Faculty of Engineering

Performance-based Durability Specifications of Fly Ash Concrete for Chloride-induced Environment

Ir. Jamil Bin Matarul

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Performance-based Durability Specifications of Fly Ash Concrete for Chloride-induced Environment

Ir. Jamil Bin Matarul

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Signature

Name: Ir. Jamil Bin Matarul

Matric No.: 15010039

Faculty of Engineering

Universiti Malaysia Sarawak

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ABSTRACT

Existing standard concrete practices under implementation of Standard Specifications for Building Works (SSBW) promptly altered from prescriptive specifications to Performance-based Durability Specifications (PBDS) as advocated by Eurocode 2. This study was carried out to overcome the chloride-induced attack problem on reinforced concrete (RC) structures settled under XS3 class exposure by utilising fly ash waste, producing non-destructive test (NDT) models and developing PBDS indicators model. The Taguchi Approach was used in this study with a combination of survey questionnaires, field investigation, experimental works and Statistical Product and Service Solutions (SPSS) modelling. The experimental work includes compressive strength (Cu), water absorption (WA), void of permeable voids (VPV) and ultrasonic pulse velocity (UPV) tests. Which, tested on tree different grades of ready-mix concretes, as well as concrete blended with Class-F fly ash with a 10% percentage increment up to 60%. Experimental work revealed that the Class-F fly ash was optimised at 30%. NDT models as represented by equation correlations of Cu1 = 31.699UPV1 – 84.641, Cu2 = 30.998UPV2 – 79.275 and Cu3 = 36.438UPV3 – 100.337. Developed PBDS indicators model equation was WA = 0.843VPV – 0.078UPV + 0.104. Meanwhile, "EXCELLENT" concrete quality rating bounded to Quality Rating Durability Compliance (QRDC) indicator values for UPV, VPV, WA and Cu should be more than 4.5 km/s, less than 10%, less than 7% and at least 55 MPa, respectively. The outcome indicators were found provide a flexible interface for client, designer or decision maker to make an accurate decision based on concrete performance, environmental sustainability and public user's safety.

Keywords: Chloride-induced, fly ash, NDT models, performance-based

Spesifikasi Ketahanan Konkrit Berasaskan Prestasi Disebabkan oleh Klorida Persekitaran

ABSTRAK

Amalan konkrit standard sedia ada di bawah pelaksanaan Spesifikasi Standard untuk Kerja Bangunan (SSBW) adalah perlu diubah daripada spesifikasi preskriptif kepada Spesifikasi Ketahanan Berasaskan Prestasi (PBDS) seperti yang dianjurkan oleh Eurocode 2. Kajian ini dijalankan untuk mengatasi masalah serangan akibat klorida pada tetulang struktur konkrit (RC) di bawah pendedahan kelas XS3 dengan menggunakan sisa abu terbang, menghasilkan model ujian tidak merosakkan (NDT) dan membangunkan model penunjuk PBDS. Kajian dilaksanakan dengan menggabungkan pendekatan Taguchi bersama soal selidik tinjauan, penyiasatan lapangan, kerja amali makmal dan pemodelan Penyelesaian Produk dan Perkhidmatan Statistik (SPSS). Kerja amali makmal termasuk kekuatan mampatan (Cu), penyerapan air (WA), lompang telap kosong (VPV) dan ujian halaju nadi ultrasonik (UPV). Diuji pada tiga gred konkrit berbeza siap campur yang diadun dengan abu terbang Kelas-F dengan peratusan penggantian sebanyak 10% hingga 60%. Kerja amali makmal mendedahkan bahawa abu terbang telah dioptimumkan pada 30%. Model NDT seperti yang diwakili oleh korelasi persamaan Cu1 = 31.699UPV1 – 84.641, Cu2 = 30.998UPV2 – 79.275 and Cu3 = 36.438UPV3 – 100.337. Persamaan model penunjuk PBDS ialah WA = 0.843VPV – 0.078UPV + 0.104. Sementara itu, penarafan kualiti konkrit "CEMERLANG" mengikut nilai penunjuk Pematuhan Ketahanan Penarafan Kualiti (QRDC) untuk UPV, VPV, WA dan Cu hendaklah masing-masing lebih daripada 4.5 km/s, kurang daripada 10%, kurang daripada 7% dan sekurang-kurangnya 55 MPa. Hasil kajian mendapati penunjuk penarafan kualiti konkrit yang dibangunkan adalah mudah diguna pakai oleh pelanggan, pereka bentuk atau pembuat keputusan untuk membuat keputusan

yang tepat berdasarkan prestasi konkrit, kelestarian alam sekitar dan keselamatan pengguna awam.

Kata kunci: *Kakisan-klorida, abu terbang, model NDT, berasaskan prestasi*

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ABNT	Brazilian National Standards Organization
ACI	American Concrete Institute
AECB	Atomic Energy Control Board
ANOVA	Analysis of Variance
AS	Australian Standard
ASTM	American Society for Testing and Materials
AVPV	Apparent Volume of Permeable Voids
BDS	Bulgarian Institute for Standardization
BS	British Standards
BSI	British Standards Institution
CCAA	Cement Concrete & Aggregates Australia
CCANZ	Cement & Concrete Association of New Zealand
CEN	Committee of European Norms
CFG	Carbon Fibre Sheets/Glass
CFS	Conceptual Framework Study
CIA	Concrete Institute of Australia
CNS	Colloida Nano Silica
COST	National Standard UPV Test Method (Russia)
COVENIN	National Standard UPV Test Method (Venezuela)
CP	Concrete of Practice
CSN	National Standard UPV Test Method (Czech Republic)