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EXPERIMENTAL STUDY OF SHORT COLUMNS BEARING CAPACITY SUBJECTED TO UNIAXIAL LOADING

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ABSTRACT:- Columns can be defined as individuals that carry loads mainly in compression. Frequently, columns carry bending moments as properly, about one or each axis of the cross section. The bending moment action may produce tensile stresses over a part of the cross section. In this research, twenty-four column samples distributed into eight groups were cast to investigate the structural behavior under loading with varying bar diameter, clear cover of vertical reinforcement and concrete strength. Samples designed to fail by tension. The loading rate was set to be from fifteen to twenty percent of designed capacity. The results showed that increasing concrete strength leads to increase in bearing capacity, the load that needs to cause the first crack and decreasing in crack width. Increasing steel bars size showed rising in a column bearing capacity, the load that needs to occur the first crack, crack width and decreasing the number of cracks in tension area. While the large concrete cover caused increasing in bearing capacity, the crack width and reduce the load that needs to produce the first crack.
Keywords: *Short columns, uniaxial loading, clear cover, bar size, tension and deflection sensors.*

1. INTRODUCTION

Columns can be defined as individuals that carry loads mainly in compression. Frequently, columns carry bending moments as properly, about one or each axis of the cross section. The bending moment might also produce tensile forces over part of the cross section [(1)]. Reinforced concrete columns support slabs and beams, and their position nevertheless grows due to the growing size of high buildings. [(2)]

Columns may be categorized based totally on:

- **Reinforcement as shown in fig. (1):**
  a) Tied columns.
  b) Spiral columns.
  c) Composite columns.
- **Loading types as shown in fig. (2):**
  a) Columns with axial loading.
  b) Columns with eccentric uniaxial loading.
  c) Columns with eccentric biaxial loading.
- **Slenderness ratio**
  a) Short columns.
  b) Slender (or long) columns. [(3)]

Extensive experimental and theoretical research were performed at the eccentrically loaded columns. Song Y. F. Moreover, Li Sh. Y. Made tests on eccentric compressive short columns for numerous concrete strength and steel content.[(4)] Furlong R.W. Supplied experimental and theoretical studies to investigate the behavior of eccentrically loaded composite columns. [5, 6] Dundar proposed an iterative method for the evaluation of arbitrarily shaped short and slender composite columns under biaxial bending and axial load. [7]

The impact of concrete cover at the structural members had been studied via many researchers. Paul O. A., Chinwuba A. And Isaac I. A. Studied concrete beam samples of 320 mm x 150 x 100 mm reinforced with 10 mm main bars and 6 mm nominal reinforcement, with Concrete cover for reinforcement various at 10 mm, 15 mm, 20 mm and 25 mm respectively. Samples had been tested with the universal testing machine. Outcomes confirmed that ultimate tensile strength decreased with decreasing concrete cover. [8] Khaldoun N. Rahal investigated the effects of increasing the thickness of the concrete side cover on the behavior of reinforced concrete beams examined in shear. The thickness of the concrete side cover ranged from 5 to 75 mm for beams with a concrete strength of 25 Mpa, and from 25 to 75 mm for beams with a concrete strength of 40MPa. The specimens with 75 mm side cover developed a sharp increase in diagonal crack width upon cracking and showed a less favorable behavior. [9] Khaldoun N. Rahal and Michael P. Collins investigated the effect of increasing the thickness of the concrete cover on the behavior of beam sections subjected to combined shear and torsion. He used seven large reinforced concrete beams with two different thicknesses of concrete cover were tested at various shear- to torque ratios and relatively little bending, the results show that increasing thickness of the concrete cover can substantially enhance the strength of sections subjected to pure shear, or combined shear and torsion. [10]

In this research, attempts have been made to evaluate bearing capacity load, reinforcement stress and displacement with different variables, for tied short column subjected to eccentric uniaxial loading. The experimental program includes cast 24 specimens with a different parameter such as concrete strength, steel bar diameter and concrete cover.

2. OBJECTIVES

The primary purpose of this study is to investigate the behavior of column through experimental research. The study included testing of twenty-four concrete columns subjected to eccentric uniaxial loading. The aim of the experimental program is to evaluate the effect of testing parameters (steel bar diameter, concrete cover and concrete strength) on the bearing capacity of columns.

3. EXPERIMENTAL PROGRAM

The variables used in this study were the steel bar diameter with (10 mm and 14 mm); the concrete cover with (35 mm and 50 mm), and the strength of the concrete (C30 and C25). The total number of specimens was 24. The test results were obtained by averaging three replicates in each group. The number of specimens casting and tested was calculated as shown below:

$$(D_1+D_2)*3+(C_{v1}+C_{v2})*3 \ \ldots\text{for } S_{c1}$$

And

$$(D_1+D_2)*3+(C_{v1}+C_{v2})*3 \ \ldots\text{for } S_{c2}$$

Where:
D = diameter of steel bars (mm)
Cv = clear concrete cover (mm)
Sc = strength of concrete (MPa)

The column was designed to fail with tension stress by applying two types of loads, moment and axial load. Specimen reinforcement was four 10 mm or 14 mm diameter (depending on specimen type) longitudinal bars, as well as 8 mm diameter stirrups, were placed into the section. Specimen length was 1200 mm, and it had two cross sections, mid-span section (B-B) with 200X200 mm and ended section (A-A) with 200X300 mm as shown in fig. (3).

Table (1) shows the concrete mixture parameters such as cement, sand, aggregate and water cement ratio. Table (2) shows the yield stress and tensile strength of steel bars. The column samples were divided into eight groups, corresponding to the testing parameters, as shown in the table (3).

3.1 Bearing capacity test.

The columns were tested under eccentric loads by a compression machine with 300T capacity. The test includes three stages as shown below:

3.1.1 Specimen installation.

The specimen was placed vertically in the compression machine and fixed with hinged supports (loading points) fig.(4). the load applied eccentrically with 110 millimeters from the column face to ensure getting a moment in addition to compressive stresses.

The machine was operated until the loading block was brought into contact with the upper surfaces of the specimen. Full contact between the load (and supporting) surfaces and the sample was ensured to secure. The load recorder was adjusted on the front panel controller to zero, to read load applied. [11] , the loading speed was 200 Newton/Second.

3.1.2 Compression, tension and deflection sensor.

The sensors system were used to monitor the specimen stresses and strains during the test. On the transverse direction, ten stress sensors were used as shown in fig.(5). While in the longitudinal direction six strain sensors were fixed as shown in fig.(6). Both stress and strain sensors were distributed on selected position at different intervals.

3.1.3 The test Aim.

The purpose of the bending test is shown in the following points:

a. Failure in bending.
b. Deflection in bending.
c. Stress and strain in bending.

Every test had multi-stages (every 20 kN the test stopped to observe the crack and record the time and crack load),

4. RESULT AND DISCUSSION

Table 4 and table 5 shows:

1. **Bearing capacity**: increasing ***concrete strength*** showed an increase in failure load, the failure load for specimen C30-50-10 greater than C25-50-10 by 17%, while C30-35-14 greater than C25-35-14 by 9%. ***Steel bars size** it* is obvious that increasing steel area showed increasing in column bearing capacity, the largest percent value 42% when compared C25-50-14 with C25-50-10, and other samples values ranged from 24% to 31%. Increasing ***Concrete cover*** caused column bearing capacity increased by 3-17.5%, the greatest increment 17.5% when comparing specimen C25-50-14 with C25-35-14.
2. **First crack load**: high ***concrete strength*** leads to increasing the load that is needed to cause the first crack; specimen C30-35-14 shows higher load value than C25-35-14 by 46%, specimen C30-35-10 has a crack load of greater than C25-35-10 by 41%, the difference between the two percentages (46% and 41%) because of the steel bar diameter. Large ***steel bars size*** increased the load that is needed to cause the first crack in the specimen to occur; the greatest increment was 13.5% when compared C30-35-10 with C30-35-14 while the lowest increment percentage was 5% when compared C25-35-10 with C25-35-14; concrete strength caused the differences. ***Concrete cover*** has an adverse relation with crack load, where the increasing in concrete cover lead to reduce the load that is needed to produce the first crack; the comparison between C30-35-10 and C30-50-10 shows a significant reduction in load crack by 90%, and 49% for C30-35-14 and C30-50-14.

3. **Maximum crack width**: increasing ***concrete strength*** showed a decrease in crack width; decreasing percentage varied from 12% to 25.3%, the largest decreasing appeared when comparing specimen C30-50-10 with C25-50-10. ***Steel bar size*** effect shows different relations depending on the concrete cover when the concrete cover (35mm) crack width decreased 7% by increasing bar size while it increased by 24.8% when increasing bar size and concrete cover (50mm). Increasing the ***concrete cover*** when the steel bar was (10mm) leads to a decrease the crack width 14.5% by comparing C30-35-10 with C30-50-10, and 1.8% for C25-35-10 and C25-50-10, while increasing the concrete cover when the steel bar was (14mm) lead to an increase the crack width 18.2% by comparing specimens C30-50-14 with C30-35-14.
4. **A cracks number in the tension zone**: by using (10mm) steel bar, the number of cracks increased by 27% when concrete cover increased; on the other hand, by using a (14mm) steel bar, it decreased by 15.7% when the concrete cover increased.

Fig. (7) Shows the stress increments with a time of steel bar for specimens C25 while fig. (8), shows the concrete stress increments with time for same specimens. The steel stress increments curve has non-uniform shape with loading time, but it would be noted that all specimens have the same plot shape. The concrete compressive behavior was uniform for all specimens with loading.

Fig. (9) and fig. (10), presents the strain behavior with sensor positions. The result shows tension (positive strain) and compressive (negative stain) area; it is clear to recognize the natural axis position.

The relation between displacement and load for specimens C30-35-10, C30-50-14, C30-35-14, and C30-50-10, showed in the fig. (11). The curve behavior for specimens in the load interval (0 to 180 kN) was almost the same; after that C30-50-14 and C30-50-10 got a little increment because of the concrete cover (50mm) effect while C30-35-10 and C30-35-14 show a high increase. Fig. (12) shows the results for specimens C25-35-10, C25-50-14, C25-35-14 and C25-50-10, which has the same behavior but the load interval was (0-150 kN).

5. CONCLUSIONS:

1. Increasing concrete strength showed an increase in bearing capacity, the load that is needed to cause the first crack and decreasing in crack width.
2. Increasing steel bars size showed an increase in a column bearing capacity, the load that is required to cause the first crack to occur, crack width and decreasing the cracks number in the tension zone.
3. Increasing concrete cover caused increasing bearing capacity, the crack width and reduced the load that is needed to produce the first crack.

6. REFERENCES

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Table 1. Mixture proportion.

Concrete strength	Cement	Sand	Aggregate	w/c
C30	1	2.7	3.4	0.45
C25	1	3	3.9	0.48

Table 2. Yield stress and Tensile Strength for steel bar.

Bar diameter (mm)	Yield stress (MPa)	Tensile strength (MPa)
10	305	365
14	312	370

Table 3. Designation column groups**.**

Designation	Concrete strength (MPa)	Concrete cover (mm)	Bar diameter (mm)
1-C30-35-10	C30	35	10
2-C30-35-14	C30	35	14
3-C30-50-10	C30	50	10
4-C30-50-14	C30	50	14
5-C25-35-10	C25	35	10
6-C25-35-14	C25	35	14
7-C25-50-10	C25	50	10
8-C25-50-14	C25	50	14

Table 4. The load results.

Sample	Initial load (kN)	First crack load (kN)	Failure load (kN)
1-C30-35-10	50	95	231
2-C30-50-10	40	50	245
3-C30-35-14	50	110	313
4-C30-50-14	30	56	300
5-C25-35-10	50	56	231
6-C25-50-10	60	79	230
7-C25-35-14	50	59	290
8-C25-50-14	30	56	321

Table 5. The crack results.

Sample	First crack load (kN)	Time to Failure crack (min)	Crack No. in the tension zone	Max. crack width (mm)	Max. crack length (mm)
1-C30-35-10	95	26.7	26	14.5	210
2-C30-50-10	50	24.2	35	12.4	209
3-C30-35-14	110	37.7	38	13.5	214
4-C30-50-14	56	38	32	16.5	207
5-C25-35-10	56	30.5	21	16.9	208
6-C25-50-10	79	25.4	29	16.6	213
7-C25-35-14	59	21.25	36	17.0	209
8-C25-50-14	56	25	31	14.5	210

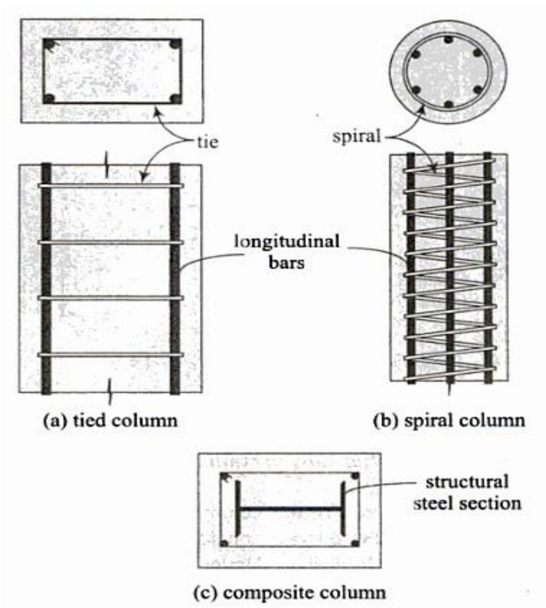


Figure1. Type of columns based on reinforcement

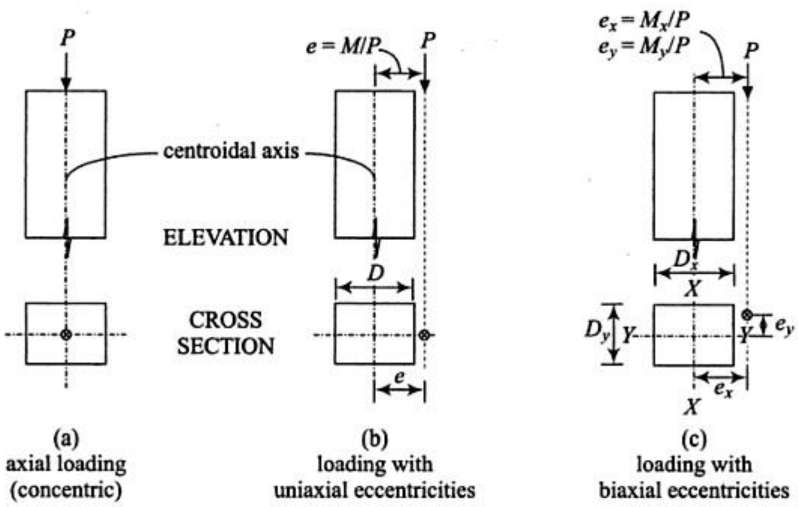


Figure 2. Loading categories in columns.

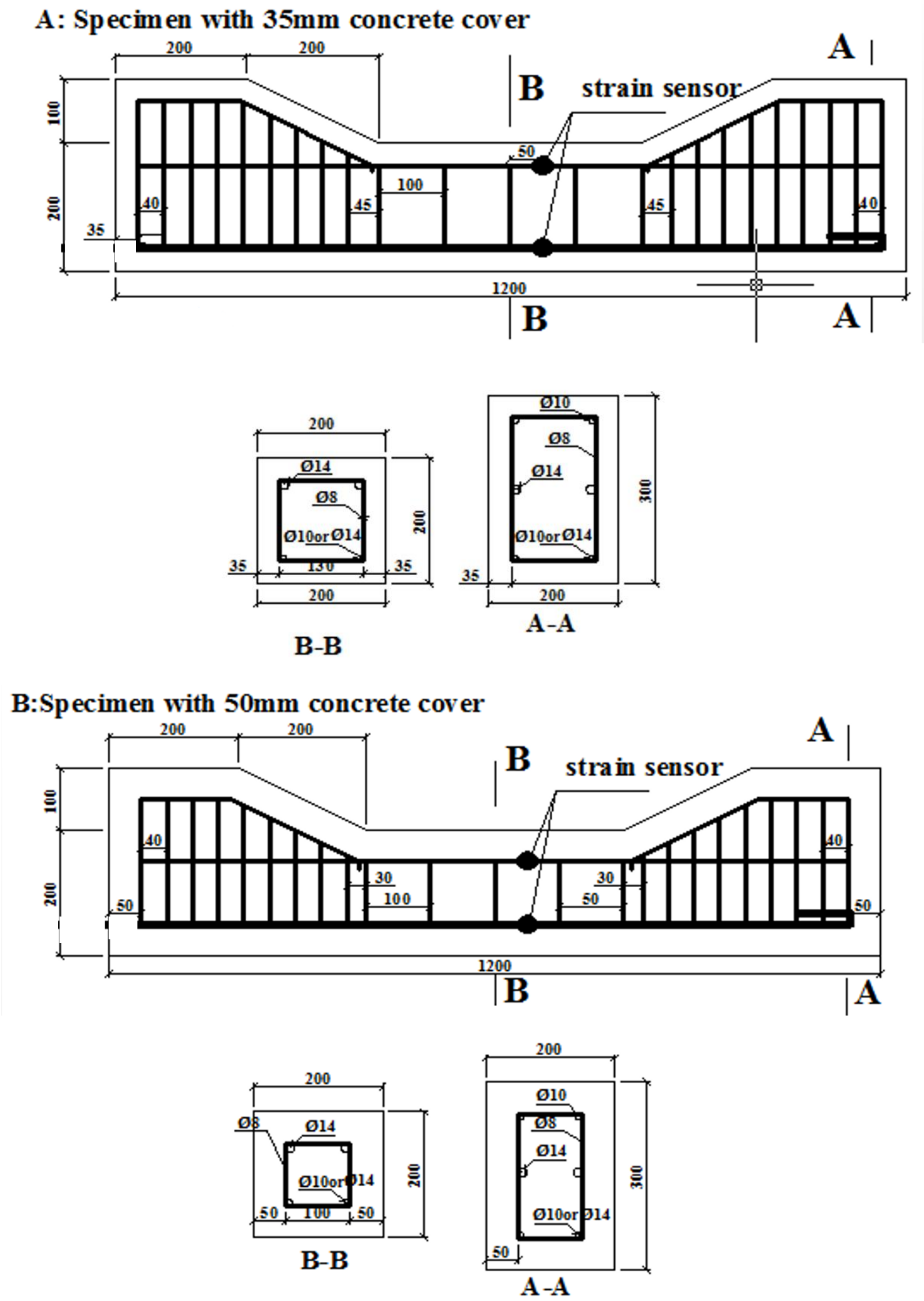


Figure 3. Reinforced concrete column specimen details.

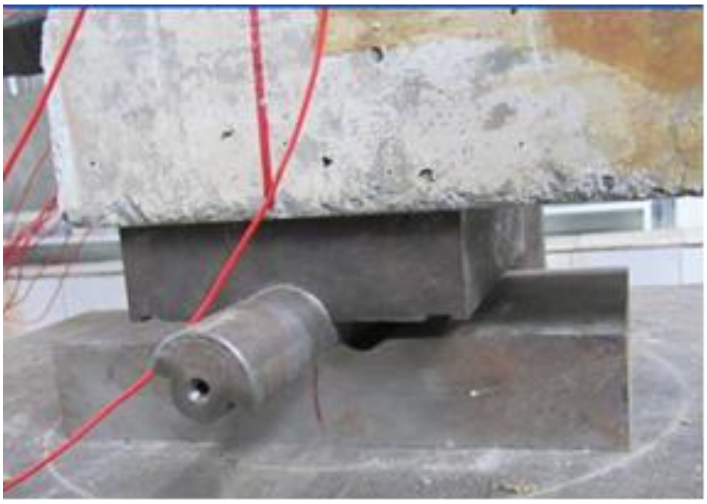


Figure 4. Specimen support with roll-plate.

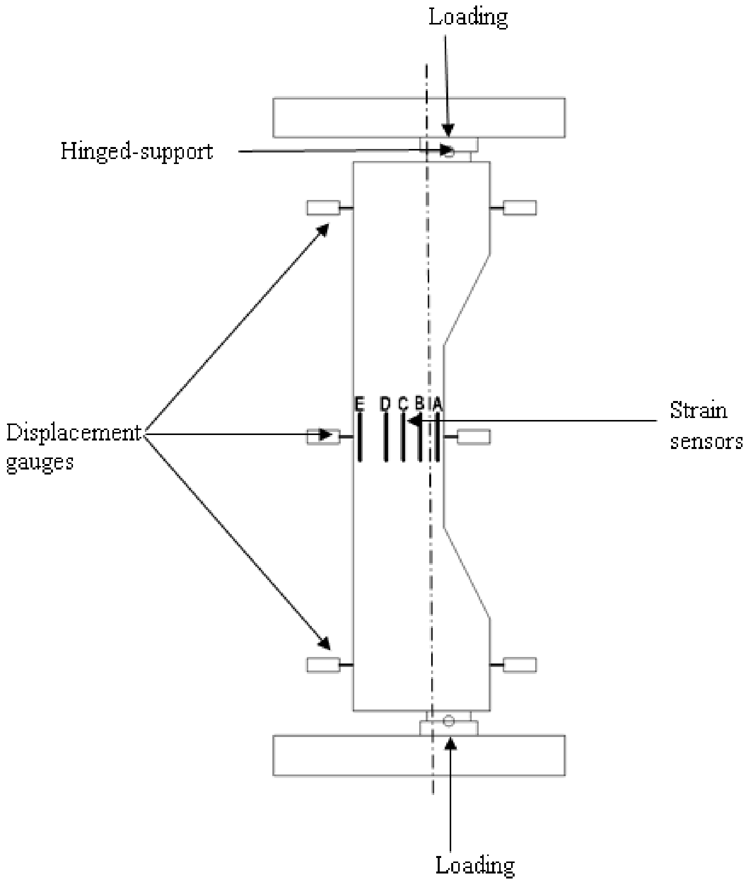


Figure 5. The sensor position on the specimen.

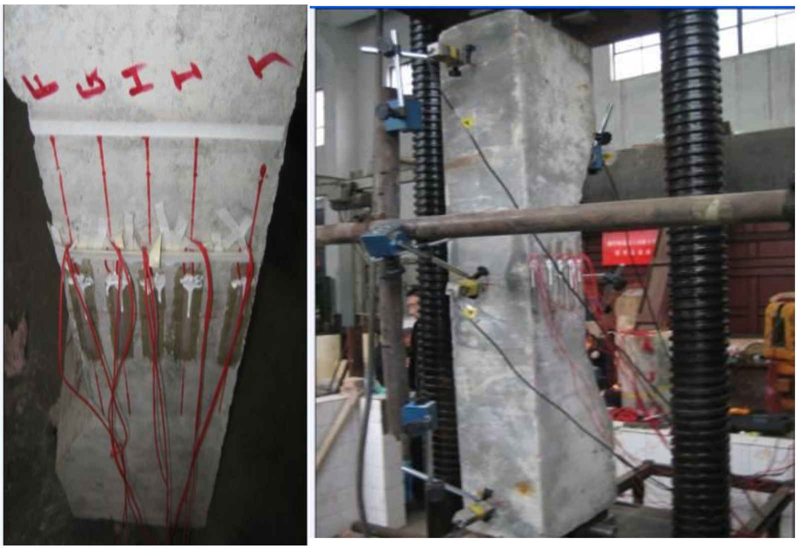


Figure 6. Displacement gauges and sensor positions on the specimen

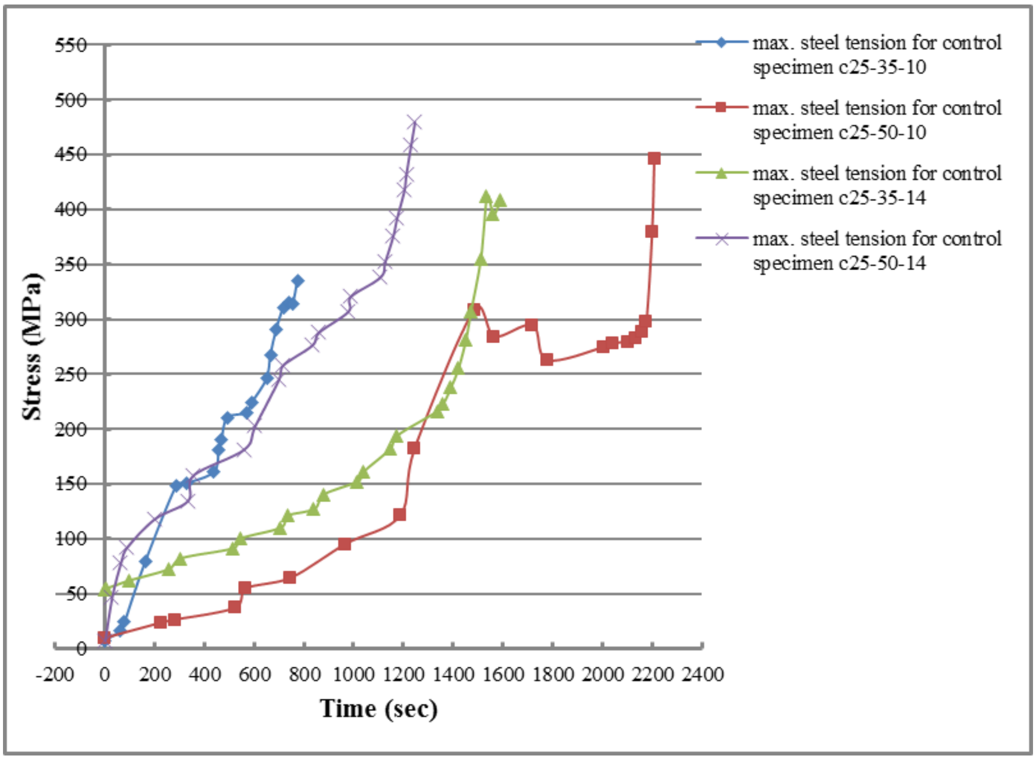


Figure 7. Steel tension stress behavior with loading time for specimen C25.

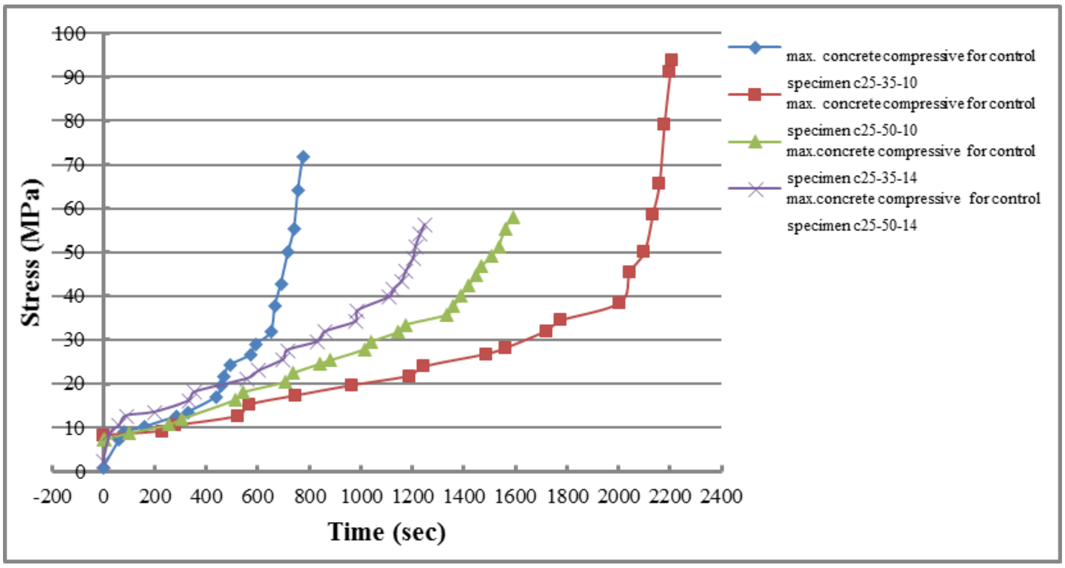


Figure 8. Concrete compressive stress behavior with loading time for specimen C25

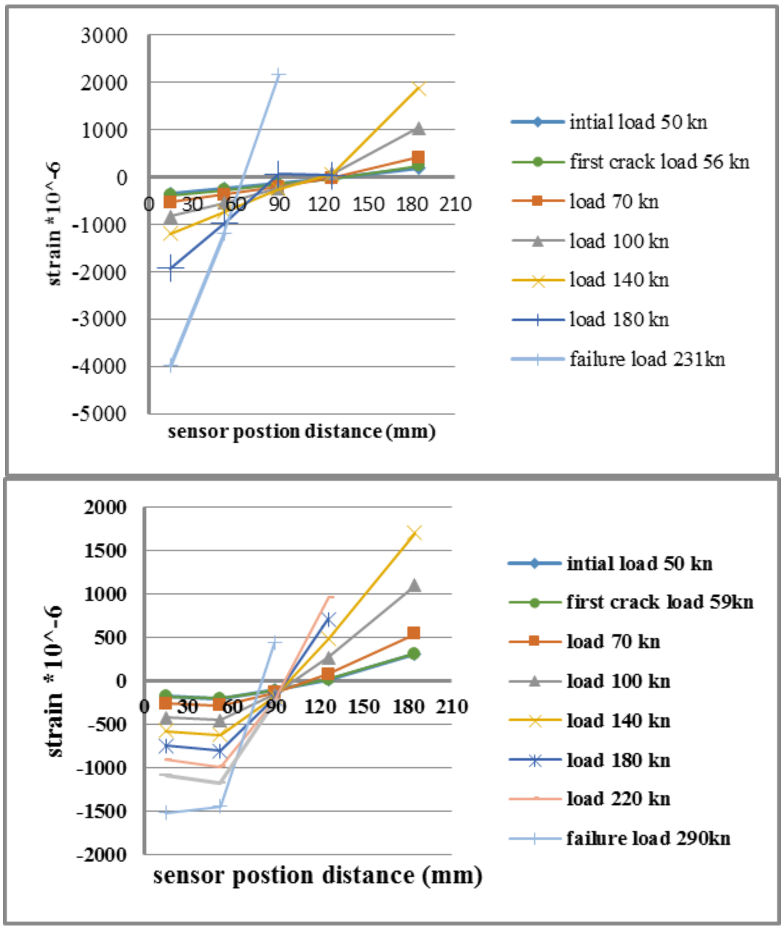
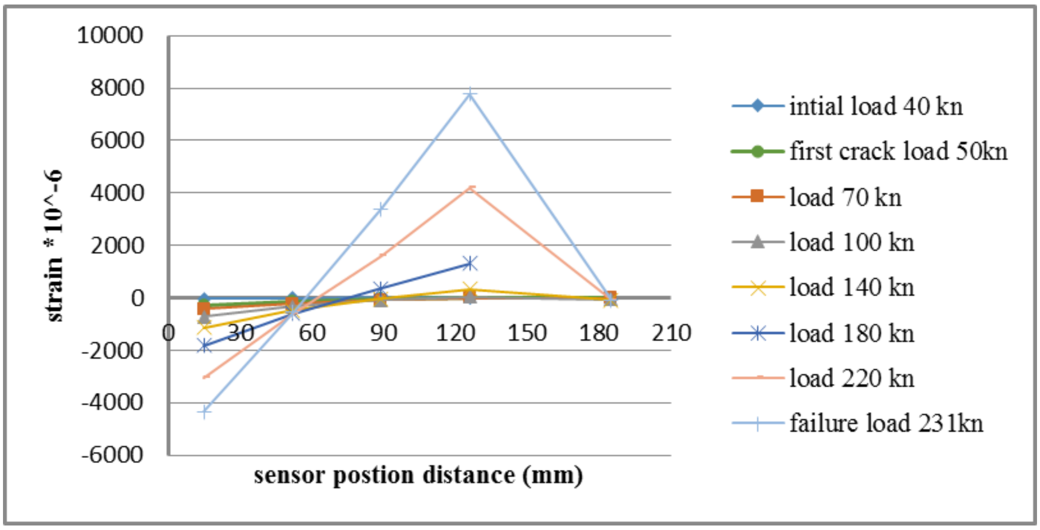


Figure 9. The strain–sensor position relationship for specimen C25-35.



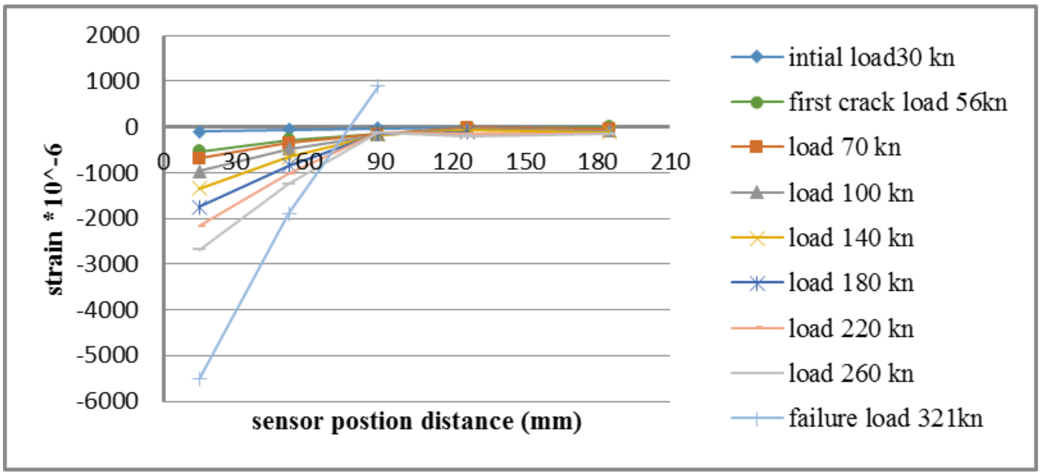


Figure 10. The strain –sensor position relationship for specimen C25-50.

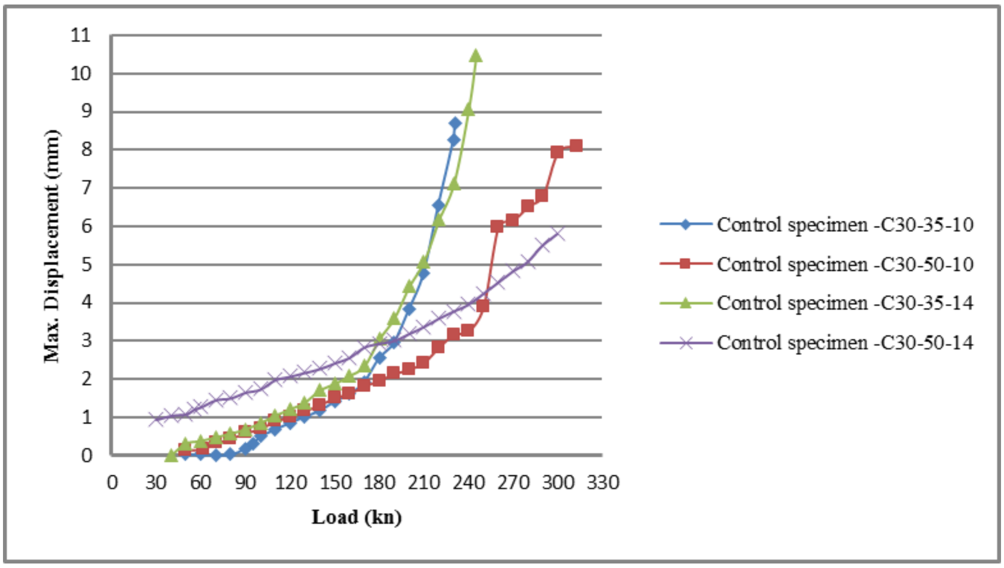


Figure 11. The Max. Displacement - Loading relation for specimenC30.

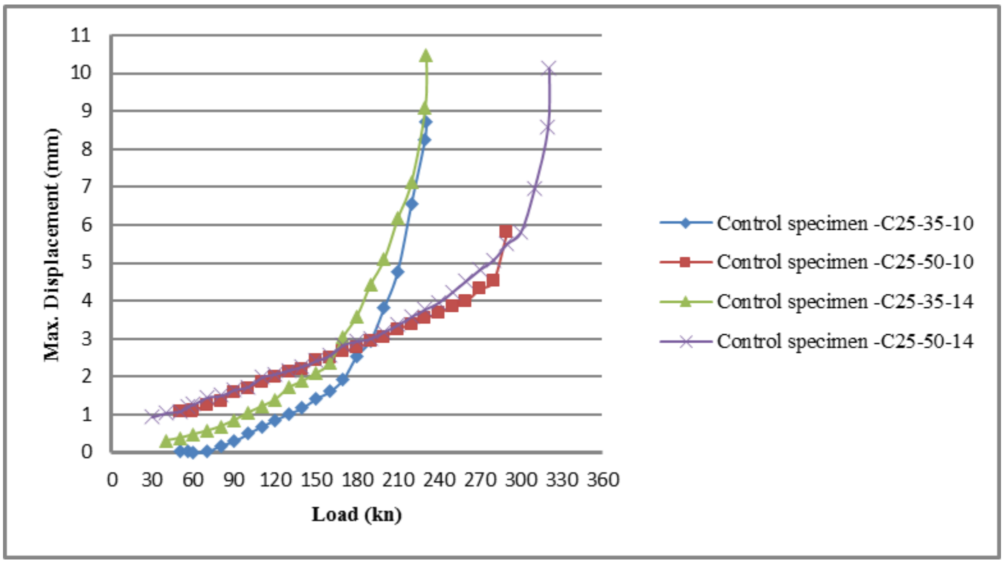


Figure 12. The Max. Displacement - loading relation for specimen C25.

دراسة عملية لسعة التحمل للأعمدة القصيرة المعرضة لأحمال لامركزية باتجاه واحد

عاصم محمد لطيف
مدرس
كلية الهندسة / جامعة تكريت

الخلاصة

تعرف الأعمدة بأنها تلك الأعضاء الإنشائية التي تتحمل بصورة رئيسية قوى الانضغاط والعزوم حول أحد أو كلا محوري مساحة المقطع. عزم الانثناء يؤدي الى توليد اجهادات الشد على جزء من مساحة المقطع. في هذا البحث تم صب أربعة وعشرين عمود موزعة على ثمان مجاميع لتحري السلوك الانشائي تحت تأثير التحميل مع تغيير أقطار قضبان حديد التسليح المستخدم، الغطاء الخرساني الصافي للقضبان العمودية ومقاومة الخرسانة، العينات صممت لتفشل نتيجة الشد. نسبة التحميل كانت تتراوح ما بين خمسة عشر الى عشرين بالمئة من الحمل التصميمي. أظهرت النتائج ان الزيادة في مقاومة الخرسانة تؤدي الى زيادة تحمل العمود، الحمل اللازم لحدوث اول تشقق ونقصان في عرض الشق. الزيادة في قطر حديد التسليح أظهرت زيادة في تحمل العمود، الحمل اللازم لحصول اول تشقق، عرض الشق ونقصان في عدد الشقوق في منطقة الشد. بينما استعمال غطاء خرساني كبير سبب زيادة في تحمل العمود، عرض الشق ونقصان في مقدار الحمل اللازم لحصول اول شق.

الكلمات الرئيسية: الاعمدة القصيرة، التحميل اللامركزي باتجاه واحد، الغطاء الخرساني، حجم حديد التسليح، حساسات الشد والانحراف.