Experimental investigation of some properties of square concrete-filled steel tubular columns containing iron filings as replacement of sand

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Abstract. This paper presents an experimental investigation of axial load projected onto concrete filled steel tube (CFST) columns and study the effect of using iron filings in the filled concrete mixture to improve the ultimate compressive strength, ductility index and energy absorption. Twelve column specimens was used in this study, three as reference and nine iron filings (CFST) column specimens as a partial replacement of sand by 2.5%, 5%, and 10% with 6 cubic, 9 cylinder and 3 prisms samples of concrete of each column specimens. Three types of stub, short and long column. These tests include performing slump, compressive strength, tensile strength and flexural strength. The results show that the concrete with iron filings have the highest compressive strength at the age of 28 days' age of 49.53 Mpa, 52.3 Mpa and 55.63 Mpa, namely more than control mix by 11%, 17% and 25%. However, ductility index and energy absorption of column specimens with iron filings become the highest at the age of 28 days.

1. Introduction
Concrete filled steel tubular (CFST) columns have been widely used in high-rise structures. The main advantages of (CFST) column are high axial load capacity, inherent ductility and toughness. The properties that distinguish (CFST) columns are derived from the behaviour of concrete and iron together, one member, and this effect is affected by the properties of the concrete core, because it prevents buckling inward [1-3]. Although research was conducted on this type of columns using normal concrete and high performance concrete, there was little use of iron filings with concrete filled steel tubular that using in this paper. The use of iron filings increases the resistance of concrete when used as an alternative to sand and thus reflected on increasing column resistance as well as improving ductility index [2]. Investigations were conducted in the past upon the restriction effected of (CFST) that show the main factors affecting the act are the diameter to thickness ratio, material payment which is associated to the strengths of material of both concrete and steel and cross-section shapes [4]. in this study the focused on the performance of concrete strength by use iron filling as a partially replacement of sand to improve the compressive strength of concrete. The creative use of waste material represents a means of lessening some of the troubles of solid waste management. Waste reuse is important from different perspectives. It decreases the pollution and helps to save and continue natural sources that are not renovated, and it also helps to save and recycle energy production processes [5]. Therefore, waste should be considered resources that can be used in various fields. Iron filings is one of material among these wastes that considered harmful effects on the environment and there is a possibility of utilization in future applications, and therefore one of the logical methods for reduction of their negative effects is the application of these materials in concrete application. Concrete plays an important role in the beneficial
use of these materials in construction [5]. Sand is a major component in concrete mixes. It is used with coarse aggregates to produce a structural concrete [6]. Because the sieve gradient of iron filings is close to the gradation of sand, therefore, they are used as partially replacement of sand in the concrete mixture, and also, the grains of iron filings have a higher tolerance to compression than the particles of sand, so it is expected that the compressive strength of the concrete will increase [7].

2. Experimental investigation

The test parameters were material strengths, ductility index and energy absorption. The material properties of steel and concrete were obtained from respective tension and crushing tests. The ultimate capacities and load-shortening relationships of the specimens were recorded for analysis.

2.1. Material properties

Tests were performed on the materials used to form concrete fillings the steel tubes columns and the steel tubes.

2.1.1. Steel tube

The steel tube was cut to the required lengths as shown in the Figure 1. Two thicknesses (t=3mm and t=4 mm) of steel tubes were used. In order to determine the real material properties, three coupons were cut from each type randomly-selected steel tubes and machined according to the requirements in ASTM A370 [8]. The average yield stress and tensile strength for steel tube with thickness of (t=3mm) were determined as 334 and 348 Mpa, respectively. For steel tube with thickness of (t=4mm), they were 290 and 432 MPa, respectively.

![Figure 1. Preparing of specimens.](image)

2.1.2. Cement

*Portland cement* type (I) was used in concrete mixtures. The laboratory tests of cement were conducted at the Misan Construction Materials Laboratory of Technical Institute. According to Iraqi Standard Specification No. 5/1984, [9]

2.1.3. Fine aggregate (sand)

Natural sand from the Basra region in the south of Iraq utilized in this study. The properties of the sand are shown in table 1. The grading of sand is shown in Figure 2. The tests were conducted according to the Iraqi Specification No. 45/1984 [10].

| Physical properties | Test result | Limits of Iraqi specification No.45/1984 |
|---------------------|-------------|----------------------------------------|
| Specific gravity    | 2.56        | -                                      |
| Sulfate content (SO₃%) | 0.29%    | 0.5% (max)                            |
| Absorption%         | 0.75%       | -                                      |
2.1.4. Coarse aggregate

The coarse aggregate was used in this study is naturally available in Chilat region eastern Amarah. Gravel with a maximum size of (10 mm). The grading of coarse aggregate according to the Iraqi Specification No.45/1984 [10] is shown in Figure 3. The properties of the gravel are shown in Table 2.

![Grading of Coarse Aggregate](image)

**Figure 2.** Grading of fine aggregate.  
**Figure 3.** Grading of coarse aggregate.

| Physical properties          | Test result | Limits of Iraqi specification No.5/1984 |
|-----------------------------|-------------|----------------------------------------|
| Specific gravity            | 2.55        | -                                      |
| Sulfate content (SO3%)      | 0.73%       | -                                      |
| Absorption%                 | 0.045       | ≤0.1                                   |

2.1.5. Water

Reverse osmosis (R.O.) water was utilized for mixing and curing all the specimens.

2.1.6. Admixture

Superplasticizer Hyperplast (PC 260) was used in this study. The properties of plasticizers are according to specifications ASTM C494-99 Types A and G [11]. The plasticizers percentage was used by weight 0.3% of cement in columns specimens, and the superplasticizer was mixed with water before mixing with concrete mixture.

2.1.7. Iron filings

Iron filings were brought from the workshops in Misan province. Figure 4 shows color and shape of iron filling sample. These granules are side product of iron manufacturing. The grading of iron filing close to grading of sand specially when use as a partially replacement of sand (2.5%, 5% and 10%) as shown by curves in Figures 5. The particles were almost the closest gradient to natural sand were graded according to Iraqi Specifications Zone II.

![Sample of Iron Filings](image)

**Figure 4.** Sample of iron filings.
Figure 5. Sieve analysis of different percentage of iron filing. (a) Sieve analysis of iron filing, (b) iron filings 2.5% of sand, (c) iron filings 5% of sand and (d) iron filing 10% of sand.

2.1.8. Concrete
The initial concrete mix proportions were calculated according to ACI Recommended Practice 211.1 then checked by trial batches [12]. The concrete was mixed in four batches with dosage of iron filings 0%, 2.5%, 5%, and 10%. From each batch, 6 concrete cubes (100x100x100 mm³), 6 cylinders (100 mm x200 mm), 3 cylinders (200mmx300) and 3 prisms (100x100x500 mm³) were prepared. The concrete cubes samples were cured for 7 days and 28 days, while other samples of concrete (cylinders and prisms) were cured on 28 days, then the concrete cubes, cylinders were tested by compression machine and prisms by flexural device. The strength (fcu), tensile strength (ft) and flexural strength (fr) of concrete were recorded. The concrete mix proportions are given in table 3.

Table 3. The concrete mix proportions.

| Cement (kg) | sand (kg) | gravel (kg) | (w/c) % | SP   |
|------------|-------|------------|-------|-----|
| 495        | 642   | 1005       | 0.39  | 1.48|

2.2. Specimens preparations
A total of 12 steel tubes columns specimens were constructed square shapes. Specimen sizes were selected depend on slenderness ratio, where three slenderness ratio are considered: 1) (kl/r <22) to ensure that columns specimens behaviours as short column, namely column height = 400 mm, 2) (kl/r>22) to ensure that column specimens behaviours as long columns, namely column height =550 mm and very short column height of two times the column width to ensure that columns specimens behaviours as stub
column, namely column height = 300 mm. Where (k) is factor of length, (l) is length of column and (r) is radius of gyration. The steel tube filled with concrete. The steel and concrete interaction was good because of the restriction and sufficient friction between them. Thus, they behave as composite column. The specimens cross-sectional dimension has been shown in table 4. The specimens are labelled according to their cross-section dimensions and concrete infill, where the first three letters ‘IRN’ indicates that there is iron filings in concrete infill, the following expression ‘L30B15t4’ indicates dimensions of specimen, L=30 cm in length, B=15 cm in width and t=4 mm in thickness, and the last number ‘1’ indicates the number of specimen and first dosage of iron filings in concrete.

| Table 4. The Cross-sectional dimension of the specimens. |
|----------------------------------------------------------|
| Type           | Specimens   | B (mm) | t (mm) | L (mm) | L/r | L/B | B/t |
|----------------|-------------|--------|--------|--------|-----|-----|-----|
| Reference      | CTRL30B15t4-0 | 150    | 4      | 300    | -   | 2   | 37.50 |
|                | CTRL40B10t3-0 | 100    | 3      | 400    | 13.89 | -   | 33.33 |
|                | CTRL55B8t3-0 | 80     | 3      | 550    | 23.87 | -   | 26.67 |
|                | IRN30B15t4-1 | 150    | 4      | 300    | -   | 2   | 37.50 |
| stub column    | IRN30B15t4-2 | 150    | 4      | 300    | -   | 2   | 37.50 |
|                | IRN30B15t4-3 | 150    | 4      | 300    | -   | 2   | 37.50 |
|                | IRN40B10t3-1 | 100    | 3      | 400    | 13.89 | -   | 33.33 |
| short column   | IRN40B10t3-2 | 100    | 3      | 400    | 13.89 | -   | 33.33 |
|                | IRN40B10t3-3 | 100    | 3      | 400    | 13.89 | -   | 33.33 |
|                | IRN55B8t3-1  | 80     | 3      | 550    | 23.87 | -   | 26.67 |
|                | IRN55B8t3-2  | 80     | 3      | 550    | 23.87 | -   | 26.67 |
|                | IRN55B8t3-3  | 80     | 3      | 550    | 23.87 | -   | 26.67 |

3. Results and discussion

3.1. Compressive strength
The British standards BS1881: Part 16:1983[13] was adopted to examine the compressive strength of concrete using cubical (100*100*100) mm$^3$ specimens for testing.

![Figure 6. Result of compressive strength for concrete cubes.](image)

The results of compressive strength for concrete mixtures with iron filings as a partially replacement of sand are shown in table 5 and Figure 6. It is evident that all samples which contain iron fillings particles with dosages ranged from 2.5% to 10% showed an increase in compressive strength. The mix that contains on 10% of iron particles as replacement of sand is the optimum percentage which gave a compressive strength of 48.83 Mpa and 55.63 Mpa at 7 and 28-day age respectively. The compressive strength is approximately linearly increased as the percentage of iron filings increased for 2.5% to 10% which presented a compressive strength in 7 days’ age 38.93 Mpa, 39.03 Mpa and 48.83 Mpa that means...
the compressive strength of specimens that contained iron filings larger than specimens of control mix by 29%, 30% and 62%, while the compressive strength in 28-day age 49.53Mpa, 52.3Mpa and 55.63 Mpa namely more than control mix by 11%, 17% and 25%.

Table 5. Results of compressive strength test of cubes.

| Material type   | Replacement percentage (%) | compressive strength 7 days (Mpa) | 28 days (Mpa) | different in compressive (%) | 7/28 Ratio |
|-----------------|----------------------------|-----------------------------------|---------------|------------------------------|------------|
| control         | -                          | 30.13                             | 44.65         | -                            | 0.67       |
| Iron Filling    | 2.5                        | 38.93                             | 49.53         | +11                          | 0.78       |
|                 | 5                          | 39.03                             | 52.30         | +17                          | 0.75       |
|                 | 10                         | 48.83                             | 55.63         | +25                          | 0.88       |

3.2. Splitting tensile strength test

The splitting tensile strength was carried out according to ASTM C496 [14] by applying compression load to the cylinder in a horizontal position, where the cylindrical samples had a dimensions of 100 x 200 mm. An average of three readings was recorded for each type of mixture. The results of splitting tensile test showed acceptable values when using iron filings as a partially replacement of sand as evident in table 6 and figure 7, so the decrease was not more than 0.05 at dosage of 2.5% iron filings as a sand replacement. However, there are clear increases from the Table 6, as it reached 22% at 5% dosage of iron filings in concrete. Using an iron filling as replacement showed increasing in splitting tensile strength at 5% and 10% dosages of iron filings by about 22% and 11% respectively. While the dosage of 2.5% showed reduction in splitting tensile strength by 5% compared control mix. The dosage of 5% of iron fillings gives optimum splitting tensile strength of 3.37MPa.

Figure 7. Result of splitting tensile test.

Table 6. Results of splitting tensile strength test.

| Material type   | Replacement percentage (%) | Splitting tensile strength f_{st} (Mpa) | change in splitting (%) | Splitting tensile strength f_{st} ACI code- eq | Experimental / ACI cod eq ratio f_{st} / f_{st} |
|-----------------|----------------------------|---------------------------------------|-------------------------|-----------------------------------------------|-----------------------------------------------|
| control         | -                          | 2.77                                  | -                       | 3.3                                           | 0.83                                          |
| Iron Filling    | 2.5                        | 2.63                                  | -5                      | 3.5                                           | 0.75                                          |
|                 | 5                          | 3.37                                  | +22                     | 3.6                                           | 0.93                                          |
|                 | 10                         | 3.07                                  | +11                     | 3.7                                           | 0.82                                          |

3.3. Flexural strength

The ASTM- C78 [15] was adopted to examine the flexural strength of concrete using prism (100*100*500) mm specimens for testing. The result of flexural strength of the concrete shown that increase in flexural strength in samples content iron filing by 11% to the reference sample at 5% of iron
filings as evident in table 7. Using an iron filling as replacement showed increasing in flexural strength from 2.5% to 10% dosages of iron filings by about 2%, 11% and 3% respectively. The dosage of 5% of iron filings gives optimum flexural strength of 7.65MPa.

**Table 7. Results of flexural strength test.**

| Material type | Replacement percentage (%) | Flexural strength $f_r$ (Mpa) | change in Flexural (%) | Flexural strength $f_r$ ACI code- eq | Experimental / ACI Eq ratio $f_r / f_{r\text{c}}$ |
|---------------|-----------------------------|-------------------------------|------------------------|---------------------------------------|-----------------------------------------------|
| control       | -                           | 6.90                          | 0                      | 3.7                                   | 1.86                                          |
|               | 2.5                         | 7.02                          | +2                     | 3.9                                   | 1.80                                          |
| Iron Filling  | 5                           | 7.65                          | +11                    | 4.0                                   | 1.91                                          |
|               | 10                          | 7.13                          | +3                     | 4.1                                   | 1.72                                          |

3.4. Modulus of elasticity

The modulus of elasticity was obtained according to ASTM C469 [16], by cylinder specimens with dimensions of 150*300 mm. The usage of compressometer of gauge length is 150 mm and dial gauge of sensitiveness (0.01mm) for bonded concrete models as shown in Figure 8.

The elastic modulus is calculated from the slope of the straight line drawn from the original up to 0.4 $f_{c'}$. It is evident from table 8 that increase in value of modulus of elasticity from 2.5 to 10% and optimum value of modulus of elasticity at 10% of iron filing as a replacement. The modulus of elasticity is approximately linearly increased as the percentage of iron filings increased for 2.5% to 10% which presented the modulus of elasticity in 28 days' age 30441 Mpa, 31181 Mpa and 33125 Mpa that means the modulus of elasticity of specimens that contained iron filings larger than specimens of control mix by 10%, 12% and 19%.

**Table 8. Results of modulus of elasticity.**

| Material type | Replacement percentage (%) | Modulus of elasticity $E_{c}$ (Mpa) | change (%) | $E_{c}$ of ACI code- eq | Experimental / ACI Eq ratio $E_{c} / E_{c\text{c}}$ |
|---------------|-----------------------------|--------------------------------------|------------|------------------------|-----------------------------------------------|
| control       | -                           | 27780                                | 0          | 28940                  | 1.0                                          |
|               | 2.5                         | 30441                                | +10        | 28505                  | 0.9                                          |
| Iron Filling  | 5                           | 31181                                | +12        | 29686                  | 1.1                                          |
|               | 10                          | 33125                                | +19        | 28307                  | 1.2                                          |

3.5. Load capacity

The experimental load capacity of concrete filled steel tube with partially sand replaced with iron fillings is presented in table 9. The experimental capacity of concrete filled steel tube is greater of the theoretical
capacity of column [17]. Using an iron filling as replacement showed increasing in load capacity of stub column specimens at 2.5% to 10% dosages of iron filings by about 10%, 3% and 9% respectively. compared control mix. The dosage of 2.5% of iron filings gives optimum load capacity of 1341Mpa. While Using an iron filling as replacement in the short column specimen showed an increasing in load capacity at 5% and 10% dosages of iron filings by about 10% and 14% respectively. compared control mix. The dosage of 2.5% of iron filings gives optimum load capacity of 853 Mpa. The long column specimens showed increasing in load capacity at 2.5% to 10% dosages of iron filings by about 13%, 18% and 12% respectively. compared control mix. The dosage of 2.5% of iron filings gives optimum load capacity of 559Mpa.

3.6. Ductility index (DI)
Ductility is an important criterion for column structures. It is defined as the ability of a material or structure member to undergo inelastic deformations with acceptable degrees of stiffness and strength reduction [18, 19]. The ductility index can be obtained from the load displacement curve by dividing the displacement at 0.85 of ultimate load (Δ0.85) on the displacement (Δu) of ultimate load [20]. The ductility index (DI=Δ0.85/Δu) for all (CFST) column was presented in table 9. The ductility index stub columns specimens are approximately linearly increased as the percentage of iron filings increased for 2.5% to 10% which presented a ductility index in 28 days’ age of 8.47%, 10.40% and 10.50% that means the ductility index of specimens that contained iron filings larger than specimens of control mix by 50%, 207% and 210%. The dosage of 10% of iron filings gives optimum ductility index of 10.5%. While The ductility index of short columns specimens is increased in the percentage of iron filings from 2.5% to 10% which presented a ductility index in 28 days’ age of 3.11%, 5.70% and 4.57% that means the ductility index of specimens that contained iron filings larger than specimens of control mix by 3%, 88% and 51%. The dosage of 5% of iron filings gives optimum ductility index of 5.70% by increment 88% ductility index more than reference specimen. The ductility index of long column specimens is increased of all percentage of iron filings increased for 2.5% to 10% which presented a ductility index in 28 days’ age of 9.4%, 8.43% and 8.88% that means the ductility index of specimens that contained iron filings larger than specimens of control mix by 453%, 396% and 422%. The dosage of 2.5 % of iron filings gives optimum ductility index of 9.4% by 453% increment more than reference specimen.

Table 9. Effect of iron filing as sand replacement on load capacity and ductility index.

| Material type | Replacement percentage (%) | Specimen   | N<sub>Exp</sub> (kN) | N<sub>theo</sub> (kN) | N<sub>Exp</sub> / N<sub>theo</sub> Ratio | DI      |
|---------------|----------------------------|------------|----------------------|----------------------|-------------------------------------|--------|
| Stub          | -                          | CTRL30B15t4-0 | 1220                | 1152                | 1.06                                | 3.38   |
|               | 2.5                       | IRNL30B15t4-1 | 1341                | 1241                | 1.08                                | 8.47   |
|               | 5                         | IRNL30B15t4-2 | 1253                | 1192                | 1.05                                | 10.92  |
|               | 10                        | IRNL30B15t4-3 | 1328                | 1214                | 1.09                                | 10.49  |
|               | -                          | CTRL40B10t3-0 | 807                 | 541                 | 1.49                                | 3.03   |
| Short         | 2.5                       | IRNL40B10t3-1 | 853                 | 580                 | 1.47                                | 3.11   |
|               | 5                         | IRNL40B10t3-2 | 730                 | 558                 | 1.31                                | 3.98   |
|               | 10                        | IRNL40B10t3-3 | 690                 | 568                 | 1.21                                | 4.57   |
|               | -                          | CTRL55B8t3-0  | 474                 | 402                 | 1.18                                | 1.69   |
| Long          | 2.5                       | IRNL55B8t3-1  | 537                 | 427                 | 1.26                                | 3.09   |
|               | 5                         | IRNL55B8t3-2  | 559                 | 413                 | 1.35                                | 9.36   |
|               | 10                        | IRNL55B8t3-3  | 530                 | 420                 | 1.26                                | 8.34   |

3.7. Toughness
Toughness is the ability of a structure to absorb and dissipate energy. It is calculating from area under load displacement curve. The ability to absorb energy by the facility is considered one of the most important characteristics of (CFST) columns, so the effect of sand replacement on this property must be
studied in terms of increasing or reducing energy absorption when partly replacing the sand with iron filings [21-23]. Displacement was measured through dial gauges along each (CFST) column interface that measured the load that applied on the (CFST) column relative to the displacement at each reading of dial gauge, the dial gauges are shown in Figure 9.

![Dial gauges on specimens](image)

**Figure 9.** Install dial gauges on specimens.

Figure 11 shows the relationship between load and displacement and the effect of sand exchange with iron filings on column behaviour. From the displacement load pattern, it is clear that the stub columns, although they have a higher compressive strength than the long columns, but have less displacement. Therefore, the best comparison is made by calculating the area under the displacement force curve to determine the absorption energy. Table 10 shows the absorption energy values for each specimen. The toughness values for the stub columns in which the iron filings were used there is clearly increasing in toughness with increment on percentage of iron filing for all percentage from 2.5% to 10% of 3993 kN.mm, 4117 kN.mm and 4014 kN.mm. The optimum value 4117 kN.mm was at 5% iron filings. The relationship is still achieved in the use of iron filings in terms of increasing toughness linearly with increment of iron filing in the concrete mix.

Table 10 shows the absorption energy values for each specimen. The toughness values for the stub columns in which the iron filings were used there is clearly increasing in toughness with increment on percentage of iron filing for all percentage from 2.5% to 10% of 3993 kN.mm, 4117 kN.mm and 4014 kN.mm. The optimum value 4117 kN.mm was at 5% iron filings. The relationship is still achieved in the use of iron filings in terms of increasing toughness linearly with increment of iron filing in the concrete mix.

### 3.8. Mode of failure

The mode of failure of concrete filled steel tubular (CFST) columns depends on the properties of the materials that consisted it and the geometric. The stub (CFST) columns specimens were failure by local buckling at mid span region. Two mechanisms of local buckling failure of stub columns were observed, the first one was initiated by crushing of concrete core then bulge steel outward in same level, while the second mechanism was initiated by shear failure in concrete core then bulge steel outward along inclined shear failure plane of concrete core. For short (CFST) columns, the observed mode of failure was local buckling in the upper half of column span, while the long (CFST) columns were failure by global buckling. Figure 10 shows All these types of failure modes.
3.9. Energy

Energy is calculated from the area under the stress-strain curve (while the toughness is the area under the load-displacement curve), the results are shown in Table 10. Figure 12 shows stress-strain curves of (CFST) column specimens. The curves have been arranged according to the concrete core strength. The response consists of three main regions. In the first region, behavior is similar to normal concrete. While the second area refers to the work of concrete and iron together to convert to the behavior of plastic, a transition zone is entered in which the tube exerts a lateral pressure on the core to counteract the core’s tendency for stiffness degradation. Finally, a third region is notable in which the tube is entirely activated, and the stiffness is mostly stabilized around a constant rate. The response in the third region is generally dependent on the stiffness of the steel tube. In the third region, response in the lateral direction is nearer to a straight line than the response in the axial direction. This is due to excessive cracking of the infilling concrete which is no longer a homogeneous material. So, lateral expansion of the specimen is directly dependent on the response of the steel tube, which is assumed to be linearly-elastic.

Figure 10. Failure modes of columns specimens. a) stub column with shear failure, b) stub column with crushed concrete, c) short column local buckling and d) long column with global buckling.

Figure 11. Load displacement curves of (CFST) column of specimens.

Figure 12. Strain-stress curves of (CFST) column specimens.
Table 10. Effect of iron filing as sand replacement on energy and Toughness.

| Material type | Replacement percentage (%) | Specimen    | $N_{\text{Exp}}$ (kN) | Energy N/mm | Toughness kN.mm | change %  |
|---------------|-----------------------------|-------------|------------------------|-------------|-----------------|-----------|
| Stub          | -                           | CTRL30B15t4-0 | 1220                   | 559032      | 3773.46         | -         |
|               | 2.5                         | IRNL30B15t4-1 | 1341                   | 591613      | 3993.39         | +6        |
|               | 5                           | IRNL30B15t4-2 | 1253                   | 637531      | 4117.11         | +9        |
|               | 10                          | IRNL30B15t4-3 | 1328                   | 594702      | 4014.20         | +6        |
|               | -                           | CTRL40B10t3-0  | 807                    | 724653      | 2898.61         | -         |
| Short         | 2.5                         | IRNL40B10t3-1  | 853                    | 797775      | 2990.42         | +3        |
|               | 5                           | IRNL40B10t3-2  | 730                    | 797357      | 3189.42         | +10       |
|               | 10                          | IRNL40B10t3-3  | 690                    | 800803      | 3193.93         | +10       |
|               | -                           | CTRL55B8t3-0   | 474                    | 518049      | 1823.53         | -         |
| Long          | 2.5                         | IRNL55B8t3-1   | 537                    | 592006      | 1910.86         | +5        |
|               | 5                           | IRNL55B8t3-2   | 559                    | 673930      | 2115.05         | +16       |
|               | 10                          | IRNL55B8t3-3   | 530                    | 810624      | 2500.06         | +37       |

4. Conclusion
The conclusions are discussed according to the results of the tests confirmed in the Tables and the resulting curves, and through them the following is evident.

- Increase the compression strength in concrete mixtures containing iron filings as a substitute for sand as the percentage of substitution increases, where the optimum value of compressive strength increasing 25% at 10% dosage of iron filings replacement.
- Naturally, splitting tensile strength in concrete samples increases, depending on the increase in compression strength of the same samples. This is another proof that the increase in splitting tensile strength as a result the use of iron filings in concrete mixtures has become acceptable. The optimum is 22% at 5% dosage of iron filings in concrete.
- It appears that the conjugation of increasing values is converged whenever the characteristics are similar, as the resistance to splitting tensile strength is close to the flexural strength behavior in their dependence on the effect of undirected tensile strength in the concrete, where optimum value is 11% at the same dosage of 5% iron filings of sand.
- There are two ways to conclude that the value of the modulus elasticity has increased. These are the values of the concrete sample results, as well as the curves of the column specimens. The optimum increased 53% at10% iron filings of sand replacement and the first stage of curves tend to left with increase amount of iron filings.
- In this study the ductility index of concrete filled steel tube column was increased with increasing of percentage of iron filings as replacement of sand in the core concrete.
- The failure modes in this study are not different from the common failure patterns, where the stub (CFST) column specimens bulge outward failure, the short (CFST) column local buckling and global buckling for long column specimens.
- In general, the results show that the column models that contain the iron filings higher, they have more energy than the ones that contain less ratios.
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