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Digital Art Depicting the Assembly of Structural Components and Nodes in the Construction Industry Using Steel Pipe Foamed Concrete

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Abstract. Steel pipe and concrete structures are increasingly used in practical engineering applications, such as large span bridges and multi-storey buildings. Its advantages such as high bearing capacity and good seismic performance are particularly prominent in engineering applications. To this end, this paper refers to the beam section form and size of a frame structure example, and designs three different forms of beam sections, such as H-shaped steel beams, I-beams and rectangular steel beams combined into combined foamed concrete beams, and box section steel pipe foamed concrete beams, respectively, and uses finite element software to carry out force analysis on them and select reasonable member forms and section sizes. The results show that the infill of foamed concrete can increase the stiffness of the compressed flange of the steel tube beam, which can make the beam more uniformly stressed, and does not have much effect on improving the shear strength and maximum deflection of the beam.

Keywords: assembled structures; steel pipe foamed concrete; axial compression; seismic performance; Digital Art Depicting; Construction Industry Using Steel Pipe
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1 INTRODUCTION

The assembled structure is a structure with prefabricated components as the main force-bearing elements connected by assembly, which can be divided into assembled concrete structure, assembled wood structure and assembled steel structure according to its constituent materials, and at present the most used in construction projects is assembled concrete structure, as shown in Figure 1. Its structure has the advantages of energy saving, environmental protection, saving formwork, etc. At the same time, the assembled concrete structure also has many disadvantages, such as self-reliance, transportation, stacking difficulties, difficult to control the seepage of joints, poor seismic performance, poor ductility, etc. [17].

Figure 1: Assembled concrete structure.

An assembled steel structure is an assembled structure made up of steel structural elements, as shown in Figure 2. Its structure has the advantages of high strength, low self-weight, large use span, good wind resistance and seismic performance. The assembled steel structure is mainly welded and bolted as the node connection of the beam and column, so its construction efficiency and quality are relatively high, and green, economic results are also relatively good [11]. However, because steel structures are heat-resistant but not fire-resistant, the load-bearing capacity of steel in case of fire will drop rapidly, resulting in the loss of load-bearing capacity of the members and causing the sudden collapse of the whole structure, which is very harmful and requires long-term coating of fire-resistant materials on the surface [21]. At the same time, steel is susceptible to corrosion, the surface also needs to be coated with anti-corrosion materials to reduce or avoid corrosion and improve the durability of the structure, and the maintenance costs invested are relatively high.

Figure 2: Assembled steel structure.

There are many advantages of assembled timber systems, such as better seismic performance, easy access to materials, environmental protection, fast construction, etc. [26]. [16] designed a 6-storey assembled orthotropic glued timber dormitory building and analyzed its static and dynamic properties using ABAQUS finite element analysis software. The results show that the assembled timber frame buildings have good bearing performance under vertical loads, a large safety reserve for load bearing capacity under small earthquakes and small inter-storey shear deformation.

However, the disadvantages of assembled timber structures are also more numerous, such as not being fire resistant, being prone to decay and having a short supply of available timber, etc. (see Figure 3)

Figure 3: Assembled timber frame.

Whether it is an assembled concrete structure or an assembled steel structure or a wooden structure, it is a structure with a relatively single building material, where the advantages of the material cannot be more excellent and the disadvantages are not compensated for, while the emergence of the assembled structure enables the advantages of the material to be more significant and the disadvantages to be compensated for [3].

Combined structures are structures in which the elements are made of a combination of materials. They are generally divided into steel and concrete composite structures and composite masonry structures. The most researched and widely used structure is the combination of steel and concrete. The combined structure of steel and concrete is a combination of steel sections welded (or cold pressed) with sections or steel plates, and then concrete poured around or inside them, so that the concrete and the sections form an integral and jointly stressed structure [18].

Commonly used at home and abroad, the combination of steel and concrete structure are: (1) compression steel plate and concrete combination floor slab; (2) steel and concrete combination beam; (3) steel and concrete structure (also called strong concrete structure); (4) steel pipe concrete structure; (5) external steel concrete structure and other five categories. Steel pipe concrete structure under the action of axial pressure, the inner filling concrete is restrained by the outer clad steel pipe, so that the core concrete is in a three-way pressure state, the compressive strength is substantially increased, so the steel pipe concrete is widely used in high pressure members [4]. The outer clad steel structure was first studied and most widely used in the former Soviet Union, and in recent years China has promoted the use of this structure mainly in power plant buildings, achieving a lot of engineering experience and economic benefits.

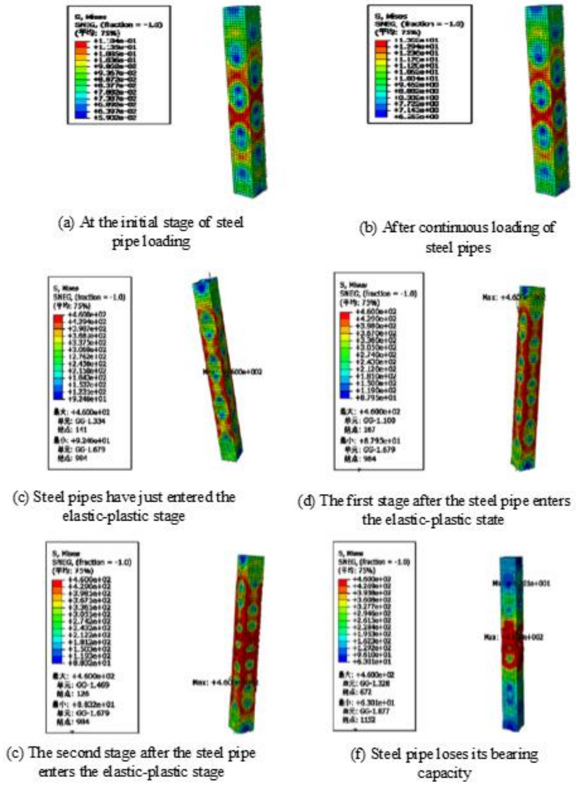
The assembled steel pipe and concrete structure is a combination of steel pipe and concrete. Concrete has high compressive strength but weak tensile strength, while steel has strong compressive and tensile strength and has good elasticity [15]. However, steel pipes are prone to buckling and loss of load-bearing capacity when subjected to pressure, and the combination of steel pipes and concrete can combine the advantages of both in the structure, which can make the concrete in a three-way pressure state, and its compressive strength is greatly increased. At the same time, due to the presence of concrete filling, improve the axial compression stiffness of the steel pipe, the two together, and thus greatly improve the load-bearing capacity of the components, compared with the traditional assembled concrete structure, assembled steel pipe concrete structure can greatly improve the effective use of the building area, and easy construction, the same load-bearing capacity conditions, assembled steel pipe concrete structure better economic efficiency, in the event of fire, due to the presence of concrete filling, absorbing most of the heat, compared to the steel structure better fire resistance performance [23]. Steel pipe concrete is widely used in high rise, super high rise, plant and large span bridges. However, again, the high cost of steel and the self-reliance of concrete make transport and construction difficult.

The above-mentioned steel pipe concrete is replaced with foamed concrete to form an assembled steel pipe foamed concrete structure. In the steel pipe foamed concrete element, the filled foamed concrete is bound by the outer clad steel pipe and the steel pipe and foamed concrete work together [9]. By comparing the stressing properties of steel pipe concrete, it is found that steel pipe foam concrete is restrained by the hoop of the steel pipe on the core foam concrete, which puts the core foam concrete in a three-way compressed state and delays the occurrence and development of its longitudinal micro-cracks, thus giving the core foam concrete a higher compressive strength and compression deformation capacity, while the inner filling foam concrete supports the outer steel pipe and enhances the geometric stability of the steel pipe wall, so that the outer steel pipe does not buckle prematurely, and thus its load-bearing capacity is enhanced [1].

2 ANALYSIS OF COMPRESSIVE STRESSES IN THE AXIS OF SQUARE STEEL TUBE FOAMED CONCRETE COLUMNS

This paper compares the axial compressive stress distribution in a hollow steel tube column not filled with foamed concrete with that in a square steel tube foamed concrete column filled with foamed concrete. However, because the stress changes in the hollow steel tube column and the square steel tube foamed concrete column are not obvious in the elastic phase, the difference in stress changes in the outer steel tube before and after filling with foamed concrete cannot be clearly seen, so the stress changes in the force process of the member are chosen just after entering the elastic-plastic phase to the loss of load-bearing capacity.

Square hollow steel tube column just began to load, the steel tube wall around a small deformation between concave and convex, the occurrence of concave deformation of the tube wall under tensile stress, the occurrence of convex deformation of the tube wall under compressive stress, the middle region of the tube wall stress and deformation value is the largest, and in turn a step to the ends of the tube wall decreasing [25]. As the load continues to increase, the stress-strain distribution does not change much, when the load is applied to 2628.24KN, the steel tube enters the elastic-plastic state, the stress-strain distribution is basically the same as the elastic stage, but the stress-strain value in the middle region of the tube wall increases sharply, when the load is applied to 2849.73KN, the steel in the middle region of the tube wall yields, the square hollow steel tube column loses its bearing capacity, and the damage is in the middle of the column The damage was caused by concave and convex bulging damage, without shear damage, the specific changes are shown in Figure 4 below.



(a) At the initial stage of steel pipe loading

(b) After continuous loading of steel pipes

(c) Steel pipes have just entered the elastic-plastic stage

(d) The first stage after the steel pipe enters the elastic-plastic state

(c) The second stage after the steel pipe enters the elastic-plastic stage

(f) Steel pipe loses its bearing capacity

Figure 4: The process of analyzing a square hollow steel tube column under axial pressure.

The stress-strain distribution at the beginning of a square steel pipe column is similar to that of a square hollow steel pipe column, except that the stress-strain values at the wall of a square steel pipe column are lower than those of a square hollow steel pipe column, especially at the depressions in the wall of the steel pipe, where the stress-strain values are smaller due to the supporting effect of the filled foam concrete [27]. The Poisson's ratio of steel is greater than that of foamed concrete, making the transverse deformation of steel greater than that of foamed concrete, and steel and foamed concrete share axial pressure, with no extrusion occurring between the two [22]. But because the modulus of elasticity of foamed concrete is only 1/200 of the steel pipe, making the axial compression stiffness of steel pipe is much greater than that of foamed concrete, steel pipe to bear the main axial pressure. Load applied to 4199.14KN, square steel pipe foam concrete column into the elastic-plastic state, when the square steel pipe foam concrete just into the elastic-plastic state, steel pipe stress distribution from the ends of the height of the column to the middle, is wavy distribution, the stress value of the middle part of the height of the column is the largest, the two ends of the smallest [10]. As the load increases, the supporting effect of the foamed concrete combined with the thin walls of the steel tubes causes the stresses to start spreading in the middle of the column height towards the ends.

When the load is applied to 5256.15KN, the steel tubes at both ends of the column height yield and bulge damage occurs. During the axial compression of the square steel tube foamed concrete column, the axial pressure on the foamed concrete is small. In the elastic phase, the foamed concrete mainly plays a supporting role for the steel tube wall, increasing the longitudinal compressive stiffness of the steel tube, making it less prone to instability [5].

When the square steel pipe foam concrete column into the elastic-plastic state, as the load continues to increase, the modulus of the steel pipe began to reduce, the force between the steel pipe and the foam concrete began to redistribute, the longitudinal pressure assumed by the foam concrete began to increase, the transverse deformation of the foam concrete more than the transverse deformation of the steel pipe, the foam concrete by the ring and radial pressure of the steel pipe, plus the longitudinal pressure itself, so that the foam concrete in a three-way pressure state, greatly increasing the compressive strength of the foam concrete, foam concrete can change the longitudinal pressure stiffness of the steel pipe for a long time. With the further increase of the load, the steel pipe yielded and lost the bearing capacity, the axial pressure on the foamed concrete increased sharply, due to the low compressive strength of the foamed concrete, making the foamed concrete and steel pipe almost at the same time to lose the bearing capacity, so in the elastic-plastic stage, the plastic strain of the foamed concrete is basically similar to that of the steel pipe, the specific changes are shown in Figure 5.

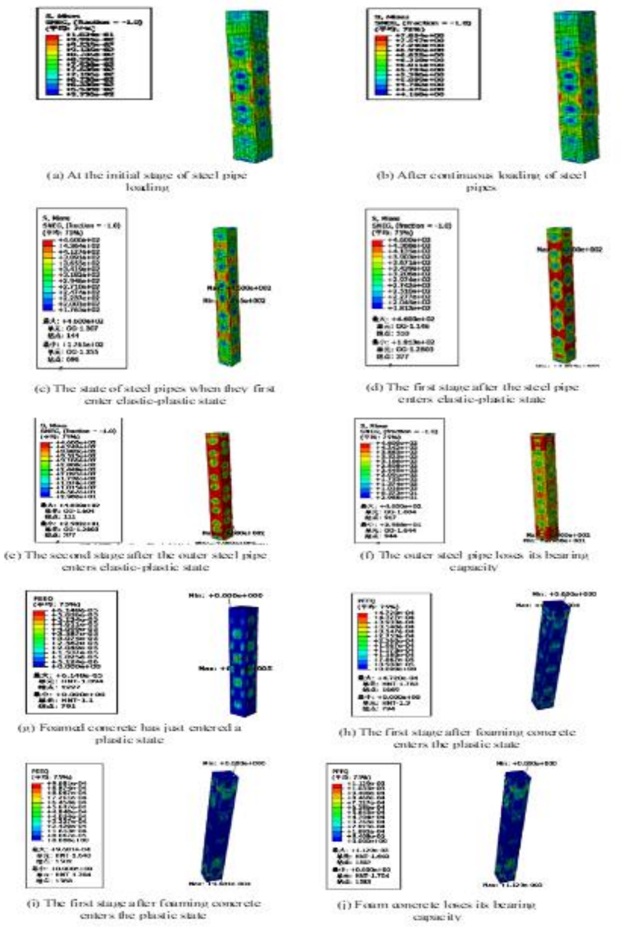


Figure 5: Analysis process of axial compression of square steel tube foam concrete columns.

Comparing the stress analysis of square hollow steel tube column and square steel tube foam concrete column under axial compression, we can find that the square steel tube is prone to buckling instability damage due to its thin wall, while the filling of foam concrete increases the longitudinal compressive stiffness of the steel tube and improves the buckling performance of the steel tube wall, which makes the overall instability damage of the hollow steel tube column change into local instability damage and increases the safety factor of the component. At the same time, the ultimate load capacity of the columns was increased by 84.5% before and after filling with foamed concrete, which greatly reduced the cost of the project while meeting the load capacity [2].

3 ANALYSIS OF COMPRESSIVE STRESSES IN THE AXIAL CENTRE OF A SQUARE-OVER-ROUND HOLLOW DOUBLE-LAYERED STEEL PIPE FOAMED CONCRETE COLUMN

As with the above-mentioned types of steel pipe concrete columns, the stresses in this section are shown from the time the member first enters the elastic-plastic phase to the time it loses its load-bearing capacity.

At the beginning of the loading of the square hollow double hollow steel tube column, the change of stress-strain of the outer steel tube is the same as that of the square hollow steel tube column, which is distributed concave and convex. The change in stress-strain value of the inner steel tube is distributed as large at the ends of the column height and small in the middle, with uniform stress-strain distribution in the middle [13]. When the load is applied to 2637.28KN, the outer steel tube enters the elastic-plastic state, the stress distribution of the outer steel tube changes to a wavy distribution in the four rhombic corners of the column height, in which the middle rhombic corner of the column height has the largest stress value, the two ends have the smallest stress value, the rest of the region are relatively small [12].

The stress distribution of the inner steel tube is the largest at both ends of the column height and the smallest in the middle, where the stress value at the lower end of the column height is the largest, but at this time the stress value of the inner steel tube does not reach the bending strength of the steel tube.

When the load reaches 2760.14KN, the stress distribution of the outer steel tube is developed from the diamond-shaped area on the four sides of the column height to the middle, the inner steel tube enters the elastic-plastic state, the stress distribution on the wall of the inner steel tube is more uniform, and the maximum stress value is constantly transformed at the two ends of the column height [19]. When the load reaches 2848.86KN, the square over round hollow double hollow steel tube column reaches the ultimate bearing capacity, the outer steel tube column in the middle of the height bulge damage, the inner steel tube column in the height of the two ends of the local instability damage.

At the beginning of the loading of a square-over-round hollow double-layered concrete column with foamed steel tubes, the stresses in the outer steel tubes are distributed in the four angles of the middle region of the column height, when the outer steel tubes are in a three-way stress state of radial and longitudinal compression and circumferential tension. The stress of the inner steel tube is uniformly distributed on the surface of the steel tube, where the stress at the upper and lower ends of the column height is relatively large, when the inner steel tube is in radial and longitudinal compression and circumferential tension, the foamed concrete has a circumferential compressive stress on the inner steel tube, which is subject to a variety of stresses [20].

The stress distribution of the inner and commitment of the foamed concrete is similar to that of the inner and outer steel tubes, at which time the foamed concrete is in a state of longitudinal, radial and circumferential three-way compressive stress. When the load is applied to 2717.08KN, the outer steel tube enters the elastic-plastic state, and the stress-strain of the outer steel tube changes to a wavy distribution in the height region of the column, with the maximum stress value at the surrounding corners [7]. The stress distribution of the inner steel tube was more uniform and did not reach the flexural strength of the steel tube. The equivalent plastic strain value of the foamed concrete was small and the distribution area was relatively small.

With the increase of external load to 4346.99KN, the square-over-round hollow double-layer steel pipe foam concrete column loses its load-bearing capacity, at this time the stress distribution range of the outer steel pipe is gradually increasing, the stress value in the middle region of the column height is the largest, and the stress value distribution is relatively uniform, and finally the middle region of the height of the outer steel pipe column is locally destabilized [8]. The stress distribution in the inner steel tube is still relatively homogeneous, with stress values increasing to some extent but not exceeding the flexural strength of the tube. The equivalent stress distribution in foamed concrete is similar to the stress distribution in the outer steel tube.

Compared with the filling of foamed concrete before and after the internal and external steel pipe and foamed concrete stress change state, it can be seen that after filling the foamed concrete, the inner steel pipe increased the axial compressive stiffness of the foamed concrete, so that the outer steel pipe bending resistance is greatly improved, the outer steel pipe and the action of the foamed concrete longer, according to the principle of stiffness distribution, the axial compressive stiffness of the outer steel pipe is greater than the axial compressive stiffness of the inner steel pipe, so The outer steel tube distribution of axial force is larger, and foamed concrete improves the buckling performance of the outer steel tube, so that the outer steel tube will not be prematurely buckled, so that the outer steel tube first lost bearing capacity, the whole structure occurs relatively large deformation and local instability damage [14]. The specific stress changes are shown in Figure 6 and Figure 7.

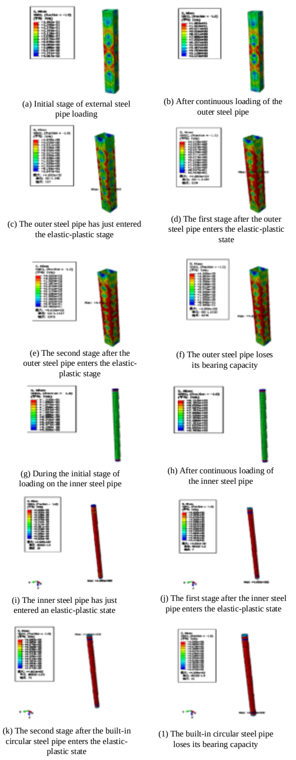


Figure 6: Analysis process of axial compression of square sleeve circular hollow steel pipe columns.

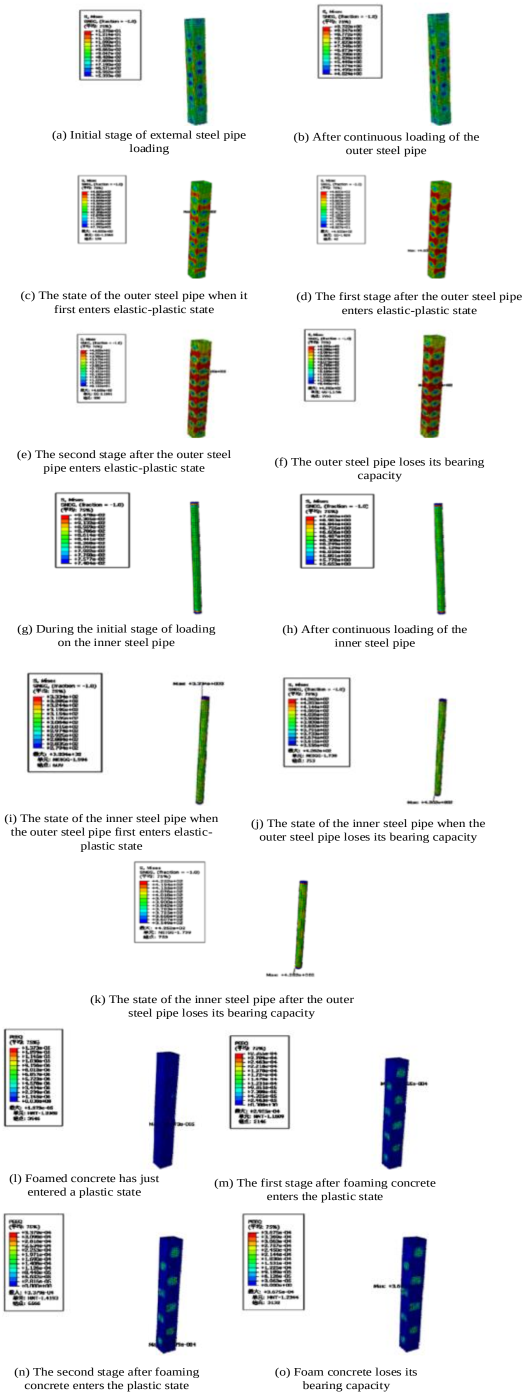


Figure 7: Analysis process diagram of axial compression of square sleeve circular hollow double-layer steel pipe foam concrete column.

4 ANALYSIS OF COMPRESSIVE STRESSES IN THE AXIS OF A CIRCULAR OVER CIRCULAR HOLLOW DOUBLE-LAYERED STEEL PIPE FOAMED CONCRETE COLUMN

The stress distribution of the outer steel tube is basically similar to that of the circular hollow double hollow steel tube column, but the stress values are relatively small, the stress values at the two ends of the height of the inner steel tube column are relatively large, and the stress distribution in the middle region is uniform. As the load increases, the stress change pattern of the outer steel tube is basically similar to that of a circular hollow steel tube column, the inner steel tube is affected by lateral bending and a large range of stresses are gathered in the middle and lower positions of the wall compression zone. When the load is added to 4086.25KN, the outer steel tube enters the elastic-plastic state, the stress distribution of the inner and outer steel tube is the same as the stress distribution of the elastic stage, but the inner steel tube does not enter the elastic-plastic state.

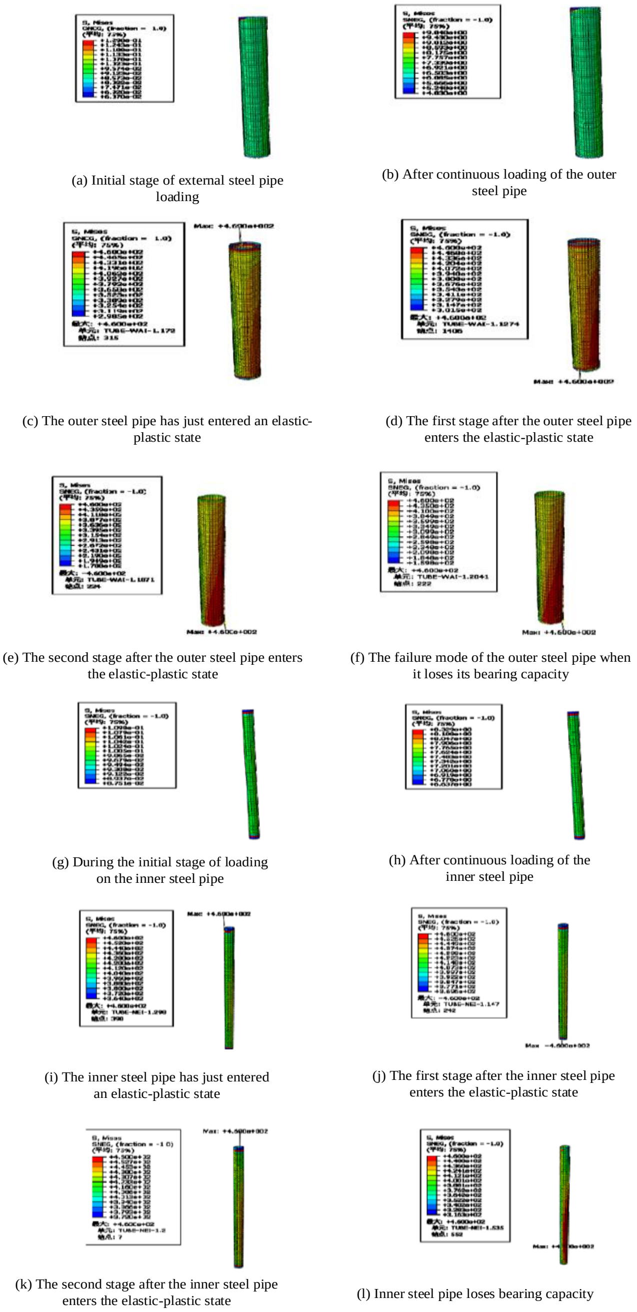
The stress distribution of the inner and outer steel tubes is similar to that of the square-over-circle hollow double-layer hollow steel tube column at the early stage of loading, and the stress value is relatively small. into the elastic-plastic state, the outer steel tube stress value distribution is more uniform, the maximum stress distribution in the upper end of the height of the column in the tensile zone, the inner steel tube stress distribution is similar to the outer steel tube, but the inner steel tube did not enter the elastic-plastic state, foam concrete equivalent plastic strain distribution in the lower end of the height of the column in the compression zone.

As the load increases, the stress value at the lower end of the column height in the compression zone of the outer steel tube increases and spreads to the upper end of the column height in the compression zone, and the spread area is relatively wide; the stress change of the inner steel tube is the same as that of the outer steel tube, and the equivalent plastic strain value of the foam concrete distribution at the lower end of the column height in the compression zone increases and spreads to the upper end, and the spread area is also relatively wide. When the load is applied to 4501.8KN, the inner steel tube enters the elastic-plastic state, the stress distribution of the inner and outer steel tubes and the plastic strain distribution of the foamed concrete are basically unchanged, and when the load is applied to 4669.8KN, the member reaches the ultimate bearing capacity and the overall instability damage occurs at the lower end of the height of the column in the compression zone.

Comparing the changes in the stress distribution of the inner and outer steel tubes and the plastic strain distribution of foamed concrete before and after filling with foamed concrete, it can be seen that the ductility of the round-over-round hollow double-layer steel tube foamed concrete column is effectively improved after the inner filling with foamed concrete, and the filling of foamed concrete can improve the flexural properties of the outer steel tube, but the improvement is relatively small, and the bearing capacity is improved by 8.75% before and after filling with foamed concrete. The specific stress distribution is shown in Figure 8 Figure 9 below.

5 ANALYSIS OF FACTORS INFLUENCING THE MECHANICAL PROPERTIES OF SQUARE STEEL TUBE FOAMED CONCRETE COLUMNS IN AXIAL COMPRESSION

In this paper, we consider the effect of width-thickness ratio (the ratio between the edge length of square steel tube and the wall thickness of steel tube), the strength of steel tube and the strength of foamed concrete on the axial compression mechanical performance of square steel tube foamed concrete column, and use the change of the load-bearing capacity enhancement rate to reflect the effect of the change of each factor on the axial compression performance of square steel tube foamed concrete column, the following will be the ultimate load-bearing capacity enhancement of square steel tube foamed concrete column compared with empty steel tube column is referred to as the load-bearing capacity enhancement rate. Also compared the variation of ultimate load carrying capacity when changing the strength of the steel tube for square hollow steel columns, and the variation of ultimate load carrying capacity when changing the strength of the steel tube for square steel foamed concrete columns, taking a column height of 3900mm as an example.



(a) Initial stage of external steel pipe loading

(b) After continuous loading of the outer steel pipe

(c) The outer steel pipe has just entered an elastic-plastic state

(d) The first stage after the outer steel pipe enters the elastic-plastic state

(e) The second stage after the outer steel pipe enters the elastic-plastic state

(f) The failure mode of the outer steel pipe when it loses its bearing capacity

(g) During the initial stage of loading on the inner steel pipe

(h) After continuous loading of the inner steel pipe

(i) The inner steel pipe has just entered an elastic-plastic state

(j) The first stage after the inner steel pipe enters the elastic-plastic state

(k) The second stage after the inner steel pipe enters the elastic-plastic state

(l) Inner steel pipe loses bearing capacity

Figure 8: Failure process of circular sleeve hollow steel pipe column under axial compression.

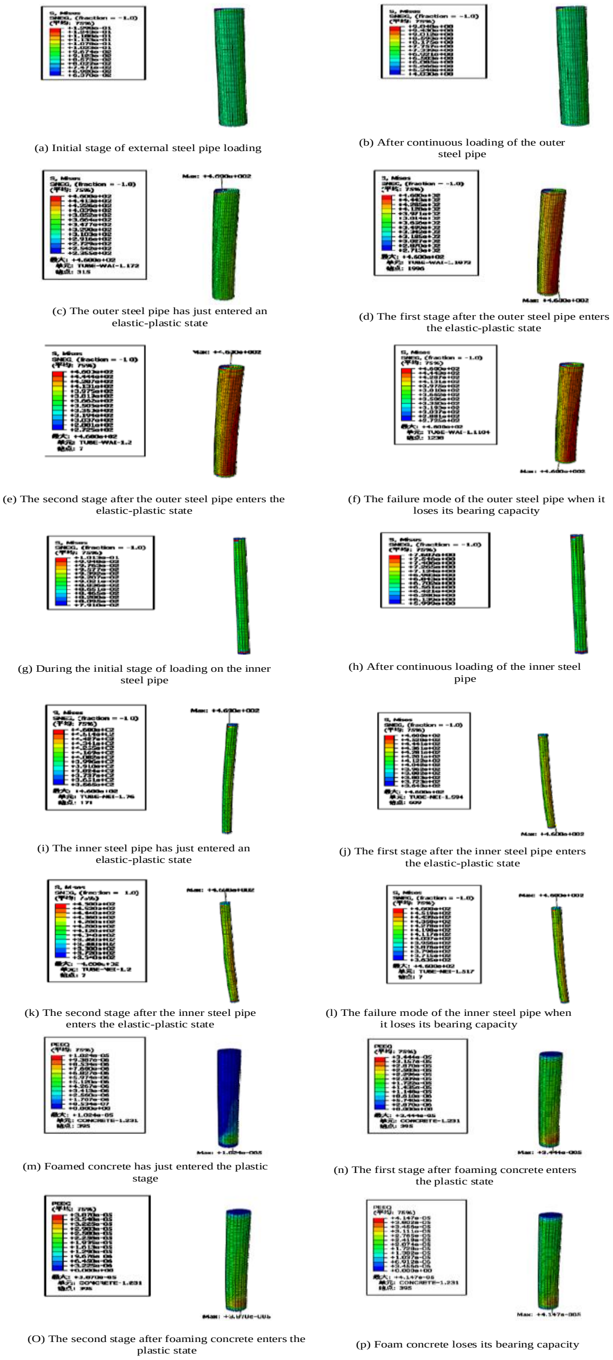
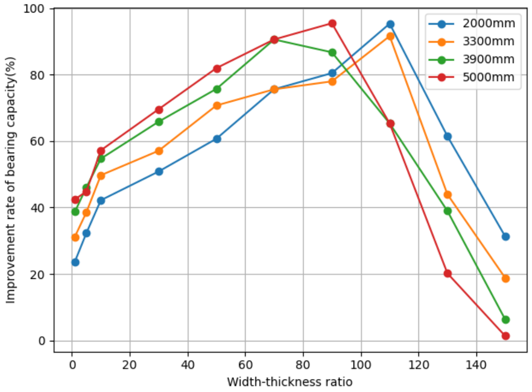
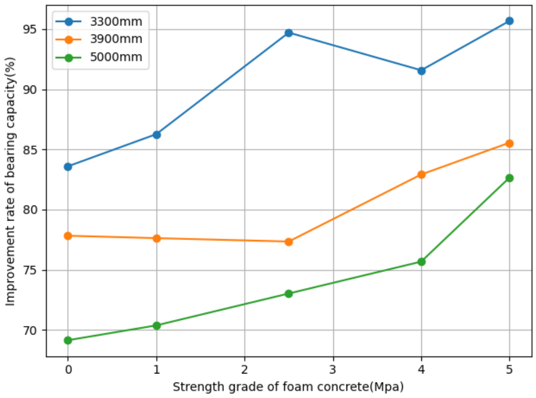


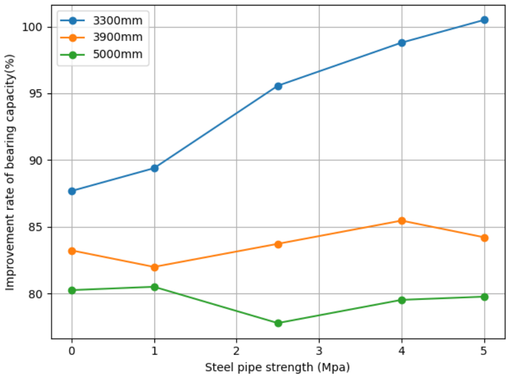
Figure 9: Axial compression damage process of a circular over circular hollow double-layered steel pipe foamed concrete column.



(a) Changing the aspect ratio



(b) Change the strength of foam concrete



(c) Change the strength of steel pipes

Figure 10: Effect of various factors on the mechanical properties of axial compression of steel pipe foamed concrete columns below different column heights.

As can be seen through Figure 10 above:

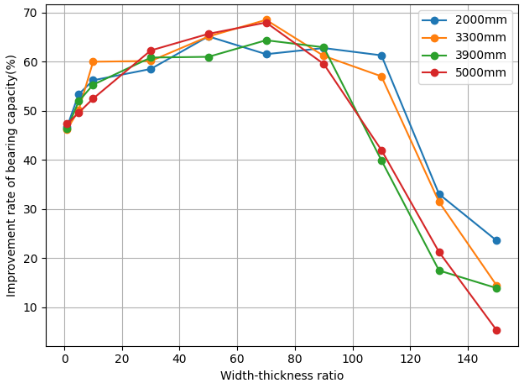
1. With the reduction of the width-thickness ratio, that is, the increase in the wall thickness of the outer square steel pipe, whether short, or long columns, square steel pipe foam concrete column axial compressive load-bearing rate are presented first increased after the trend of decreasing, the greater the width-thickness ratio, the thinner the wall of the steel pipe, the easier the steel pipe instability, and filling foam concrete can increase the stiffness of the wall of the steel pipe, so that the steel pipe is not easy to instability, but the strength of foam concrete is relatively low, for the thin wall of the steel pipe, and can not prevent its buckling instability. The smaller the width-thickness ratio, the thicker the wall of the steel pipe, the more stable the mechanical properties of the steel pipe, the less likely to overturn, but the square steel pipe itself is extremely unstable, so the wall is not very thick in the case of filling foam concrete can effectively prevent premature buckling of the steel pipe. Therefore, within the range of load-bearing capacity, square steel pipe foam concrete column axial compression of the best width-thickness ratio between 64.29-90, that is, the wall thickness of 5-7mm when the most suitable [24],[6].

2. With the increase in the strength of foamed concrete, whether short columns, or long columns, square steel pipe foamed concrete column axial compressive bearing capacity increase rate are showing an increasing trend, the higher the strength of foamed concrete, the greater its axial compressive stiffness, can bear the external load is also greater, the steel pipe bear the external load will be relatively reduced, so the higher the strength of foamed concrete, the greater its ultimate bearing capacity increase rate.

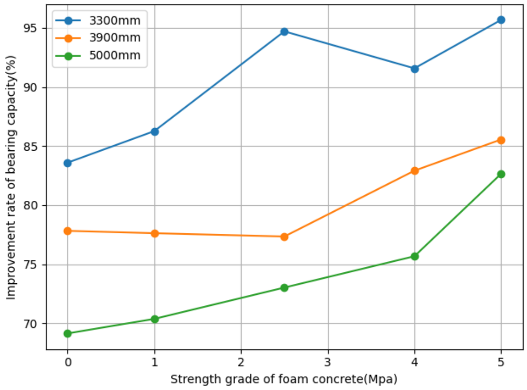
3. with the increase of steel tube strength, square steel tube foam concrete column bearing capacity increase rate also increased, thin-walled square steel tube is not stable, prone to buckling instability, filled with foam concrete makes the steel tube wall stiffness increased, and filled with foam concrete axial compressive stiffness is very low far less than the steel tube, so the external load is basically borne by the steel tube, when the steel tube strength increases, its load distribution ratio remains unchanged. Steel pipe still and foam concrete at the same time into the plastic, but the greater the strength of the steel pipe, the longer the interaction between the foam concrete and steel pipe, so its ultimate load-bearing capacity is greater, but its stability performance is not determined by the strength of the steel pipe, so the magnitude of the increase is not very obvious, the change is relatively small, but with the increase in column height, the more unstable the steel pipe, increase the strength of the steel pipe, foam concrete and steel pipe between The longer the action time, the greater the rate of increase of its ultimate bearing capacity.

6 ANALYSIS OF THE FACTORS INFLUENCING THE AXIAL COMPRESSION MECHANICAL PROPERTIES OF CONCRETE COLUMNS

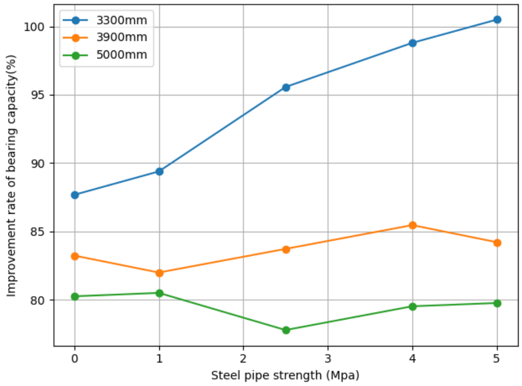
Considering the influence of width-thickness ratio (the ratio of outer steel tube edge length and outer steel tube wall thickness), steel tube strength and foamed concrete strength on the axial compression mechanical performance of square hollow double steel tube foamed concrete column, the change of bearing capacity enhancement rate is used to reflect the influence of the change of factors on the axial compression performance of square hollow double steel tube foamed concrete column, the following will square hollow double steel tube foamed concrete column compared with empty steel tube column The following will be the ultimate load bearing capacity compared to the empty steel column of the increase in the magnitude of the load bearing capacity is referred to as the rate of increase, the specific change law as shown in Figure 11.



(a) Changing the aspect ratio



(b) Change the strength of foam concrete



(c) Change the strength of steel pipes

Figure 11: Influence of various factors on the load carrying capacity improvement rate of hollow double-layered steel pipe foamed concrete columns with different column heights below the set circle.

As can be seen from Figure 11:

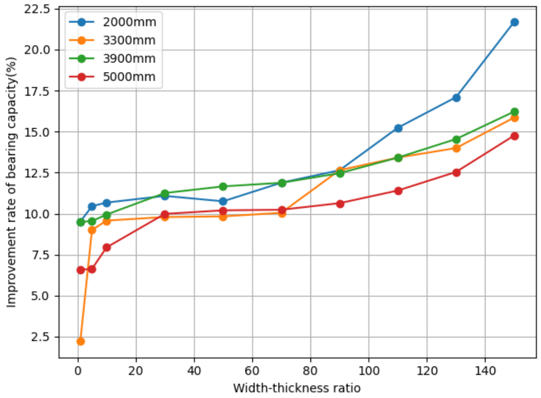
1. with the reduction of the width-thickness ratio, that is, the increase in the wall thickness of the outer square steel tube, whether short, or long columns, square-over-round hollow double-layered steel pipe foamed concrete column axial compression load lifting rate are presented first increased and then reduced trend. The reason for this is the same as the principle of square steel foamed concrete column, the difference is that the inner steel tube shares part of the external load, so that the outer steel tube is not prone to buckling instability, square hollow double steel foamed concrete column compared to square steel foamed concrete column of the ultimate bearing capacity of the rate of change is smaller. The optimum width-to-thickness ratio for a square-over-round hollow double-layered steel foamed concrete column in axial compression is between 64.29 and 90, i.e. a wall thickness of 5-7 mm is most suitable.

2. With the increase of the strength of the foamed concrete, the increase of the axial compression load-bearing capacity of the square-over-round hollow double-layered steel tube foamed concrete column shows an increasing trend, and the increase is relatively obvious. With the increase of the column height, the square set round hollow double-layer steel pipe foamed concrete column axial compression load lifting rate shows a trend of first increasing and then decreasing, combined with the test and finite element to prove that changing the strength grade of foamed concrete on the round set round hollow double-layer steel pipe foamed concrete column axial compression load lifting rate has a relatively large impact, and the square steel pipe is more unstable than the round steel pipe, the change of its load lifting rate is more obvious.

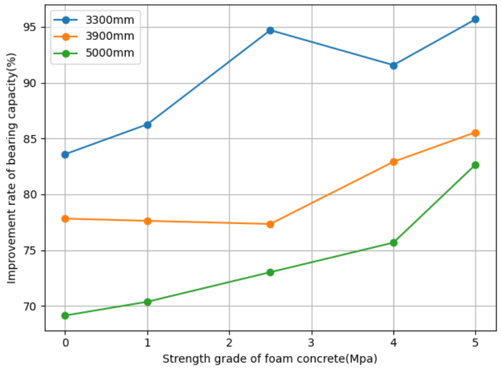
3. When the column height is relatively small, with the increase in steel tube strength, the load-bearing capacity of round steel pipe foam concrete column has a small change, when the column height is relatively large, with the increase in steel tube strength, the load-bearing capacity of round steel pipe foam concrete column presents a substantial decline. Therefore, in the range of bearing capacity allowed, it is appropriate to use low strength steel pipe. It also shows that as the strength of the steel pipe changes, the ultimate load capacity of the member has a small change in the rate of increase.

7 ANALYSIS OF THE FACTORS INFLUENCING THE AXIAL COMPRESSION MECHANICAL PROPERTIES OF ROUND-OVER-ROUND HOLLOW DOUBLE-LAYERED STEEL PIPE FOAMED CONCRETE COLUMNS

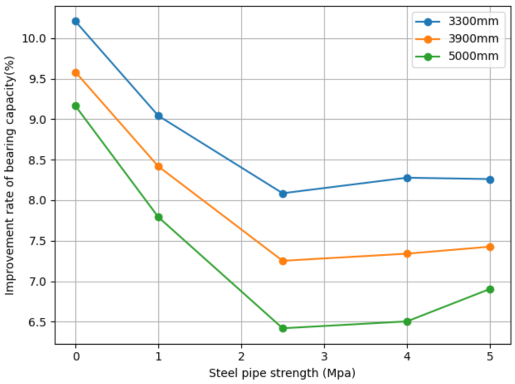
Consider the width-thickness ratio, steel tube strength, foamed concrete strength on round hollow double steel tube foamed concrete column axial compression mechanical properties, the use of load-bearing capacity to reflect the changes in factors on the impact of round hollow double steel tube foamed concrete column axial compression properties, the following will be round hollow double steel tube foamed concrete column compared to empty steel tube column of the ultimate load-bearing capacity of the increase in magnitude is referred to as The rate of increase in load carrying capacity. (as Figure 12). It also compares the variation of ultimate load bearing capacity when changing the strength of inner and outer steel tubes for round-over-round hollow double-layered hollow steel tube columns, and the variation of ultimate load bearing capacity when changing the strength of inner and outer steel tubes for round-over-round hollow double-layered hollow steel tube foamed concrete columns with a column height of 3900 mm as an example.



(a) Changing the aspect ratio



(b) Change the strength of foam concrete



(c) Change the strength of steel pipes

Figure 12: Influence of various factors on the load carrying capacity improvement rate of hollow double-layered steel pipe foamed concrete columns with different column heights with round over round.

As can be seen from Figure 12:

1. With the reduction of the diameter-thickness ratio, i.e. the increase of the wall thickness of the outer round steel tube, whether it is a short column, or a long column, round hollow double-layered steel tube foamed concrete column axial compression load lifting rate all show a decreasing trend, the reason is similar to the round steel tube foamed concrete column, the difference is that due to the existence of the inner steel tube, making the outer steel tube more stable, so its ultimate bearing capacity lifting rate of change is not as large as the round The reason for this is similar to that of the round steel foamed concrete column. Therefore, within the range of load-bearing capacity, the outer steel tube wall thickness of the round hollow double-layer steel tube foam concrete column should not be too thick.

2. With the increase in the strength of foamed concrete, round hollow double steel tube foamed concrete column axial compressive load carrying capacity increase trend, the increase is relatively obvious, the reason is similar to the round steel tube foamed concrete column.

3. As the strength of the steel tube increases, the load carrying capacity of the round-over-round hollow double storey steel foamed concrete column decreases to a small extent and then rises to a small extent. The reason for this is similar to that of the smaller round steel foamed concrete column, except that the stability of the outer steel tube is improved by the presence of the inner steel tube. Therefore it also shows that as the strength of the steel tube increases, the ultimate load capacity of the element first shows a small decrease and then a small increase in the rate of increase of the ultimate load capacity.

8 CONCLUSION

In this paper, with reference to the maximum axial force of a frame structure, four types of cross-sectional columns, namely, square steel pipe foamed concrete, round steel pipe foamed concrete, square hollow double steel pipe foamed concrete, and round hollow double steel pipe foamed concrete, are designed. The column members were subjected to axial compression and eccentric compression using ABQUS finite element software. The effects of width-to-thickness ratio, strength of steel pipe and strength of foamed concrete on the axial and eccentric compressive load capacity increase rates of the four types of cross-sectional columns compared to the empty steel pipe columns were considered and analyzed using the ABAQUS finite element software.create a digital art piece that not only showcases the assembly of structural components and nodes in construction but also captures the artistry and precision that goes into the construction industry's innovative processes.

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