LIST OF TABLES

NOTATION

The letter symbols used in this thesis are defined when they are first introduced. However, the symbols, which are frequently used, are defined below:

α_1 = Coefficient represents the effect of the form of the bars assuming adequate cover.
α_2 = Coefficient represents the effect of concrete cover.
α_3 = Coefficient represents the effect of confinement by transverse reinforcement.
α_5 = Coefficient represents the effect of the pressure transverse to the plane of splitting along the design anchorage length.
Δf_s= Change of steel stress over unit length.
$\sum 0$ = Nominal surface area of a bar of unit length.
μ= Ratio of longitudinal reinforcement.
A_b = Nominal bar area.
$A_{brg} = A_n = A_{nh}$= Net bearing area of head.
A_{gh}= Gross head area.
A_{no} = Basic failure surface area.
A_s = Area of steel reinforcement.
A_{tr} = Total area of transverse reinforcement within the spacing, s.
b = the width of the section.
c = Minimum cover dimension, measured to bar center.
C_1 = Minimum edge distance.
C_1 = The edge distance.
c_2 = Minimum cover dimension, measured in direction orthogonal to c.
C_2 = Minimum orthogonal edge distance.
c_b= Minimum spacing or cover dimension.
$d^/$ = The distance from the face of the column to centroid of the column longitudinal reinforcement closest to face.
d_b = The bar diameter.
d_{cs}= Spacing or cover dimension.
f_{bd}= The design value of the ultimate bond stress.
f_{bu}= The bond stress.
f_c = Concrete compressive stress.
$f_c^/$= Compressive strength of concrete cylinder.
f_{ctd} = The design value of concrete tensile strength.
f_{cu} = Concrete cube compressive strength.
f_s = The design stress in the bar.
f_u = Tensile strength of bar.
f_u = Ultimate bar stress.
f_y = Yield stress of reinforcement.
f_{yt} = Yield stress of transverse reinforcement being developed.
h_d = Embedment depth.
k_1 = The bar location factor.
k_2 = Coating factor.
k_3 =The concrete density factor.
k_4 = The bar size factor.
k_{tr} = Transverse reinforcement index.
L_d = Required embedment length.

l_{dt} = Development length for headed deformed bars in tension.
$L_{o,\ min}$ = The minimum lap length.
L_o= Lap splice length.
N = Bearing strength capacity.
n = Number of bars or wires being developed along the plane of splitting.
NR= Not Recorded.
NY= No Yield was recorded.
P = Jack applied load.
P_{cr} = Load at first visible flexural crack at mid-span.
P_{crh} = Load at first visible flexural crack at head of bar.
P_u = Anchorage capacity.
P_u = Blowout capacity.
P_u = Ultimate load.
P_Y = Load at which flexural steel yields.
q= Change of bar force over unit length.
s = Maximum spacing of transverse reinforcement within L_d, center-to-center.
α = Represents end bar conditions (straight or end hook).
α = Confining reinforcement factor.
β = Cover size factor.
β = Represents bar type coefficient (plain or deformed).
γ = Anchorage condition factor.
ε_{cr} = Strain at first crack load.
ε_{crh} = Strain at first crack load at head.
ε_{cu} = Ultimate concrete Strain.
ε_s = Tensile strain of steel.
ε_u = Strain at failure load.
ε_y= Yield strain of steel.
η_1 = Coefficient related to the quality of the bond condition and the position of bar.
η_2 = Coefficient related to the bar diameter.
λ = Lightweight aggregate concrete factor.
φ_b = (πd_b) is a bar perimeter.
Ψ = Radial disturbance factor.
Ψ_e = Factor used to modify development length based on reinforcement coating.
Ψ_s= Reinforcement size factor.
Ψ_t = Reinforcement location factor.

ABSTRACT

The main objective of this thesis was to study the behavior of headed bars with lap splices in tension zones in reinforced concrete slabs. The effect of several variables affecting the behavior of flexural members with lap splice in tension was studied. The experimental program was carried out at the Reinforced Concrete Laboratory, Faculty of Engineering, Alexandria University. The experimental study consisted of nine simply supported reinforced concrete one-way slabs. All tested slabs had the same dimensions (2400 mm x 1000 mm x 120 mm), the same longitudinal reinforcement ratio (μ= 0.413%). The thickness of clear concrete cover from bottom, side cover, and relative head area were kept constant as 20 mm, 60 mm, and 6.91 respectively. All slabs were tested using four lines loading, until failure occurred. The main studied variables were:

1- Lap splice length (15, 27, and 45 times the bar diameter, d_b).
2- Confinement in the lap splice zone; two kinds of confinement were used. These include transverse embedded beams with stirrups and circular spiral stirrups around the spliced bars, with a constant lap length of 15 times the bar diameter (d_b).
3- Effect of debonding the spliced bars in the lap splice zone.
4- Effect of applying repeated cyclic loading on the behavior and the integrity of lap joint of the slabs provided with different confinement schemes in the lap zone.

Test results were illustrated and discussed in details. Some of outcome conclusions may be summarized as follows for the dimensions and reinforcement used in the present study:

1- The behavior of ordinary slab without splice can be achieved in slabs with spliced tension reinforcement with 100% cut off ratio when the lap splice length equals to 45 d_b without headed bars, and without using any confinement at the splice zone. This behavior can be obtained when the lap length equals to 27 d_b with headed bars, and without using any confinement at the splice zone, or when the lap length equals to 15 d_b with headed bars, and confinement at splice zone was provided.
2- Spliced slabs with the lap length 15 d_b with headed bars, without using any confinement at the spliced zone, and with 100% cut off ratio, a reduction in ductility and ultimate load capacity occurred. The mode of failure changed from ductile flexural failure to brittle (bottom split).
3- In spliced slabs with the lap length 15 d_b, 100% cut off ratio, and provided with confinement in the spliced zone, the mode of failure changed from brittle (as occurred for slab without confinement) to ductile flexural failure.
4- Debonding of the lapped headed bars resulted in a fewer number of surface cracks but with larger width comparing with the similar bonded specimen. Also, debonding resulted in a loss of ductility and the overall capacity was also reduced due to the loss of bond contribution. Generally, this specimen showed less ductility than that of the unspliced specimen, and the failure was brittle.
5- Slabs subjected to repeated cyclic loading and had different confinement stirrups in the lap zone showed energy dissipation, exhibited good ductility, and also showed almost stable hysteric loops. The integrity of the lap joint was preserved during all the loading and unloading cycles.