University of Nottingham
UK | CHINA | MALAYSIA

UK pavement design – the normal and the not-so-normal

Andrew Dawson

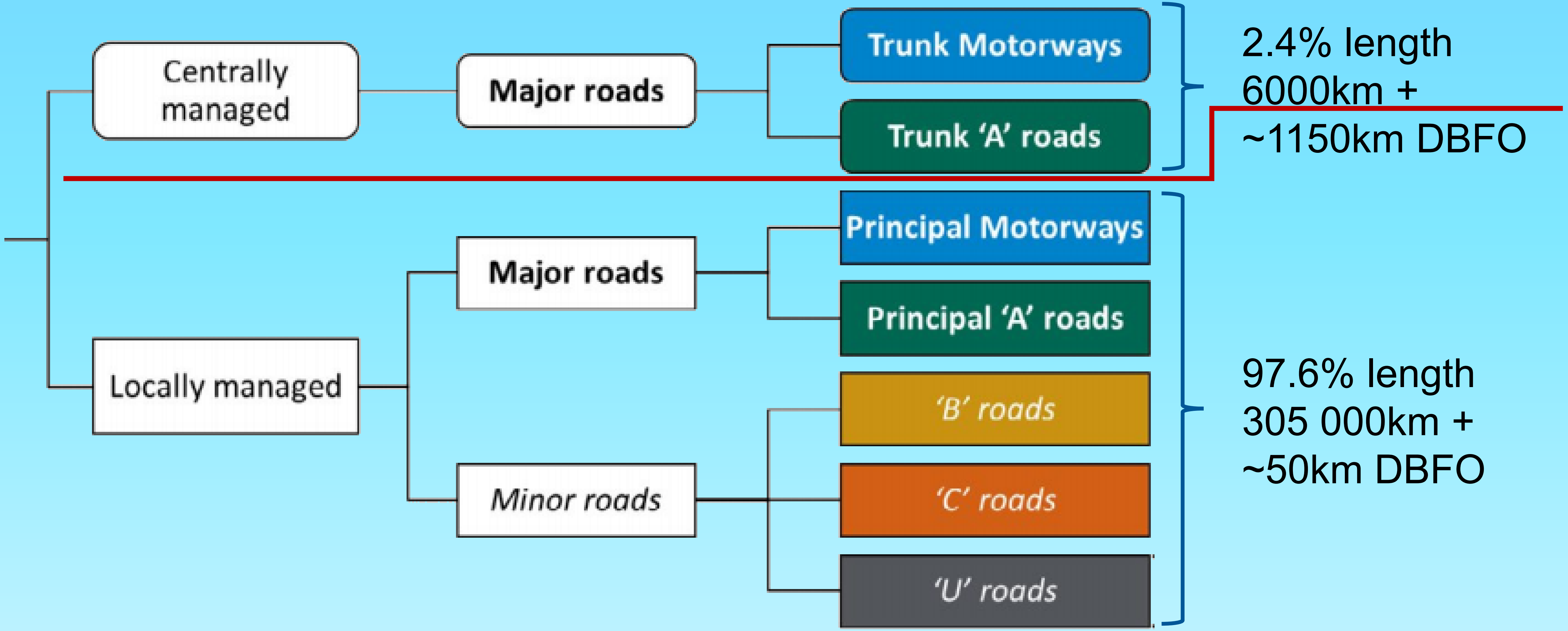
Some of you visited Nottingham in September

Greetings from Robin Hood!

Key points on ownership

- The road "owner" usually dictates the design method
- Major roads are owned by England / Wales / Scotland / N. Ireland
- Authorities are "Highways England" / "Transport Scotland" / "Llywodraeth Cymru" / "Department for Infrastructure"
  - These (usually) produce common guidance
  - About 1200km of their roads are owned through a DBFO company
- Highways England owns ~4500 miles (7 200km) of road
- Total road length in England is ~190 000 miles (305 000km)
- Highways England roads are 2.4% of English network but carry 33% of traffic and >50% of truck traffic
- Other roads are owned by local authorities (counties / cities)

England’s road network



Local Authorities and DBFOs are free to adopt their own design methods

High

williamsleatag

Home

FAQs

Design Manual for Roads and Bridges (DMRB)

(Please note: An alpha numeric Index for the complete DMRB can be found in Volume 0 Section 1 Part 1).

DMRB	Design Manual
MCHW	Contract Documents
IANs	Interim Advice Notes
NMM and RWSC	Network Management / Servicing
ADMM	Asset Data Management Manual
TMMM	Technology Manage't & Maintenance

Volume 12	Traffic Appraisal of Road Schemes
Volume 13	Economic Assessment of Road Schemes
Volume 14	Economic Assessment of Road Maintenance
Volume 15	Economic Assessment of Road Schemes in Scotland

University of Nottingham
UK | CHINA | MALAYSIA

williamsleatag

Home
FAQs
DMRB
MCHW
IANs
NMM and RWSC
ADMM
TMMM
Pilots and Trials
Further Technical Information
The Traffic Systems & Signing Registry

Design Manual for Roads and Bridges (DMRB)

(Please note: An alpha numeric Index for the complete DMRB can be found in Volume 0 Section 1 Part 1).

DMRB Table of Contents

Volume	
Volume 0	Introduction and General Requirements
Volume 1	Highway Structures: Approval Procedures and General Design
Volume 2	Highway Structures: Design (Substructures & Special Substructures), Materials
Volume 3	Highway Structures: Inspection & Maintenance
Volume 4	Geotechnics & Drainage
Volume 5	Assessment & Preparation of Road Schemes
Volume 6	Road Geometry
Volume 7	Pavement Design & Maintenance
Volume 8	Traffic Signs & Lighting
Volume 9	Traffic Control & Communications
Volume 10	Environmental Design
Volume 11	Environmental Assessment
Volume 12	Traffic Appraisal of Road Schemes
Volume 13	Economic Assessment of Road Schemes
Volume 14	Economic Assessment of Road Maintenance
Volume 15	Economic Assessment of Road Schemes in Scotland

University of Nottingham
UK | CHINA | MALAYSIA

DESIGN MANUAL FOR ROADS AND BRIDGES

VOLUME 7 PAVEMENT DESIGN AND MAINTENANCE

SECTION 2 PAVEMENT DESIGN AND CONSTRUCTION

PART 3

HD 26/06

PAVEMENT DESIGN

www.standardsforhighways.co.uk

VOLUME 7 - PAVEMENT DESIGN AND MAINTENANCE

Section 1 Preamble

Not Used

Section 2 Pavement Design and Construction

Part 1	HD 24/06	Traffic Assessment
Part 2	Not Used	
Part 3	HD 26/06	Pavement Design
Part 4	HD 27/15	Pavement Construction Methods
Part 5	CD 239	Footway and cycleway pavement design

Section 3 Pavement Maintenance Assessment

...

Section 4 Pavement Maintenance Methods

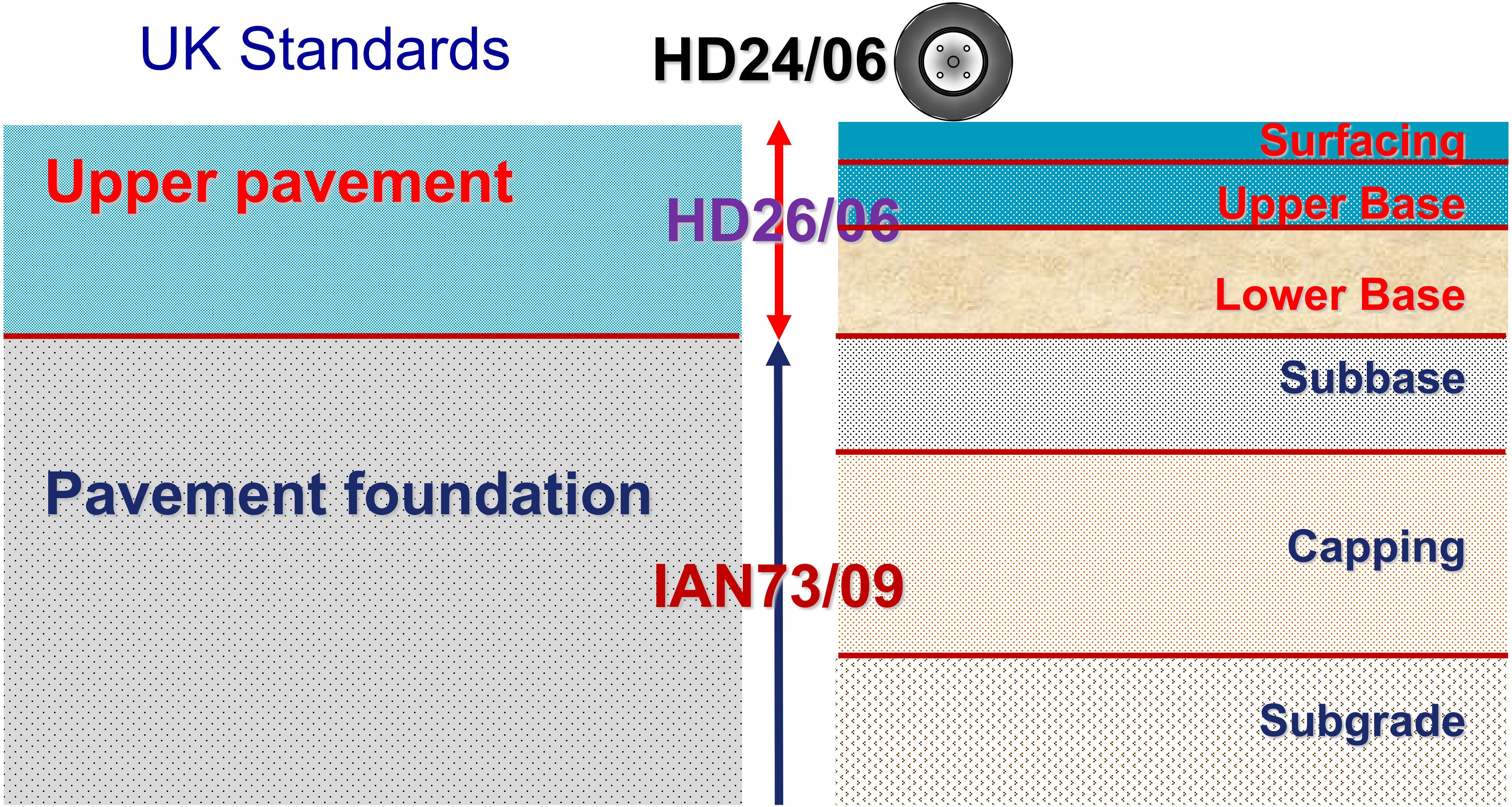
...

Section 5 Surfacing and Surfacing Materials

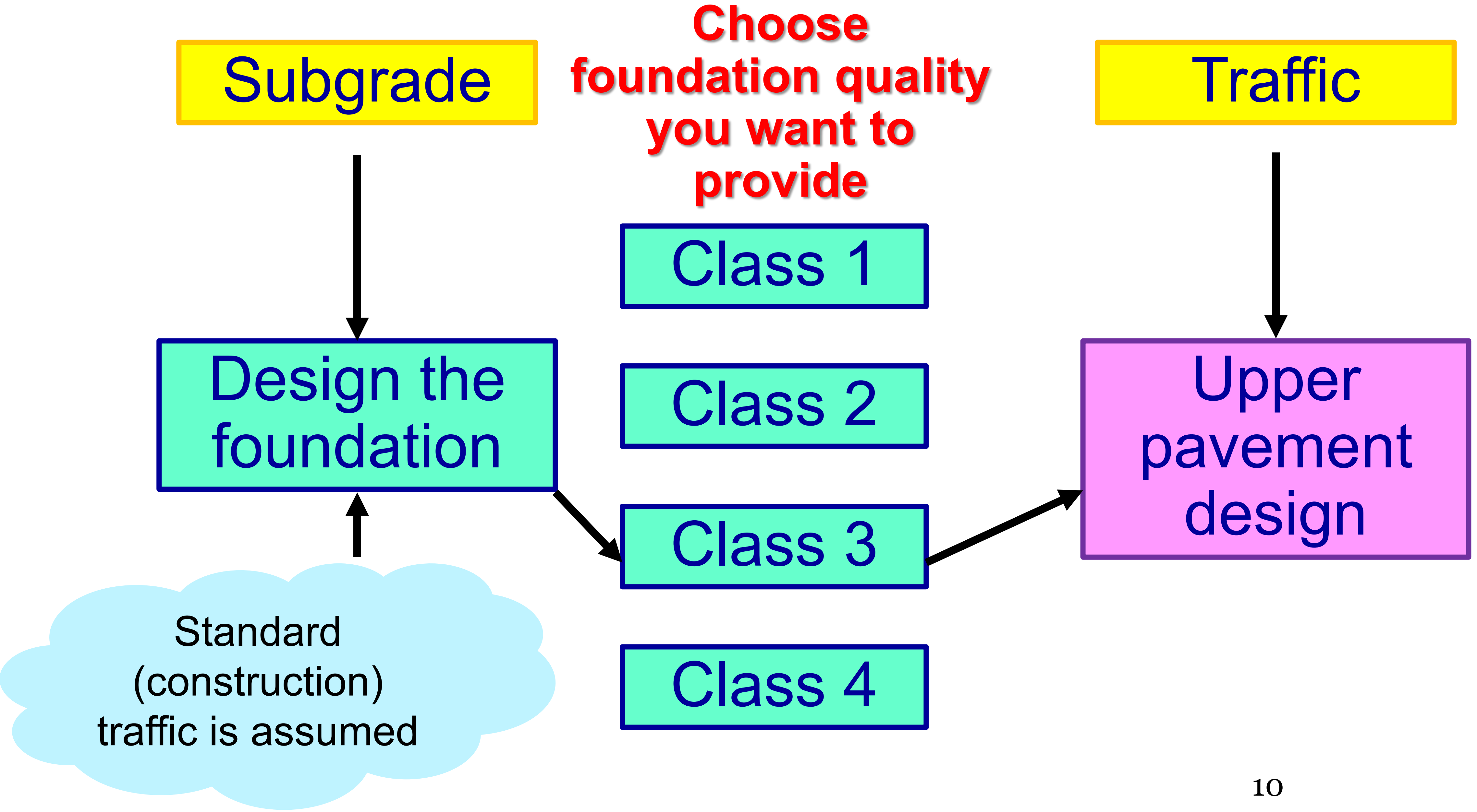
Part 1	CD 236	Surface Course Materials for Construction (Revision 3)
Part 2	HD 37/99	Bituminous Surfacing Materials and Techniques
Part 3	HD 38/16	Concrete Surfacing and Materials

Design

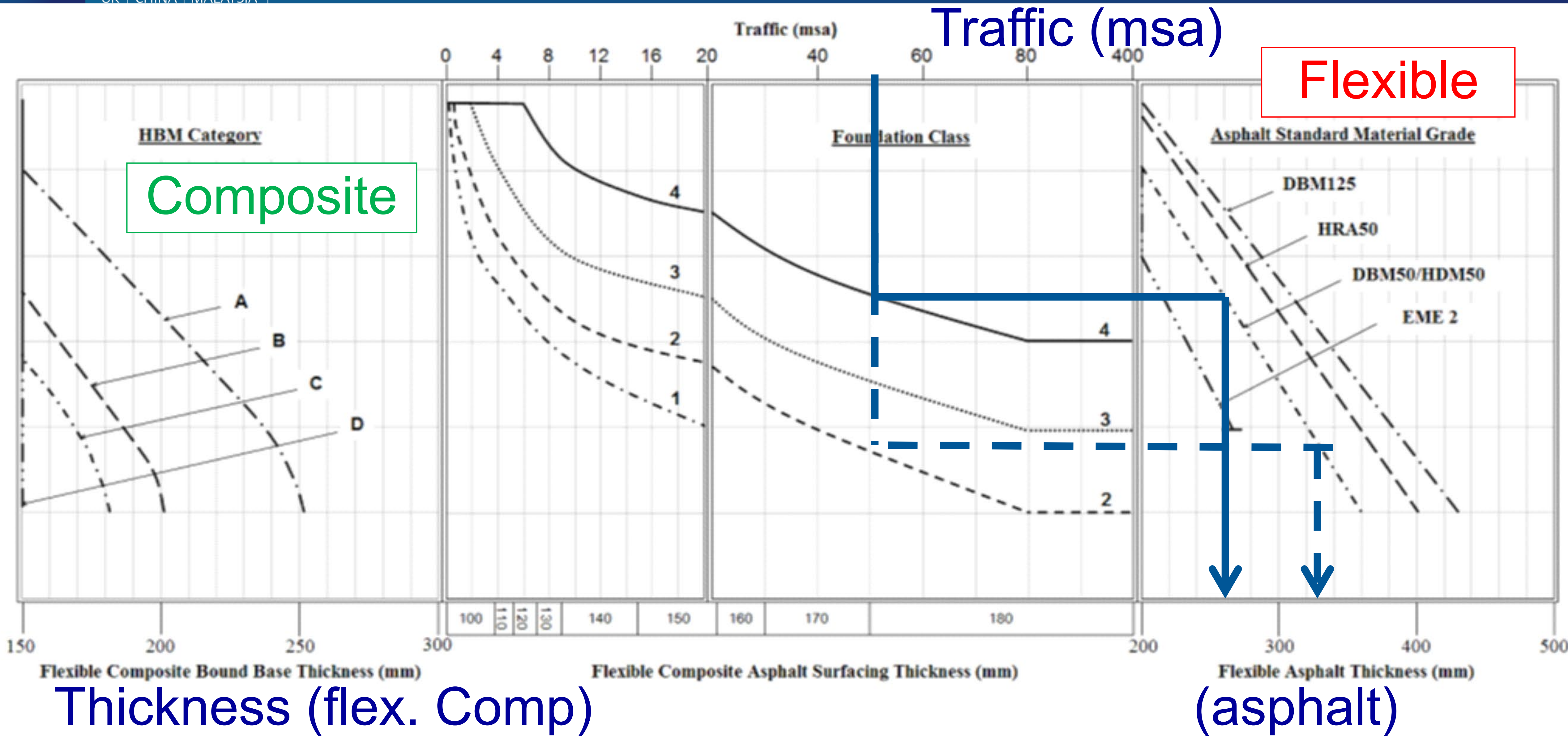
UK Standards



Design Logic



Simple design charts



UK Standards – **HD26/06**

Foundation design (IAN 73/06 rev09)

Choice of classes based on **stiffness**

Class **1**. Capping only

Class **2**. Granular subbase

Class **3**. Weak HBM subbas

Class **4**. Strong HBM subba

Measured using a
dynamic plate test

Foundation Roles

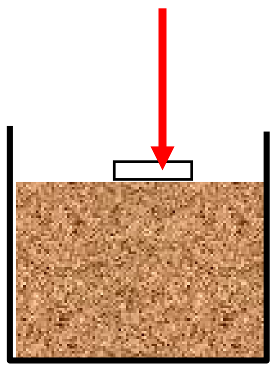
1. **Protect the subgrade**: Natural ground cannot usually bear traffic load directly; it would deform and rut. ✓ *stiffness helps*
2. **Support overlying layers**: Minimise bending of valuable upper pavement layers ✓ *stiffness helps*
3. **Guard against deformation in the pavement layers**: All pavement materials must be stable enough not to deform. × *not really stiffness*
4. **Ensure 'maintainability'**: The design must ensure that it is possible to carry out necessary maintenance. × *not stiffness*

Determining foundation modulus

How do you find a **Stiffness Modulus?**

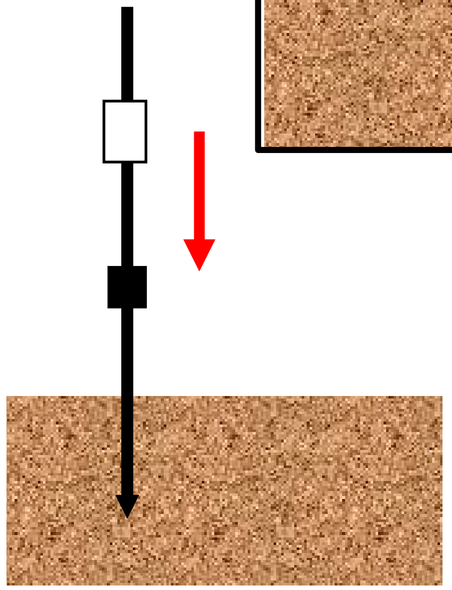
From CBR (either lab or insitu)

Modulus = 17.6 CBR$^{0.64}$



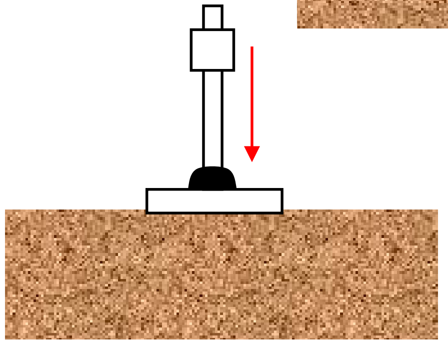
From DCP (insitu)

Penetration rate → CBR → Modulus



From Dynamic Plate Test (a.k.a. Light Weight Deflectometer)

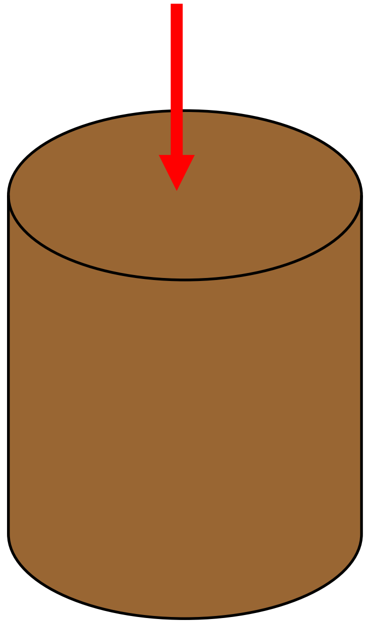
Direct measure of Modulus



Laboratory evaluation of foundation modulus

From laboratory stiffness tests (static modulus)

But be careful about water content,stress conditions, age etc; – especially **HBM**s (insitu <<< lab)



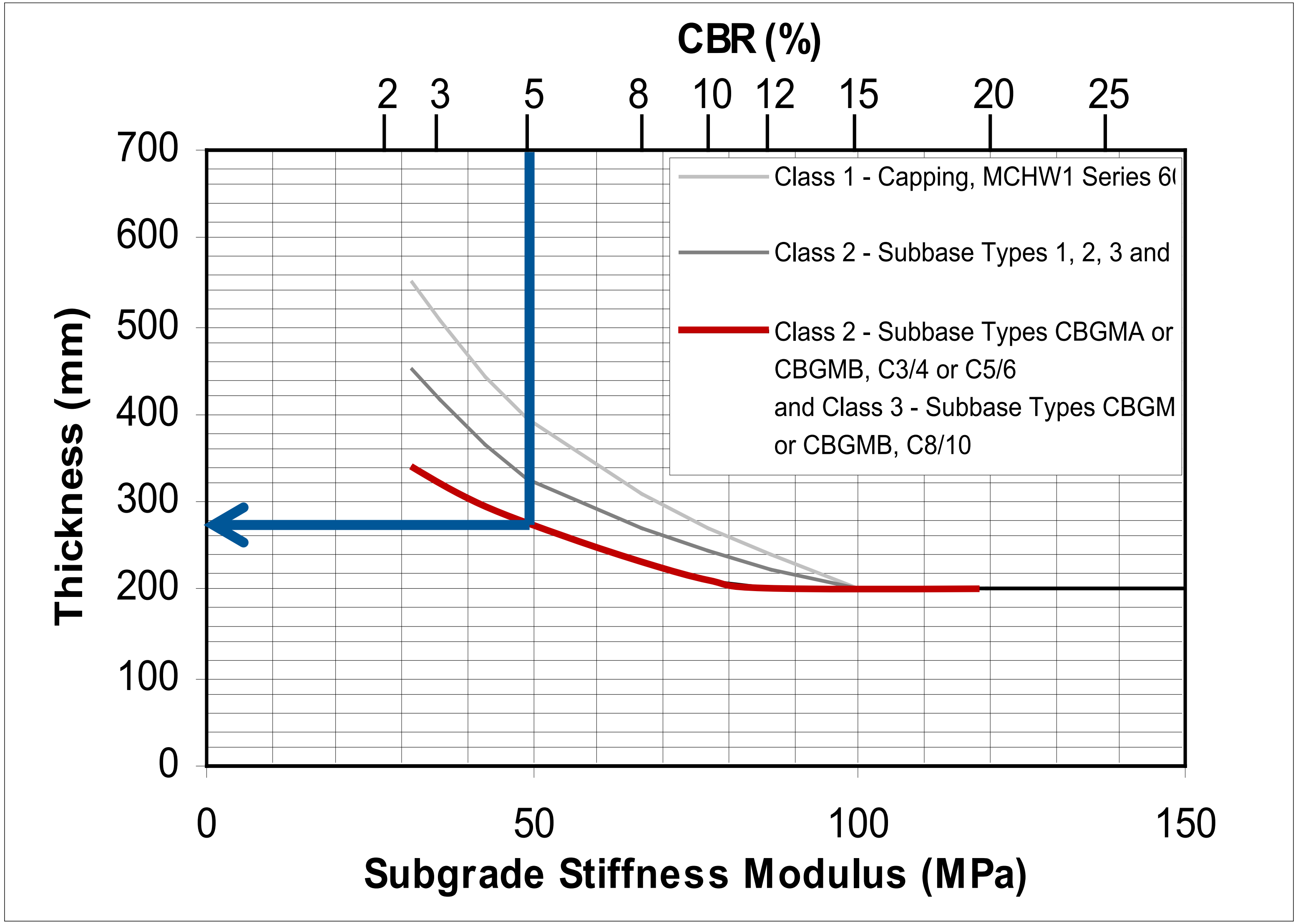
UK Standard – **IAN73/06**

No testing, conservative, foundation option

These are **Restricted designs**; for a single foundation layer

Thicker than really needed, but no testing needed

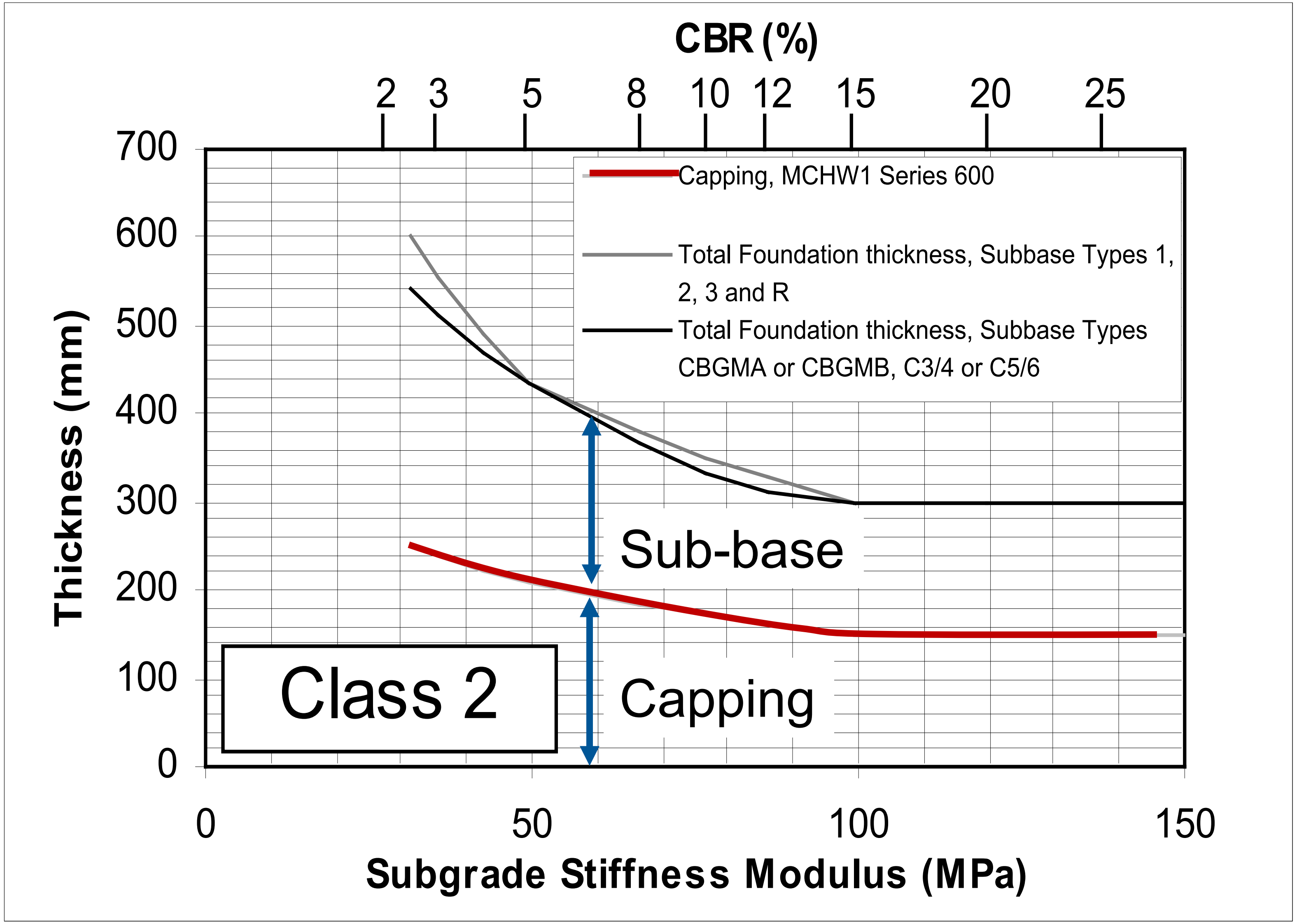
You can still use **CBR** for the subgrade if you wish!



UK Standard – IAN73/06

Common design – class 2 foundation

Restricted designs;
two foundation layers

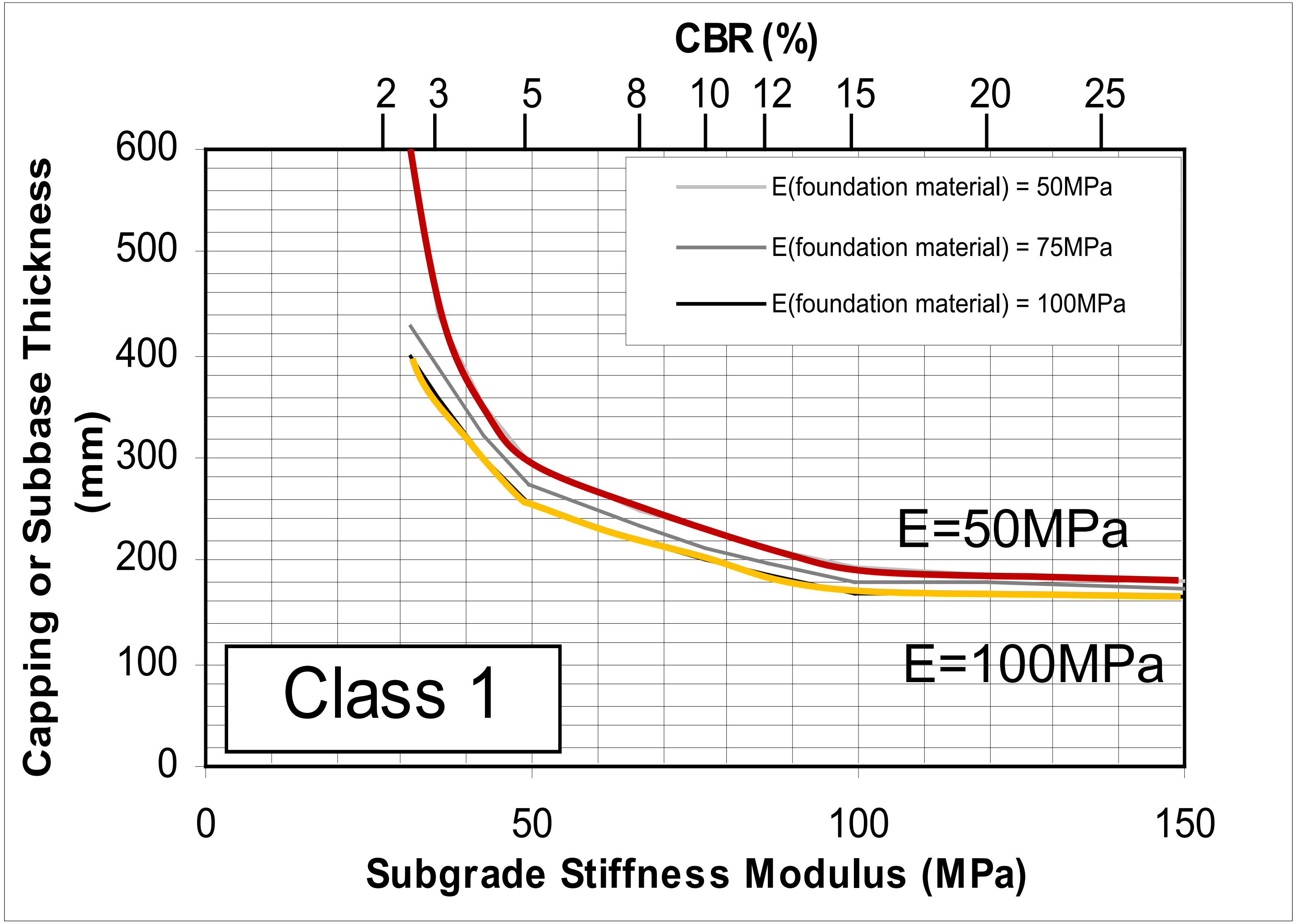


UK Standard – IAN73/06

Stiffness based, risk adopting, design

But there are also **thinner designs** – but the contractor carries the risk now!

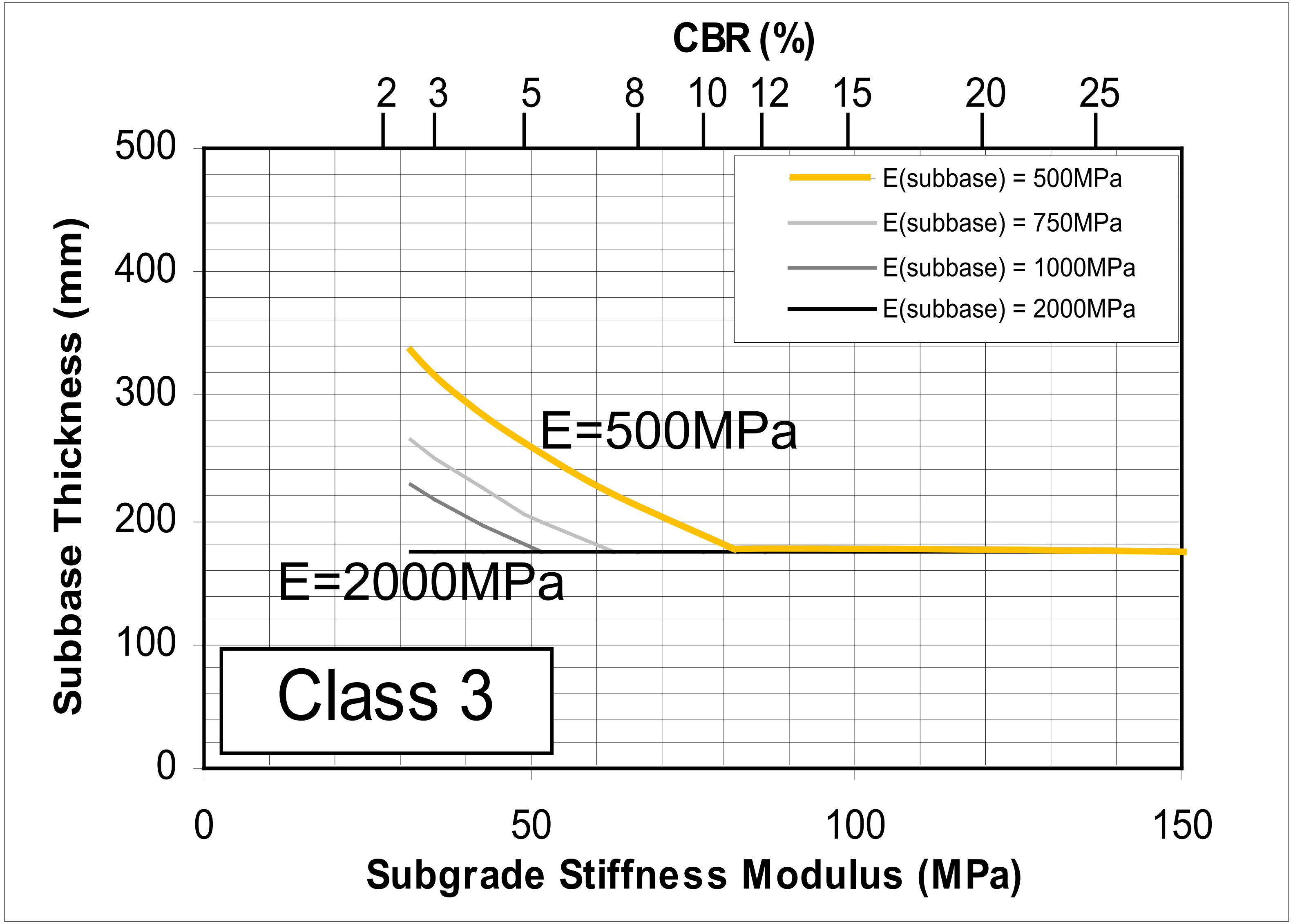
These are **Performance designs**



UK Standard – IAN73/06

Also for stiffer foundations – e.g. Class 3

Performance design Class 3

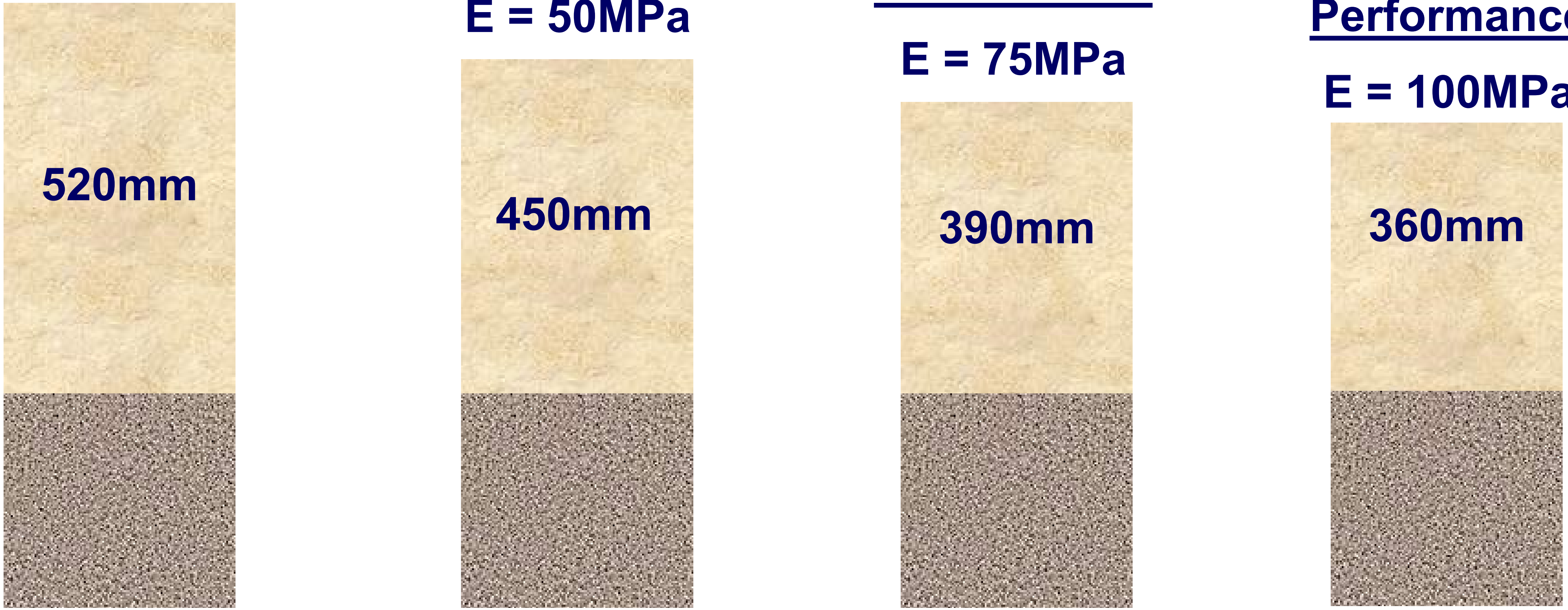


UK Standards – IAN73/06

Example – Foundation Class 1

Equivalent Designs – 35MPa Subgrade (3% CBR)

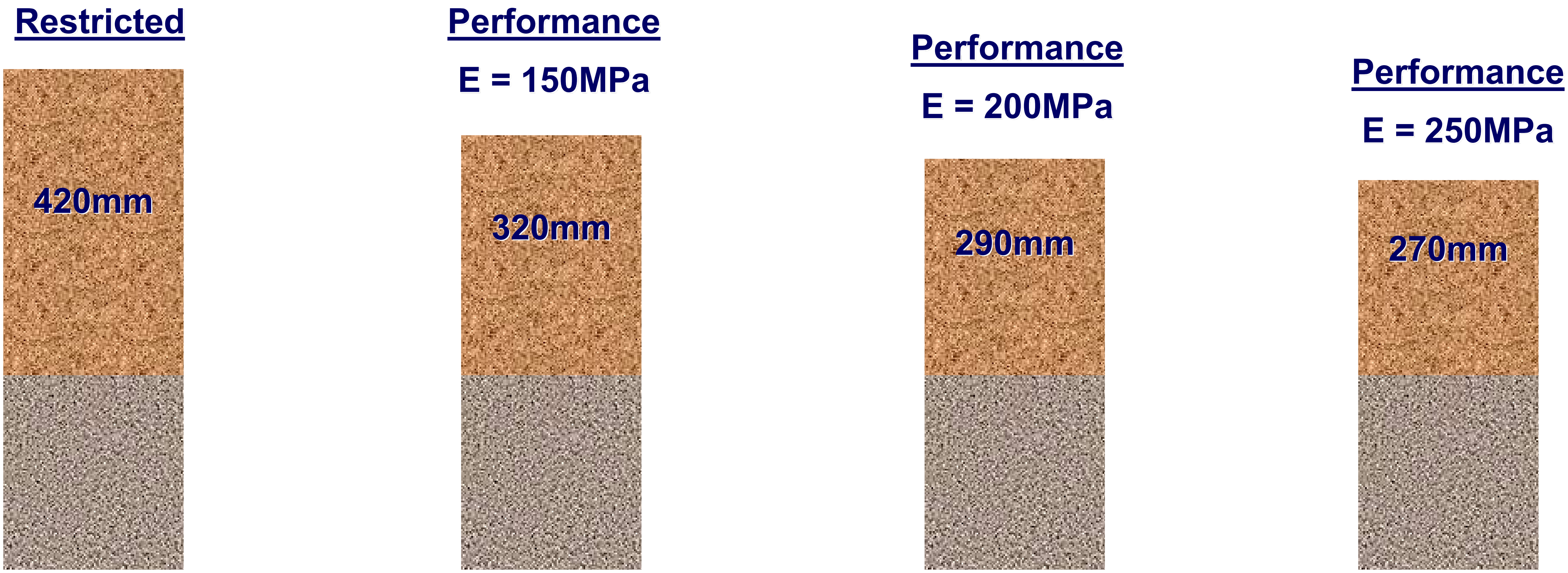
Restricted | **Performance** E = 50MPa | **Performance** E = 75MPa | **Performance** E = 100MPa



UK Standard – **IAN73/06**

Example – Foundation Class 2

Equivalent Designs – 35MPa Subgrade (3% CBR)



UK Standard – **IAN73/06**

Upper pavement design

Now you come to the **upper part** of the pavement

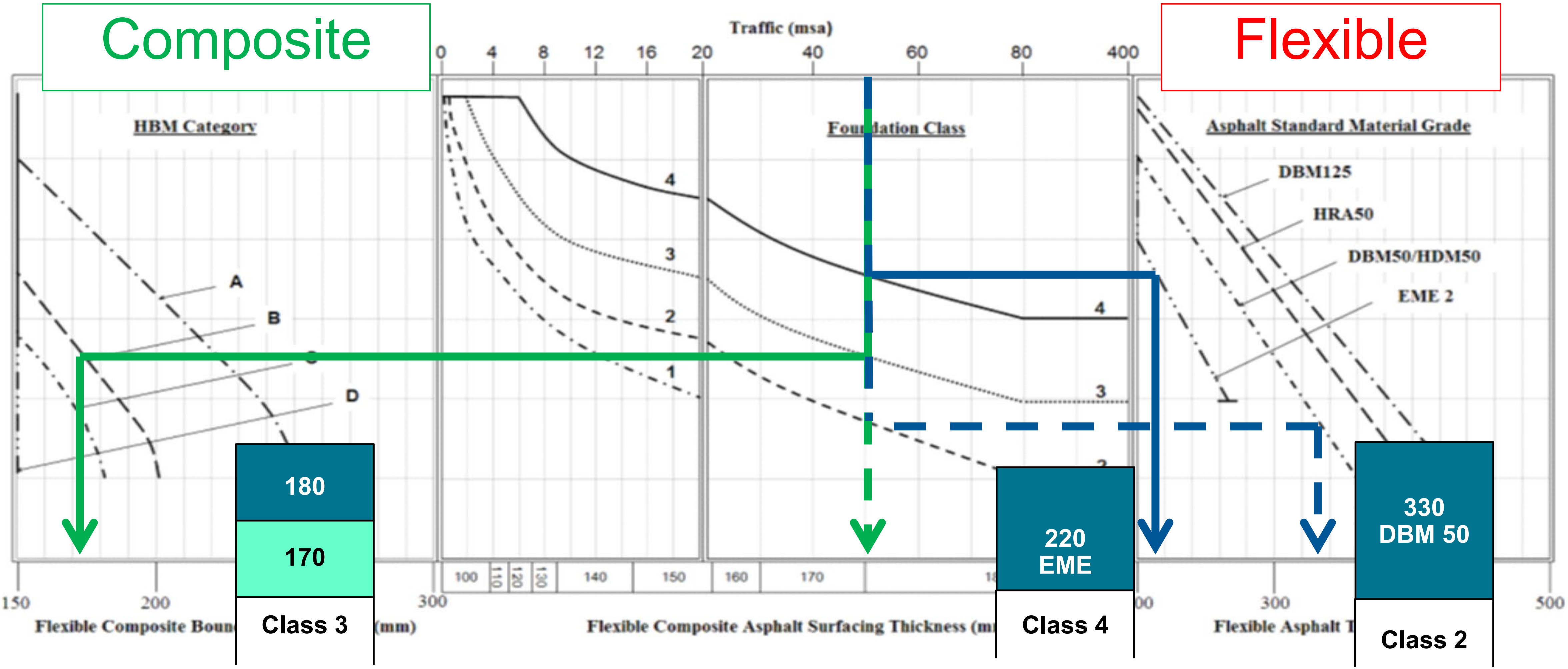
The first thing to sort out is the traffic in millions of standard (80kN) axle loads (**msa**)

UK Standards – **HD24/06**

Loading - HD24/06

Vehicle Type	Wear Factors (= conversion factor to standard axles)						
	Hakim (1998)	Frith et al (1997)	Highways England (**HD24**)		Collop (1999)		
					Flexible		Rigid
			Maintenance	New road	Rut'g	Fatigue	
2 axle rigid	-	0.40	0.40	0.60	1.16	1.46	0.68
3 axle rigid	1.16	1.26	2.30	3.40	2.32	2.39	1.29
3 axle artic'd	0.39	0.65	1.70	2.50	1.79	1.63	0.68
4 axle rigid	1.75	2.80	3.00	4.60	2.85	3.12	2.12
4 axle artic'd	0.84	1.00	1.70	2.50	2.71	2.26	1.10
5 axle artic'd	2.02	2.50	2.90	4.40	3.70	3.94	2.65
6 axle artic'd	1.78	1.69	3.70	5.60	3.94	3.03	1.48

Upper pavement thickness



UK Standard – **HD26/06**

University of Nottingham
UK | CHINA | MALAYSIA

Do-it-yourself designs

- DBFO organisations don't have to follow any design process
  - They have a delivery requirement (residual pavement life at end of contract and maximum permitted maintenance occupancy during contract)
  - They might employ a specialist designer's approach
- Local authorities can do anything they like
  - In practice they usually copy Highways England designs due to lack of expertise and to avoid risk/litigation
  - Often leads to over-design and/or unresponsive design to local conditions, materials, climate

Conclusions

- UK designs have derived from empirical design charts
- Empiricism has been refined by much work (originally by TRL)
- Addition of new materials, new loadings, new reliability targets, etc. has relied upon analytical extrapolation
- The resulting documents are reasonably flexible for designers of heavily trafficked roads
- There's no generally accepted appropriate method for city streets and local / minor roads

University of Nottingham
UK | CHINA | MALAYSIA

Thank you!