EUROCODE 6

Design of masonry structures

The NTC Comparative Studies

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for UK

by John Morton UK NTC

The National Technical Coordinator had two main tasks:

1 Calibration Exercise.
2 Preparing the National Annexes.

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1 Calibration Exercise.
2 Preparing the National Annexes

Both under the direction of the BSI Committee B525/6.

There had been design exercises done before:

1 "Real Building" Calibration Exercise.
2 BDA study on the Draft EN (Late 80s).

[a Calibration Exercise between CP 111 & BS 5628 done in the Mid/late 70s]

Calibration Exercise. (~2000 / 01)

It was decided to do two exercises:

1 Parametric study
2 Real building study

[A repeat of the earlier ‘Real Building’ exercise]

PARAMETRIC STUDY

BS5628

Bricks / blocks
4 mortars
Wall Height h + ts

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? Design load (γ_m= 3.5)

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EC6

Same brick / block
Same mortar
Same h & ts
What value of γ_M allows the same design load to be carried as in the BS5628 design.

BS5628

Bricks / blocks
4 mortars
Wall Height h + ts
? Design load (γ_m= 3.5)

'Tweak' for the loading side (1.05)

EC6

Same brick/block
Same mortar
Same h & t
What value of γ_m allows the same design load to be carried as in BS5628 design.

Results

γ_M required for parity with BS5628

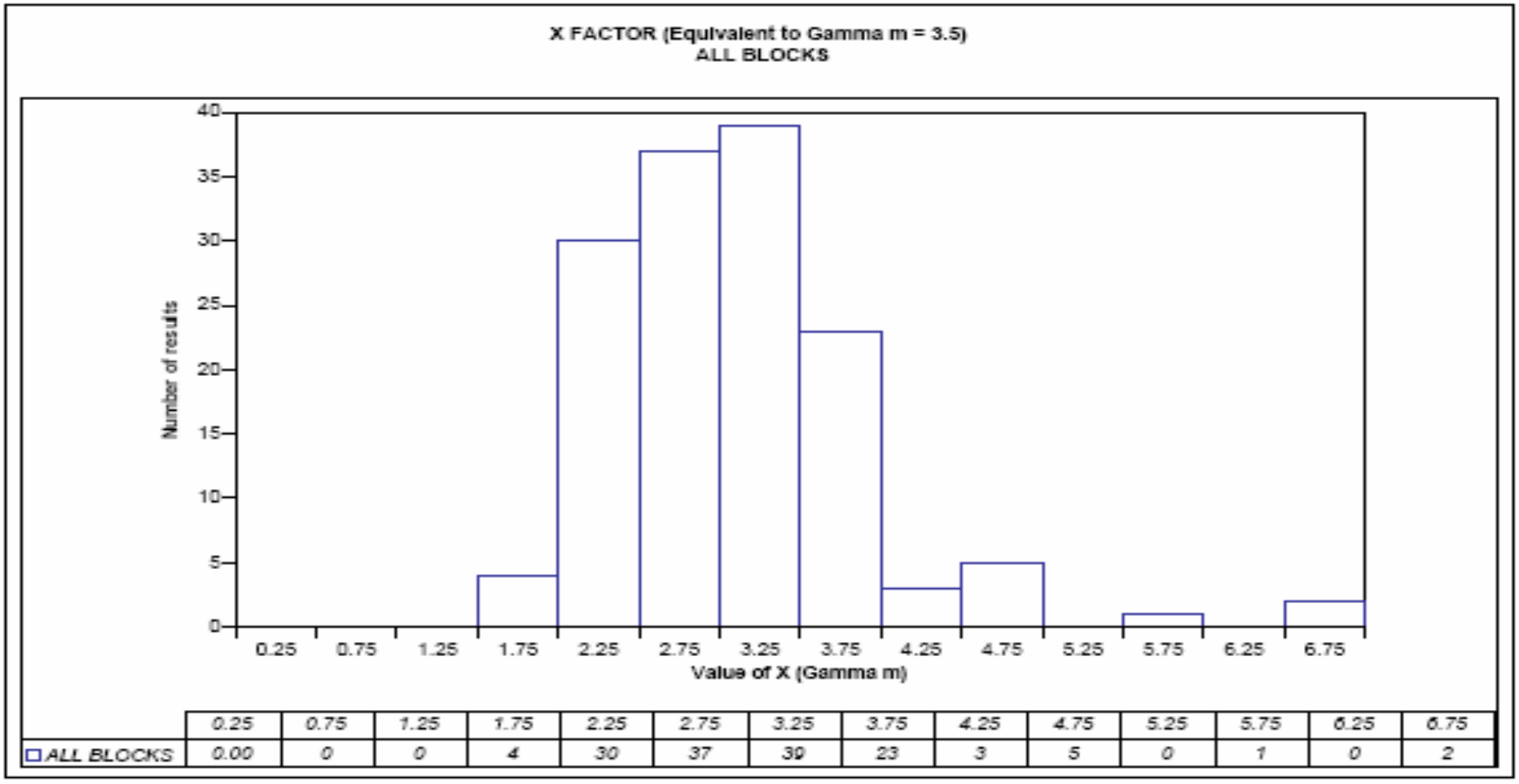
Eccentricity = 0.05t, 0.1t, 0.2t, & 0.3t

Bricks plus Blocks

(504 results)

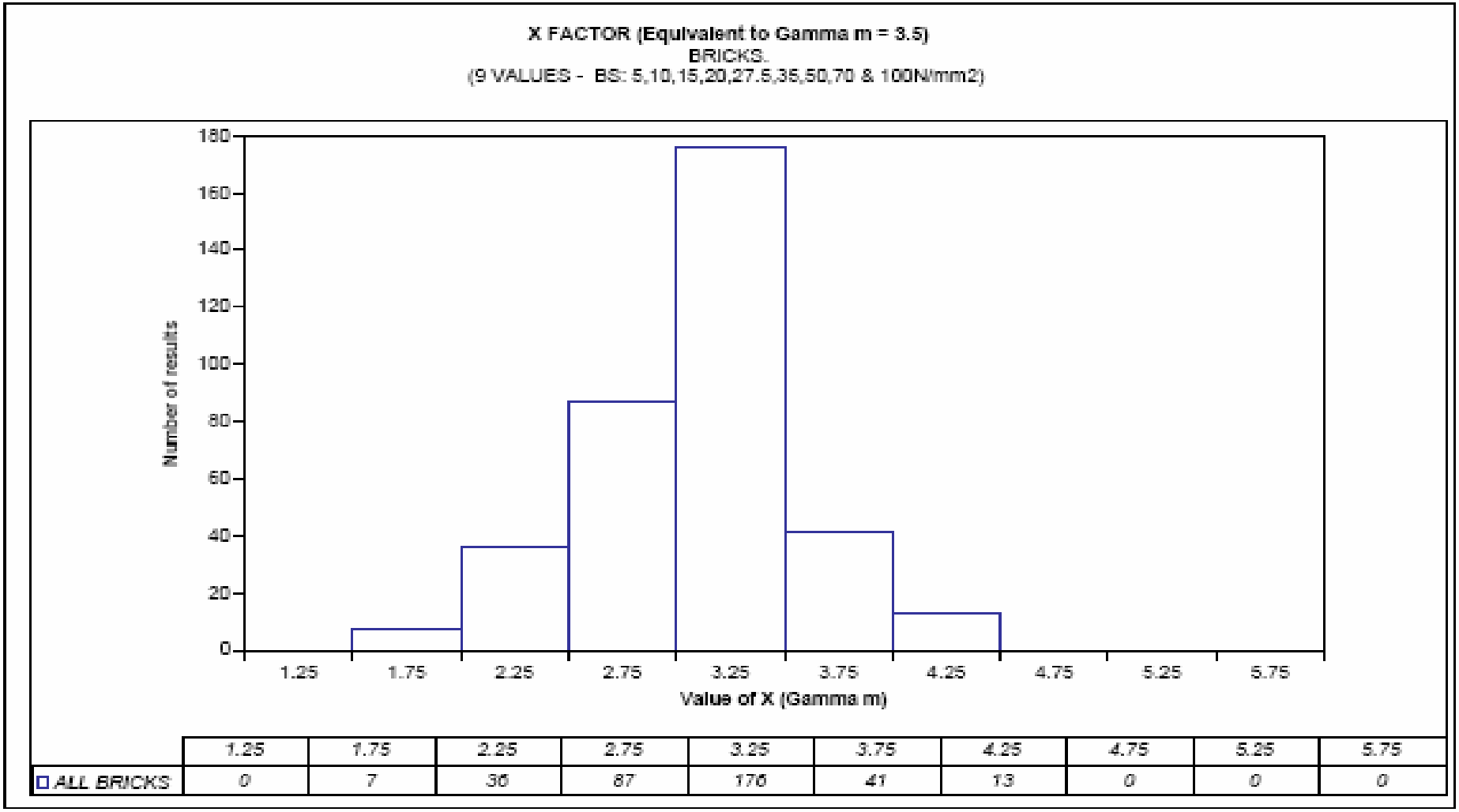
Max = 6.57
Min = 1.70
Ave = 3.09

Results	γ_M required for parity with BS5628
Eccentricity = 0.05t, 0.1t, 0.2t, & 0.3t	
Blocks only	**Max = 6.57** **Min = 1.70** **Ave = 3.09**
(144 results)	
Bricks only	**Max = 4.42** **Min = 1.81** **Ave = 3.09**
(360 results)	



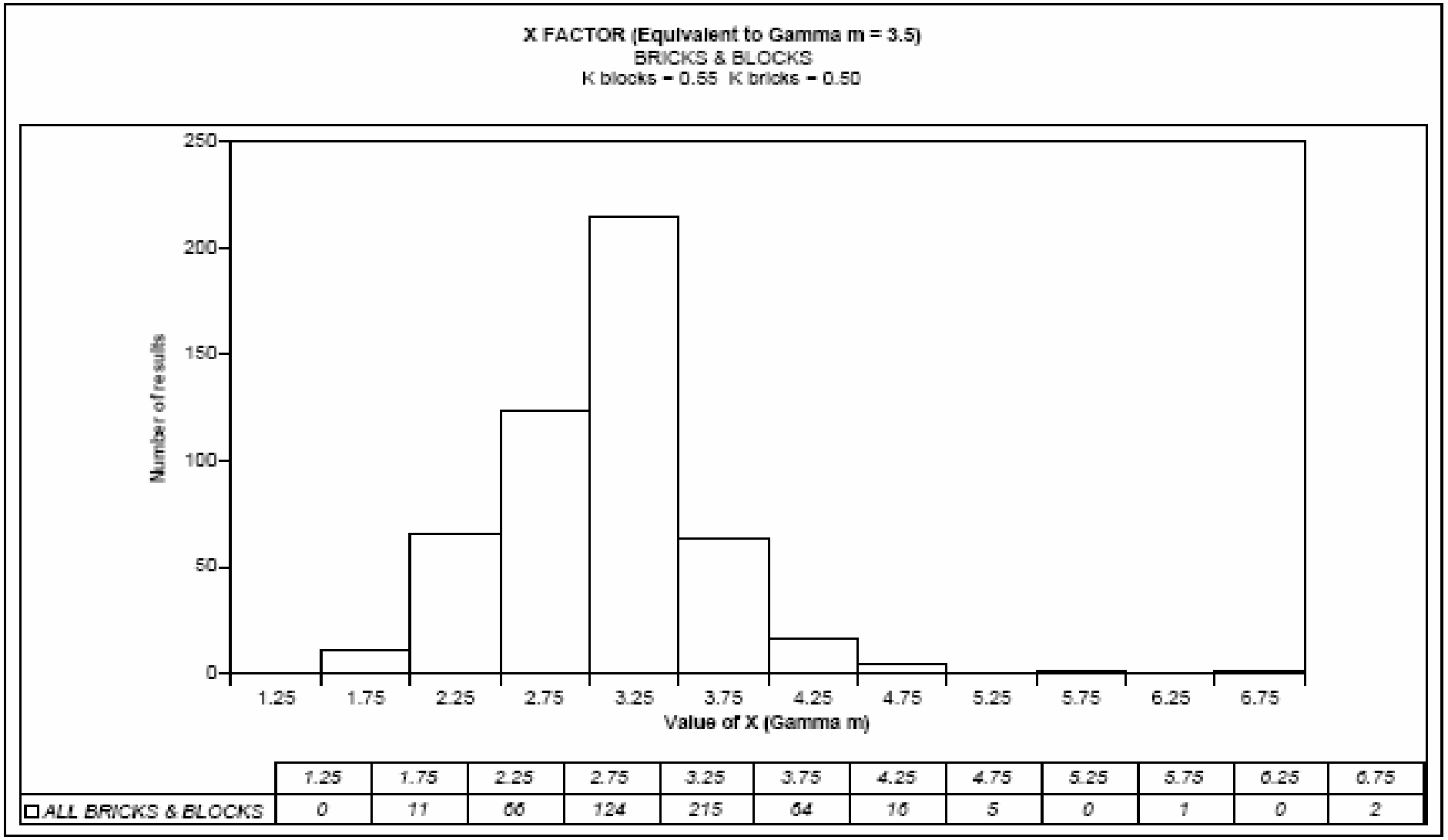
	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75
ALL BLOCKS	0.00	0	0	4	30	37	39	23	3	5	0	1	0	2

ChBlocks3.5 20060527Final PARA Hists to 0.3 CR 0 all bricks.xls



	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75
ALL BRICKS	0	7	36	87	176	41	13	0	0	0

The NTC Comparative Studies
Parametric Study



	1.25	1.75	2.25	2.75	3.25	3.75	4.25	4.75	5.25	5.75	6.25	6.75
ALL BRICKS & BLOCKS	0	11	66	124	215	64	16	5	0	1	0	2

Results

γ_M required for parity with BS5628

Eccentricity = 0.05t, 0.1t, 0.2t, & 0.3t & 0.4t

Bricks plus Blocks

(630 results)

Max = 6.57
Min = 1.21
Ave = 2.93

The NTC Comparative Studies
Parametric Study

PARAMETRIC STUDY

RESULTS SUMMARY

Equivalent γ_M's required using EC6 for parity to BS value of 3.5

	Max	Min	Average	
Eccentricity up to 0.4t				
BLOCKS	6.57	1.21	2.91	
BRICKS	4.42	1.30	2.94	
BLOCKS AND BRICKS	**6.57**	**1.21**	**2.93**	
Eccentricity up to 0.3t				
BLOCKS AND BRICKS	**6.57**	**1.70**	**3.09**	

REAL BUILDING STUDY

12 storey structure

- internal & external walls
- internal solid, external cavity
- top, 3rd, 6th, 9th & ground floor
- floor spans 2m, 3m, 5m & 7m
  in all combinations

Methodology.

Using a 12 storey structure the following designs were done:

Wall 1 (top), Wall 3, Wall 6, Wall 9 & Wall 12 (bottom)

using both external cavity walls and internal solid walls with floor spans both sides

using 7m 5m & 3m spans for floors and 2m spans for corridors

using 250mm and 175mm deep slabs for the 7m and 5m spans respectively and 150mm slabs for the 3m and 2m floor and corridor spans

using γ_f values of BS : 1.4 & 1.6 and EC : 1.35 & 1.5

BLOCKWORK

100 mm Blockwork in Cavity Wall (with 102.5 mm brickwork outer leaf)

100 mm Blockwork Solid Internal Wall

150 mm Blockwork in Cavity Wall (with 102.5 mm brickwork outer leaf)

150 mm Blockwork Solid Internal Wall

BRICKWORK

102.5 mm Brickwork in Cavity Wall (with 102.5 mm brickwork outer leaf)

102.5 mm Brickwork Solid Internal Wall

215 mm Brickwork in Cavity Wall (with 102.5 mm brickwork outer leaf)

215 mm Brickwork Solid Internal Wall

RESULTS SUMMARY		
Equivalent γ_M's required using EC6 for parity to BS value of 3.5		
	Average Value of the Equivalent gamma m (Over all 12 storeys)	Average Value of the Equivalent gamma m (Over only top 6 storeys)
Blockwork		
100 mm Cavity	2.76	2.90
100 mm Solid	2.62	2.64
150 mm Cavity	3.15	3.20
150 mm Solid	3.13	3.22

RESULTS SUMMARY		
Equivalent γ_M's required using EC6 for parity to BS value of 3.5		
	Average Value of the Equivalent gamma m (Over all 12 storeys)	Average Value of the Equivalent gamma m (Over only top 6 storeys)
Brickwork		
102.5 mm Cavity	3.68	3.58
102.5 mm Solid	3.96	3.91
215 mm Cavity	2.86	2.83
215 mm Solid	3.05	2.94

INTERNAL SOLID WALL						
Blockwork	100mm	Spans	7&7	7&5	7&3	7&2
		Top 12	2.28	2.65	3.16	3.43
		Wall 9	2.06	2.29	2.19	2.22
		Wall 6	2.6	2.74	2.66	2.69
		Wall 3	NO	NO	NO	2.74
		Ground 0	NO	NO	NO	NO
	Average over 12 storeys		2.31	2.56	2.67	2.77
	Average over 6 storeys		2.31	2.56	2.67	2.78

EXTERNAL CAVITY WALL						
Blockwork	100 mm	Spans	7	5	3	
Brickwork	102.5 mm					
		Top 12	3.34	3.74	3.48	
		Wall 9	2.47	2.79	3.32	
		Wall 6	2.81	3.01	3.85	
		Wall 3	2.73	3.09	3.48	
		Ground 0	2.92	2.91	3.38	
						Average =
	Average over 12 storeys		2.85	3.11	3.50	3.15
	Average over 6 storeys		2.87	3.18	3.55	3.20

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100 mm Blockwork Solid Internal Wall

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Parametric Study
Real Building Study

Where did this all lead to?

Parametric Study
Real Building Study

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Values for γ_M in the National Annexes

UK NA to BS EN 1996-1-1:2005

UK National Annex to Eurocode 6: Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures

There is the full table of γ_M values - as called for in EC6.

This Table does not translate well into a slide - too much information.

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Only 2 Classes of execution control and Category I & II units

Values of γ_M for ultimate limit states

Class of execution control: [A]	γ_M	
	1 [A]	2 [A]
Material		
Masonry		
When in a state of direct or flexural compression		
Unreinforced masonry made with:		
units of category I	2,3 [D] *	2,7 [D] *
units of category II	2,6 [D] *	3,0 [D] *
Reinforced masonry made with:		
units of category I	2,0 [D]	[B]
units of category II	2,3 [D]	[B]

WHERE TO NEXT?

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Study funded to collate all the γ_M values from across all CEN members.

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Work in Progress!

in 5 – 8 years – lower γ_m values??

Thanks to:

ODPM/DCLG Richard Shipman (Geoff Harding)

Steering Group:
Barry Haseltine Cliff Fudge Peter Watt / Ali Arasteh

BSI B525/6/102 Committee [Clare Price]

END

John Morton March 2009