

Behavior and Flexural Strength of Ferrocement One Way Slabs With Square Openings

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ABSTRACT

The paper presents experimental results of nine ferrocement one way slabs with openings subjected to two point loads taking into consideration number of mesh layers and size of the openings as variables.

The results showed that by increasing number of mesh layers the slabs' flexural strength increased and size of the openings have negative effect on flexural strength of the slabs.

Finally emperical equations are suggested to calculate cracking and ultimate loads in terms of width of the openings and number of mesh layers and the results showed good agreement with experimental values.

INTRODUCTION

Ferrocement is a term given by "Nervi" to describe a thin slab which consists of portland cement mortar reinforced with multiple layers of steel wire mesh on both sides of the slab, usually with steel reinforcing bars called skeletal steel sandwiched in the middle of the slab (1).

Ferrocement has many advantages over conventional reinforced concrete, such as improvement in tensile and flexural strengths, ductility, impact resistance and crack arresting properties (2,3). Although the concept of ferrocement is almost as old as reinforced concrete, the real developement took place in recent years. The mechanical properties, and hence the technical information are now fairly well established (4,5,6). This has given an impetus to its application in various structures and structural elements such as boats, shell and folded plate structures, silos, water tanks (7,8), slabs (9,10) etc.

The present study was primarily aimed to study experimentally the behavior and flexural strength of ferrocement one way slabs with square openings under two point loads taking into consideration number of wire mesh layers and size of the openings as variables.

EXPERIMENTAL WORK

The experimental work consisted of casting nine ferrocement one way slabs of dimensions 25x300x750 mm. The slabs were divided into three groups according to the size of openings. Each group consists of three slabs reinforced with 0, 4 and 7 layers of wire mesh. Group one has no openings while group two contains 30x30 mm openings and group three contains 60x60 mm openings, see Table 1.

Ordinary portland cement (type 1) within Iraqi specifications and natural sand of 2.6 mm maximum size were used for the mortar. The mix proportions were 1:2 [cement- sand (by weight)] and the water/cement ratio of 0.55 by weight. Galvanized Hexagonal woven wire meshes of yield strength 310 Mpa were used. The geometry and dimensions of the mesh are shown in Fig. (1).

Four cylinders 100x200 mm and two prisms 75x75x400 mm were also casted with each slab in order to determine the compressive, splitting tensile and flexural strengths of the mortar.

The slabs were casted in a wooden mould in three layers and each layer was compacted on a large vibrating table. Two days later the specimens were demoulded and after 28 days curing in water the slabs were tested under two concentrated loads using a hydraulic jack of 10 tons maximum capacity. The dimensions and loading arrangement of the specimens are shown in Fig.(2). Position of the opening is shown in Plate1.

TEST RESULTS AND DISCUSSION

Behavior of the Slabs:

The load- deflection curves of the three groups of slabs are presented in Figs. 3 , 4 and 5 . It can be seen that the slabs behaved in an elastic manner at early stages of loading. The slope of this initial straight portion of the curve, which is a measure of uncracked stiffness, depends significantly on size of the openings and number of wire mesh layers.

At early stages of loading the deflection increased by increasing size of the openings and decreasing number of wire mesh layers, but at ultimate stage the deflection increased with increasing number of mesh layers.

First Cracking Load :

The load at first crack was affected primarily by the size of openings. The results showed by increasing size of the openings from 0 to 30x30 mm the load at first crack decreased by 17.50% and 11.11% for slabs reinforced with 0, 4 and 7 layers of wire mesh, respectively. While by

changing size of the opening from 0 to 60x60 mm the load at first crack decreased by 25.00%, 18.60% and 20.00%, see Table 1 and Fig. 6.

The results also showed the load at first crack was affected by number of mesh layers. When the number of mesh layers varied from 0 to 4, the first cracking load increased by 7.50%, 12.12% and 16.67% for solid slabs and slabs with 30x30 mm and 60x60 mm openings, respectively. While by increasing the number of mesh layers from 0 to 7, the load at first crack increased by 12.50%, 21.21% and 20%, see Table 1 and Fig. 7.

Ultimate Load Capacity:

As for cracking load the ultimate load decreased by increasing size of the openings. When the size of the openings varied from 0 to 30x30 mm, the ultimate load decreased by 17.50%, 14.28% and 11.11% for slabs reinforced with 0, 4 and 7 layers of wire mesh, respectively. While by increasing size of the openings from 0 to 60x60 mm the ultimate load capacity decreased by 25.00%, 18.57% and 16.67%, see Table 1 and Fig. 8. The results also showed that by increasing number of mesh layers from 0 to 4, the ultimate load increased by 75.00%, 81.81% and 90.00% for solid slabs with 30x30 mm and 60x60 mm openings, respectively. While by increasing number of mesh layers from 0 to 7 the ultimate load increased by 125%, 142.42% and 150%, see Table 1 and Fig. 9.

ANALYSIS OF RESULTS

A simple relation in the form of:-

$$Y = a_0 + a_1 x_1 + a_2 x_2 \dots \dots (1)$$

was proposed where:-

Y= Predicted value of cracking load (P_{cr}) or ultimate load (P_u), kN,

x_1 = Side length of the openings, mm,

x_2 = Number of wire mesh layers and

a_0 , a_1 and a_2 are constants to be determined.

By applying the least- square principles (11), the error function is:-

$$E = \sum_{1}^n (Y - y)^2 \quad \dots \dots (2)$$

Where:-

E: Error function,

y: Experimental value of P_{cr} or P_u in kN and

n= Number of tested slabs.

The error function can be written as:

$$E = \sum_{i=1}^n (a_0 + a_1 \cdot x_1 + a_2 \cdot x_2 - y)^2 \quad \dots(3)$$

The error function (E) will then be minimized to find the value of the constants such as:

$$\frac{\partial E}{\partial a_0} = 0 \quad \dots(4)$$

$$\frac{\partial E}{\partial a_1} = 0 \quad \dots(5)$$

$$\frac{\partial E}{\partial a_2} = 0 \quad \dots(6)$$

This leads to a set of simultaneous equations which can be written in a matrix form:-

n	$\sum x_1$	$\sum x_2$	a_0	$\sum y$
$\sum x_1$	$\sum x_1^2$	$\sum x_1 x_2$	a_1	$\sum y x_1$
$\sum x_2$	$\sum x_1 x_2$	$\sum x_2^2$	a_2	$\sum y x_2$

These equations were solved and the following relations were found:-

$$P_{cr} = 1.9078 + 0.0073x_1 + 0.0432x_2, \text{ correlation coeff.} = r = 0.98 \quad \dots(8)$$

$$P_u = 1.9693 + 0.0097x_1 + 0.3407x_2, \text{ correlaton coeff.} = r = 0.997 \quad \dots(9)$$

Theoretical results obtained from equations 8 and 9 showed good agreement with those obtained from tests, see Fig. 10 and 11.

CONCLUSIONS

Based on the experimental tests concluded in the present study the following conclusions can be drawn:-

1. The load- deflection curve of one way forrecement slabs at early stages of loading is nearly a straight line and the slope which is a measure of uncracked stiffness decreased by increasing size of the openings and decreasing number of mesh layers.
2. The load at first crack and the ultimate load of the slabs decreased significantly by increasing size of the openings and increased by increasing number of mesh layers.

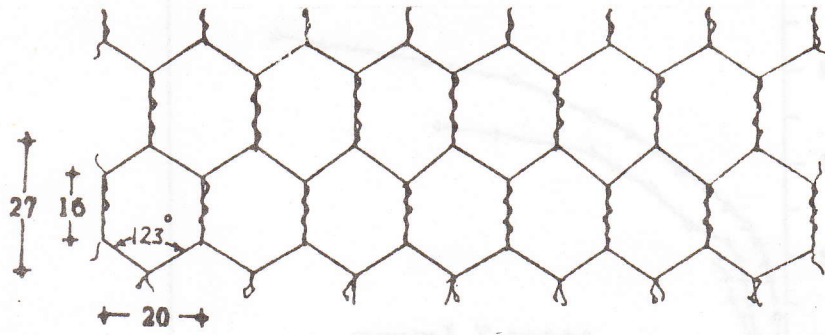
3. The effect of number of mesh layers on first cracking load and ultimate load capacity are more pronounced when the sizes of the openings are increased.
4. Empirical equations are proposed to calculate cracking load (P_{cr}) and ultimate load capacity (P_u) depending on the dimensions of the openings and number of wire mesh layers and the results showed good agreements with experimental values.

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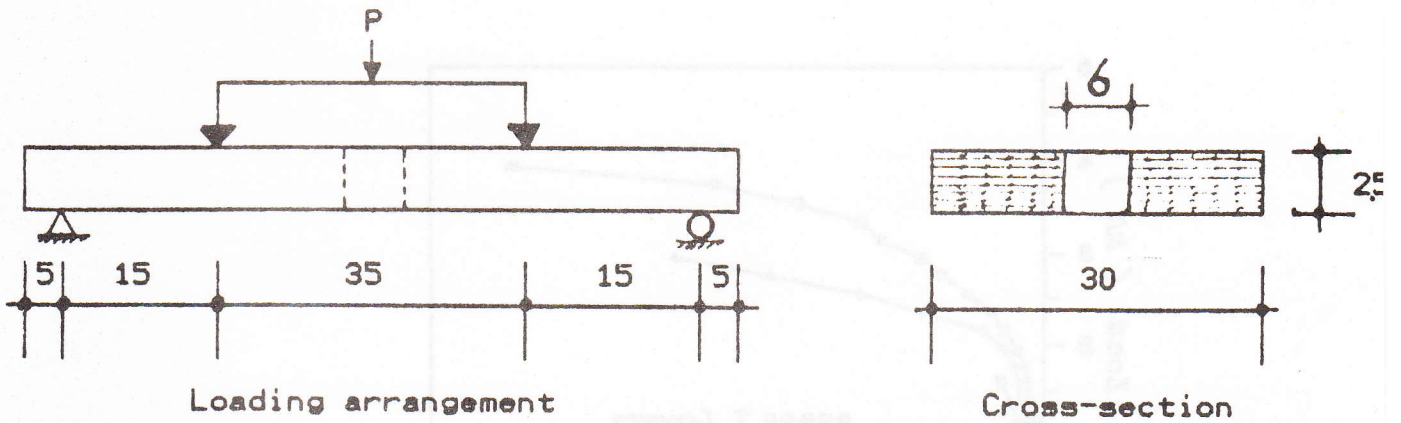
Table (1) : Experimental Program and Results .

Group No.	Slab No.	Size of Open.	No. of Layers	fc MPa	fsp MPa	fr MPa	Pcr KN	Pu KN	%Decr. Pcr	%Incr. Pcr	%Decr. Pu	%Incr. Pu
One	S10	-----	0	42.0	3.1	4.7	1.96	-----	-----	-----	-----	-----
	S11	-----	4	42.2	3.9	4.7	2.11	-----	-	-----	-----	-
	S12	-----	7	40.0	3.7	4.9	2.21	3	-----	7.50	-----	75.00
Two	S20	30*30	0	40.0	3.7	4.9	1.62	1	17.50	-----	17.50	-----
	S21	30*30	4	42.2	3.9	4.7	1.81	2	13.95	-	14.28	-
	S22	30*30	7	42.0	3.1	4.7	1.96	4	11.11	12.12	11.11	81.81
Three	S30	60*60	0	44.0	4.0	5.2	1.47	2	25.00	-----	25.00	-----
	S31	60*60	4	44.0	4.0	5.2	1.72	7	18.60	-	18.57	-
	S32	60*60	7	42.5	4.2	4.7	1.77	9	20.00	16.67	16.67	90.00
								8		20.00		150.00



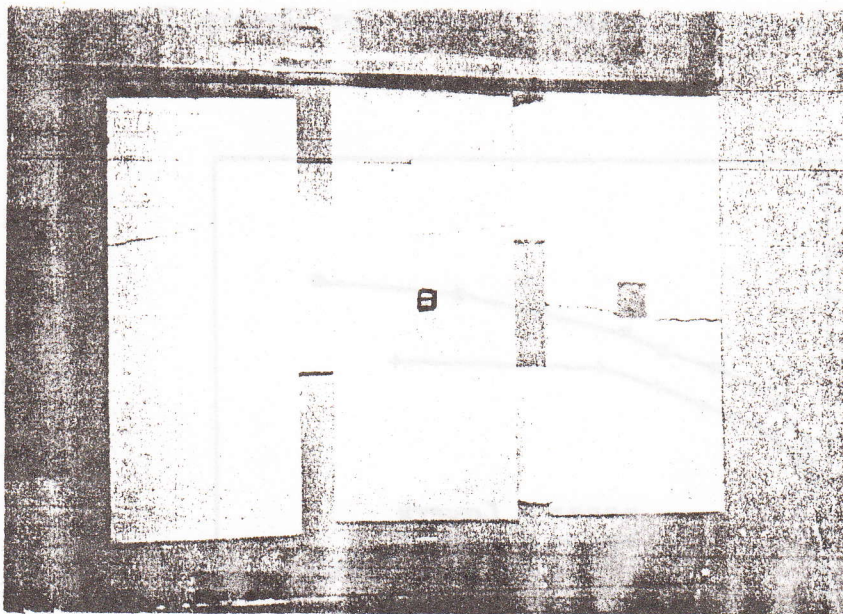
All dimensions are in mm
 Wire diameter = 0.7 mm

Fig.(1): The Geometry and Dimensions of the Wire Meshes



All dimensions are in cm

Fig.(2): The Dimensions and Loading Arrangement of Tested Slabs



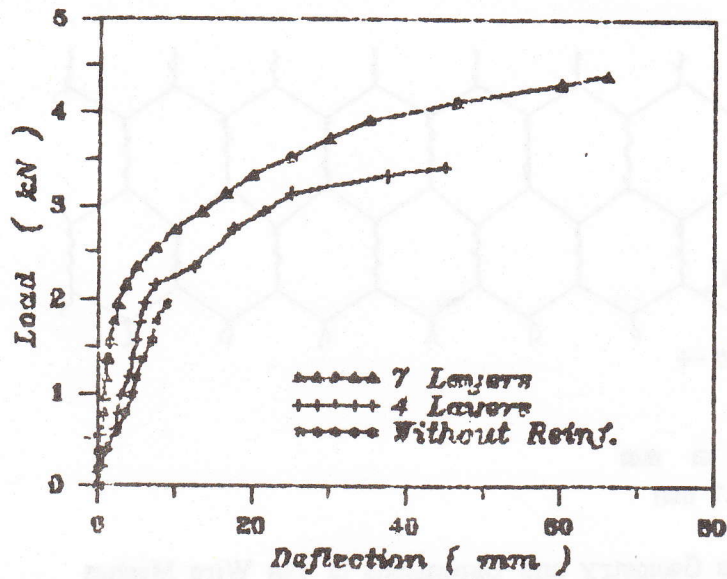


Fig.(3): Load-Deflection Curves for Group One

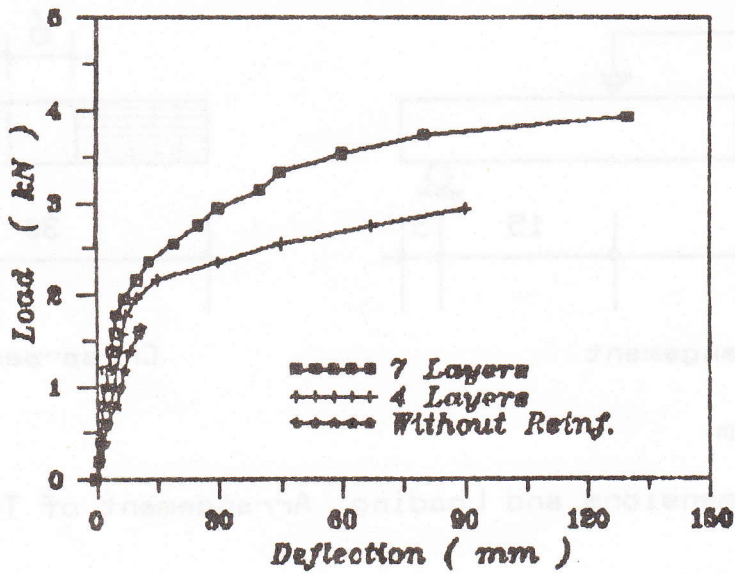
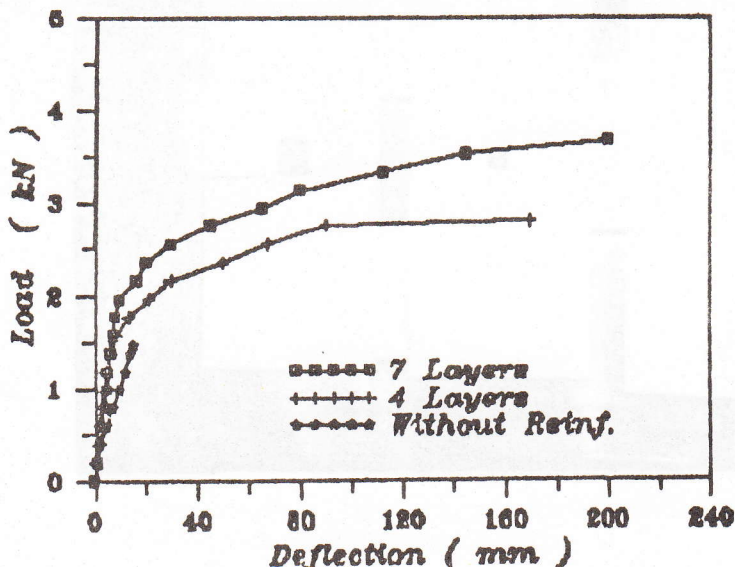


Fig.(4): Load-Deflection Curves for Group Two



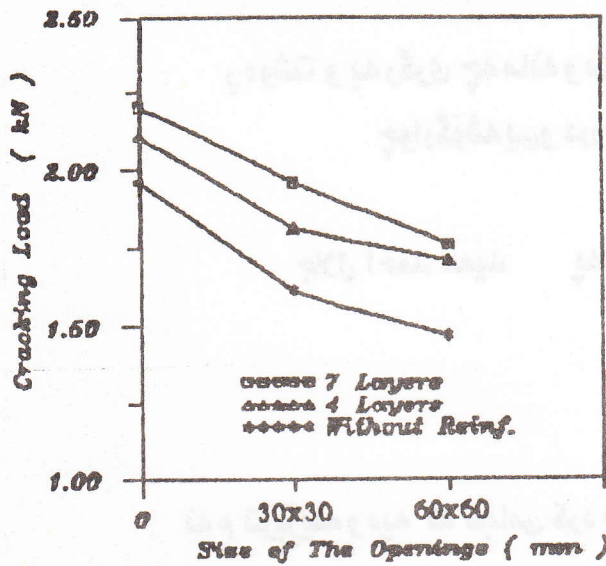


Fig.(6): Effect of Openings on Cracking Load

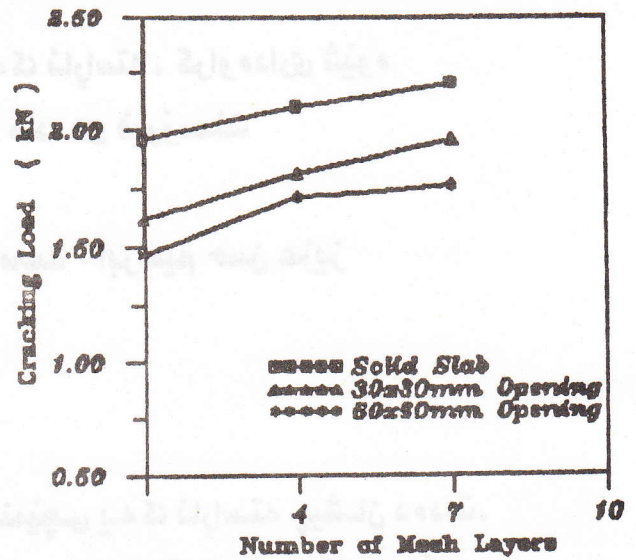


Fig.(7): Effect of Number of Mesh Layers on Cracking Load

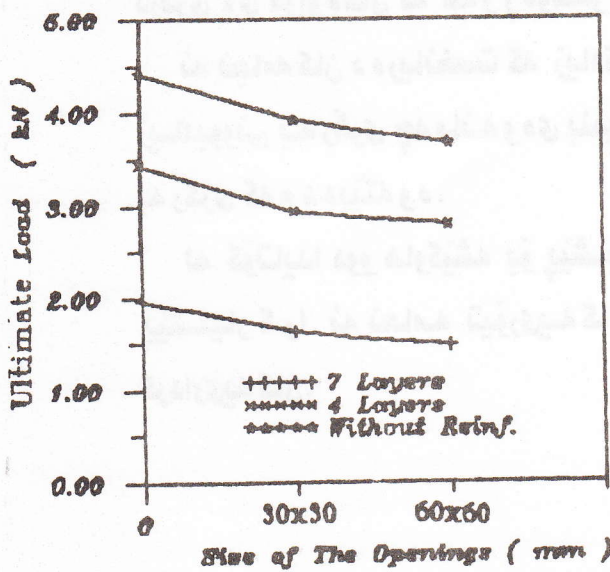


Fig.(8): Effect of Openings on Ultimate Load

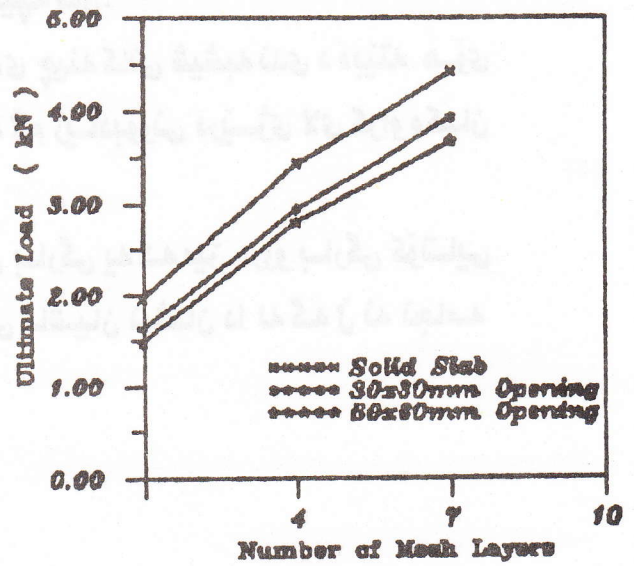
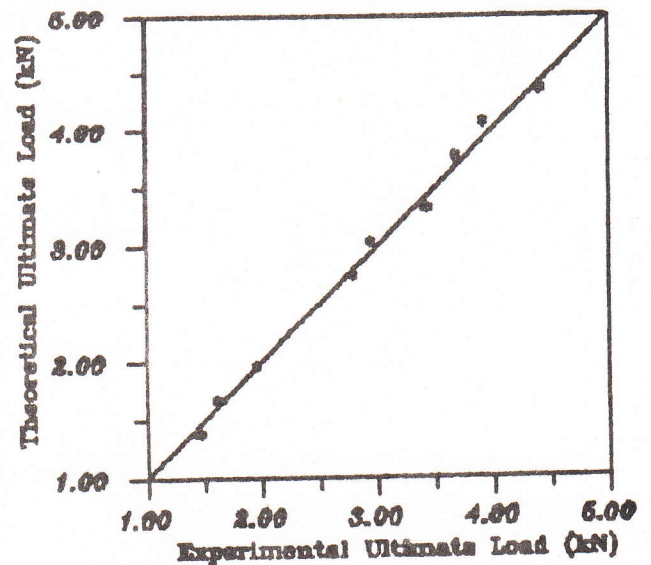
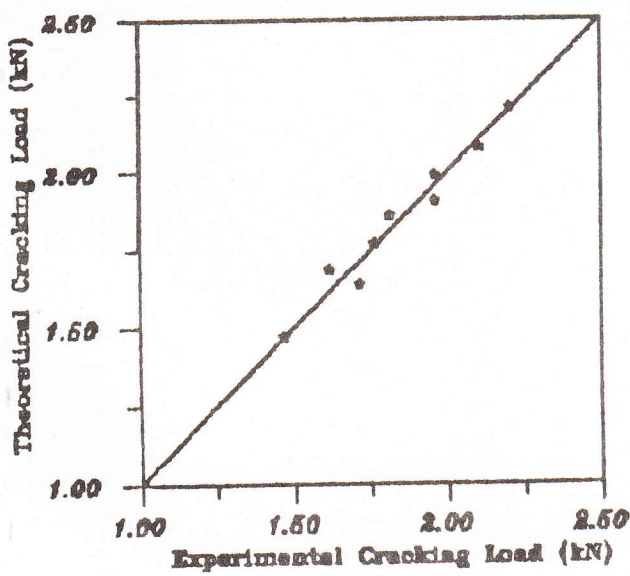


Fig.(9): Effect of Number of Mesh Layers on Ultimate Load



رەوشت و بەرگری چه مانه وهی بنمیچی یه ک ناراسته ، کراوه داری شیوه
چوارگۆشه یی و دروست کراو له ماده هی فیروسمنت

جلال احمد سعید په یمان حسن محمد ابراهیم حسن عزیز

کورتە

نه م توێژینه وهیه نه نجامی کرده وهی نو بنمیچی یه ک ناراسته پیشان ده دات،
نه م بنمیچانه کراوه دارن له ناوه راستاو دروست کراون له فیروسمنتو له ژیر کاریگه ری
دوو بارگه دان بو مه به سستی دیاری کردنی کاریگه ری ژماره ی چینه کانی شیشه ندی و
دریژی لای کراوه کان له سه ره وشتو به رگری بنمیچه کان.

نه نجامه کان ده ریانخست که زیاد کردنی ژماره ی چینه کانی شیشه ندی ده بیته هوی
زیاد بوونی به رگری چه مانه وهی بنمیچه کان به لام زیاد بوونی دریژی لای کراوه کان
به رگری که م ده بیته وه .

له کوتایدا دوو هاوکیشه بو پیشبینی کردنی بارگی یه که مین درزو بارگی کوتایی
پیشنیار کرا. نه نجامه تیوری یه کان نزیکیه کی باشیان نشان دا له گه ل نه نجامه
کرداری یه کان.

السلوك والمقاومة الانثنائية لبلاطات فيروسمنت باتجاه واحد والحاوية على فتحات مربعة

جلال احمد سعيد ييمان حسن محمد ابراهيم حسن عزيز

الخلاصة

يقدم البحث نتائج فحوص مختبرية لتسع بلاطات فيروسمنت باتجاه واحد والحاوية على فتحات مربعة وتحت تأثير حملين مركزين اخذا بنظر الاعتبار عدد طبقات المشبك الفولاذي ومساحة الفتحات المربعة كمتغيرات . بينت النتائج بان زيادة عدد المشبكات تزيد من المقاومة الانثنائية وان زيادة مساحة الفتحات لها تأثير سلبي على المقاومة الانثنائية .

كما وقدمت معادلات تجريبية لحساب حمل التشقق والحمل القصوى للبلاطات بدلالة عرض الفتحات وعدد المشبكات واطهرت النتائج توافقا جيدا مع نتائج الفحوص .