following fire exposure.The axial load level (0, 0.3, 0.6) and cross-section type (circular, square, or rectangular) were the test parameters. The columns' ultimate lateral strength, flexural stiffness, dissipated energy, and ductility are compared and examined.All of the test specimens were found to behave ductilely, and the testing went smoothly and carefully.Concrete-filled empty primary segments' definitive parallel strength and flexural firmness diminished after fire openness, as per test results.[6], It is demonstrated that CFHS(Concrete-filled hollow steel (CFHS)) columns have numerous advantages over standard steel and reinforced concrete and have been utilized in the construction of bridges and buildings, including high-rise structures.Since sustainability is a major concern right now, more work and improvements are needed to figure out if green materials can be used in the concrete core of CFHS columns, especially when they are subjected to fire and cyclic loads. [7].Following prolonged axial load exposure to fire, cyclic behavior is observed in eight concrete-filled steel tubular (CFT) columns.The specimens were simultaneously heated by blowing liquefied petroleum gas fire into a stackable electrical furnace to resemble a real fire attack.A hybrid heating strategy that makes use of both gas and electricity makes it possible to control the heating of the furnace in a straight forward and secure manner in order to guarantee that the furnace's average temperature adhered as closely as was humanly possible to the ISO-834 standard fire curve. After the CFT columns had been heated for a predetermined amount of time while the axial load remained constant, the specimens were cooled to room temperature in accordance with the ISO-834 fire standard.Finally, constant axial and lateral cyclic loading were applied to the columns.Although parametric studies on the effect of the exposed surface area of columns, distribution of reinforcement on column faces, grades of steel, support conditions, and load eccentricity are scarce in the technical literature, the CFT columns experienced significant residual deformations during the cooling phase as a result of the sustained pre-load [8]. Since fires may have very different heating and cooling regimes, this method's general applicability is up for debate.As a result, we still don't know enough about how concrete buildings actually behave before and after a fire.When evaluating the structural performance of a structure following a fire, especially in light of the remaining seismic capacity, the behavior that occurs following cooling is of particular significance.High-temperature strength loss in concrete and steel reinforcement is partially recovered during the cooling phase. [9]. The tests included a residual load test, a one-hour compartment fire, and cyclic lateral loading to resemble earthquake damage.The test results demonstrated that the assumption of uniform temperature, which is implicit in many design fires, is incorrect because structural temperatures varied significantly within a compartment. [10]. the thermal behavior simulation of high-strength high-volume fly ash nano-silica (HSHVFANS) reinforced concrete (RC) slab exposed to various fire curves using finite element (FE). The experiment includes a medium-scale furnace test (ISO 834 fire curve load, 120 min) of the member ,and Results show locations and depths of concrete spalling and temperature distribution at depths 30, 60, 90, and 200 mm. As limited numbers of thermocouples are utilized,it may or may not spall, the temperature distributions at locations of spalling are simulated.[11] .

2-Specimens Details

The size and shape of models are fixed.These columns have square cross-sections with definite and consistent dimensions.With a length of (700) mm and a cross-section of (150 * 150) mm around the center component, each column measured 1300 mm in length .Figure 1 shows the dimensions of the corbel, which are 150 x 300 x 300 mm. Its function is to exert an axial load. All of the samples are reinforced with a transparent concrete cover (25 mm).and four longitudinal steel bars of "Φ12 mm" (= 0.02). On the column, steel links with a 100mm c/c spacing and a diameter of 4mm are also used. All samples are constructed to "ACI Code 318" [12] specifications.(Fig .2) showcases the arches and details of the columns' reinforcements.The ongoing experimental concentrate on analyzes four models, with "C1 to C4". The "control" in this group is the first column, C1, which does not experience any "fire exposure."where as the other columns(C2, C3, and C4) were subjected to cyclic burning with an eccentric preload of "E=75" mm to "30 percent Pu." Table1: reveals the particulars of each column.

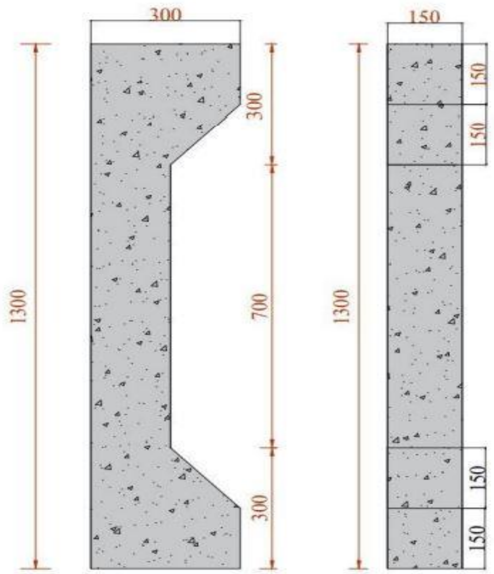


Figure 1. Concrete's column geometric

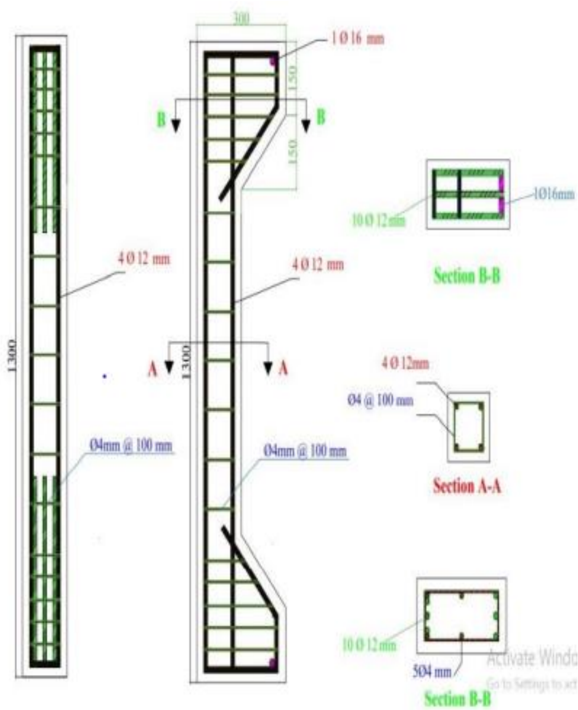


Figure 2. Details about the tested columns' reinforcement

Table1. Specifics of tested specimens

No.Specimen Symbol (Ci)	exposure cyclic fire (F)	Notes
C1E1	___	Control
C2E1	F1	___
C3E1	F2	___
C4E1	F3	

3- Material and Mix Productions

3.1. Material

Cement: During the course of this study, the formwork of the column models and samples was constructed with Type 1 ordinary Portland cement Fine aggregate (sand) and coarse aggregate (gravel) were used in the project.It is used for classification because it falls within the top and bottom bounds of the Iraqi Standard, Area (IQ.S 45/1984) [13].In NSC, well-graded, rounded gravel with a maximum size of 14 mm was used as coarse aggregate.In Badura, however, coarse aggregate consisted of well-graded, rounded gravel with a maximum size of 14 mm [14].In order to separate the excess volume, the gravel was sieved at "14 mm" and washed several times with water before being dried.) Two sizes of Ukrainian reinforcing bars (Φ12, Φ4) were used in this study.Reinforcing bars with a diameter of less than (Φ12) mm are used to reinforce both tension and compression .The connecting rods have a diameter of (Φ4) mm.

3.2. Design of Concrete Mix

The ACI-211[15] is used to calculate the proportes of the Normal Strength concrete mix.A 1:1.73:2.2 (wt) ratio of (cement:) was determined after testing several combinations.The best were found to be gravel and sand.After 28 days, the trail mix's nominal cylinder compressive strength is "31.79" MPa.The mix proportions are shown in Table 2.

Table 2. Tested Columns' Experimental Findings

	Experimental Materials	Amount
1	water/cement ratio	0.49
2	Cement (kg/m3)	423
3	Sand (kg/m3)	732
4	Gravel (kg/m3)	934
5	Water (kg/m3)	207
6	f c' (28 days) MPa	31.79

3.3. Casting Procedures

In order to prepare the concrete for pouring the columns in this project, a rotary mixer with a capacity of "0.1 m3," was used. Samples in the shapes of cubes (150 * 150 * 150 mm) and cylinders (150 * 300 mm) were modeled during the casting process.To prevent the inner surfaces of the cubes and cylinders from sticking to the concrete when they hardened, they were cleaned and lubricated[16].There were three layers of concrete poured, with a penis compacting each layer.The steel cages for the "columns" were then fixed and reinforced in solid wooden molds to prevent opening the mold when using the electric vibrator while preparing the columns for casting.An integrated vibrator was used to fill each mold with one layer of concrete, crush it, and then vibrate it for two minutes. As depicted in Figure3

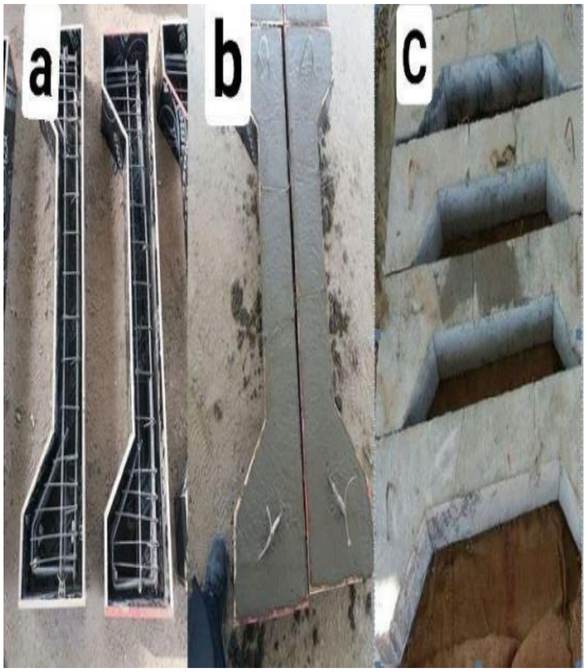


Figure 3. Phases of the casting process

3.4. Fire Test

The columns were attacked more than a month after they were erected. As depicted in Figure 4, a brick burner with dimensions of "1400 x 1400 x 1100" mm was used to burn all of the columns.All tests maintained cyclic fire of the columns with continuous loading while burning, with the exception of the control without fire for column "C1."

- Column "C2" burned four cycles, at a rate of (four days) the inside oven reached a temperature of about"400C°" . The burning time for each cycles was (45) minutes
- Column "C3" burned four cycles, at a rate of (four days) the inside oven reached a temperature of about"400C°" . The burning time for each cycles was (75) minutes.
- Column "C4" burned four cycles, at a rate of (four days) the inside oven reached a temperature of about "600C°" . The burning time for each cycles was (45) minutes.

After the user installs a digital temperature controller, an electronic system that directs gas through to open and close the gas regulator and a sensor made up of "K" thermocouples with a diameter of "4 mm" and a cover at the top to measure the required oven temperature control the oven's temperature. The samples were brought down to room temperature and the burner hood raised to resemble the actual cooling phase of the fire. each Column with a length of "700" mm is exposed to fire.A "77KN" eccentric load and a "163 KN" concentric load—equivalent to "30%" of the total load—are applied to each sample.the stove and the accessories that came with it.The stove and equipment with the preload mechanism are depicted in Figures 4 and 5. The furnace's average temperature was measured as closely as a possible comparison and using the ASTM E119-8810.standard curve during the test using controlled fire, as depicted in Figure 6.

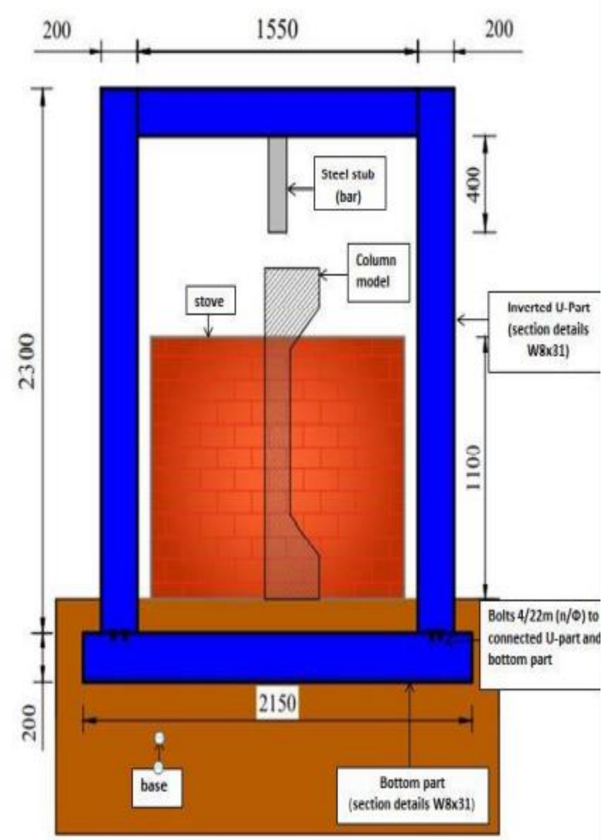


Figure 4. Specifics about the loading frame

Figure 5 .the act of exposing a fire through the use of pre-loading

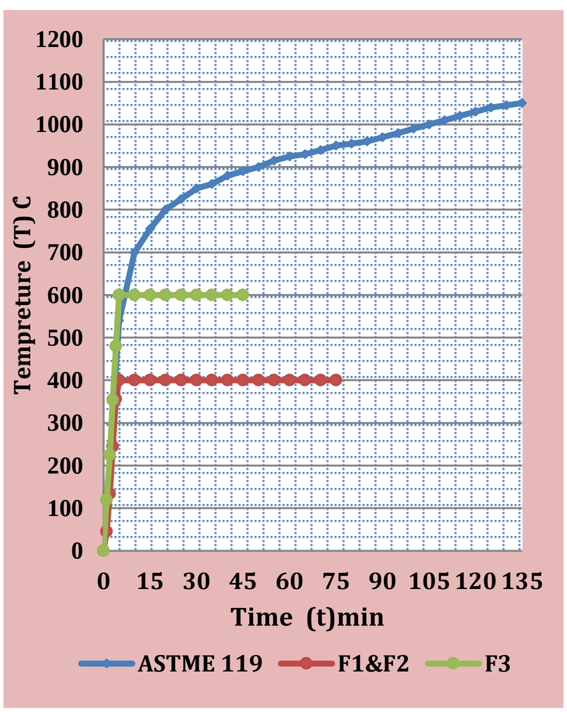


Figure 6. Temperature graph from ASTM E119

4. Test setup and procedure

•Eccentric loads were applied to each sample until they failed.

• A machine for testing electrohydraulics with a maximum range of "2500"

•As depicted in Figure 7, the lateral and axial mid-height displacements for each load increase were measured using two disc gauges with a deflection amplitude of 20 mm and an accuracy of "0.001 mm" Each.

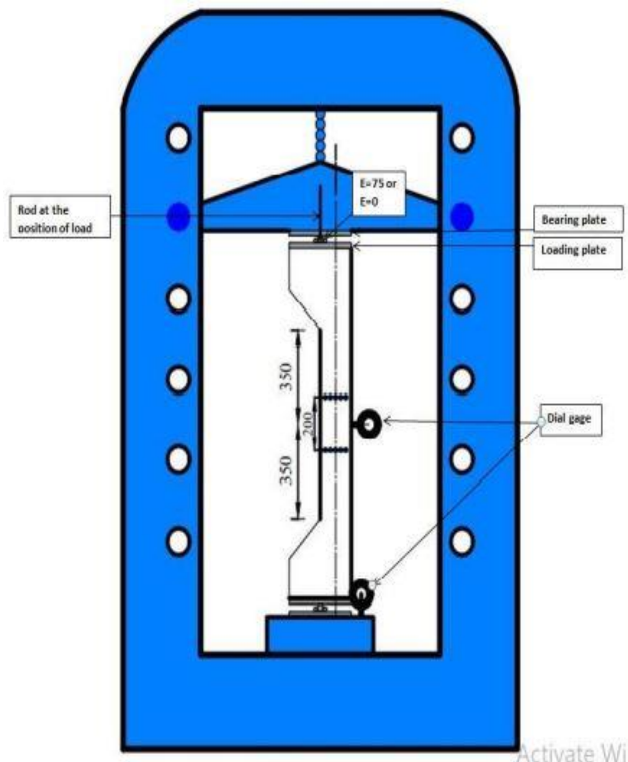


Figure 7. setup for the instruments and tests

5 . Results and Discussion

The results of the tests that were carried out on each column are compared to the results that were carried out on the columns. This is done in order to compare the effect of periodic burning duration and Intensity while maintaining the stability of the load and the percentage of deviation.The failure mode, maximum load capacity, first crack load, axial deformation, and failure mode of the column samples were examined ,as depicted in Table 3 That is shown in Figure 8.

Table3.Tested Columns' Experimental Findings

Specimen (Ci)	Ultimate Load Pu (kN)	Service-level displacement Load s*(mm)		Mode of Failure
		Axial	Lateral	
C_1	261	5.12	3.9	compression Failure gradually
C_2F_1	190	4.96	5.84	compression Failure gradually
C_3F_2	185	7.41	8.52	compression Failure gradually
C_4F_3	166	7.58	8.76	compression Failure gradually

*Δs= displacement at service load (Ps =0.65 Pu)[17].

5.1. Failure Models, Cracking, And Ultimate Loads

• Control Column C1

This specimen has a cross-section of (150*150), is reinforced with steel bars (4 x 12 mm), has a the load eccentricity of (e = 75 mm and e/h = 0.5), and has a longitudinal reinforcing spacing of (100 mm). Under axial load, the first visible crack is a horizontal crack on the column's top high (80 kN). The unanticipated compression failure occurred at load (261 kN)The curves for lateral displacement and axial deformation are shown in Figure 9.

• Column C2F1

This specimen is reinforced with steel bars "4 x 12 mm" with a 100 mm longitudinal reinforcing spacing. It is made of regular concrete with a cross-section of (150*150) and the load eccentricity of "e = 75 "mm and e/h = 0.5."At a temperature of "400C," it was burned for 45 minutes at a rate of two days at a time with continuous loading. At hub load, a flat break on the pressure side close to the section's top corbel (25) KN is the main noticeable break. The outer sheathing and torsion of the longitudinal reinforcing bars abruptly failed on the compression side when subjected to a load of (190) kN. Figure9 depicts the lateral displacement and axial deformation curves.

• Column C3F2

This specimen was burned for four days at a rate of (75) minutes at "400" degrees Celsius. It is made of regular concrete with a cross-section of (150*150) and the load eccentricity of (e = 75 mm). It is supported by steel bars (4 x 12 mm) with a longitudinal reinforcing spacing of (100 mm).The outer sheathing and torsion of the longitudinal reinforcing bars abruptly failed on the compression side when the load was (185) kN, and the first obvious crack was on the tension side, close to the column's top corbel (24)KN .Figure 9 depicts the lateral displacement and axial deformation curves.

• Column C4F3

This specimen was burned for four days at a rate of 45 minutes at "600" degrees Celsius. It is made of regular concrete with a cross-section of (150*150) and the load eccentricity of (e = 75 mm). It is supported by steel bars (4 x 12 mm) with a longitudinal reinforcing spacing of (100 mm).The first obvious crack was on the tension side, close to the column's top corbel (22 KN). On the compression side, the outer sheathing and torsion of the longitudinal reinforcing bars abruptly failed under a load of (166) kN. Figure 9 depicts the lateral displacement and axial deformation curves.

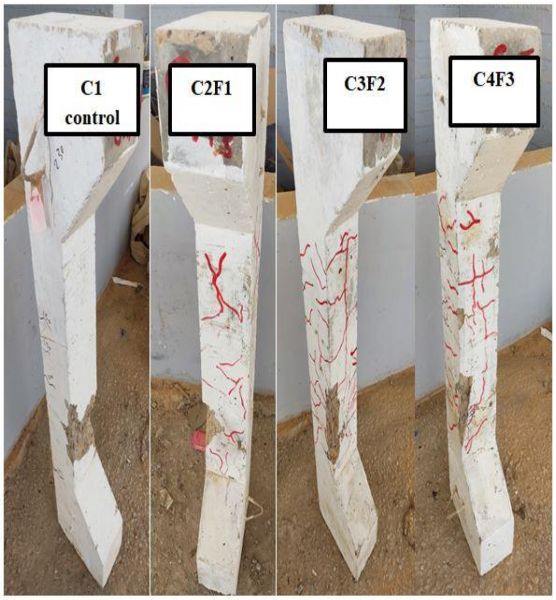
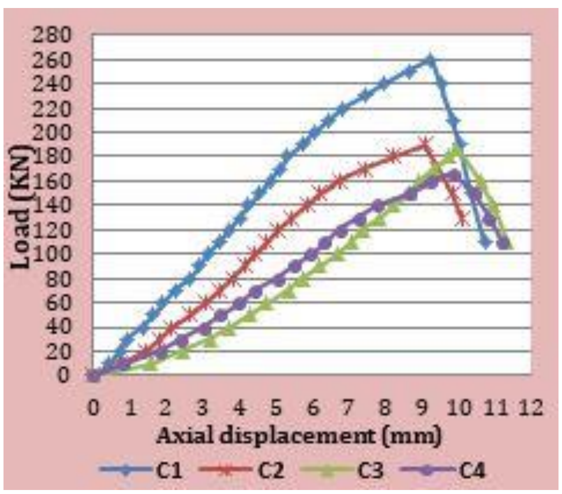


Figure8.Column specimen failure mode and crack pattern



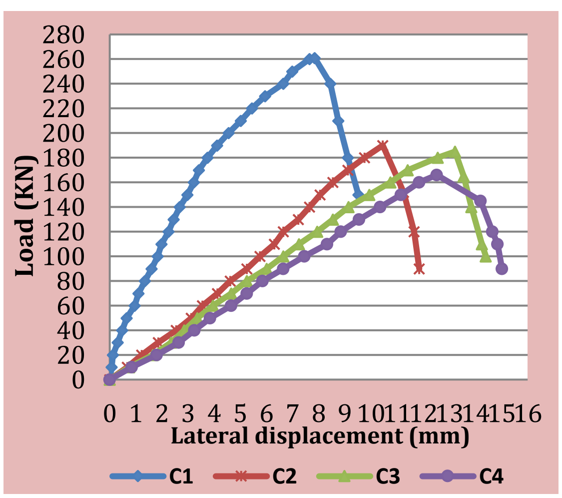


Figure 9. The specimens' load-deflection curves (C1, C2, C3, C4)

5Crack Width and Pattern of Cracking for Columns

Crack gauges are used to measure the crack width at the beginning of loaded, controlled reinforcement of concrete columns that do not have any cracks.In eccentrically loaded column samples, the transverse cracks typically appear in the tension region in the middle;The so-called "hair line cracks" that appear on fire-damaged models indicate that they have fractured in the past;During the combustion process, the axial application of load causes the red cracks;and test deflection is the cause of the black cracks.For post-burning column samples, Table 4 displays the maximum fracture width and service load of repaired and unrepaired column samples.

Table 4.width of the columns crack

No. Specimen Symbol (Ci)	Maximum crack width after cyclic fire exposure (mm)	Crack width at Ultimate load (mm)	Location of crack
C_1	_	0.7	In the middle of the column
C_2F_1	0.46	2.7	In the first quarter of the column
C_3F_2	0.53	2.9	In the last quarter of the column
C_4F_3	0.62	3.7	In the last quarter of the column

6- Conclusion

The cracks width and spread increase when it is exposure to cyclic fire with continuous loading through a specific duration, too when to increasing the duration of exposure to cyclic fire and target temperature.

The experimental results showed that with pre-load during the exposure to cyclic fire applied on the column, the bearing capacity of the column decreased. all samples loading an eccentric load with "e = 75 mm","e / h = 0.50," and the ratio Celsius (30%Pu) continuously throughout the burning period. The first column(C1) was the sample control, and the second column was subjected to four burning cycles over the course of four days, with a duration specific of "45 minutes" for each cycle, at a temperature of "400 °C", that to be amount losses (C2= 27.20) comparison to (C1),C4=36.40 and the third column was subjected to four burning cycles over the course of four days, with a duration longer amount of "75 minutes" for each cycle, at a temperature of "400 °C, "that to be amount losses (C3= 29.12) comparison to (C1), the four column(C4) was subjected to four burning cycles over the course of an of four days, with a duration specific of "45 minutes" for each cycle, at a temperature of "600 °C " ,that to be amount losses (C4=36.40) comparison to (C1).

The load first crack for column decrease with exposure cyclic fire and increasing duration for burning cyclic and increasing target temperature.The axial and lateral displacement increasing with exposure cyclic fire and increasing duration for burning cyclic and increasing target temperature .

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