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Material and Techniques

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ARRA	Asphalt Recycling and Reclaiming Association
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio
CCSA	Charcoal Coconut Shell Ash
CIPR	Cold In-Place Recycling
CMA	Coarse Mixed Aggregate
DAD	Damage Avoidance Design
DCP	Dynamic Cone Penetrometer
DSR	Dynamic Shear Rheometer
ECC	Engineered Cementitious Composites
EMV	Equivalent Mortar Volume
EVA	Ethylene Vinyl Acetate
FCA	Fine Ceramic Aggregate
FHWA	Federal Highway Administration
FWD	Falling Weight Deflectometer
GGBS	Ground Granulated Blast Furnace Ash
HCL	Hydrochloride Acid
HPC	High Performance Concrete
ITS	Indirect Tensile Test
IBS	Industrialized Building System
LDPE	Low-density Polyethylene
MCE	Maximum Considered Earthquake

MDD	Maximum Dry Density
MOE	Modulus of Elasticity
MOR	Modulus of Rupture
NA	Natural Aggregate
NCA	Nano Charcoal
OMC	Optimum Moisture Content
OPC	Ordinary Portland Cement
PE	Polyethylene Fibre
PFA	Pulverized Fuel Ash
PI	Penetration Index
PMAE	Polymer Modified Asphalt Emulsion
PP	Polypropylene Fibre
PVA	Polyvinyl Alcohol Fibre
RA	Recycled Aggregate
RAC	Recycle Aggregate Concrete
RAP	Reclaimed Asphalt Pavement
RA-SCC	Recycle Aggregate Self Compacting Concrete
RCA	Recycled Concrete Aggregate
RC	Reinforced Concrete
RCF	Recycled Concrete Fines
REAM	Road Engineering Association of Malaysia
SBR	Styrene Butadiene Rubber
SBS	Styrene Butadiene Styrene
SP	Superplasticizer
TFB	Tunnel Form Building
UCS	Unconfined Compression Test
UTM	Universal Testing Machine

WWCB	Wood-wool Cement Board
XRF	X-Ray Fluorescence

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PREFACE

This book presents research-based best practices related to green infrastructure by highlighting modern techniques and tools that integrate the invention technology. These approaches are based on the current problems in the construction industry. Concrete is a major material used in the construction industry and it is never been claimed as an environmentally friendly material because of its damaging nature resource consumption. This book emphasizes the Recycle Aggregate (RCA), fines concrete and POFA concrete as a construction material. Meanwhile, the existing pavement materials were also investigated for sustainable pavement by providing the alternative binder using charcoal ash from coconut shell. Furthermore, the innovative Wood-Wool Cement Board (WWCB) as a sustainable green infrastructure material.

Chapter 1 - This review paper provides an inclusive summary of the use of RCA in concrete and an overview of its influence on the properties of RCA in concrete. It has been found that the mechanical and durability performance of RCA concrete is commonly lower compared to conventional concrete. The previous research showed that the reason for the poor quality of the RCA is the residual adhered mortar. This adhered mortar is reported as the main cause of the quality issue of RCA concrete. However, recent research showed the possibility to use the RCA in the production of concrete with very comparable mechanical and durability performance when surface treatment applied on the RCA. The use of the RCA as a substitute for the natural aggregate in concrete applications is limited to low or moderate grade concrete due to limited knowledge and experimentation on the HPC production. Thus, more research needs to be conducted on the surface treated RCA and its influence on the properties of high-performance concrete as compare to

both HPC with untreated RCA and conventional HPC. Extending the application of RCA toward the production of HPC appears to be a promising contribution towards the sustainability of the environment and the industry.

Chapter 2 - Compression test of Series 1 indicates that green ECC mixture with 70% of GGBS has shown enhancement in compressive strength over normal concrete. When the ratio of river sand to binder was fixed at 0.2, optimum compressive strength i.e. 90.3 MPa is attained when fiber 2.0% in volume fraction was employed. The use of RCF to replace river sand in ECC G70F2.5 yields slightly better result of compressive strength compared to its counterpart. Due to the limitation of this study, more research is needed to confirm the feasibility of using RCF to replace river sand in different fiber content.

Chapter 3 - CIPR is an economical and environmentally sound alternative to conventional rehabilitation methods such as structural overlay or reconstruction. The reuse of existing pavement materials is a sustainable approach to pavement rehabilitation as new materials are conserved. Its use in Malaysia is expected to increase in the future as more pavement rehabilitation works instead of new roads construction will be carried out to preserve the integrity of the pavement structure and to extend the pavement life. However, an adequate understanding of the CIPR process, its suitability and limitations are essential for the correct pavement candidate to be chosen, for the works to be carried out successfully and for the pavement to perform satisfactorily.

Chapter 4 - The workability and compressive strength of normal concrete using POFA as partial cement replacement were investigated. Four types of mix design, including control design for concrete with normal strength of 30 N/mm2 at the age of 28 days. Replacement of cement by 5% of POFA produces equal compressive strength with concrete without POFA when the concrete reaches 28 days of age.

Chapter 5 - Good quality of pavement should have high structural integrity, which provides a strong, smooth, and safe riding surface for road users. In Malaysia, a common type of distress in asphalt pavement is permanent deformation. This study attempts to investigating NCA from coconut shell that is utilized as the main material in the bitumen modification. The effects of NCA on the bitumen subjected to numerous grinding times are evaluated, and the optimum grinding time that can produce the optimum NCA is determined. The optimum grinding time that showed the highest performance of bitumen was 30 h, which produced the optimum size of 148 nm. The incorporation of NCA increased the stiffness of the bitumen up to 47% and increased the softening point value by approximately 12% higher than the virgin binder. The PI values for the modified bitumen were not within the specified range, but the values did not exceed –2, except for the NCA0 and NCA5.

Chapter 6 - Poor performances of precast buildings during earthquakes were due to inadequate connections between the structure's components, insufficient seating and anchorage and poor workmanship and quality materials used. It is important to investigate their seismic performance by conducting experimental work, analyzing the data and modelling them using nonlinear time history analysis of the earthquake's excitations. The elastic stiffness is higher than secant stiffness for the single bay double-storey house, exterior beam-column joints with corbels and three-storey tunnel form buildings. Displacement ductility for all the three specimens are less than two (2) and to survive under earthquake attack, the ductility of the structure should be within the range from three (3) to six (6) as specified by the current seismic code of practice (EC8). Most of the failure mode occurred at the wall-beam joints, wall-foundation joints, beam-column joints, wall-slab joints and column-foundation joints where all the vertical loads and horizontal loads are meet at these points. It can be concluded that, single and double tunnel TFB with shear walls performed the best as compared to precast beam-column joint with corbel and precast shear-key wall panel.

Chapter 7 - Wood-cement composite which is a hybrid material that made from of cement and lignocellulosic material is gaining traction globally. Various studies are being conducted intensively to investigate its properties. In many parts of the word, it is also being manufactured industrially in the form of wall panels. To this day, conventional composite panels bonded by adhesive are manufactured in a greater volume than wood-cement composite. wood-cement composites are extremely useful especially in the prefabricated construction applications that utilize non-load bearing elements such as walls, ceiling and insulation panel. The developments of wood-cement hybrid composites which are low in cost have been regarded as a significant contribution to alleviate the housing problem faced by many developing countries.

INTRODUCTION

This book entitled '**Green Infrastructure Materials and Techniques**' has been written in such a way that it will benefit the postgraduate and undergraduate students, supervisors, lecturers, construction industries and manufacturers. Human being produces a lot of waste such as food waste, agriculture waste, construction waste, industrial waste and chemical waste which harmful to the societies. Furthermore, these wastes need to through away on dumping site which is limited and could significantly impacts to the environments. One of the most excellent initiatives is to recycle these wastes into products that can be used by the societies toward clean and green environments.

Recycle Concrete Aggregate (RCA) can be obtained from demolition buildings and dumping construction site. The RCA's surface treatment can be done by soaking RCA into HCI solution which can improve the mechanical and physical properties of concrete. Green Engineered Cementitious Concrete (ECC) is made from cement, Ground Granulated Blast-Furnace Slag (GGBS), polypropylene fibers, water, superplasticizer and recycle sand from demolishing buildings. Cold In-Place Recycling (CIPR) is a pavement rehabilitation technique where the existing pavement materials are reused in-place along with additional virgin aggregates for the construction of the roads and highways. Palm Oil Fuel Ash (POFA) is a by-product waste from palm oil factories after burning the fibers and shell which used as partial replacement of cement. POFA can improve the compressive strength, porosity, tensile strength and superior filing ability in the concrete. Nano Charcoal Ash (NCA) is produced after burning the coconut shell and grinding it into the nano-size particles. NCA is used as an alternative binder in producing bitumen for pavement in construction of roads and highways.

The recycle concrete aggregate and sand together with POFA as partial replacement of cement can be used as green infrastructure materials for the construction of structural elements such as precast wall panel, beam-column joint with corbels and tunnel form building as described in this book. Recycle aggregates from existing roads can use again using CIPR technique together with NCA as alternative binder for the construction of roads and highways. The wood wools can be obtained from debarked timber either from softwood or hardwood to make Wood-wool Cement Board (WWCB) which can be used as wall panels for the construction of houses, warehouses and shop lots.

By using green recycle construction materials in developing and construction new houses and commercial buildings; we can sustain our environment for future generation. Therefore, our world will be become green, less emission of CO_2, save from chemical waste, fresh atmosphere and hence reduce the global warming effects.

1 SURFACE TREATED RECYCLED CONCRETE AGGREGATE(RCA) AS GREEN CONSTRUCTION MATERIAL

Aiman Alodain, Ahmad Ruslan Mohd Ridzuan, Mohd Afiq Mohd Fauzi, Nor Hayati Abdul Hamid and Mohd Shafee Harun

1.1 INTRODUCTION

Concrete has never been claimed as an environmentally friendly material because of its damaging nature resource consumption and severe environmental impact after used. Nevertheless, it will remain one of the major construction materials being utilized worldwide for the construction of infrastructures, houses and commercial buildings. By taking the concept of sustainable development into consideration, the concrete industry has to be implemented at various strategies with regards to future used of concrete, for instance the recycle used of aggregate. In general, aggregates occupy about 55% to 80% of concrete volume of the constructed buildings. Without any proper alternative of aggregates being utilized for the year future, the concrete industry globally will consume about 8 to 12 billion tons annually of natural aggregates after the year 2010 (Tu et al., 2006). The large consumption of natural aggregates from the quarry will affect the environment and reduce the natural resources.