INVESTIGATION OF MECHANICAL PROPERTIES OF CONCRETE CONTAINING RECYCLED RUBBER FROM WASTE TIRES

By

Ahmed Zaki Saber Zaki

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Structural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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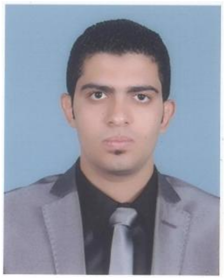

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Title of Thesis:
Investigation of Mechanical Properties of Concrete Containing Recycled Rubber from Waste Tires

Key Words:
Mechanical properties; Rubberized concrete; Fine rubber; Coarse rubber; Scrap tires

Summary:
Disposal of tire rubber waste is a major ecological issue around the world. Millions of scrap tires are thrown away every year, discarded or even buried resulting in a very dangerous environmental threat. Burning of these tires was the cheapest and easiest way of disposal, which leads to fire hazards. After burning process, the left powder pollutes surrounding soil. Temperature also rises in the around area and toxic smoke with harmful components which have critical impact on humans, plants and animals. Safest and practical solutions for eliminating scrap tire are the best way, one of them is to utilize this scrap into concrete industry as partial replacer for both natural fine aggregate (FA) and coarse aggregate (CA) forming conventional plain rubberized concrete (PRC). In this study, control mixture and other six rubberized mixes, contained rubber, were prepared with incorporated rubber particles as a partial substituent to each of fine and coarse aggregates at replacement levels of 10, 20 and 30%. In the study presented herein, workability, compressive strength, static modulus of elasticity, tensile strength, flexural strength, flexural toughness, abrasion resistance, impact resistance, bond strength and density of concrete mixes have been assessed. It was found that flexural toughness, abrasion resistance and impact resistance of PRC were increased with the increase of crumb rubber content while consistency, compressive strength, static modulus of elasticity, tensile strength, flexural strength, bond strength and density decreased when referencing to the control mix. The results showed that the optimum replacement percent of FA with fine rubber particles (FRP) was 30%, while for mixes with CA partially replaced by coarse rubber particles (CRP), the optimum replacement percent was 10%.

To my family…

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Declaration

Declared that except citation to certain references to other researchers, the work included into this thesis is the result of investigation executed by the author under the supervision of supervisors Prof. Dr. Hossam Hodhod, Professor, Department of Civil Engineering, Cairo University, and Dr. Hatem Ibrahim, Associate Professor, Department of Civil Engineering, Cairo University. This thesis or any part of it has not been submitted before to any other University or Institute for a scientific degree or diploma.

September, 2018
Ahmed Zaki

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Nomenclature

σ_c	Concrete compressive strength, kgf/cm^2
P_c	Ultimate compressive load or compressive load at failure, kgf
A_c	Loaded compressed average area, cm^2
σ_{st}	Splitting tensile strength, kgf/cm^2
P_{st}	Maximum splitting load or splitting load at failure, kgf
d_{cy}	Measured diameter of cylinder specimen, cm
l_{cy}	Measured length of cylinder specimen, cm
σ_{ft}	Concrete flexural tensile strength, kgf/cm^2
M_f	Flexural Moment of resistance of concrete section, kgf.cm
S_b	Concrete beam elastic modulus, cm^4
P_f	Load at which beam was broken in flexure, kgf
b_b	Measured width of beam specimen, cm
d_b	Measured depth of beam specimen, cm
l_b	Measured supporting length of beam specimen, cm
E_c	Concrete static Young's modulus, kgf/cm^2
σ_2	Stress corresponding to one-third of concrete characteristic strength, kgf/cm^2
σ_1	Constant stress equals 5 kgf/cm^2
ε_2	Longitudinal compressive strain corresponding to one-third of concrete characteristic strength
ε_1	Longitudinal compressive strain corresponding to 5 kgf/cm^2 stress
E_{ft}	Concrete flexural toughness, kgf.mm
E_{fti}	Concrete flexural toughness at each load increment, kgf.mm
P_i, P_{i-1}	Successive applied loads on concrete beam specimen, kgf
Δ_i, Δ_{i-1}	Successive corresponding vertical beam deflections due to P_i and P_{i-1} loads, mm
N_1	Number of blows, of drop weight, which caused first visible crack
N_2	Number of blows, of drop weight, which caused specimen failure
U_{im}	Impact energy absorbed by concrete specimen, kg.mm
n_{im}	Number of blows of impacted specimens
m_{im}	Dropping mass at impact test, kg
V_{im}	Velocity of dropped mass at impact, mm/s
H_{im}	Drop down height at impact, mm
a_{im}	Acceleration of dropped mass at impact, mm/s^2
t_{im}	Required time for mass to drop on concrete specimen, s
W_{im}	Weight of dropped hammer at impact, kgf
g	Constant ground acceleration, mm/s^2
σ_{bo}	Developed concrete bond strength, kgf/cm^2
P_{bo}	Ultimate pull-out load, kgf
A_s	Loaded steel average surface area at bonding test, cm^2
D_{av}	Average diameter of steel bar, cm
L_s	Steel reinforcing bar embedded length, cm

Abbreviations

PC	Plain (conventional) Concrete
PRC	Plain Rubberized Concrete
FA	Fine aggregate
CA	Coarse aggregate
FRP	Fine rubber particles as a substitution to fine aggregate (sand)
CRP	Coarse rubber particles as a substitution to coarse aggregate (dolomite)
$F\text{-}R_n\%$	Fine rubber replacement with n value instead of fine aggregates
$C\text{-}R_n\%$	Coarse rubber replacement with n value instead of coarse aggregates
SP	Super plasticizer
w/c	Water/ cement ratio
ASTM	American Society for Testing and Materials
BS	British Standards
HRWR	High range water reducer
ACI	American Concrete Institute
Av	Algebraic average
EPA	Environmental Protection Agency, United States
fib	International federation of concrete