Highways

Fifth edition

This book is dedicated to

Nuala Rose O'Flaherty

In memoriam

Highways

The location, design, construction and
maintenance of road pavements

Fifth edition

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My colleagues and I are indebted to the many organisations and journals that allowed us to reproduce diagrams and tables from their publications. Most commonly, the reference is given in the title of each figure and table, but sometimes it is referred to in the text. The material that is quoted from government publications is Crown copyright and is reproduced by permission of The Stationery Office.

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Last, but far from least, I pay tribute to my wife Nuala, who helped me immeasurably in the development and preparation of the previous editions of this textbook. Her love, support and forbearance will never be forgotten by me.

Coleman O'Flaherty

*Launceston, Tasmania
August 2015*

Abbreviations and terminology

AADF	average annual daily flow
AADT	annual average daily traffic
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
AAV	aggregate abrasion value
AFNOR	Association Française de Normalisation
AGS	Association of Geotechnical Specialists
APL	actual point load
ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
ASTM	American Society for Testing and Materials
AUTL	asphalt for ultra-thin layers
BBA	British Board of Agrément
BGS	British Geological Survey
BIM	building information modelling
BoQ	bill of quantities
BSI	British Standards Institution
CAD	computer-aided design
CBA	cost-benefit analysis
CBGM	cement bound granular material
CBR	California bearing ratio
CEC	cation exchange capacity
CEN	Comité Européen de Normalisation (European Committee for Standardization)
COBie	Construction Operations Building Information Exchange
CPIC	Construction Project Information Committee
CPT	cone penetration test
CRCB	continuously reinforced concrete base
CRCP	continuously reinforced concrete pavement
CT	circular texture
c_u	shear strength
D&B	design-and-build
DBFO	design, build, finance and operate
DCP	dynamic cone penetrometer
DEM	digital elevation model
DIN	Deutsches Institut für Normung, German Institute for Standardization
DfT	Department for Transport
DLP	Determinate-life pavement
DoP	declaration of performance
DUPV	dry unpolished value
EAL	equivalent axle load
ECI	early contractor involvement
EFTA	European Free Trade Association
EIAs	environmental impact assessments
EME	Enrobé à module élevé

EOTA	European Organisation for Technical Approvals
ESAL	equivalent standard axle load
ESPL	equivalent single point load
EVA	ethylene vinyl acetate
FAP	friction after polishing
FBA	furnace bottom ash
FEA	finite-element analysis
FPC	factory production control
FWD	falling-weight deflectometer
GBBS	ground granulated blast furnace slag
GIR	ground investigation report
GISs	geographical information systems
GNCA	granular base with no cementing action
G_{sa}	apparent specific gravity
G_{sb}	bulk specific gravity
G_{se}	effective specific gravity
HAGDMS	Highways Agency geotechnical database management system
HAPAS	Highway Authorities product approval scheme
HAPMS	Highways Agency pavement management system
HAWRAT	Highways Agency water risk assessment tool
HBM	hydraulically bound mixture
HCV	heavy commercial vehicle
HDM	heavy duty macadam
HFS	high-friction surfacing (BBTM, from its French name 'béton bitumineux très mince')
HMB	high-modulus base
HRA	hot rolled asphalts
HSE	Health and Safety Executive
I_c	consistency index
ICL	initial consumption of lime
ICS	initial consumption of stabiliser
I_d	density index
I_L	liquidity index
I_p or PI	plasticity index
IRI	international roughness index
ISO	International Organization for Standardization
ISOHDM	International Study of Highway Development and Management
ISSA	International Slurry Surfacing Association
ITT	initial type test
JRC	jointed reinforced concrete
LiDAR	light detecting and ranging
LLP	long-life pavement

LWD	lightweight deflectometer
LWT	loaded wheel test
MAAT	mean annual air temperature
MCV	moisture condition value test,
MDE	micro-Deval value
MEPDG	Mechanistic–Empirical Pavement Design Guide
MMS	minimum mass for sieving
MMTD	mean measured texture depth
MSW	municipal solid waste
MSWIBA	municipal solid waste incinerator bottom ash
MSWIFA	municipal solid waste incinerator fly ash
MTD	macro-texture depth
NPV	net present value
NSC	network structural condition
OMC	optimum moisture content
OS	Ordnance Survey
PA	porous asphalt
PE	polyethylene
PFA	Pulverised fuel ash
PI	penetration index for bitumen; plasticity index for soil
PIARC	Permanent International Association of Road Congresses
PMB	polymer-modified bitumen
PP	polypropylene
PPP	public–private partnership
PQC	pavement quality concrete
PSI	present serviceability index
PSMCs	performance-specified maintenance contracts
PSSR	preliminary sources study report
PSV	polished stone value
PTV	pendulum test value
PV	present value
PVC	polyvinylchloride
QP	quality protocol
QUADRO	QUeues And Delays at ROadworks
RAP	reclaimed asphalt pavement
RCA	recycled concrete aggregate
RCC	roller-compacted concrete
RD _{app}	apparent relative density
RD _{ssd}	saturated surface-dry relative density
RTFO	rolling thin-film oven test,
RTM	road test machine
SBS	styrene–butadiene–styrene
SCRIM	Sideway-force Coefficient Routine Investigation Machine
SEBS	styrene–ethylene–butadiene–styrene
SFC	sideways-force coefficient

SIS	styrene–isoprene–styrene
SMA	stone mastic asphalt
SN	structural number
SP	softening point
SPT	standard penetration test
SPZs	source protection zones
SRTM	Shuttle Radar Topographic Mission
SuDS	sustainable drainage system
SWEEP	Software for the Whole-life Economic Evaluation of Pavements
TRACS	TRAffic speed Condition Survey
TSD	traffic-speed deflectometer
TTBM	total thickness of bituminous material
UCS	unconfined compressive strength test
ULLP	Upgradeable to long-life pavement
URC	jointed unreinforced concrete
VFB	voids filled with bitumen
VMA	voids in the mineral aggregate
WIM	weigh-in-motion
w _L or LL	liquid limit
w _p or PL	plastic limit
WRAP	Waste and Resources Action Programme
WTAT	wet track abrasion test
WUPV	wet unpolished value