Rehabilitation of Four Stories Concrete Building

Nihad T. Khshain
Department of Civil Engineering/ College of Engineering/ Baghdad University

Abstract

A four stories concrete building has damage in most ground floor columns and it is considered unsafe for exploitation. In this paper, a method was explained and implemented to be the solution for this problem. The technique of repair consists, enclosing the existing ground floor damage column cross-section by reinforced concrete shell, contained longitudinal steel arrange around the existing column and transverse steel (stirrups) arrange along the existing column connected together by wire, and connect the additional longitudinal and transverse steel to original reinforced concrete damaged column by shear connectors.

Finally covering with ordinary concrete. Reinforced concrete shell designed as compression member columns. By using this technique of repair, it can improve and increase the strength of ground floor columns to carry the applied loads with safety, more economic and accepted final look.

Key word: Repair of reinforced concrete columns- covering of reinforced concrete columns - reinforced concrete columns –columns.

Introduction

The building is four stories of concrete. It was built in 2004 AC. After the exploitation by six year the ground floor columns are damage as shown in Figure 1.The building was considered unsafe. In spite of the fact that the covering technique is commonly used, no reliable and sufficient test results are available on the subject, which shadows certain aspects of the technique such as the behavior and strength of the repaired member. Up to now the covering technique has been applied to respond to two different requirements: strengthening before damage, and repairing after damage. In previous test series, perimeters of the columns have been totally repair and, axial load with bending moment were applied to columns of single and, double curvature(1,2,3).

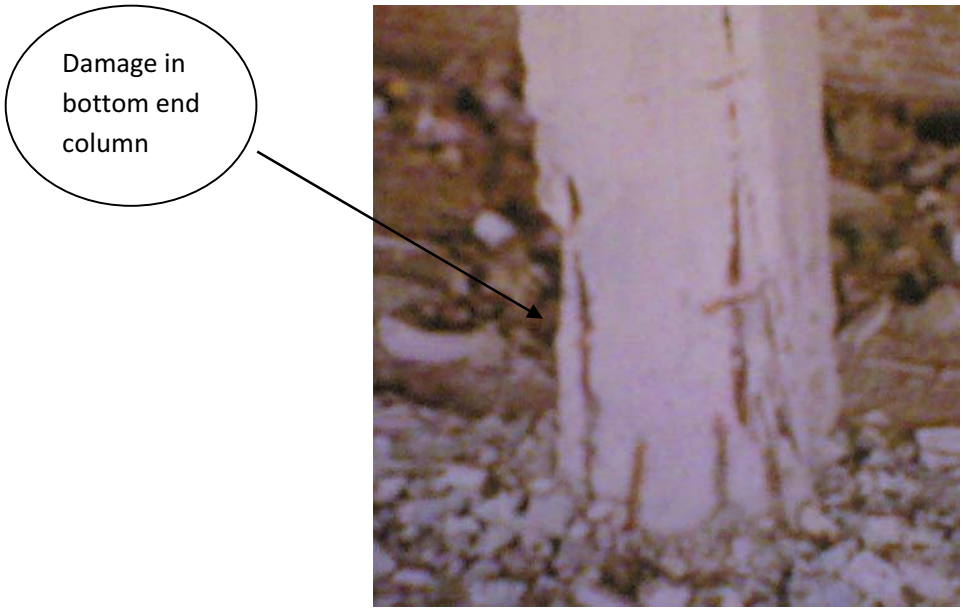


Figure (1): The interior ground floor damage column

Technique of Repairing

To check the structural failure, an investigation in design requirement for this building and a non-destructive test [Schmidt hammer test **(ASTM C805)**, and Ultrasonic pulse velocity test **(ASTM C597)**] were conducted in the reinforced concrete damaged columns in different locations for obtaining a relative value for the concrete strength; It was found that the damage in reinforced concrete columns occur due to:

1-Using of service loading above the service load limits assumed in design.

2-Using of the structure for other purposes than its in tented purpose.

3.Lesser concrete strength than assumed.

Thus, the repair of damage reinforced concrete columns can be made by increasing the columns strength.

The technique of repair is based on covering the damaged column by an additional shell consist of longitudinal steel arrange around the existing column and transverse steel (stirrups) arrange along the existing column connected together by wire, and connect the additional longitudinal and transverse steel to original reinforced concrete damage column by shear connector, finally covering with ordinary concrete, so as to increase the cross sectional area and the strength. Reinforced concrete shell designed as a compression member column (4). In this technique damage regions are removed and the buckled reinforcement bars are straightened before the application of the covering technique.

Figs (2,3) showing the repair technique which used in this paper for repair the damage in reinforced concrete ground floor columns, and Fig.4 showing the final face of the ground floor damage columns after the repair of the ground floor damage columns.

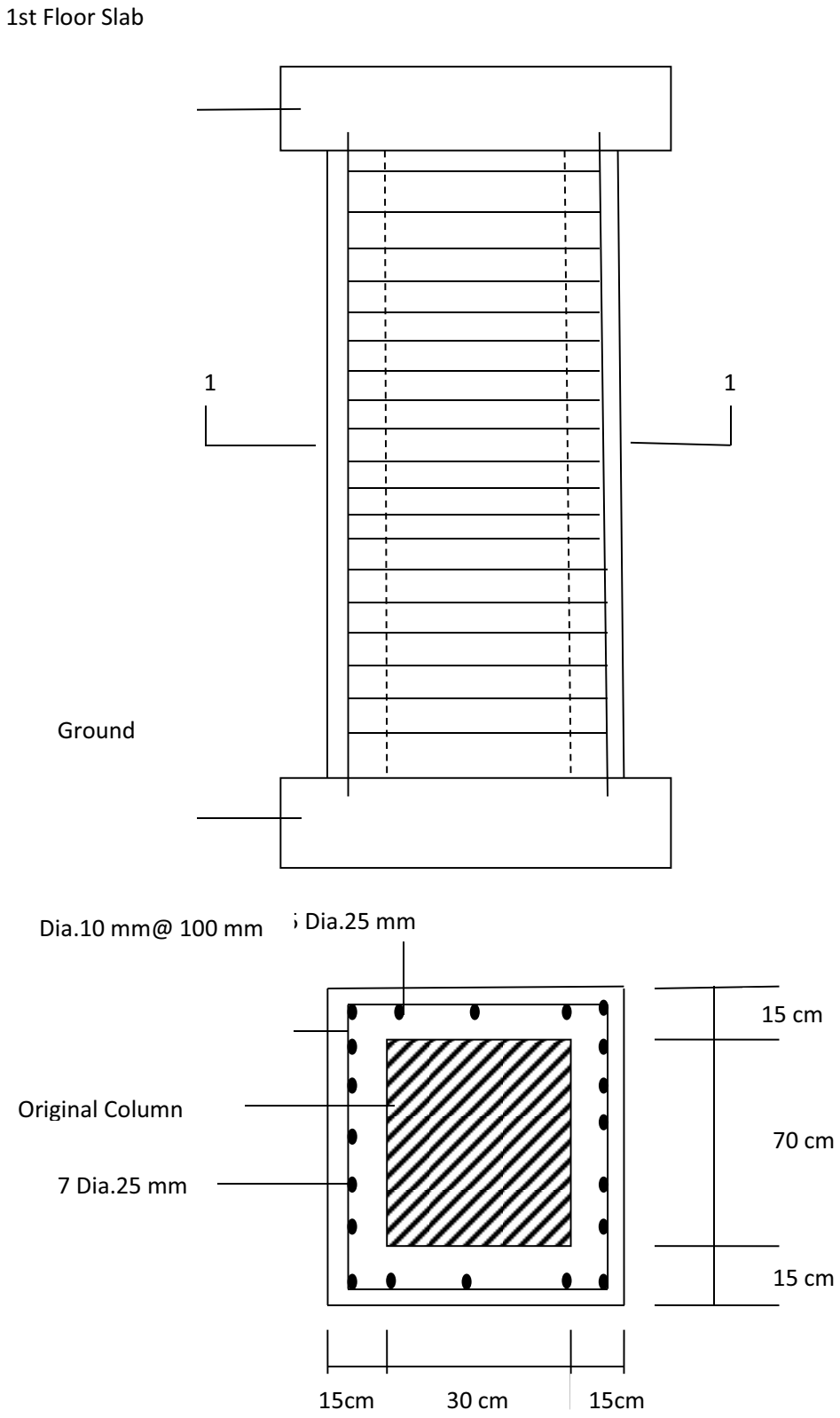


Figure (2): General view for repair technique

Figure (3): The repair technique for damage columns

Figure (4): The final face of the ground floor damage columns after the repair

Experimental work

Material Properties

The properties of materials used in any structure are of considerable importance **(5, 6)**. The properties of materials used in the current study are presented here. Standard tests according to the American Society for Testing and Materials (ASTM) and Iraqi specifications were conducted to determine the properties of materials.

Concrete

Normal weight concrete was used to cast all concrete components in this study. Mix design is based on several trial mixes in order to have the most suitable fractions of components, and it arrives at the following proportions by weight: 1 cement; 1.5 sand; 3.0 gravel, to give a 28-day cylinder compressive strength of 30 N/mm2 approximately. The water/cement ratio was 0.45 giving a slump of 80mm-100mm (medium workable mix). The mix design was according to ACI 211.1-91 **(6)**.

Cement

Ordinary Portland cement (Type I) was used in this study. The physical analysis and chemical test results for the used cement are given in Tables 1 and 2 respectively. They conform to the Iraqi specification No. 5/1984 **(7)**.

Table 1: Physical composition of cement.

Physical properties	Test results	Iraqi specification No. 5/1984 **(7)**
Fineness using Blain air permeability apparatus (m2/kg)	250	230**
Soundness using autoclave method	0.24%	0.8%*
Setting time using Vicat's instrument		
Initial (min.)	90	45**
Final (hr.)	5.5	10*
Compressive strength for cement paste cube (70.7mm) at:		
3 days (N/mm2)	9.25	5**
7 days (N/mm2)	25.5	23**

* Maximum limit . ** Minimum limit.

Table 2: Chemical composition of cement#

No.	Compound composition	Chemical composition	Weight (%)	Iraqi specification No. 5/1984 **(7)**
1	Lime	CaO	62.8	-
2	Silica	SiO2	21.44	-
3	Alumina	Al2O3	5.52	-
4	Iron oxide	Fe2O3	3.12	-
5	Magnesia	MgO	2.9	5*
6	Sulfate	SO3	2.47	2.8*
7	Loss on ignition	L.O.I	1.07	4.0*
8	Insoluble residue	I.R	0.68	1.5*
9	Lime saturation factor	L.S.F	0.83	0.66-1.02
10	Tricalcium aluminates	C3A	9.25	-
11	Tricalcium silicate	C3S	41.33	-
12	Diacalcium silicate	C2S	29.1	-
13	Tricalcium alumoma ferrite	C4AF	9.12	-

* Maximum limit.

Fine Aggregate (Sand)

Natural sand from Al-Akhaidher region in Iraq was used for concrete mixes in this study. The fine aggregate has 4.75mm maximum size with rounded-shape particles and smooth texture with fineness modulus of 2.84. The grading of the fine aggregate is shown in Table 3 and Fig.5. The obtained results indicated that the fine aggregate grading and the sulfate content were within the limits of Iraqi specification No. 45/1984 **(8)**. Table 4 shows the specific gravity, sulfate content and absorption of the fine aggregate.

Table 3 Grading of fine aggregate

No.	Sieve size	Passing (%)	
		Fine aggregate	Iraqi specification No. 45/1984 for Zone II **(8)**
1	4.75 mm	93.56	90-100
2	2.36 mm	76.77	75-100
3	1.18 mm	64.44	55-90
4	600 µm	50.47	35-59
5	300 µm	14.88	8-30
6	150 µm	2.55	0-10
7	Pan	0	-

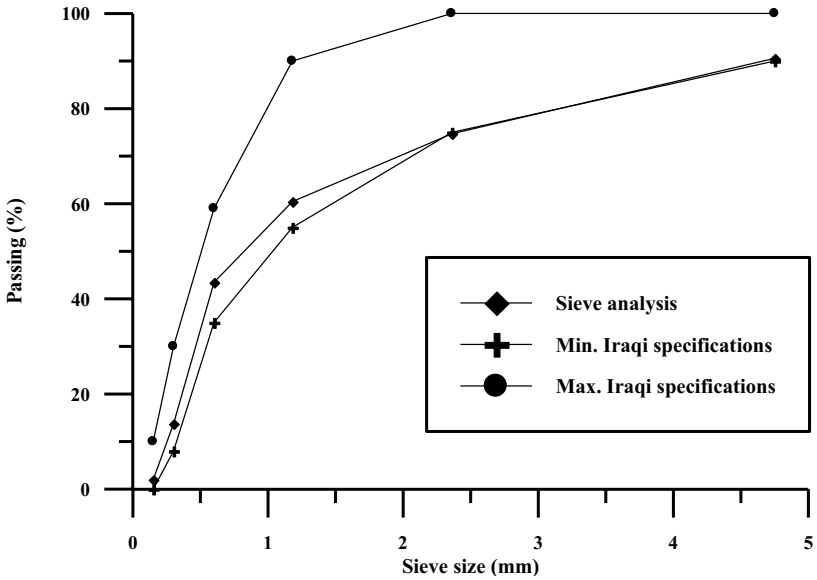


Figure (5): Sieve analysis of fine aggregate

Table 4 Physical properties of fine aggregate#

Physical properties	Test results	Iraqi specification No. 45/1984 for Zone II **(8)**
Specific gravity	2.77	-
Sulfate content	0.18 %	≤ 0.5 %
Absorption	0.77 %	-

Coarse Aggregate (Gravel)

Crushed gravel with maximum size of 14mm was used throughout this study. The specific gravity and absorption were 2.77 and 0.68% respectively. The grading of the coarse aggregate is shown in Table 5 and Fig.6 .The obtained results indicated that the coarse aggregate grading were within the requirements of Iraqi specification No. 45/1984 **(8)**.

Table 5: Grading of coarse aggregate.

No.	Sieve size	Passing (%)	
		Coarse aggregate	Iraqi specification No. 45/1984 **(8)**
1	14 mm	98.1	90-100
2	10mm	58.31	50-85
3	5mm	3.6	0-10
4	Pan	0	-

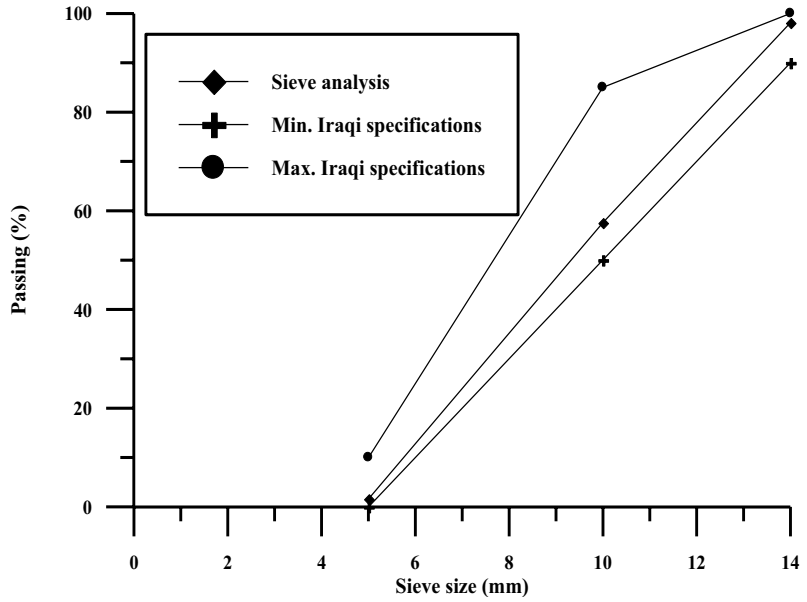


Figure (6): Sieve analysis of coarse aggregate

Reinforcement bar

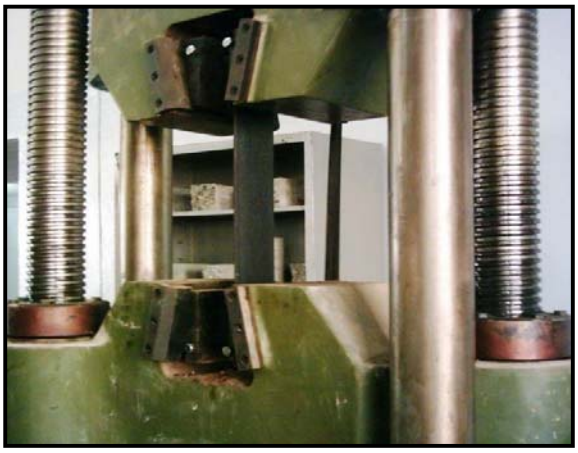
Tensile tests were conducted on several specimens, at least three specimens, prepared from the steel reinforcement bars which were used in this study. Static yield stress and ultimate strength are summarized in Table 6. All steel reinforcement, used in this study, is assumed to have a modulus of elasticity equal to 210000N/mm2. The tensile tests were performed using the testing machine available at the building material laboratory in the

College of Engineering, Al-Mustansiriya University. The load and elongation readings were obtained from a digital computer complementary with the testing machine, as shown in Fig.7.

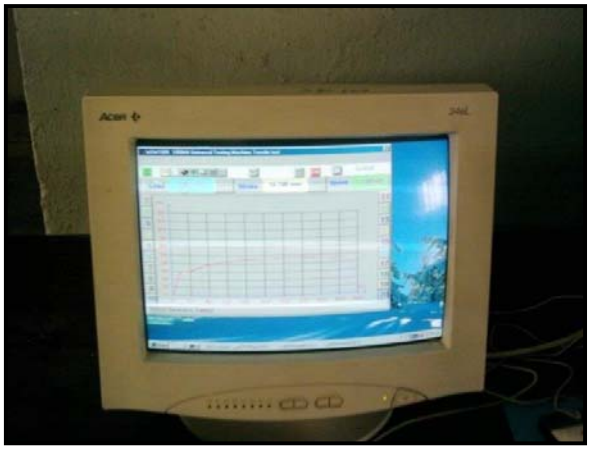
Table 6: Specifications and test results of steel reinforcement bar values.

Reinforcement bar diameter (mm)	Yield Stress fy (N/mm2)	Ultimate Strength fu (N/mm2)	Modulus of Elasticity E * (N/mm2)
10	582	683	210000
25	596	686	210000

* Assumed value.



(a)



(b)

Figure (7): Photograph of tensile steel testing machine (a) Mechanical part (b) Digital part

Conclusions

The following point can be drawn from this paper:

1. The repair technique are the best way to maintain the building from removal and it can be used again. To monitor this work and to insure the stability of the building it is suggested to install marks for monitoring and to check the safety of the building during the exploitation.
2. If partial repair must be used (for damage columns in the building edge), the existing cover of the column must be removed completely and additional ties must be placed around the column.
3. When the existing and additional transverse ties are arranged properly, confinement of concrete is increased considerably. Therefore anchorage of additional transverse ties is important from the confinement point of view.

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أعادة تأهيل بناية هيكلية خرسانية مكونة من أربعة طوابق

نهاد طارق خشين

قسم الهندسة المدنية/ كلية الهندسة/ جامعة بغداد

الخلاصة

بناية هيكلية خرسانية ذات أربعة طوابق تعرضت أعمدتها بالطابق الأرضي إلى تدهور وتلف وسقوط الغطاء الخراساني لمعظم الأعمدة واعتبرت غير أمينة لإشغالها. تم في هذه الدراسة عرض طريقة إنشائية للمعالجة تمثلت بتغليف الأعمدة الخراسانية المتضررة بالخرسانة المسلحة، باستخدام هذا الأسلوب بالمعالجة فان مقطع العمود الأصلي المتضرر يتم أحاطته بهيكل خراساني مسلح بحديد تسليح طولي يتوزع على محيط العمود الأصلي وحديد تسليح أفقي(اتاري) منتشر على طول العمود الأصلي موزع بمسافات معينة حسب التصميم، ويرتبط حديد التسليح الإضافي الطولي والأفقي بالعمود الأصلي المتضرر بواسطة مسامير قص. تم تصميم الهيكل الخرساني المسلح كعنصر انضغاط لتحسين تحمل الأعمدة المتضررة.
نتائج العمل والإنشاء بينت بان طريقة المعالجة ناجحة ولم تظهر أي تشققات جديدة حيث تم تحميل البناية بعد استكمال المعالجة ومنذ سنة حتى كتابة هذه الدراسة وقد تم استكمال الانهاءات بها. والآن المبنى يستخدم بشكل كامل وبأمان تام، وبكلفة اقتصادية مناسبة ومظهر نهائي مقبول من الناحية المعمارية.