OPTIMIZATION OF STEEL FIBRE REINFORCED CONCRETE AS CONCRETE TOPPING IN COMPOSITE SLAB CONSTRUCTION

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ABSTRACT

Steel fibre can act as an alternative to replace the conventional prefabricated welded wire mesh (PWWM). It serves as a secondary reinforcement in concrete topping of the precast composite slab construction. Hence, an in-depth study on the performance was conducted to prove the notion. The study was essential due to the differences of behaviours between steel fibre in the compression and the flexural zone of the composite slab. In fact, there was no sufficient knowledge of compression mechanism of steel fibre reinforced concrete (SFRC) due to the lack of study in this area. The main objectives of this study were to investigate the structural performance of composite slab where SFRC was applied in the concrete topping and to develop an analytical model to predict the shear strength of the composite slab by validating the model with the experimental results. Aspect ratio and volume fraction were emphasised in selecting the most suitable type of steel fibre in this study. The experimental results showed that SFRC concrete topping improved the ultimate load and failure mechanism. The results also suggested that the ideal types of steel fibre to be applied in the concrete topping are SF60 and SF33 with optimum volume fraction between 0.75% and 1.00%. Furthermore, it was proven that the SFRC concrete topping has improved the shear capacity of the composite slab by 17%. The performance of the proposed analytical model in predicting the ultimate shear capacity of the composite slab with SFRC concrete topping was considered good due to its strong correlation with the experimental data. This suggested that steel fibre was suitable to replace PWWM as secondary reinforcement in concrete topping in precast composite slab construction. The proposed analytical model can also be used to predict the shear capacity of the composite slab with SFRC concrete topping.

ABSTRAK

Gentian keluli boleh menjadi alternatif untuk menggantikan fabrikasi jaringan besi kimpal (PWWM). Ia bertindak sebagai pengukuh kedua di dalam tutup konkrit bagi pembinaan papak pra-tuang komposit. Maka, kajian mendalam terhadap prestasi ini dijalankan untuk membuktikan pernyataan ini. Penyelidikan ini penting disebabkan perbezaan tingkah laku di antara gentian keluli di dalam zon mampatan dan lenturan bagi papak komposit. Hakikatnya, terdapat kekurangan maklumat terhadap mekanisma mampatan gentian keluli konkrit bertetulang (SFRC) disebabkan kurangnya penyelidikan bagi lapangan ini. Objektif utama penyelidikan adalah mengkaji tingkah laku struktur SFRC sebagai penutup bagi papak komposit dan menerbitkan model analitikal bagi penganggaran kekuatan ricih papak komposit dengan membuktikan model kepada keputusan eksperimen. Nisbah aspek dan pecahan isipadu ditekankan untuk memilih gentian keluli yang paling sesuai dalam penyelidikan ini. Keputusan eksperimen menunjukkan tutup konkrit SFRC meningkatkan beban muktamad dan memperbaiki mekanisma kegagalan. Dapatan kajian turut mencadangkan gentian keluli yang sesuai di dalam tutup konkrit adalah SF60 dan SF33 dengan pecahan isipadu optimum di antara 0.75% dan 1.00%. Selanjutnya, telah terbukti bahawa tutup konkrit SFRC meningkatkan kekuatan ricih papak komposit sebanyak 17%. Prestasi model analitikal yang dicadangkan dalam menganggarkan kapasiti ricih muktamad papak komposit dengan tutup konkrit SFRC didapati sesuai oleh kerana korelasinya yang tinggi dengan data eksperimen. Ini mencadangkan bahawa gentian keluli adalah sesuai bagi mengantikan PWWM sebagai pengukuh kedua di dalam tutup konkrit bagi pembinaan papak pra-tuang komposit. Model analitikal yang dicadangkan turut sesuai digunakan untuk menganggarkan kapasiti ricih bagi papak komposit dengan tutup konkrit SFRC.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

ROMAN UPPER CASE LETTERS

$A_{c,cube}$	-	Cross-sectional area of the specimen which is perpendicular to the applied compressive force, mm^2
A_c	-	Area of concrete cross section, mm^2
A_f	-	Cross-sectional area of individual fibre, mm^2
A_{fx}	-	Total area of effective fibre reinforcement, mm^2
A_s	-	Area of longitudinal steel reinforcement, mm^2
CI	-	Confidence interval
COV	-	Coefficient of variation
$C_{Rd,c}$	-	Nationally determined parameter proposed by RILEM for shear design
E	-	Modulus of Elasticity, kN/mm^2
F_{cube}	-	Maximum compression force at failure, N
F_{split}	-	Maximum load at failure, N/mm^2
FC	-	Fibre count
L/D	-	Fibre aspect ratio
MOR	-	Modulus of rupture, N/mm^2
N_{ed}	-	Axial force due to load, kN
P_{crack}	-	First cracking load, kN
P_{max}	-	Maximum load, kN
P_{flex}	-	The load at first peak, peak and residual, N
P_1	-	First peak load, kN
P_P	-	Peak load, kN
P_{150}^D	-	Residual load at net deflection of $L/150$, kN

P_{600}^{D}	-	Residual load at net deflection of $L/600$, kN
RI	-	Fibre reinforcing index, %
RI_w	-	Fibre reinforcing index by means of weight fractions of fibres, %
$R_{e,3}$	-	Equivalent flexural ratio in JCI-SF
R^2	-	Coefficient of correlation
$T.R.$	-	Toughness ratio
T_{150}^{D}	-	Flexural toughness
V	-	Ultimate shear capacity, kN
V_{cz}	-	Shear force contribution from the compressize zone, kN
V_f	-	Fibre volume fraction, %

ROMAN LOWER CASE LETTER

a/d	-	Shear span-to-effective depth ratio
b	-	Width of the section, mm
b_{flex}	-	The width of specimen in flexural strength test failure, mm
b_v	-	Shear width of the section, mm
d	-	Depth of section, mm
d_{flex}	-	The depth of specimen in flexural strength test failure, mm
d_{split}	-	The designated cross-sectional dimension in tensile strength test, mm
e	-	Demec coefficient
f_{cy}	-	Cylinder compressive strength, N/mm^2
f_{cu}	-	Cube compressive strength, N/mm^2
$f_{cu,base}$	-	Cube compressive strength of a concrete base, N/mm^2
$f_{cu,topping}$	-	Cube compressive strength of a concrete topping, N/mm^2
f_{ct}	-	Tensile splitting strength, N/mm^2
f_p	-	Peak strength, N/mm^2
$f_{Rk,4}$	-	Residual flexural strength measured in BS EN 14651:2005, N/mm^2