LEARNING ABOUT CONCRETE-FILLED TUBE USING CHATGPT

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Abstract: ChatGPT is an artificial intelligence that can understand context and respond appropriately. It could be used for research on a topic. However, ChatGPT does not always provide accurate information. Its performance has not been tested in engineering fields. In this study, ChatGPT was consulted about concrete-filled tubes (CFT), which is a structural element primarily subjected to axial load. Fifty-eight questions were posted to ChatGPT. ChatGPT's responses (370 sentences) were evaluated. ChatGPT generated plagiarism-free statements, with only a 12% Turnitin similarity index. 78.6% of ChatGPT's sentences were long and complex. Thus, Hemingway Editor gave them a Grade 14 for poor readability. The information given by ChatGPT can be classified as correct, erroneous, contradictory, and unverified. ChatGPT could be used as a research tool, but with limitations. It can explain the basic concepts of CFT but also provide inaccurate and contradictory information. A researcher needs to be cautious while using ChatGPT in research. ChatGPT could be used to test some hypotheses or theories. However, the quality of the output is dependent on the user's critical inputs and an in-depth conversation with ChatGPT.

Keywords: *ChatGPT, artificial intelligence, concrete-filled tube, axial load, confinement*

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INTRODUCTION

ChatGPT is an artificial intelligence (AI) large language model (LLM) introduced in November 2022 [1]. It quickly gained worldwide attention. ChatGPT can understand context and respond appropriately [2]. The responses are clear in exposition, precise concerning examples used, and relevant to the requests [2]. ChatGPT can even answer follow-up questions, admit its mistakes, challenge incorrect premises, and reject inappropriate requests due to the dialogue format [3].

ChatGPT can generate convincing writing for any given topic [4]. Researchers used ChatGPT to generate readable titles and text, as well as search for and summarise literature [5]. It can generate plausible-seeming research studies for well-ranked journals [1]. With the addition of private data and researcher expertise, the output was impressive [1]. ChatGPT was even acknowledged as a co-author in many scientific papers [6].

However, ChatGPT does not always provide accurate information. [4] reported that ChatGPT's responses were grammatically correct but not necessarily factual. Researchers must be cautious while using ChatGPT to produce scientific articles. Incorrect information may jeopardise their credibility.

In this study, ChatGPT was consulted about an engineering topic, concrete-filled tubes (CFT). CFT-related questions were posted, and ChatGPT's responses were evaluated. The aims were to (a) evaluate ChatGPT's performance on CFT and (b) learn about CFT. ChatGPT has been assessed for clinical [7] – [9] and financial knowledge [1]. It has not yet been examined on engineering topics, notably CFT.

This paper demonstrates a process of learning about CFT through ChatGPT. ChatGPT's ability to explain and synthesise concepts was assessed. The characteristics and limitations of ChatGPT were observed. ChatGPT's descriptions of CFT are highlighted, and the information's accuracy was checked against the literature. Also, the potential studies for CFT are discussed.

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RESEARCH SIGNIFICANCE

This study explores the use of ChatGPT in engineering research. By investigating the performance of ChatGPT in providing accurate information on CFT, this study provides insights into how to effectively use ChatGPT in engineering research.

METHODOLOGY

In total, 58 questions related to CFT were posted to ChatGPT (Table 1). The questions were not predetermined beforehand. Most of the questions were responsive to ChatGPT's responses. When the information given was deemed insufficient, ambiguous, or not making sense, follow-up questions were posted to seek further clarification (Figure 1). The chat with ChatGPT ended upon reaching the point of saturation.

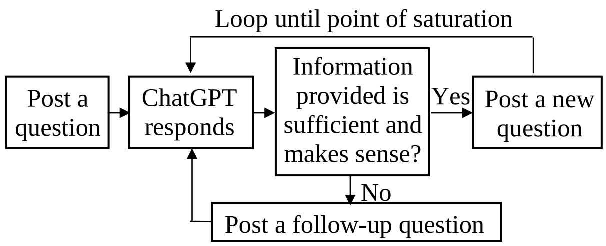

Figure 1 Procedure of inquiring ChatGPT

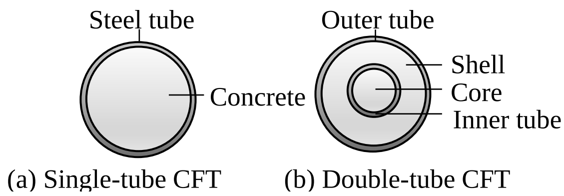

Figure 2 Typical designs of CFT

This study focused on the simplest form of CFT. It comprised one steel tube filled with normal concrete (Figure 2). CFTs made of FRP and plastic tubes were briefly discussed. The double-tube or more advanced forms of CFT, as well as those made of other infill materials, were not covered. The discussion focused mainly on CFT as a column, primarily subject to axial load. The other applications of CFT were not within the scope.

Table 1 Five-eight questions posted to ChatGPT

Inquiry	Follow-up questions
1. What is concrete-filled tube (CFT) in structural engineering field? 2. Who invented CFT? 3. What are the advantages of CFT? 4. What are the disadvantages of CFT?	5. How can CFTs have the advantages of being highly ductile while at the same time having the disadvantages of having limited ductility? 6. Can you elaborate more on the circumstances that lead to CFTs having limited ductility? 7. You mentioned that CFTs have excellent fire resistance. If CFTs are made of steel tubes, shouldn't they be vulnerable to fire? 8. You are referring to CFTs with steel tubes embedded in concrete? 9. When a steel tube is filled with concrete and acts as the formwork during construction, by right, the steel is outside of the concrete. 10. Can you elaborate more on "limited availability," which is one of the disadvantages you mentioned? 11. You mentioned that one of the advantages of CFT is its ease of construction. Then, it is said to have a relatively complex manufacturing process. 12. Can you elaborate on the manufacturing process, which is complex?
13. Other than steel, can CFT be made of other materials?	14. Is there any other material that may be suitable for CFT? 15. You are referring to replacing the steel or FRP tube with high-performance concrete? 16. Is there any difference in terms of the structural behaviour of CFTs between high-performance concrete and normal concrete when they are used to fill the steel or FRP tube? 17. You are saying that CFT with high-performance concrete would always perform better than normal concrete? 18. Which one was first invented, CFT made of steel tube or FRP tube?
19. How about CFT made of plastic tube?	20. CFT made of plastic tubes, you are referring to PVC, uPVC, HDPE, etc.?
21. How is the performance of a CFT as compared with a conventional concrete column of equal size? 22. How does the confinement effect function in CFT?	23. You mentioned that plastic tubes are typically not as strong or stiff as steel or FRP tubes. Can you provide me with the properties of these materials, such as the tensile strength, modulus of elasticity, and breaking strain? 24. Is the 400 to 500 MPa steel tensile strength referring to steel tube? 25. I thought mild steel tube is more common. The yield strength is about 250 MPa. 26. During our discussion, there were several times you apologized for any confusion that your response may have caused. Does it mean that the information provided was inaccurate and that corrections were made, or were you just providing clarification for the points that I had misunderstood?
27. Is it common for CFT to be applied in the construction industry, or is it still in the research stage? What is the level of acceptance among the industry practitioners?	28. Can you name the countries where CFT has been well-established and widely used? 29. What do you see in terms of the prospects of CFT? Is there any recommendation for future research? 30. You mentioned that CFT is vulnerable to local buckling. Can you elaborate more on this? 31. You are referring to the buckling of the CFT column or the local buckling of the tube section under axial load? 32. What are the slenderness limits for CFT local buckling and global buckling?
33. How does the tube thickness influence the structural behaviour of a CFT column? 34. How about the effects of the tube diameter?	35. A larger tube diameter can provide better confinement of the concrete core. How is it so? 36. How can a larger tube diameter lead to an increase in the thickness of the concrete cover? Shouldn't the concrete be within the tube? 37. For "thicker concrete cover," you are referring to a large concrete section? 38. Since the concrete is cast within the tube and the tube is used as the permanent formwork for the concrete, shouldn't the concrete be intact with the tube after casting? How would a larger tube diameter provide more room for the concrete to deform and expand during loading? 39. When the concrete is intact with the tube, there should be no space between them. This is regardless of the diameter of the CFT tube. A larger tube diameter does not give more room for the concrete to expand and deform.
40. Adopting the concepts of modulus of elasticity and Poisson's ratio, what do you see in terms of the interaction between the concrete and the tube of a CFT? Which of them will expand faster?	41. When the concrete experiences a larger deformation than the tube, confinement takes place. 42. What are the Poisson's ratios for concrete, steel tube and FRP tube? 43. Explain Poisson's ratio in layman's terms. 44. Let's say the Poisson's ratio for a material is 0.2. What does it imply? 45. Let us consider both the modulus of elasticity and the Poisson's ratio for CFT. The concrete has a lower modulus of elasticity than the steel or FRP tube. It will undergo larger compressive deformation when subjected to axial load. At the same time, its Poisson's ratio is lower than the tube. This will lead to a small degree of radial expansion as a result of the compressive deformation under axial load. On the other hand, the steel or FRP tube has a higher modulus of elasticity. It undergoes a smaller compressive deformation. Its Poisson's ratio, on the other hand, is greater than that of the concrete. This means that a larger lateral expansion is expected. Now, what will be the combined effects of these? Will the concrete expand faster than the steel tube? Will the confinement still take place? 46. Is there any way to quantify or predict the expansion rate of concrete relative to the tube? Let's say the modulus of elasticity of concrete is 30 GPa and that of steel is 200 GPa. As for Poisson's ratio, the concrete is 0.2, whereas the steel tube is 200 GPa. 47. Where can I find the source of those mathematical equations?

Inquiry	Follow-up questions
	48. Based on the modulus of elasticity and Poisson's ratio of the concrete and the steel tube stated just now, can you compute the expansion rates for concrete and steel tubes? Based on the calculated results, can you conclude if the CFT is in a confined state? 49. The confinement of the concrete is not solely determined by the expansion rates of the concrete and the steel tube. Can you elaborate more on this? 50. When the concrete expands faster than the steel tube, confinement is created, isn't it? This is, of course, provided that the steel tube is fully resistant to the expanding stress caused by the concrete. The expanding stress of the concrete subsequently creates radial tensile stress in the steel tube. This creates strain in the steel tube. If we can calculate the radial strain of the steel tube, will we be able to conclude if the CFT is in a confined state? 51. You mentioned that "if the calculated radial strain of the steel tube is less than the yield strain of the steel, then the CFT can be considered to be in a confined state." This may not be necessarily true under all circumstances, isn't it? It will only be valid when, at the same time, the concrete's expansion rate is higher than the tube's expansion rate. Am I right? 52. Thus far, is there any research investigating this? I mean determining if CFT is in a confined state through quantifying the expansion rates and the radial strain of the concrete and steel tube. What do you see? Would this be a research gap to be filled? 53. Can you provide the source of the relevant studies?
54. What do you see as the future trend of CFT technology? What are the potential scientific breakthroughs?	55. Other than having CFTs as columns, is there any other potential application of CFT? 56. Can CFT be used as a driven pile for building foundations? 57. Is there any research on this? Can you provide me with the source? 58. Can CFT be used as a beam? Is there any research on this? Can you provide me with the sources?

ChatGPT's performance was evaluated in three major aspects, as shown in Table 2. The evaluation performed included a plagiarism check, a readability rating, and fact-checking. ChatGPT's characteristics and limitations were observed. Inaccurate information was highlighted.

Table 2 Evaluation of the performance of ChatGPT

Evaluation	Evaluation performed
Can ChatGPT comprehensively explain concepts?	Plagiarism check and readability rating
Can ChatGPT provide the correct information?	Fact-checking for the content and the references given
Can ChatGPT synthesize knowledge?	Fact-checking for the concepts.

RESULTS AND DISCUSSIONS

A. PLAGIARISM AND READABILITY CHECK

ChatGPT generated responses in 175 paragraphs totaling 370 sentences and 8449 words. These responses were checked for plagiarism with Turnitin (https://www.turnitin.com/). The similarity index was 12%, well below the 20% requirement of most institutions. The similarity for internet sources and publications was 7% and 10%, respectively. There were no individual sources with more than 1% matches. This means that ChatGPT was able to generate plagiarism-free responses. This finding is consistent with that of [7], who observed that the abstracts generated by ChatGPT did not alarm plagiarism detection models.

The responses were then checked for readability using Hemingway Editor (https://hemingwayapp.com/). The readability of ChatGPT's responses was rated as Grade 14 (poor). Good readability should be below Grade 9. Out of 370 sentences, 218 were identified as very hard to read and 73 as hard to read. In other words, 78.6% of ChatGPT's responses were long and complex sentences.

Overall, ChatGPT's responses were insightful, covering many aspects. It used simple terms in its statements and usually ended with a summary. This helps readers quickly grasp the main points. However, ChatGPT sometimes made ambiguous statements, which are not suitable for academic writing. Table 3 shows some ambiguous statements made by ChatGPT. Nevertheless, one may always ask ChatGPT for further clarification.

Table 3 Ambiguous statements by ChatGPT's

ChatGPT's statements	Remarks
The level of acceptance among industry practitioners varies depending on the region and the specific application. In some regions, CFT is a well-established and widely used system, while in others, it may be less commonly used.	It is unclear in which countries CFT is common and in which it is not.
The limits for local buckling and global buckling are different and are determined by different buckling modes and failure criteria.	The limits for local and global buckling are not specified.
In some regions, CFTs may not be readily available, which can make them more expensive or difficult to obtain.	It is unclear in which region CFTs are not readily available.
In some cases, I may have provided information that was not accurate, and in those cases, I would correct my statement to ensure that the information I provided was as accurate as possible. In other cases, I may have been clarifying certain points or providing additional information to help address any misunderstandings or gaps in knowledge.	It is unclear which information was inaccurate and which was accurate.

B. FACT-CHECK

ChatGPT responses on CFT can be classified as correct, erroneous, contradictory, or unverified. Table 4 lists the correct information, with sources cited as support. Table 5 lists the erroneous information with corrections based on the literature. Table 6 shows the contradictory information provided by ChatGPT. Table 7 outlines the unverified information. The information was suspected to be

Table 4 Correct information given by ChatGPT on CFT

No.	Correct information
1.	CFT is composed of a steel tube filled with concrete [10], [11].
2.	CFT is commonly used in building and bridge construction [12], [13].
3.	CFTs are relatively easy to fabricate and install [14].
4.	Shear failure happens in a brittle manner [15].
5.	The steel tube acts as a formwork during construction [14], [16].
6.	CFT's tube can be made of FRP [17] – [19], aluminium [20], [21] and PVC [10], [22] – [24].
7.	FRP CFTs are resistant to corrosion and other environmental factors [25].
8.	CFT filled with high-performance concrete has greater stiffness, higher strength, and improved resistance to cracking or deformation than normal concrete [26].
9.	The use of high-performance concrete can allow for the design of more slender and lightweight CFT structures [26].
10.	The tube provides lateral confinement to the concrete [27] – [29], preventing the concrete from expanding laterally [30].
11.	The confinement effect of the tube can increase the strength and ductility of the concrete [27], [31].
12.	The confinement helps to improve the energy absorption capacity of the CFT [22], [32].
13.	Local buckling occurs when a CFT column experiences an axial load [33].
14.	Thicker tubes increase the amount of confinement provided to the concrete core [34], [35].
15.	Thicker tubes can provide additional strength and stiffness to the column [36].
16.	The confinement provided by the steel tube can help prevent concrete spalling [31].
17.	The confinement can increase the compressive strength of the concrete [31].
18.	The modulus of elasticity of steel is higher than that of concrete [37]. Under load, the steel tube will experience a smaller strain than the concrete.
19.	The Poisson's ratio of steel is 0.3, whereas that of concrete is 0.1 to 0.2 [37].

Table 5 Incorrect information given by ChatGPT on CFT

Incorrect information	Correction
CFT was invented by a Swiss engineer, Robert Maillart.	Robert Maillart did not invent CFT [38].
CFT was first used in the construction of the Eiffel Tower in Paris.	The Eiffel Tower is made of iron, not CFT [39].
CFT is fire-resistant. The concrete in the tube provides excellent fire resistance, protecting the steel from the effects of high temperatures.	The concrete in the steel tube is unable to protect the steel against high temperatures as the steel is exposed. Nevertheless, the presence of the concrete infill does improve fire resistance [16].
The concrete in the tube protects the steel from corrosion, making CFTs highly durable.	CTF's steel tube is exposed. Thus, it is prone to corrosion [40].
A larger tube diameter leads to an increase in the thickness of the concrete cover.	CTF has no concrete cover. The concrete is in the tube.
Timber CFTs have been proposed as a sustainable alternative to steel or concrete, particularly in low-rise building applications.	The authors were not aware of any CFT made of timber tubes. However, there are CFTs with timber infill [41] – [43].
High-performance concrete in CFTs can also present some challenges, particularly with regard to compaction and consolidation of the concrete within the tube.	High-performance concrete has a high compressive strength and a low water-to-binder ratio [44]. The workability issue can be overcome by adding the superplasticizer to the mix.
The bond between the tube and the concrete is also an important factor that can affect the overall performance of the column.	When steel tube and concrete are loaded simultaneously, the bond between the steel and concrete has an insignificant effect on CFT's performance [45]. It is essential when there is load transfer between the tube and concrete [46], such as moment, buckling, flexural bending, or eccentric load.
Steel (400 to 500 MPa) is typically associated with the steel tube used in a concrete-filled tube (CFT) column.	Mild carbon steel (250 to 300 MPa) is more commonly used for CFT. The relevant studies include [37], [47] – [49].
A larger tube diameter can provide better confinement of the concrete core.	The diameter-to-thickness ratio would be more relevant to the confinement in CFT. A thin tube with a large diameter would have low confinement. Researchers used the diameter-to-thickness ratio as one of the study parameters [12], [18], [50], [51].
The confinement effect can also be increased due to the higher surface area of the steel tube in contact with the concrete, which can help distribute the loads more evenly and enhance the bond between the steel or FRP tube and the concrete.	The contact surface area and the bond with concrete are not the root causes of the confinement. The confinement decreases as the diameter-to-thickness ratio increases [12], [52], and this reduces the ultimate axial strain [53].
A larger tube diameter can reduce the likelihood of local buckling, as the column will have a larger effective slenderness ratio, which can improve the overall strength and stiffness of the column.	The resistance of steel tubes with a large diameter-to-thickness ratio is dominated by local buckling [54]. A thick tube with a large diameter does not necessarily undergo local buckling.

erroneous but was not verified due to the author's constraints and a lack of evidence.

ChatGPT was right about CFT in many aspects (Table 4). CFT is a composite member made of a tube and concrete infill [10], [11]. It is commonly used in buildings and bridges [12], [13]. The tube acts as a permanent formwork during construction [14]. The tube confines the concrete [55], preventing the concrete from expanding

Table 6 Contracting points given by ChatGPT

Response 1	Response 2	Remarks
High ductility is an advantage of CFT.	CFT has the disadvantage of limited ductility.	ChatGPT's clarification was not persuasive.
Steel tube is typically embedded in the concrete, which helps to protect it from the effects of high temperatures during a fire.	The steel tube acts as a formwork during construction and is typically positioned on the outside of the concrete.	ChatGPT's clarification did not address the contradicting points.
CFTs are relatively easy to fabricate and install.	The design and construction of CFTs can be more complex than other types of structures.	ChatGPT further explained that the manufacturing process of the steel tube is complex, but the casting of CFT is relatively simple.
A larger tube diameter does not provide more room for the concrete to expand and deform, as the concrete is contained within the tube and cannot expand beyond its boundaries.	A larger tube diameter can provide a thicker concrete cover, as there is more space between the tube and the surface of the concrete.	ChatGPT's clarification was unclear and not persuasive.
A larger tube diameter can reduce the likelihood of local buckling, as the column will have a larger effective slenderness ratio.	Larger-diameter tubes can also increase the risk of local buckling, particularly if the tube thickness is not increased proportionally.	ChatGPT mistakenly mixed up the concepts of local and global buckling.

Table 7 Unverified statements of ChatGPT

No.	Unverified statement
1.	CFT has been widely used in Asia and the Middle East, such as in Japan, South Korea, China, the United Arab Emirates, and Singapore.
2.	CFT has been used in the Burj Khalifa of the United Arab Emirates.
3.	CFT has been used in the Marina Bay Sands project in Singapore.
4.	The slenderness ratio limit for local buckling of CFT columns can vary from 20 to 120, depending on the tube material and diameter.
5.	The slenderness ratio limit for global buckling of CFT columns can vary from 30 to 80, depending on the design code, loading condition, and column configuration.
6.	It is not possible to calculate the expansion rates for the concrete and steel tubes based solely on their modulus of elasticity and Poisson's ratio.
7.	The confinement of the concrete cannot be conclusively determined based solely on the modulus of elasticity and Poisson's ratio of the concrete and steel tube.
8.	An equation to calculate the radial expansion of the concrete: $$\varepsilon_r = \frac{v_c}{(1+v_c)(1-2v_c)}\varepsilon \quad (1)$$ where ε_r is the radial strain, ε_a is the axial strain, and v_c is the Poisson's ratio of the concrete.
9.	An equation to calculate the axial strain in the concrete: $$\varepsilon_c = \frac{\sigma_c}{E_c} - \frac{v_c}{(1+v_c)(1-2v_c)}\varepsilon_a \quad (2)$$ where ε_c is the axial strain in the concrete, σ_c is the compressive stress in the concrete, E_c is the modulus of elasticity of the concrete, and ε_a is the axial strain of concrete.
10.	An equation to calculate the axial strain in the tube: $$\varepsilon_t = \frac{\sigma_t}{E_t} + \frac{v_t}{1-v_t}\varepsilon_a \quad (3)$$ where ε_t is the axial strain in the tube, σ_t is the compressive stress in the tube, E_t is the modulus of elasticity of the tube, v_t is the Poisson's ratio of the tube, and ε_a is the axial strain of tube.

laterally under axial load [56]. On the other hand, concrete prevents the steel tube from buckling inward [55]. For these reasons, CFT outperforms unconfined concrete in terms of axial strength, ductility, energy absorption, and post-peak strength [15], [57] – [60].

ChatGPT provided some incorrect information about CFT (Table 5). According to ChatGPT, the concrete acts as a cover to protect the steel tube from high temperatures and corrosion. This is not true. CFT's steel tube is exposed to the environment [61]. Steel is vulnerable to fire [62] and corrosion [61]. Nevertheless, the presence of the concrete infill does improve fire resistance [16]. ChatGPT was also wrong about the inventor of CFT and its application to the Eiffel Tower (Table 5). ChatGPT stated that CFT can be made of timber. The authors were not aware of any CFT made of timber tubes. However, there are CFTs with timber infill [41] – [43].

Occasionally, ChatGPT provided contradicting information (Table 6). ChatGPT said in different responses that CFT has high ductility and limited ductility. In one response, the concrete is in the tube, but in another response, the steel tube is embedded in the concrete. ChatGPT apologised five times for providing confusing responses. It then provided corrections or clarifications, but not all were persuasive. ChatGPT admitted that it may have provided erroneous information in some cases, but in others, it was clarifying points or providing further information to address misunderstandings. It, however, did not specify which information was incorrect and which was being further clarified.

Buckling occurs when a slender CFT experiences an axial load. There are local and global bucklings (Figure 3). ChatGPT correctly defined the two bucklings, although the concepts were mixed up. Initially, local buckling was universally referred to as "buckling" in ChatGPT's responses. Local buckling happens when the tube's slenderness ratio is relatively high and the tube's wall is relatively thin. Under an axial load, the tube's wall tends to buckle outwardly (Figure 3(b)). This localised damage reduces the tube's ability to confine and strengthen the concrete. Thus, CFT's load capacity reduces, resulting in premature failure. Then, upon inquiry, ChatGPT clarified that CFT can also experience global buckling. It occurs in slender CFT that is subjected to lateral loads. CFT deforms and bends away from its longitudinal axis as a result (Figure 3(c)). Thereafter, ChatGPT made it clear in its responses if it was referring to local or global buckling.

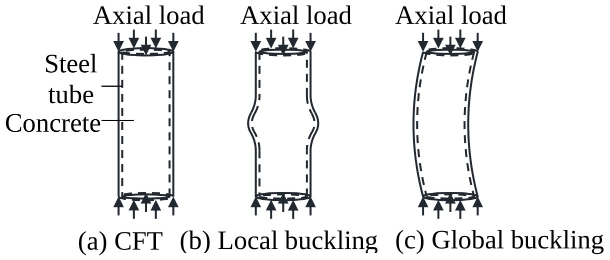

Figure 3 Type of buckling

According to ChatGPT, the confinement provided by the concrete can increase buckling resistance. In fact, concrete does not provide confinement to the tube. Yet, it provides a reaction, preventing the tube from buckling inwardly [55]. This reaction helps to prevent or delay local buckling [31], [60] but has little effect on global buckling.

The confinement effectiveness decreases as CFT's slenderness ratio increases [56]. According to ChatGPT, CFT's slenderness limits for local and global bucklings are 20 to 120 and 30 to 80, respectively, depending on the diameter, material properties, and boundary conditions. These values were not verified in this study. Nevertheless, [63] listed the slenderness limits given by design codes as functions of steel tubes' modulus of elasticity and yield strength. Compressive buckling does not occur if the slenderness ratio is less than 3 [64]. [65] observed buckling failure in their specimens with aspect ratios of 6 and 8.

Plastic tube may be used to make CFTs, but it is not as common as steel or FRP. According to ChatGPT, they are not as well-suited for CFTs as steel and FRP tubes. Plastic tubes are not as strong as steel or FRP tubes, which can limit their use in high-load applications. Furthermore, plastic tubes may be less resistant to UV exposure and temperature fluctuations. Nevertheless, there are studies of CFTs made of plastic tubes. PVC [23], [24], [66], uPVC [32], [65], [67], HDPE [68], and PE tubes [69] can be used. Plastic tubes offer little axial load capacity due to their low modulus of elasticity and yield strength [70]. Their confinement is less than that of steel tubes [71]. Nevertheless, due to the considerable plastic deformation [17], plastic tubes increase the ductility and energy absorption of CFT [68], [72].

According to ChatGPT, a larger tube diameter provides more room for the concrete to expand during loading. ChatGPT, however, was unable to justify why this is the case. The concrete is cast within the tube. Unless there are honeycombs, there should be no space between the concrete and the tube. However, concrete shrinks somewhat as it dries and hardens [73]. This results in a tiny gap between the concrete and the tube [73], [74]. According to ChatGPT, the "room" in the CFT can increase its ductility and energy dissipation capacity. This is incorrect. The gap would slightly delay the confinement action in CFT [73], [74]. It contributes very little to increasing CFT's ductility and energy dissipation capacity.

ChatGPT could be used to test hypotheses or theories. An in-depth chat with ChatGPT might spark new research ideas. ChatGPT was asked to discuss the potential behaviour of CFT under axial load based on the elastic modulus and Poisson's ratio of steel and concrete. Steel is stiffer than concrete due to its higher elastic modulus (Table 8). Under a load, the steel tube would have a smaller deformation than the concrete. On this basis, confinement in the CFT is possible. Concrete, on the other hand, has a lower Poisson's ratio than steel (Table 8). Under the same amount of axial strain, it would undergo less lateral expansion [75]. Confinement in CFT might not occur if the steel tube expanded faster than the concrete. Both of these cases were conditional on (a) the absence of the gap between the concrete and the steel tube and (b) the yield strain of the steel tube not being exceeded. Their interaction would determine confinement in CFT.

Table 8 Material properties given by ChatGPT

Type	Tensile strength (MPa)	Modulus of elasticity (GPa)	Breaking strain (%)	Poisson's ratio
Steel	400 to 500	200	15 to 25	0.3
FRP	500*[1], 2000*[2]	50 – 150	1 to 4	0.2 to 0.3
PVC	45 to 65	2 to 3	40 to 60.	
uPVC	50 to 70	2 to 3	20 to 60	
HDPE	20 to 40	0.8 to 1.5	700 to 1,000	
Concrete				0.1 to 0.2

*[1]*GFRP*, [2]*CFRP*

If the confinement in CFT can be quantified, it might be a breakthrough. This is possible, conditional on successfully quantifying (a) the axial strain of concrete and steel tube based on the elastic modulus, (b) the lateral expansion of concrete and steel tube based on the Poisson's ratio, and (c) the shrinkage gap between concrete and steel tube. If the transverse tension of the steel tube is measured, the confinement stress could also be estimated. This could be a potential research study in the future. The authors are not aware of any relevant studies at the moment.

ChatGPT recommended the following future studies for CFT:

- The development of new materials and technologies that can improve the performance of CFT, such as high-performance concrete or advanced fiber composites.
- The development of more accurate and efficient modelling and analysis tools that can help engineers design CFT structures more effectively.

Table 9 Checking the references stated by ChatGPT

References given by ChatGPT	Remarks
"Mechanics of Materials" by Beer and Johnston,	The book existed [82]. Only the first two authors were mentioned.
"Elasticity" by Timoshenko and Goodier,	The book existed [83].
"Theory of Elasticity" by Landau and Lifshitz	The book existed [84]. The first and the last authors were mentioned.
Teng, J. G., & Chen, J. F. (2002). Behavior and design of concrete-filled steel columns. Journal of structural engineering, 128(7), 868-880.	The journal, volume, issue, and year existed. The article and authors were not found.
Guo, X., & Tao, Z. (2017). Analytical solutions for predicting the stress-strain behavior of concrete confined by circular steel tubes under uniaxial compression. Construction and Building Materials, 149, 341-356.	The journal, volume, and year existed. The article and authors were not found.
Guo, X., & Tao, Z. (2018). Analytical solutions for predicting the stress-strain behavior of concrete confined by FRP tubes under uniaxial compression. Composite Structures, 203, 143-154.	The journal, volume, and year existed. The article and authors were not found.
Wu, Y. F., He, W. Y., Wang, D., & Jiang, W. (2014). Behavior of concrete-filled stainless steel tubular stub columns under axial compression. Thin-Walled Structures, 84, 282-292.	The journal, volume, and year existed. The article and authors were not found.
Chen, J. H., Wang, J. H., & Han L. H. (2010) Experimental and numerical study on bearing capacity of concrete-filled steel tubular (CFST) pile. Construction and Building Materials, 24(9).	The journal, volume, issue, and year existed. The article and authors were not found.
Cao, H. Y., Huang, Z. C., & Li, G. Q. (2008) Static and dynamic behavior of concrete-filled steel tube (CFST) piles under axial loading. Journal of Central South University of Technology, 15(4).	The journal, volume, issue, and year existed. The article and authors were not found.
Chen, W., Hu, G., & Liu, H. (2004) Experimental study of concrete-filled steel tube pile with enlarged end. Journal of Constructional Steel Research, 60(7).	The journal, volume, issue, and year existed. The article and authors were not found.
Lianxiang Ma & Yongjiu Shi (2004) Behavior and Design of Concrete-Filled Steel Tube Beams. Journal of Constructional Steel Research.	The journal and year existed. The article and authors were not found.
Xuming Zhang, et al. (2006) Finite element analysis of concrete-filled steel tubular beams under transverse loading. Journal of Constructional Steel Research.	The journal and year existed. The article and authors were not found.
"Experimental investigation of concrete-filled steel tube beam-column joints under cyclic loading" by Yanshan Lou, et al. (Journal of Constructional Steel Research, 2010)	The journal and year existed. The article and authors were not found.
"Performance of concrete-filled steel tube beam-to-column connections subjected to cyclic loading" by Yanshan Lou, et al. (Journal of Constructional Steel Research, 2012)	The journal and year existed. The article and authors were not found.

- To explore the behaviour of CFT under extreme loading conditions, such as earthquakes, hurricanes, or terrorist attacks
- Exploration of new construction methods for CFT that could reduce construction time and cost while maintaining high quality and performance.
- Integration of CFT with other technologies such as sensors, automation, and robotics that could improve construction efficiency, reduce costs, and enhance structural performance.

The recommended future studies were conceptually sound but somewhat general. ChatGPT was then asked if CFT could be used as a driven pile for building foundations. The response was affirmative. ChatGPT asserted that there were relevant studies and recommended some research articles. None of the articles existed. Nevertheless, some relevant studies were found in the literature [76] – [78]. This may be an interesting research topic for CFT.

ChatGPT recommended three books and eleven research articles in total (Table 9). The books existed, but not the research articles. ChatGPT only mentioned two authors per book. Not all authors were acknowledged when there were more authors. Still, the information was sufficient to trace the books. The research articles mentioned by ChatGPT were all incorrect. The journals, volumes, issues, and years were available, but the articles were not. Those were prestigious journals classified as Q1 and Q2 [79]. Based on the results, researchers may ask ChatGPT to recommend books but not research articles.

It seems that ChatGPT was intelligent enough to paraphrase statements and combine concepts. However, it might not know when to quote information, especially when citing a reference. At the moment, it is hard to say if ChatGPT was recommending the right books. Although the books existed, their contents were not checked. According to ChatGPT, those books contained mathematical equations for calculating the radial expansion of concrete and the axial strain of concrete and tubes (Eqns. (1), (2), and (3) in Table 7).

C. CHATGPT AS A RESEARCH TOOL?

ChatGPT can integrate concepts and generate plagiarism-free writing. As a tool for research, ChatGPT has drawbacks. Humans and AI-detection models can still detect ChatGPT's text [7]. Despite the concerns, academic dishonesty can happen with or without ChatGPT. ChatGPT mistakenly blends true and false information in their responses. This necessitates fact-checking, which is time-consuming. According to [80], ChatGPT would be more accurate when more human peers correctly answered a specific question. Inaccurate information might not be detected without careful thought. Thus, researchers should be cautious and sceptical while using ChatGPT.

ChatGPT can easily explain complicated concepts. It also allows users to seek further clarifications until all doubts are cleared. This is more convenient than reading research articles. ChatGPT's prompt responses save researchers time spent searching the internet for answers. It helps researchers quickly grasp the basic principles of a topic, easing the literature review process. However, ChatGPT tends to give general and occasionally ambiguous statements. Researchers cannot fully rely on ChatGPT for in-depth research.

ChatGPT could be used to test some hypotheses or theories. The quality of the output can vary significantly depending on (a) the researchers' creativity and reasoning skills, (b) the quality and preciseness of the question asked, (c) the inclusion of key concepts in the discussion, and (d) rigorous fact-checking. One could ask ChatGPT about any topic, but the information is not up-to-date. ChatGPT had limited knowledge of the world after 2021 [81], meaning the information was two years behind.

CONCLUSIONS

This study learned about concrete-filled tubes (CFT) using ChatGPT. It comprises two main parts: (a) assessing the performance of ChatGPT in providing reliable information and (b) acquiring correct information about CFT. ChatGPT produced plagiarism-free statements with only a 12% Turnitin similarity index. 78.6% of ChatGPT’s responses were long and complex sentences. Thus, Hemingway Editor rated them Grade 14 for poor readability. ChatGPT’s responses were classified as correct, erroneous, contradictory, and unconfirmed. ChatGPT was right about the basic principles and applications of CFTs. It can explain the concepts of confinement, modulus of elasticity, and Poisson’s ratio in the context of CFT. However, ChatGPT had difficulty making sense of the interactions between CFT’s components.

Researchers can work within ChatGPT's limits to accomplish their research goals. ChatGPT’s ability to logically synthesise knowledge may be used to test hypotheses or theories. In-depth and critical discussions with ChatGPT might spark new research ideas. ChatGPT is presently unable to produce an accurate and up-to-date research literature review on its own.

Despite the comprehensive analysis of ChatGPT, there may be limitations in this study. ChatGPT may respond differently to a topic depending on the questions posed. The questions need to be explicit enough for ChatGPT to respond appropriately. The user’s critical inputs may govern how well ChatGPT responds. Users may help ChatGPT synthesise information by contributing pertinent ideas.

The age of artificial intelligence has begun. More AI with capabilities equivalent to or superior to ChatGPT will soon be available. AI will be widely used in research, despite any concerns. In the right hands, ChatGPT can be a useful research tool. It helps boost productivity when producing quality research articles. ChatGPT, at its current stage, does not exempt researchers from the essential technical expertise, qualities, and professionalism. Conducting good research would still require integrity, critical thinking, creativity, rigour, and fact-finding.

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REFERENCES

[1] M. Dowling and B. Lucey, "ChatGPT for (Finance) research: The Bananarama Conjecture," Finance Research Letters, p. 103662, 2023.

[2] S. Teo, "ChatGPT: The end of online exam integrity?," arXiv:2212.09292v1, 2022.

[3] W. Jiao, W. Wang, J.-t. Huang, X. Wang, and Z. Tu, "Is ChatGPT a good translator? A preliminary study," arXiv:2301.08745v2, 2023.

[4] K. Lehnert, "AI insights into theoretical physics and the Swampland Program: A journey through the cosmos with ChatGPT," arXiv:2301.08155v1 2023.

[5] M. Hutson, "Could AI help you to write your next paper? ," Nature, vol. 611, pp. 192-193, 2022.

[6] C. Stokel-Walker, "ChatGPT listed as author on research papers: many scientists disapprove," Nature, 2023.

[7] C. A. Gao, F. M. Howard, N. S. Markov, E. C. Dyer, S. Ramesh, Y. Luo, et al., "Comparing scientific abstracts generated by ChatGPT to original abstracts using an artificial intelligence output detector, plagiarism detector, and blinded human reviewers," bioRxiv, 2022.

[8] A. Gilson, C. Safranek, T. Huang, V. Socrates, L. Chi, R. A. Taylor, et al., "How does ChatGPT perform on the medical licensing exams? The implications of large language models for medical education and knowledge assessment," medRxiv, 2022.

[9] T. H. Kung, M. Cheatham, ChatGPT, A. Medenilla, C. Sillos, L. D. Leon, et al., " Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using Large Language Models" medRxiv, 2022.

[10] A. A. Azeez, N. Jamaluddin, N. A. Rahman, D. R. Hassen, and A. N. Attiyah, "Experimental and analytical study of PVC confined concrete cylinders,"

Journal of Engineering and Applied Sciences, vol. 13, pp. 2145 - 2151, 2018.

[11] M. Abramski, P. Korzeniowski, and K. Klempka, "Experimental studies of concrete-filled composite tubes under axial short- and long-term loads," Materials, vol. 13, p. 2080, 2020.

[12] F. Abed, M. AlHamaydeh, and S. Abdalla, "Experimental and numerical investigations of the compressive behavior of concrete filled steel tubes (CFSTs)," Journal of Constructional Steel Research, vol. 80, pp. 429-439, 2013.

[13] R. Chacón, "Circular concrete-filled tubular columns: State of the art oriented to the vulnerability assessment," The Open Civil Engineering Journal, vol. 9, pp. 249-259, 2015.

[14] X.-L. Zhao and L.-H. Han, "Double skin composite construction," Progress in Structural Engineering and Materials, vol. 8, pp. 93-102, 2006.

[15] P. K. Gupta, "Confinement of concrete columns with unplasticized Poly-vinyl chloride tubes," International Journal of Advanced Structural Engineering, vol. 5, p. 19, 2013.

[16] S. Hong and A. H. Varma, "Analytical modeling of the standard fire behavior of loaded CFT columns," Journal of Constructional Steel Research, vol. 65, pp. 54-69, 2009.

[17] M. Fakharifar and G. Chen, "FRP-confined concrete filled PVC tubes: A new design concept for ductile column construction in seismic regions," Construction and Building Materials, vol. 130, pp. 1-10, 2017.

[18] Y. L. Li, X. L. Zhao, R. K. R. Singh, and S. Al-Saadi, "Experimental study on seawater and sea sand concrete filled GFRP and stainless steel tubular stub columns," Thin-Walled Structures, vol. 106, pp. 390-406, 2016.

[19] H. Toutanji and M. Saafi, "Durability studies on concrete columns encased in PVC–FRP composite tubes," Composite Structures, vol. 54, pp. 27-35, 2001.

[20] Z. Chen, W. Xu, and J. Zhou, "Mechanical performance of marine concrete filled CFRP-aluminum alloy tube columns under axial compression: Experiment and finite element analysis," Engineering Structures, vol. 272, p. 114993, 2022.

[21] S. Fayed and W. Mansour, "Structural performance of seasand recycled aggregate concrete filled Solid/Hollow aluminum tubular Columns: An experimental work," Structures, vol. 47, pp. 1323-1340, 2023.

[22] M. Marzouck and K. Sennah, "Concrete-filled PVC tubes as compression members," in Composite Materials in Concrete Construction, pp. 31-37, 2002.

[23] R. Khapre and K. Gonnade, "Experimental and computational study on concrete filled PVC plastic tubes placed in columns," Helix, vol. 10, pp. 165-169, 2020.

[24] R. Sasikanth and M. Soundar Rajan, "Experimental investigation of concrete filled PVC tube columns confined by plain PVC socket," IT in Industry, vol. 9, pp. 217-222, 2021.

[25] M. Bazli, Y.-L. Li, X.-L. Zhao, R. K. S. Raman, Y. Bai, S. Al-Saadi, et al., "Durability of seawater and sea sand concrete filled filament wound FRP tubes under seawater environments," Composites Part B: Engineering, vol. 202, p. 108409, 2020.

[26] J. M. Portolés, E. Serra, and M. L. Romero, "Influence of ultra-high strength infill in slender concrete-filled steel tubular columns," Journal of Constructional Steel Research, vol. 86, pp. 107-114, 2013.

[27] F. Alatshan, S. A. Osman, R. Hamid, and F. Mashiri, "Stiffened concrete-filled steel tubes: A systematic review," Thin-Walled Structures, vol. 148, p. 106590, 2020.

[28] L. Na, L. Yiyan, L. Shan, and L. Lan, "Slenderness effects on concrete-filled steel tube columns confined with CFRP," Journal of Constructional Steel Research, vol. 143, pp. 110-118, 2018.

[29] Z. Dong, T. Han, B. Zhang, H. Zhu, G. Wu, Y. Wei, et al., "A review of the research and application progress of new types of concrete-filled FRP tubular members," Construction and Building Materials, vol. 312, p. 125353, 2021.

[30] P. Feng, Z. Li, Y. Zou, and J.-Q. Yang, "Axial compressive performance of concrete-filled steel tube stub columns with high-strength spiral confined concrete core," Thin-Walled Structures, vol. 185, p. 110534, 2023.

[31] V. V. Cao, Q. D. Le, and P. T. Nguyen, "Experimental behaviour of concrete-filled steel tubes under cyclic axial compression," Advances in Structural Engineering, vol. 23, pp. 74-88, 2020.

[32] A. M. Woldemariam, W. O. Oyawa, and T. Nyomboi, "Structural Performance of uPVC Confined Concrete Equivalent Cylinders Under Axial Compression Loads," Buildings, vol. 9, p. 82, 2019.

[33] N. A. Abdulla, "A strain model for uPVC tube-confined concrete," Cogent Engineering, vol. 8, 2021.

[34] J.-Y. Wang and Q.-B. Yang, "Investigation on compressive behaviors of thermoplastic pipe confined concrete," Construction and Building Materials, vol. 35, pp. 578-585, 2012.

[35] J. Wang and Q. Yang, "Experimental study on mechanical properties of concrete confined with plastic pipe," ACI Materials Journal, vol. 107, pp. 132-137, 2010.

[36] X. Zhang, W. Kong, Y. Zhu, and Y. Chen, "Investigation on various section GFRP profile strengthening concrete-filled GFRP tubular columns," Composite Structures, vol. 283, p. 115055, 2022.

[37] Q. Chang, C. Zhao, L. Xing, W. Ahmad, M. F. Javed, F. Aslam, et al., "Concrete filled double steel tube columns incorporating UPVC pipes under uniaxial

compressive load at ambient and elevated temperature," Case Studies in Construction Materials, vol. 16, p. e00907, 2022.

[38] Wikipedia. Robert Maillart. Available: https://en.wikipedia.org/wiki/Robert_Maillart. [Accessed Feb. 15, 2023]

[39] Toureiffel Paris. 15 essential things to know about the Eiffel Tower. Available: https://www.toureiffel.paris/en/news/history-and-culture/15-essential-things-know-about-eiffel-tower#:~:text=The%20Eiffel%20Tower%20is%20made,in%20Levallois%20Perret%20using%20rivets. [Accessed Feb. 15, 2023]

[40] Y. Du, D. Gao, Z. Chen, X.-f. Deng, and K. Qian, "Experimental study on the flexural behavior of square high-strength concrete-filled steel tube beams with different CFRP wrapping schemes," Composite Structures, vol. 304, p. 116325, 2023.

[41] M. Gorji Azandariani, T. Ghanbari-Ghazijahani, A. Mohebkhah, and M. Classen, "Concrete- and timber-filled tubes under axial compression – Numerical and theoretical study," Journal of Building Engineering, vol. 44, p. 103231, 2021.

[42] T. Ghanbari-Ghazijahani, G. A. Magsi, D. Gu, A. Nabati, and C.-T. Ng, "Double-skin concrete-timber-filled steel columns under compression," Engineering Structures, vol. 200, p. 109537, 2019.

[43] A. Nabati, T. Ghanbari-Ghazijahani, and C.-T. Ng, "CFRP-reinforced concrete-filled steel tubes with timber core under axial loading," Composite Structures, vol. 217, pp. 37-49, 2019.

[44] Y. Huang, J. Wang, Q. a. Wei, H. Shang, and X. Liu, "Creep behaviour of ultra-high-performance concrete (UHPC): A review," Journal of Building Engineering, p. 106187, 2023.

[45] Z. Tao, T.-Y. Song, B. Uy, and L.-H. Han, "Bond behavior in concrete-filled steel tubes," Journal of Constructional Steel Research, vol. 120, pp. 81-93, 2016.

[46] L.-H. Han, C.-Y. Xu, and Z. Tao, "Performance of concrete filled stainless steel tubular (CFSST) columns and joints: Summary of recent research," Journal of Constructional Steel Research, vol. 152, pp. 117-131, 2019.

[47] M. N. Baig, J. Fan, and J. Nie, "Strength of concrete filled steel tubular columns," Tsinghua Science & Technology, vol. 11, pp. 657-666, 2006.

[48] M. F. Javed, H. Rafiq, M. A. Khan, F. Aslam, M. A. Musarat, and N. I. Vatin, "Axial behavior of concrete-filled double-skin tubular stub columns incorporating PVC pipes," Crystals, vol. 11, p. 1434, 2021.

[49] M. Abramski, "Load-carrying capacity of axially loaded concrete-filled steel tubular columns made of thin tubes," Archives of Civil and Mechanical Engineering, vol. 18, pp. 902-913, 2018.

[50] P. K. Gupta and V. K. Verma, "Study of concrete-filled unplasticized poly-vinyl chloride tubes in marine environment," Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, vol. 230, pp. 229-240, 2016.

[51] Y. L. Li, X. L. Zhao, R. K. Singh Raman, and X. Yu, "Axial compression tests on seawater and sea sand concrete-filled double-skin stainless steel circular tubes," Engineering Structures, vol. 176, pp. 426-438, 2018.

[52] W. Wang, H. Ma, Z. Li, and Z. Tang, "Size effect in circular concrete-filled steel tubes with different diameter-to-thickness ratios under axial compression," Engineering Structures, vol. 151, pp. 554-567, 2017.

[53] Y. L. Li, X. L. Zhao, R. K. Raman Singh, and S. Al-Saadi, "Tests on seawater and sea sand concrete-filled CFRP, BFRP and stainless steel tubular stub columns," Thin-Walled Structures, vol. 108, pp. 163-184, 2016.

[54] P. Ayough, N. H. R. Sulong, and Z. Ibrahim, "Analysis and review of concrete-filled double skin steel tubes under compression," Thin-Walled Structures, vol. 148, p. 106495, 2020.

[55] B. Evirgen, A. Tuncan, and K. Taskin, "Structural behavior of concrete filled steel tubular sections (CFT/CFSt) under axial compression," Thin-Walled Structures, vol. 80, pp. 46-56, 2014.

[56] W. O. Oyawa, N. K. Gathimba, and G. N. Mang'uriu, "Innovative composite concrete filled plastic tubes in compression," presented at the The 2015 World Congress on Advances in Structural Engineering and Mechanics (ASEM 15), Incheon, Korea, 2015.

[57] A. L. Krishan, V. I. Rimshin, and E. A. Troshkina, "Deformability of volume-compressed concrete core of concrete filled steel tube columns," IOP Conference Series: Materials Science and Engineering, vol. 753, p. 022053, 2020.

[58] A. M. Woldemariam, W. O. Oyawa, and T. Nyomboi, "The behavior of concrete-filled single and double-skin uPVC tubular columns under axial compression loads," The Open Construction and Building Technology Journal, vol. 13, pp. 164-177, 2019.

[59] M. Osman and A. E.-k. S. Soliman, "Behavior of confined columns under different techniques," World Academy of Science, Engineering and Technology, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering, vol. 9, pp. 70-78, 2015.

[60] L. He, S. Lin, and H. Jiang, "Confinement effect of concrete-filled steel tube columns with infill concrete of different strength grades," Frontiers in Materials, vol. 6, 2019-April-18 2019.

[61] F. Yuan, M. Chen, H. Huang, L. Xie, and C. Wang, "Circular concrete filled steel tubular (CFST) columns under cyclic load and acid rain attack: Test

simulation," Thin-Walled Structures, vol. 122, pp. 90-101, 2018.

[62] S. Han, Y. Chen, and W. Xie, "Behaviour of square hollow steel tubular (SHST) stub columns after elevated temperature," Journal of Constructional Steel Research, vol. 136, pp. 177-192, 2017.

[63] Z.-B. Wang, Z. Tao, L.-H. Han, B. Uy, D. Lam, and W.-H. Kang, "Strength, stiffness and ductility of concrete-filled steel columns under axial compression," Engineering Structures, vol. 135, pp. 209-221, 2017.

[64] Q.-L. Wang, Z. Zhao, Y.-B. Shao, and Q.-L. Li, "Static behavior of axially compressed square concrete filled CFRP-steel tubular (S-CF-CFRP-ST) columns with moderate slenderness," Thin-Walled Structures, vol. 110, pp. 106-122, 2017.

[65] A. M. Woldemariam, W. O. Oyawa, and T. Nyomboi, "Experimental studies on the behavior of concrete-filled uPVC tubular columns under axial compression loads," Cogent Engineering, vol. 7, p. 1768649, 2020.

[66] N. Jamaluddin, A. A. Azeez, N. Abd Rahman, A. N. Attiyah, M. H. Wan Ibrahim, N. Mohamad, et al., "Experimental investigation of concrete filled PVC tube columns confined by plain PVC socket," MATEC Web Conf., vol. 103, p. 02006, 2017.

[67] N. Abduljabar Abdulla, "Strength models for uPVC-confined concrete," Construction and Building Materials, vol. 310, p. 125070, 2021.

[68] A. E. Kurtoglu, A. K. Hussein, M. E. Gulsan, M. F. Altan, and A. Cevik, "Mechanical investigation and durability of HDPE-confined SCC columns exposed to severe environment," KSCE Journal of Civil Engineering, vol. 22, pp. 5046-5057, 2018.

[69] Y.-c. Guo, P.-y. Huang, Y. Yang, and L.-j. Li, "Experimental studies on axially loaded concrete columns confined by different materials," Key Engineering Materials, vol. 400-402, pp. 513-518, 2009.

[70] M. Fakharifar and G. Chen, "Compressive behavior of FRP-confined concrete-filled PVC tubular columns," Composite Structures, vol. 141, pp. 91-109, 2016.

[71] S. Mohammad Askari, A. Khaloo, M. H. Borhani, and M. S. Tale Masoule, "Performance of polypropylene fiber reinforced concrete-filled UPVC tube columns under axial compression," Construction and Building Materials, vol. 231, p. 117049, 2020.

[72] A. E. Kurtoğlu, A. K. Hussein, M. E. Gülşan, and A. Çevik, "Flexural behavior of HDPE tubular beams filled with self-compacting geopolymer concrete," Thin-Walled Structures, vol. 167, p. 108096, 2021.

[73] T. Vincent and T. Ozbakkaloglu, "Influence of shrinkage on compressive behavior of concrete-filled FRP tubes: An experimental study on interface gap effect," Construction and Building Materials, vol. 75, pp. 144-156, 2015.

[74] T. Ozbakkaloglu and T. Xie, "Geopolymer concrete-filled FRP tubes: Behavior of circular and square columns under axial compression," Composites Part B: Engineering, vol. 96, pp. 215-230, 2016.

[75] T. Ekmekyapar and B. J. M. Al-Eliwi, "Concrete filled double circular steel tube (CFDCST) stub columns," Engineering Structures, vol. 135, pp. 68-80, 2017.

[76] N. Subedi, S. Thusoo, T. Obara, S. Kono, O. Kaneko, T. Hayakawa, et al., "Flexural performance of cast-in-place concrete-filled steel tube piles under varying axial load," Thin-Walled Structures, vol. 174, p. 109130, 2022.

[77] Z. Chen, S. Pu, and H. Wang, "Numerical analysis on the bending capacity of the concrete-filled micro-steel-tube piles," Mathematical Problems in Engineering, vol. 2022, p. 2317594, 2022.

[78] Y. Dong, Z. Feng, H. Hu, J. He, Q. Zhang, and F. Wang, "The horizontal bearing capacity of composite concrete-filled steel tube piles," Advances in Civil Engineering, vol. 2020, p. 3241602, 2020.

[79] S. J. C. R. (SJR). Scimago Journal & Country Rank (SJR) https://www.scimagojr.com/.

[80] F. Antaki, S. Touma, D. Milad, J. El-Khoury, and R. Duval, "Evaluating the performance of ChatGPT in Ophthalmology: An analysis of its successes and shortcomings," medRxiv, 2023.

[81] Natalie. ChatGPT General FAQ: Commonly asked questions about ChatGPT. Available: https://help.openai.com/en/articles/6783457-chatgpt-general-faq. [Accessed Mar. 4, 2023]

[82] Ferdinand P. Beer, E. Russell Johnston Jr., John T. DeWolf, David F. Mazurek, Mechanics of Materials, 7th ed. New York: McGraw Hill, 2014.

[83] Timoshenko & J. N. Goodier, Theory of Elasticity, 3rd ed. New York: McGrew-Hill, 1970.

[84] L D Landau, L. P. Pitaevskii, A. M. Kosevich, E.M. Lifshitz, Theory of Elasticity: Volume 7 (Theoretical Physics), 3rd ed. New York: Butterworth-Heinemann, 1986.