus (2021) and Fapohunda (2023b) encompassed the construction activities enumerated in Table 4. The learning of civil engineering began at High school. With the exception of structures for private individuals, most construction works were undertaken by the reigning Emperor or Magistrate, including temples or worship centres. They are thus what can be termed "institutional construction". On the other hand, what constitutes Building construction in the Nigerian environment, though not compulsory, was not disclosed by the NERDC (2013), but the practice is not as wide as the Caesar's Rome counterpart as can be observed in Table 4. Also, the practice in Nigeria is not institutional in outlook.

Table 3: Expected Syllabus Content in Nigerian Schools (NERDC, 2013)

S/no	Stages	Some of the content of the Syllabus	
1	Early child care Development Education (ECCDE) - Up to 4 years old (in daycare centres,- fully in the **hands of private sector**, social development services)	• Teachings to: - Inculcate social, moral norms and values - Inculcate in the child spirit of enquiry and creativity through the exploration of nature and the environment, art, music, - Develop sense of cooperation and team spirit - Stimulate good habits in child and good health habits - Rudiments of numbers, letters, colour, shapes, forms, etc. through play	
2	5 - 15 years old (Basic Education) -	Pre-Primary – 1 year	The same as in ECCDE at daycare centres
		Primary Education – 6 years	There is a specific curriculum consisting of: - English studies - One Nigerian Language - Mathematics - Basic Science and Technology (Basic Science, Basic Technology, Information Technology and Physical and Health Education) - Religious and National values (Christian Religious Studies, Islamic Studies, Social Studies, Civil Education, Security Education) - Cultural and creative arts - Arabic (Optional)
		Junior Secondary Education – 3 years	There is a specific curriculum; and it is as in Primary Education (above) in addition to - Pre-Vocational studies (Home Economics, Agriculture) - French language - Business Studies
3	Post-Basic Education (> 15 years old)	• Compulsory and Cross-cutting Subjects (English Language, Mathematics, Trade and Civic Education) • Science and Mathematics (Biology, Chemistry, Physics, Further Mathematics, Health Education, Agriculture, Physical Education, Computer Studies) - Technology (Technical Drawing, General Metal Work, Basic Electricity, Electronics, Auto Mechanics, Building Construction, Woodwork, Home Management and Food and Nutrition. • Humanities (Christian Religious Studies, Islamic Studies, Visual Arts, Music, History, Geography, Government, Economics, Literature-in-English, French, Arabic, Any Nigerian Language with Curriculum.) • Business studies (Stores Management, Accounting, Commerce, Office Practice, Insurance) • Trade and Entrepreneurships Subject. (34 subjects are listed)	

Table 4: The Scope of Civil engineering in the Caesar's time

S/No	**Civil Engineering**	**Types**	**Divisions**	**Descriptions**
1	The art of Civil Engineering	Construction of Fortified Towns/Cities	NA	NA
		Construction of Public buildings	Defensive	Planning of Walls
				Towers
				Gates
				Devices for resisting hostile attacks
			Religious	Erection Fanes
				Erection of Temples to Immortal Gods
			Utilitarian	• Erection of meeting places for public use • Harbour • Markets • Colonnades • Baths (but were a place for social life, news, gossip, lectures, and games (board games, exercise, games with balls). • Theatres (a place for entertainment) • Amphitheatres (modern day Stadium) • Promenade • Bridges • Roads • Aqueducts (water carriers) • Forum (a central **open space** used as a meeting place, market, or gathering place for political discussion or demonstration, a central city location critical for communicating ideas and news. It also comprised of several public buildings that included courts, jails, and government facilities). • Circuses (for horse and chariot racing) • Basilica (Basilicas were halls of justice and commercial marketplaces
		Structures for private individual	In the city	NA
			In the countryside	NA
2	Making of time-pieces	Sundials, water clocks,	NA	For measuring time
3	Construction of machinery	For military purpose	NA	Catapults, ballistae, siege machines, tortoise, towers, amongst others
		For non-military purposes	NA	Hoisting machines, engines for raising water, water wheels, water mills, water screws, pump, odometer, amongst others.

An institutional or community-centred orientation of the training of civil engineers will make some courses in humanity, social sciences, philosophy, and law reasonable as will be seen shortly in the curriculum of civil engineers in the Caesar's Rome. This is because institutions exist for a community; and all the elements in it must meet and learn how to interact peacefully.

It is the human beings in the community that is important as a whole, not in part; before the practice of the profession. Presently, an average Nigerian civil engineer does not think that his/her profession has anything to do with Law, or Social sciences, or Philosophy, etc., or the development of ethical issues as a condition for communal interactions that engineering infrastructures and construction promote. The character development for good neighbourliness begins at home, and the home is the subset of the whole society. Romans thus located this in the formative years of the early life of the Roman citizens at home as can be seen in Table 1 to nurture and develop the character in Table 2 out of which many curriculum features of civil engineering in the time of Caesar developed. For example, from item 13 of Table 2 (respect for pledged words), the Roman civil engineers exercise great care in contracting because the Roman legal doctrine of *pacta sunt servanda* ("contracts must be honored") imposed strict contractual liability unless non-performance was excused under the doctrine of *rebus sic stantibus* ("provided the circumstances remain unchanged") (Bruner, 2007). These ancient principles undergird the modern law of contract and its legal doctrines of sanctity of contract, force majeure, and impracticability. This learning began at Roman home (Bruner, 2007).

(iv) The Content of Civil Engineering Curriculum in Caesar's Time

Against the background of the foundation laid by going through the curriculum contents of Table 1, the curriculum for civil engineering, arranged into nine (9) groups in Caesar times is presented in Table 5. Looking at the contents of Table 5, the contents of the curriculum may seem strange in Nigeria, especially when observed that the construction of machines and engines are included as part of the curriculum, but it is not strange to the United Kingdom and European Nations. For example, in 1828, the Institution of Civil Engineers (ICE) was established through Royal Charter (ICE, 2014).

Table 5: Breakdown of the curriculum of Civil engineering according to Vitruvius's (Fapohunda, 2023; Bianco, 2023)

S/no	Knowledge Required	Relevance to the Profession
1	Skillfulness with pencil	a) Enables ability to sketch the appearances of work being proposed
2	Knowledge of Geometry	a) This impacts ability to use of ruler and compass required for making plans of buildings on the ground. b) Necessary for the right application of square, the level instrument and the plummet. c) To learn Optics in Geometry enable light to the building to be drawn from fixed quarters of the Heaven. d) The arithmetical part of geometry enables the cost of the building to be calculated and measurement to be computed. e) Geometrical theories and methods allow symmetrical problems to be solved.
3	Knowledge of Political History	a) This is necessary to be able to preserve or repair the society and her infrastructures.
4	Knowledge of Philosophy	a) This is to make the **Civil Engineer** not to be self-assuming, but make him courteous, just, honest and without avariciousness. b) Necessary for Civil Engineer to be honest and incorruptible. c) To learn Physics and its fundamentals, which is taught under Philosophy so as to be able handle numerous construction works.
5	Knowledge of Music	a) To acquire knowledge of canonical and mathematical theory. b) To enables the tuning of ballistae, catapult and scorpions to proper key. c) To impact the skill necessary to make water organs and objects which resemble them.

6	Knowledge of Medicine	a) To settle the issues of climate, air, healthiness or otherwise of sites and the use of different waters to ensure healthiness of dwellings.
7	Know opinion of Jurists	a) To ensure that in the drawing up contracts, interests of both the employer and contractor are safely guarded. b) To impact understanding of laws governing some elements of building, for example, drains, windows, water supplies, etc.
8	Knowledge of Astronomy	a) For the location East, West, South and North. b) To acquire the knowledge of Constellations and Stars.
9	Theory of Heavens	a) For finding equinox, solstice, course of stars and revolution of the firmament. b) To be able to understand the Theory of Heavens. c) To give the skills necessary to construct machines and engines.

In the definition, mechanical science and construction of machinery were part of what constituted civil engineering. An excerpt from that charter says:

> "*. . . . Thomas Telford, of Abingdon Street, in the City of Westminster, Esquire, a fellow of the Royal Societies of London and Edinburgh, and others, had formed themselves into a Society for the general advancement of Mechanical Science, and more particularly for promoting the acquisition of that species of knowledge which constitutes the profession of a Civil Engineer, being the art of directing the great sources of power in Nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation, and docks, for internal intercourse and exchange, and in the construction of ports, harbours, moles, breakwaters, and lighthouses, and in the art of navigation by artificial power for the purposes of commerce, and in the construction and adaptation of machinery, and in the drainage of cities and towns . . .":*

It can be observed that many of the construction works listed in Table 4 – practised in Caesar's time - are included in this Charter. Times and development have not changed this definition of civil engineering, as the current amended charter which came into effect in 2022, as other amended charters in 2015, 2018 still retain this definition (ICE, 2022). The phrase "the powers in Nature" was expressed in chapters 9 and 10 of the "Ten Books on Architecture". Thus, the ICE (2022) definition of civil engineering had inputs from knowledge and practices that dated to the time of Caesar's Imperial Rome. By contrast, the Nigeria's Institution of Civil Engineers (NICE, 2023) defined civil engineering as:

> "A professional service engineering practice that applies the knowledge of mathematics and the physical sciences to design, construct and maintain the physical and naturally built environment for the benefit of man and the environment".

The NICE definition has a limited scope in application compared to the ICE definition (2015 – 2022). It may be tempting to argue that the categories of disciplines in Table 5 are not nowadays required in structural and civil engineering education. They are definitely relevant and their lack is evident in its practice, especially in sub-Sahara African Nations like Nigeria. The subjects in categories 3 (history), 4 (philosophy), and 5 (Law or Jurisprudence), are no doubt progression from education in the early years depicted Table 1; placed at home in the Caesar's Rome but in the hand of private operators in Nigeria. Vitruvius seemed to be saying that without the training that impacts citizenship consciousness and values, civil engineering does not exist. As can be seen in Table 5, the inclusion of philosophy and associated studies renders a professional "just and honest without avariciousness, According to Vitruvius, for no work can be rightly done without honesty and incorruptibility". Home is the beginning of the training for true philosophical development in a child. The ancient Romans held fast to the sayings of Solomon (2014) that when children are trained in the way they should go, they will not depart from it. This is now termed professional conduct, an important dimension enshrined in national legislations and endorsed worldwide by professional chambers. In addition, the study of physics, the bedrock of engineering, according to Table 5 must be learnt from platform of philosophy. The modern practice does not see any relationship between philosophy and construction works. And by that, he meant the Greek philosophies of Plato, Socrates, Epicureans, and so on. It may be necessary to introduce philosophical studies into the Postgraduate curriculum, especially at the Doctoral level, when the minds of candidates are now mature. This will make the title "Doctor of Philosophy" meaningful. Jurisprudence is important to be able to draw and comprehend contractual duties and obligations. Faithfulness to pledge words is a

precursor to faithfulness to written agreement and contract (Table 1 – 2). The study of astrology and concept of the theory of Heaven in the Table 5 are insight that the present space agencies/stations/explorations and all the associated national infrastructures of the developed Nations had root in the Caesars's Rome. This underscores the earlier conclusion that civil engineering, as practiced in the Caesar's Rome was the profession of (or in partnership with) the state. It is in this domain that the phrase "power in the nature" was derived and clues on how machineries were constructed was given. After setting forth that the principles governing machines (*mẹchanẹ)* and engines (*organon*) are different from each other, Vitruvius in Book X, Chapter 1, No. 4, he says:

> " . . ***All machinery*** is derived from nature, and is founded on the teaching and instruction of the revolution of the firmament. Let us but consider the connected revolutions of the sun, the moon, and the five planets, without the revolution of which, due to mechanism, we should not have had the alternation of day and night, nor the ripening of fruits. Thus, when our ancestors had seen that this was so, they took *their* ***models from nature***, and by imitating them were led on by divine facts, until they perfected the contrivances which are so serviceable in our life. Some things, with a view to greater convenience, they worked out by means of ***machines*** and their revolutions, others by means of ***engines*****,** and so, whatever they found to be useful for investigations, for the arts, and for established practices, they took care to improve step by step on scientific principles.

It is obvious the invention of structural element that they called "*arche*" and domes was by observation and imitation of the visual shape of the sky above. This portion of the treatise needs to be studied for the development of engineering infrastructure which is impossible without equipment. The inclusion of medicine as part of the curriculum is also reasonable since most civil engineering works are carried out in the open field, and thus, civil engineers must be educated in health and sanitary issues that are not found on sites.

(v) The Final Comments

It was earlier said in the opening sentence that structural and civil engineering (SCE) practice are not as dynamic and robust when compared to the developed Nations. This paper looked at the foundations of SCE in sub-Sahara Africa using Nigeria as case study and that of the United Kingdom. From the available information in the public domain, strong and sustained link to SCE training and practices to ancient Caesar's Rome in the training of SCE in UK were established. Although grounded in the practice and technology of ancient Caesar's Rome, the principles put forward in *De Architectura* remain valid today for effective, sustainable structural and civil engineering design based on rigorous education and a good knowledge of structural engineering materials and construction. This is the reason why they form the bedrock of the definition of civil engineering by ICE (2022. The education that Vitruvius advocated was not academic, but pragmatic. He called for civil engineers to lay good foundation for a wide and deep "wholistic" education so as to be able to address the well-being of all in their work. He intended that civil engineering issues be comprehended through interdisciplinary but integrated education, beginning from tender years so as to recognize interconnectivity between all studies and thus able to comprehend how and when to apply them (Bianco, 2023).

Conclusions and Recommendations

From the analysis of the data obtained from this investigation, the following conclusions are made.

i. Structural and Civil engineering (SCE) training and practices in the United Kingdom are linked to the training and practices of SCE in the classical Caesar's imperial Rome.
ii. The profession of SCE is closely linked to the State.
iii. Structural and Civil engineering (SCE) training and practices in the classical Caesar's imperial Rome had a very wide and deep foundation that encompassed many branches of learning.
iv. The ICE curriculum of SCE had as part of its contents, a module dealing with the development and construction of SCE equipment and machinery, just like the curriculum contents of SCE in the Caesar's time.
v. The development and construction of SCE equipment and machinery are linked to the space studies.
vi. Latin and Greek languages seem to be the language of SCE and vehicle for the conveyance of SCE educational resources.

Based on the findings from this study, the followings are recommended.

i. The policy of placing early education into the hands of private operators should be reviewed.
ii. The study of developmental languages of Greek and Latin should be encouraged at all levels of education for access to thought forms and precepts that form the bedrock of SCE knowledge and understanding.
iii. Philosophical studies should be introduced as part of the curriculum contents of graduate programs.
iv. The Government of the developing Nations should establish and adequately fund space

research program, which seems to be the domain from which to tap the resources necessary for the development and construction of engineering equipment and machinery.

v. Also, the definition of civil engineering should be re-worded and be in line with ICE definition, for dynamism and robustness in structural and civil engineering training and practices from generation to generation.

Acknowledgement

The authors sincerely acknowledge the efforts of Engr. Bolorunduro for proof-reading the manuscript.

References

Ade-Ajayi, J. F. NSE (1995). History of the Nigerians Society of Engineers. Nigerian Society of Engineers, Lagos.

Augustus, D. 2021. The Deeds of Divine Augustus. Translated by Thomas Bushnell, BSG. Retrieved from http://classics.mit.edu/Augustus/deeds.html.

Barrow, R. H. (1953). The Romans, Penguin Publishers, 22–23.

Bianco, L. (2023). Architecture. Engineering and Building Science: The Contemporary Relevance of Vitruvius's De Architectura. Sustainability, 15, 4150. Retrieved from https://doi.org/10.3390/su1505415.

Bruner, P. L. (2007). The Historical Emergence of Construction Law. *William Mitchell Law Review*: 34;1, Article 6. Retrieved from: http://open.mitchellhamline.edu/wmlr/vol34/iss1/6.

COREN (2021). Foreign Artisan Importation into Nigeria, Shameful. Retrieved from https://www.blueprint.ng/foregn-artisans..

D'Ambrosio, E.; Marra, F.; Cavallo, A.; Gaeta, M.; Ventura, G. (2015). Provenance materials for Vitruvius harenae fossiciae and pulvis puteolanis: Geochemical signature and historical–archaeological implications. *J. Archaeol. Sci. Rep. 2*, 186–203.

Fapohunda, C. (2023a). The Depiction of Structural and Civil Engineering in Vitruvius's Ten Books on Architecture – A State of the Art Review. Architecture and Engineering – Journal of Saint Petersburg State University of Architecture and Civil Engineering. 8, 1; 2 – 12.

Fapohunda, C. (2023b). Overview of Structural Engineering Education Required for the Understanding of Vitruvius's Ten Books on Architecture. Malaysian Journal of Civil Engineering. 35, 2; 13 – 20.

Fox, A. (2021). Nearly 2,000 years on, how are the Colosseum and the Pantheon still standing despite earthquakes, floods and military conflicts?. Retrieved from https://www.bbc.com/travel/article/20211213-how-are romes-monuments-still-standing.

Gladstone, J., Churu, G., Tixier, J., & Van Gaalen, N. (2022). Engineering Education in ``Developing Nations: Progress on the School of Engineering at Northrise University in ``Ndola, Zambia. Retrieved from https://digitalcollections.dordt.edu/faculty_work/1440.

Goldberg, D. E. and Somerville, M. (2016). A Whole New Engineer – The Coming Revolution in Engineering Education. Three Joy Associates Inc. Michigan.

Houston, R. 2016. Augustus and Julio-Claudian. Retrieved from https://silo.tips/download/augustus-and-the-julio-claudians.

ICE (2015). Royal Charter, By-laws, Regulations and Rules. The Institution of Civil Engineers, One Great George Street, Westminster, London SW1P 3AA.

ICE (2018). Royal Charter, By-laws, Regulations and Rules. The Institution of Civil Engineers, One Great George Street, Westminster, London SW1P 3AA.

ICE (2022). Royal Charter, By-laws, Regulations and Rules. The Institution of Civil Engineers, One Great George Street, Westminster, London SW1P 3AA.

Justinian, F. (2023). The Institute of Justinian (translation by J. B. Moyle, Oxford, 1911). Retrieved from https://www.amesfoundation.law.harvard.edu.

Keener, C. S. 1993. IVP Bible Background Commentary New Testament. InterVarsity Press.

Milliken, E. K. (1958).The Roman People. George G. Harrop and Co. Ltd. London, pp. 11 – 12.

Moses, Y. (2014). The Book of Genesis – Chapter 11: 1 - 8. The Holy Bible Authorized King James Version, Bible Society of Nigeria, Lagos Nigeria.

NICE (2023) Definition of Civil engineering. Retrieved from http://www.nicenigerian.org/web.

NPE (2013). National Policy on Education. Nigerian Education Research and Development Council (NERDC), 6th Edition.

Paul, A. (2014a). The Epistle to the Romans – Chapter 13, Verse 1 – 10. The Holy Bible Authorized King James Version, Bible Society of Nigeria, Lagos Nigeria.

Paul, A. (2014b). The Epistle to the Ephesians – Chapter 6, Verse 11 – 22. The Holy Bible Authorized King James Version, Bible Society of Nigeria, Lagos Nigeria.

Solomon, D. (2014). Proverbs 22: 6. The Holy Bible Authorized King James Version, Bible Society of Nigeria, Lagos Nigeria.

Vitruvius, M. P. (1914). Ten Books on Architecture. Cambridge, UK: Harvard, University Press.