

## PREFACE

اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ مِثْلُ نُورِهِ كَمِثْلِ شَجَرَةٍ فِيهَا مِصْبَاحٌ  
فِي زُجْجَةٍ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ  
لَا شَرْبِيَّةٍ فِيهَا لَئِنْ لَمْ تَمْسَسْهُ نَارٌ نُورٌ عَلَى نُورٍ يَهْدِي اللَّهُ  
مَنْ يَشَاءُ وَيُضِلُّهُمُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ

سورة النور 35

## DEDICATION

إلى رمز السعادة في البلاد ،،  
إلى من للتقدم خير هادي ،،  
إليك مع التواضع يا ملاذي ،،  
أقدم ما يطيب له فؤادي ،،  
قصائد لم تكن لولاك تهدي ،،  
ولم يك ربما لولاك هادي ،،  
فإن تقبل وذا أمني وقصدي ،،  
أصير موقراً في كل نادي ،،  
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إلى أمي وأبي ،،  
إلى إخوتي وأخواتي ،،  
أصدقائي ،،  
إلى الأخ الفقيه أحمد بابكر عبدالرحمن ،،

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## **ABSTRACT - ENGLISH**

Reinforced concrete buildings comprises majority of buildings in urban areas. In reinforced concrete slabs the major challenge occurs when high dead-weight of concrete restricts the span length and thus longer spans are not feasible with normal construction practices.

It is a known fact that excellent concrete molding capability and various innovations over the past few years on maximizing the material utilization led to development of ribbed one way, two way and pre-stressed slabs.

In this study a comparison of materials quantity of waffle slabs and flat slabs has been carried out. For analysis purpose slabs are modeled in computer program SAFE V.12 and the output results obtained from the analysis are compared with the manual analysis results and then used in manual design. In this study a square slab of 6×6 m panels is modeled for both waffle and flat slab under the same loading conditions and using the same construction material. The models are used to study parameters like maximum deflection, maximum bending moment and punching shear resistance.

The amount of concrete and reinforcement required in slab signify the superiority of waffle slab over flat slab and consequently can be employed in various applications as an economical alternative for flat slab.

## ABSTRACT - ARABIC

تشكل المباني الخرسانية الغالبية العظمى من المباني في المناطق الحضرية. للبلاطات الخرسانية المسلحة يكمن التحدي الرئيسي في تقيّد طول بحر البلاطة بالوزن الميت الكبير للخرسانة وبالتالي تكون الأبحر الطويلة غير مجدية في ممارسات البناء العادية.

من المعلوم أن الإبتكارات المختلفة خلال السنوات القليلة الماضية لزيادة إستغلال المواد وكذلك المقدرة على صب الخرسانة بصورة ممتازة أدت إلى تطور البلاطات المعصبة ذات الإتجاهين وذات الإتجاه الواحد والبلاطات سابقة الإجهاد.

في هذه الدراسة تم عمل مقارنة من ناحية الكميات لبلاطة مسطحة وبلاطة معصبة في إتجاهين. لتحليل البلاطات تم استخدام برنامج الحاسوب "SAFE" وتمت مقارنة النتائج المتحصل عليها من التحليل مع نتائج التحليل اليدوي ومن ثم تم استخدام نتائج التحليل باستخدام الحاسوب في التصميم اليدوي لكل من البلاطتين. في هذه الدراسة تم نمذجة بلاطة مربعة بأبحر 6×6 م لكل من البلاطة المسطحة والمعصبة تحت نفس ظروف التحميل ونفس مواد التشييد. من خلال النماذج تمت دراسة كل من الترخيم وعزوم الانحناء القصوى ومقاومة القص الثاقب في البلاطات.

نتائج كميات الخرسانة وحديد التسليح المطلوبة تفيد بتفوق البلاطة المعصبة على البلاطة المسطحة وبناء على ذلك يمكن استخدامها في التطبيقات المختلفة كبديل إقتصادي للبلاطة المسطحة.

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## TABLE OF NOTATIONS AND ABBREVIATIONS

### Roman upper case letters

A	Area
$A_s$	Area reinforcement steel
E	Young's modulus
I	Moment of inertia
$M_x$	Bending moment in x-direction
$M_y$	Bending moment in y-direction
P	Point load
V	Shear force

### Roman lower case letters

b	Width
$d$	Effective depth of cross—section
$h$	Height
$k$	Structural stiffness
$l$	Length
$q$	Distributed load
$s$	Space between reinforcement bars
$u$	Displacement.
$F_{cu}$	Characteristic compressive strength of concrete
$f_y$	Yield stress

### Greek lower case letters

$\beta$	Moment distribution factor.
$\epsilon$	Strain
$\phi$	Diameter

$\nu$  Poisson's ratio

## Abbreviations

DOF	Decreases of Freedom
FEM	Finite Element Method
FD	FEM-Design
SM	Strip Method
YL	Yield Line Theory