

Structural use of concrete —

**Part 3: Design charts for singly
reinforced beams, doubly reinforced
beams and rectangular columns**

UDC 624.012.3/.4 + 691.3

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Civil Engineering and Building Structures Standards Committee (CSB/-) to Technical Committee CSB/39, upon which the following bodies were represented:

Association of Consulting Engineers
 British Aggregate Construction Materials Industries
 British Precast Concrete Federation Ltd.
 British Railways Board
 British Ready Mixed Concrete Association
 British Reinforcement Manufacturers' Association
 British Steel Industry
 Building Employers' Confederation
 Cement Admixtures Association
 Cement and Concrete Association
 Cement Makers' Federation
 Concrete Society
 Department of the Environment (Building Research Establishment)
 Department of the Environment (Housing and Construction Industries)
 Department of the Environment (Property Services Agency)
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 Institution of Civil Engineers
 Institution of Structural Engineers
 Precast Flooring Federation
 Royal Institute of British Architects
 Sand and Gravel Association Limited

This British Standard, having been prepared under the direction of the Civil Engineering and Building Structures Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 December 1985

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The following BSI references relate to the work on this standard:
 Committee reference CSB/39
 Draft (ref 84/14533) announced
BSI News October 1985

Amendments issued since publication

| Amd. No. | Date of issue | Comments |
|----------|---------------|---------------------------------------|
| 5918 | May 1989 | Indicated by a sideline in the margin |
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ISBN 0 580 14781 9

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| f_y | Chart number |
| 250 | 1 |
| 460 | 2 |
| Doubly reinforced beams | |
| f_y f_{cu} d'/d | Chart number |
| 460 25 | 0.10 3 |
| | 0.15 4 |
| | 0.20 5 |
| 460 30 | 0.10 6 |
| | 0.15 7 |
| | 0.20 8 |
| 460 35 | 0.10 9 |
| | 0.15 10 |
| | 0.20 11 |
| 460 40 | 0.10 12 |
| | 0.15 13 |
| | 0.20 14 |
| 460 45 | 0.10 15 |
| | 0.15 16 |
| | 0.20 17 |
| 460 50 | 0.10 18 |
| | 0.15 19 |
| | 0.20 20 |
| Rectangular columns | |
| f_y f_{cu} d/h | Chart number |
| 460 25 | 0.75 21 |
| | 0.80 22 |
| | 0.85 23 |
| | 0.90 24 |
| | 0.95 25 |
| 460 30 | 0.75 26 |
| | 0.80 27 |
| | 0.85 28 |
| | 0.90 29 |
| | 0.95 30 |
| 460 35 | 0.75 31 |

| | | | |
|---|----|------|-------------------|
| | | 0.80 | 32 |
| | | 0.85 | 33 |
| | | 0.90 | 34 |
| | | 0.95 | 35 |
| 460 | 40 | 0.75 | 36 |
| | | 0.80 | 37 |
| | | 0.85 | 38 |
| | | 0.90 | 39 |
| | | 0.95 | 40 |
| 460 | 45 | 0.75 | 41 |
| | | 0.80 | 42 |
| | | 0.85 | 43 |
| | | 0.90 | 44 |
| | | 0.95 | 45 |
| 460 | 50 | 0.75 | 46 |
| | | 0.80 | 47 |
| | | 0.85 | 48 |
| | | 0.90 | 49 |
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Foreword

This Part of BS 8110 has been prepared under the direction of the Civil Engineering and Building Structures Standards Committee.

BS 8110 deals with the structural use of concrete. It is published in three Parts:

- *Part 1: Code of practice for design and construction;*
- *Part 2: Code of practice for special circumstances;*
- *Part 3: Design charts for singly reinforced beams, doubly reinforced beams and rectangular columns.*

The design charts in this Part of BS 8110 have been prepared in accordance with the assumptions laid down in Part 1, with the intention that they may be used as standard charts and so avoid duplication of effort by individual design offices.

This Part of BS 8110 reflects the change in the characteristic strength of available reinforcing steel and supersedes CP 110-2:1972 and CP 110-3:1972 which are both withdrawn.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 2 to 56, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 General

1.1 Scope

This part of BS 8110 covers design charts for singly reinforced beams, doubly reinforced beams and rectangular columns. These design charts cannot be used to obtain the complete detailed design of any member but they may be used as an aid when analysing the cross section of a member at the ultimate limit state. The charts have been based on the assumptions laid down in BS 8110-1, use being made of the parabolic-rectangular stress block throughout. Full details of the derivation of the charts are given in Appendix.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

1.2 Symbols

For the purposes of this Part of BS 8110 the definitions of the symbols given in BS 8110-1 and BS 8110-2 apply together with the following which are used in Appendix.

| | |
|--------------|---|
| f_{sc} | Stress in reinforcement in compression at the ultimate limit state |
| f_{st} | Stress in reinforcement in tension at the ultimate limit state |
| ϵ_0 | Strain at the point on the parabolic-rectangular stress-strain diagram where the parabolic section joins the linear section ($\epsilon_0 = 2.4 \times 10^{-4} \sqrt{f_{cu}/\gamma_m}$). |

1.3 Use of charts

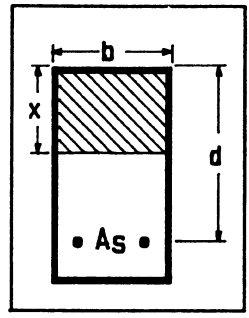
Design examples illustrating the use of the charts are given in Appendix B.

The values of K indicated on the column design charts are the additional moment reduction coefficients given by equation 33 of BS 8110-1:1985.

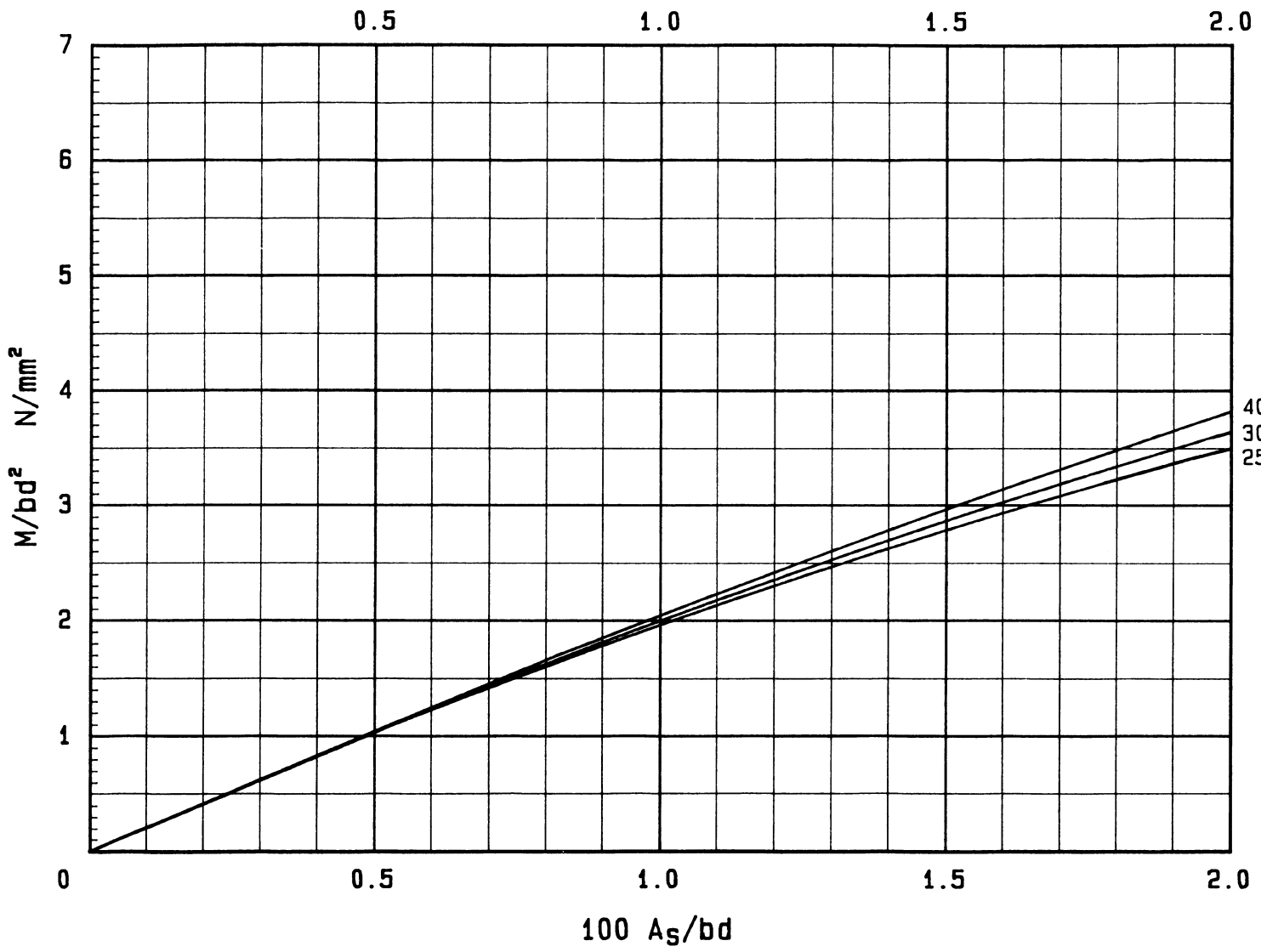
2 Design charts

Design charts Nos. 1 to 50 are given on the following pages.

f_{cu} N/mm²



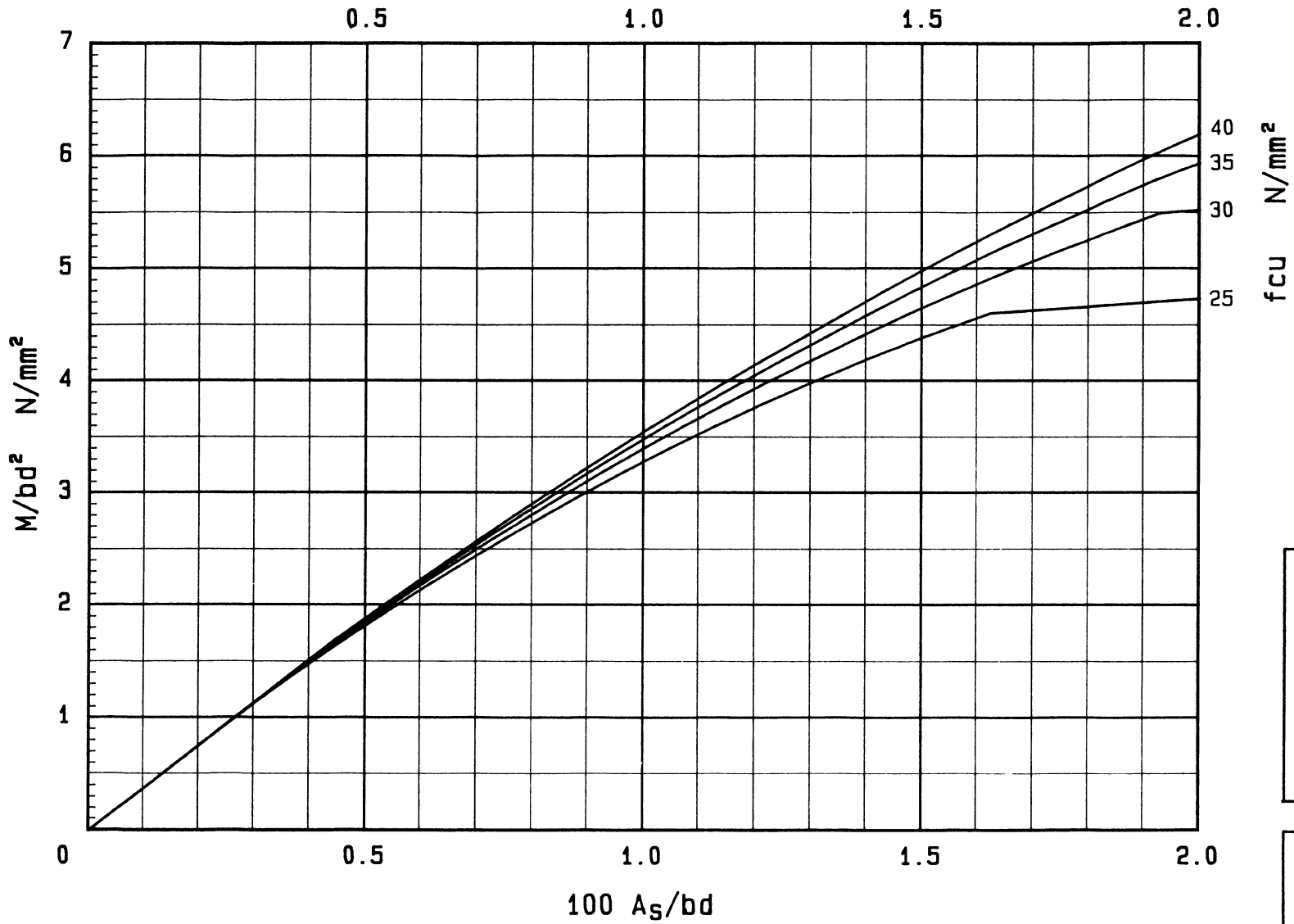
f_y 250



Singly reinforced beams

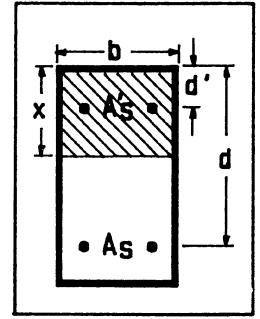
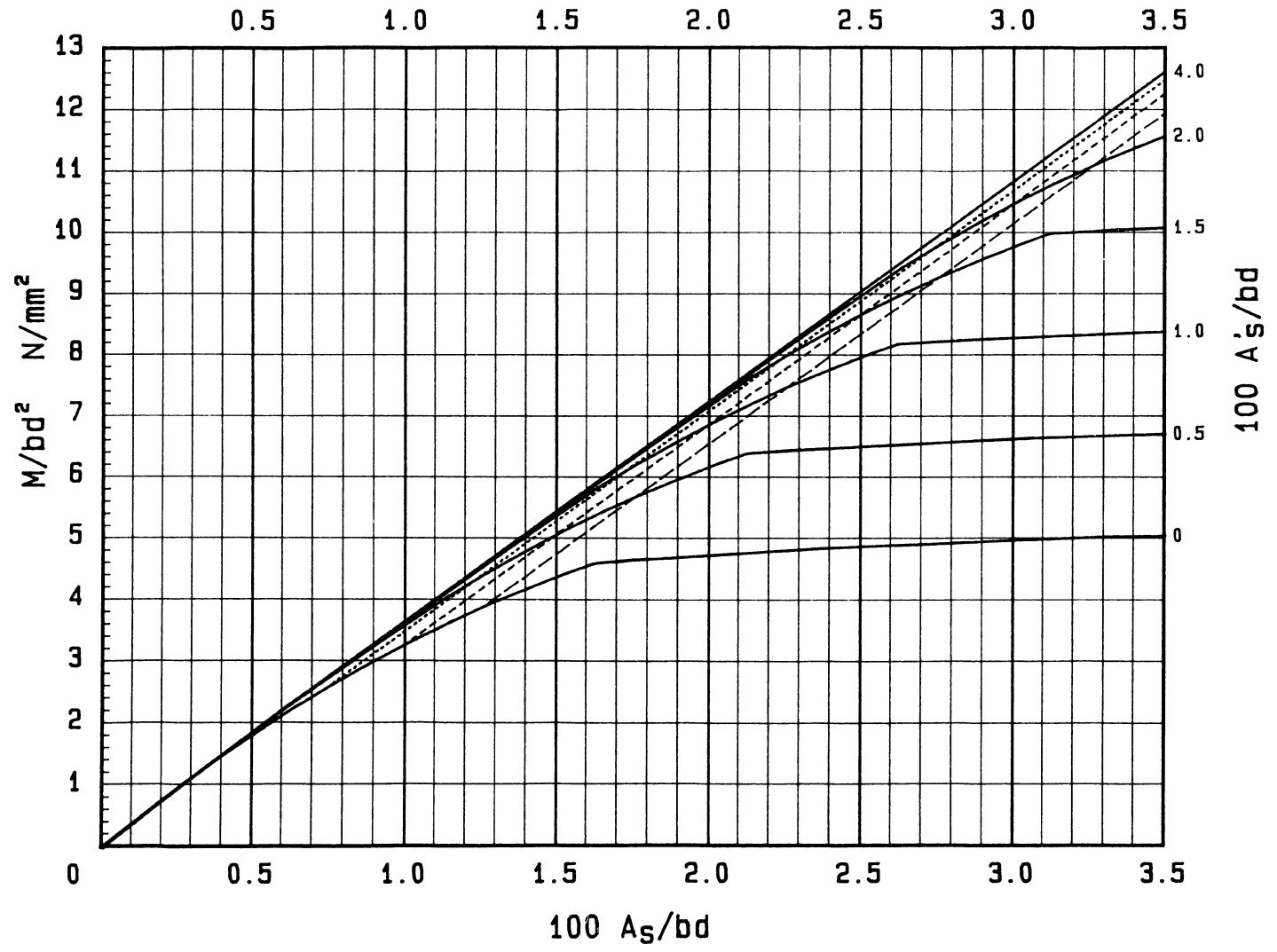
Chart No. 1

Chart No. 2



Singly reinforced beams

$x/d = 0.3$
 $x/d = 0.4$ - - - -
 $x/d = 0.5$ - - - -

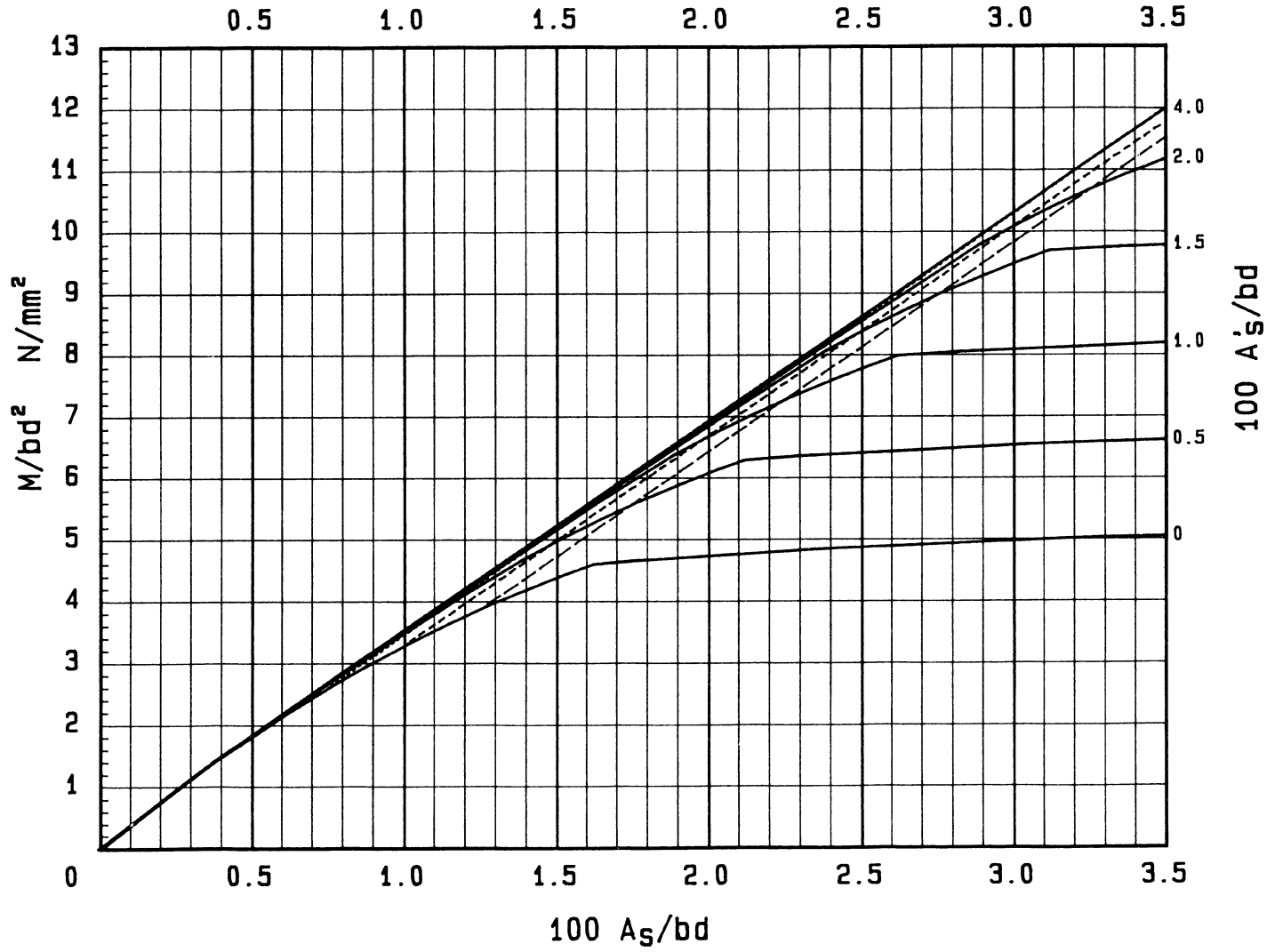


| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d'/d | 0.10 |

Doubly reinforced beams

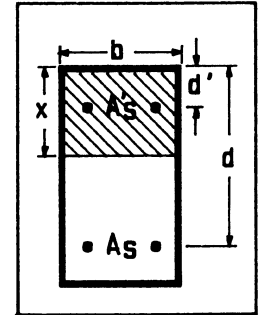
Chart No. 3

Chart No. 4



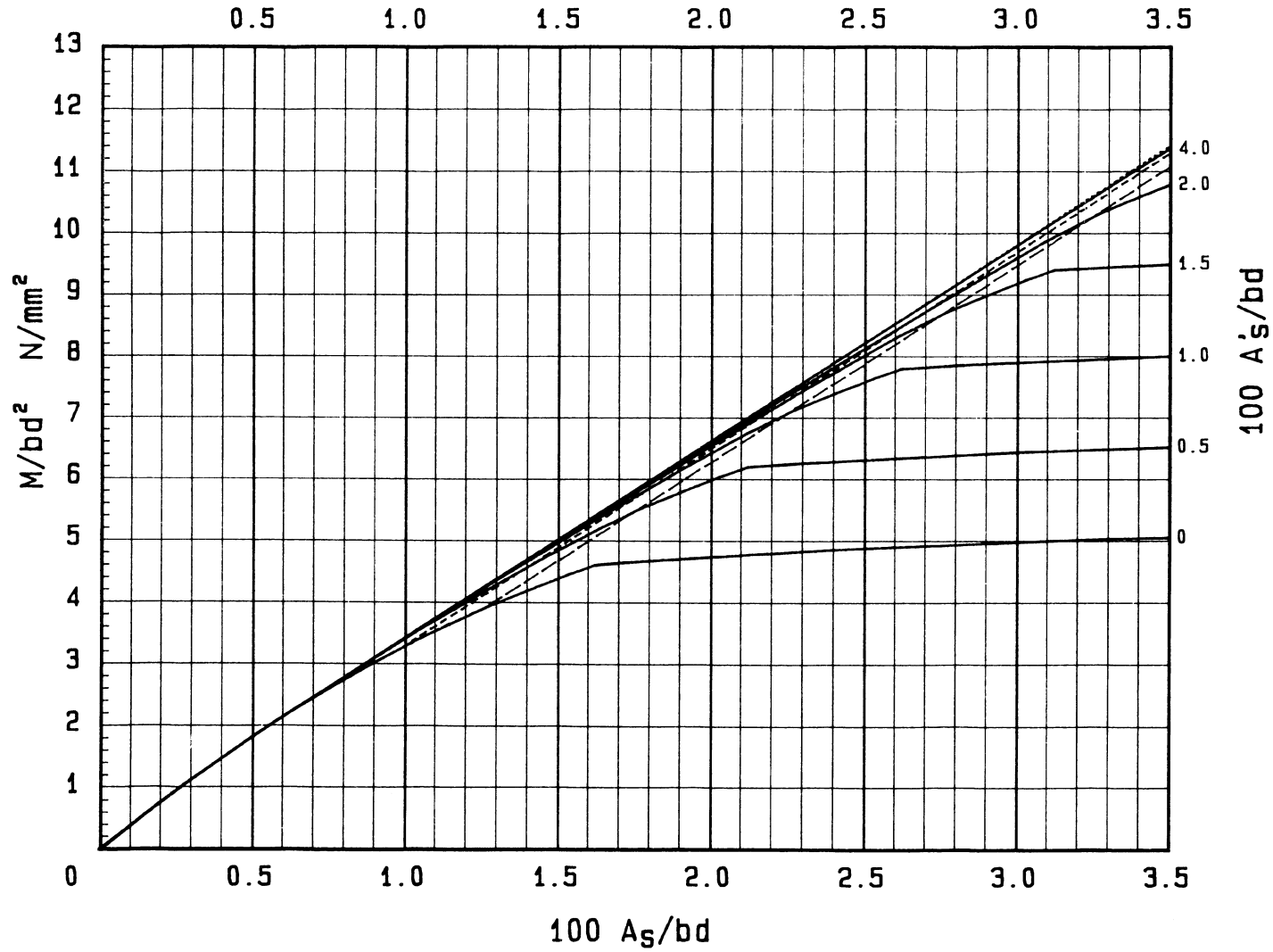
Doubly reinforced beams

$x/d = 0.3$
 $x/d = 0.4$
 $x/d = 0.5$ - - -



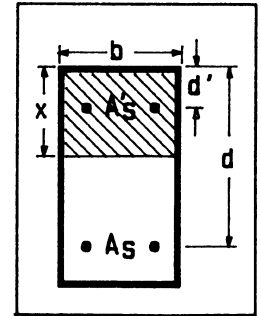
| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| a'/d | 0.15 |

Chart No. 5



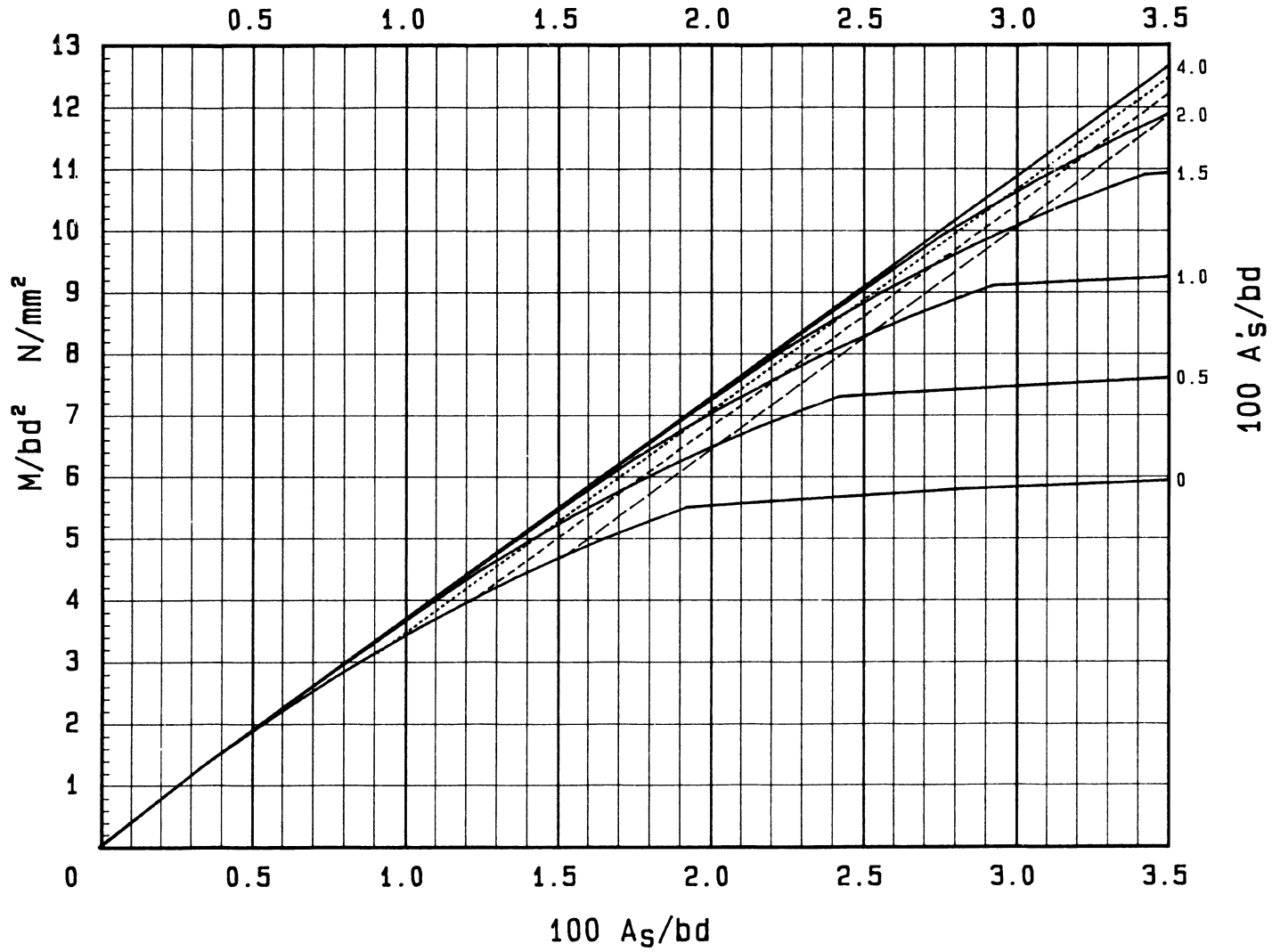
Doubly reinforced beams

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - · - - - (dash-dot line)

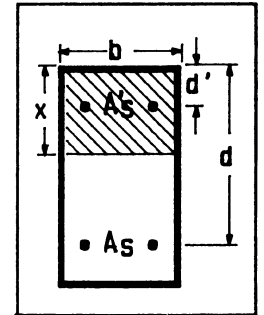


| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d'/d | 0.20 |

Chart No. 6



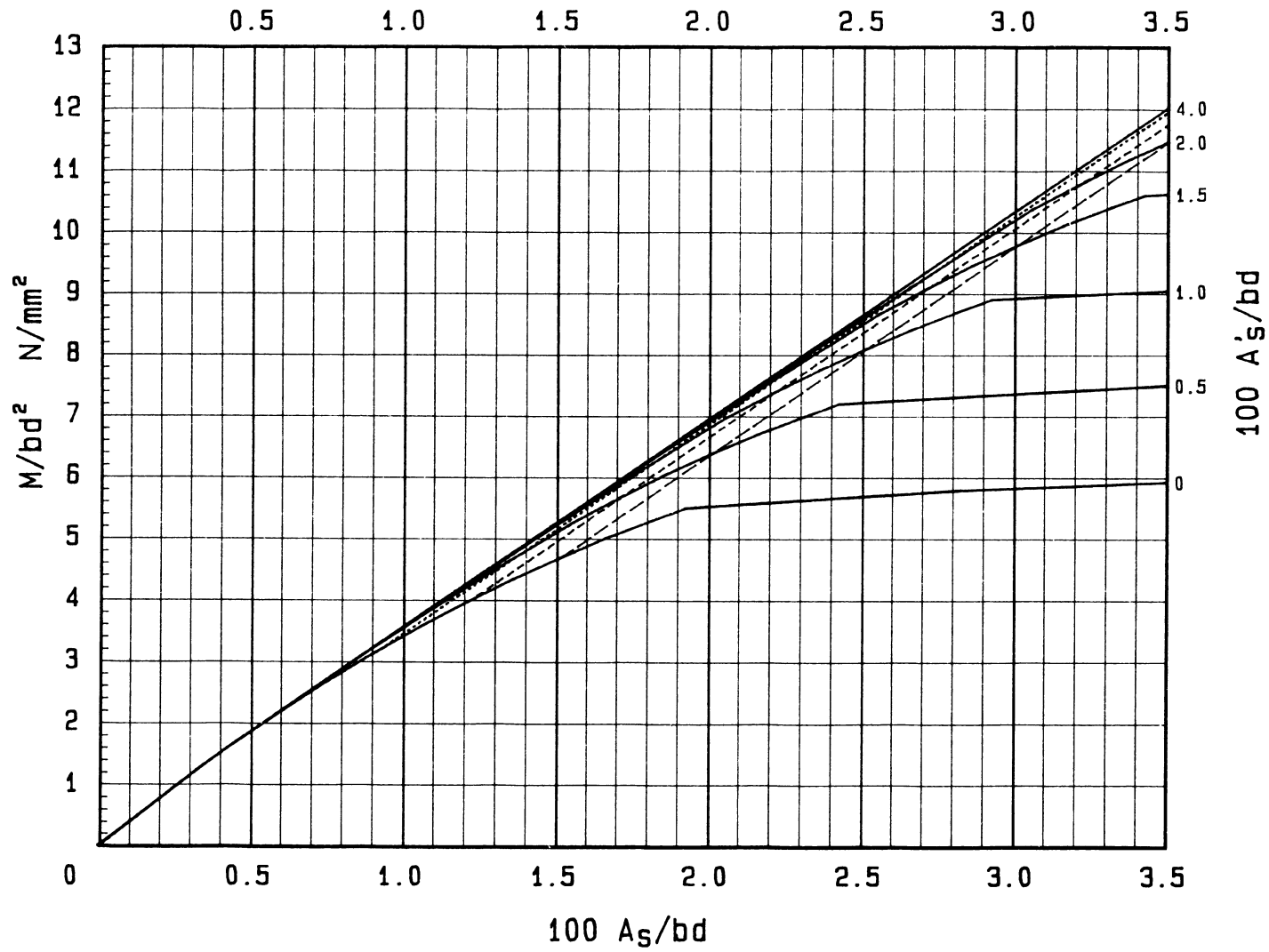
$x/d = 0.3$
 $x/d = 0.4$ - - - -
 $x/d = 0.5$ - · - ·



| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d'/d | 0.10 |

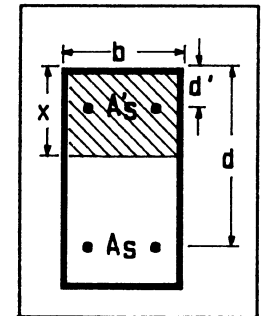
Doubly reinforced beams

Chart No. 7



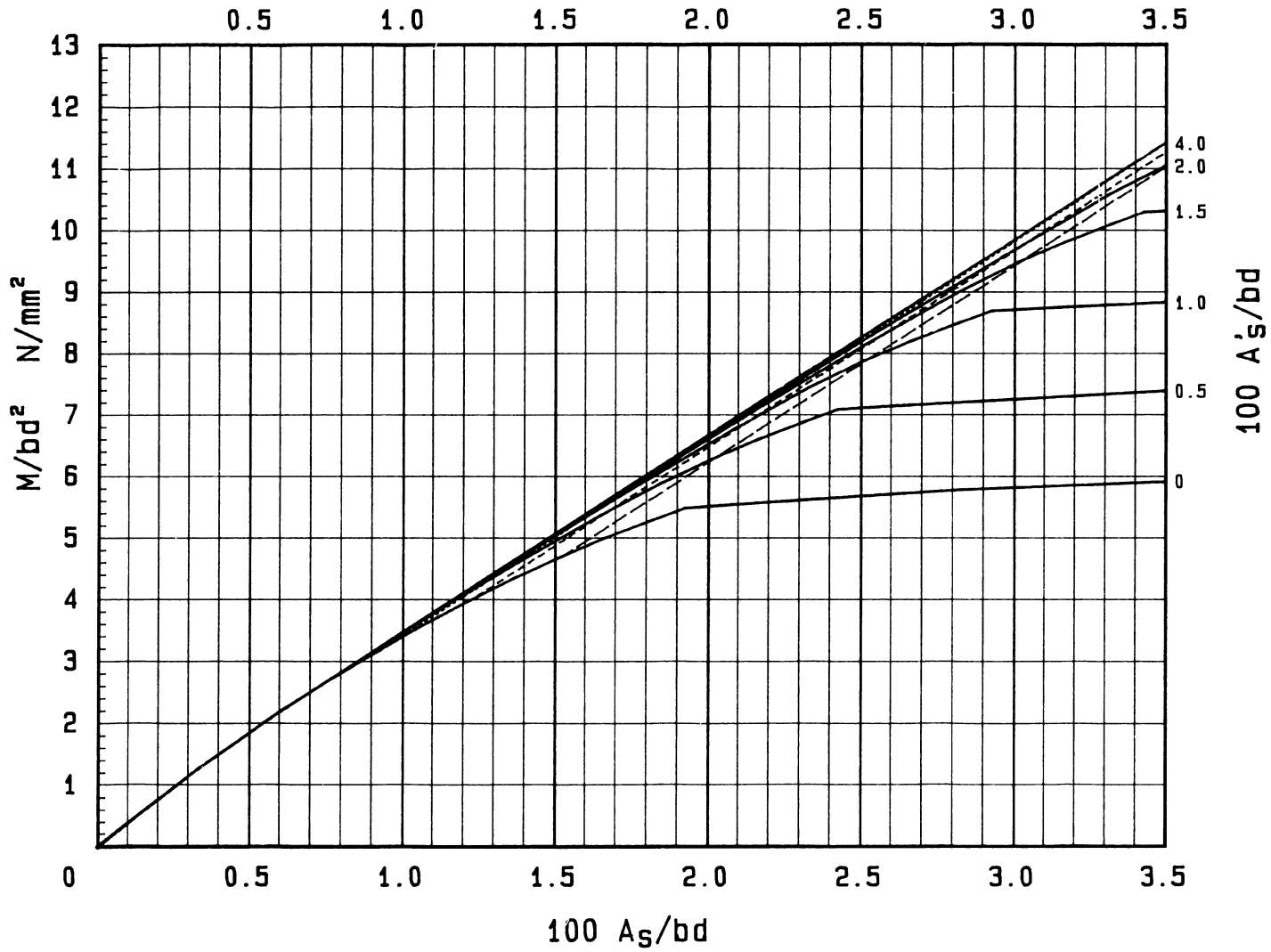
Doubly reinforced beams

$x/d = 0.3$
 $x/d = 0.4$
 $x/d = 0.5$ - - -

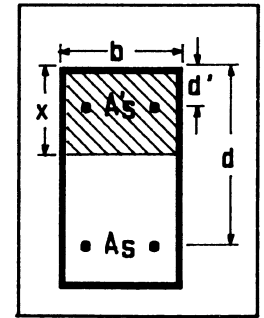


| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d'/d | 0.15 |

Chart No. 8



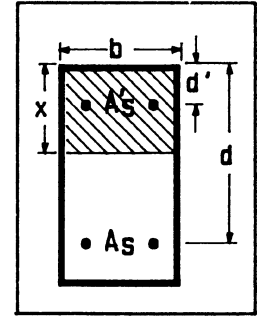
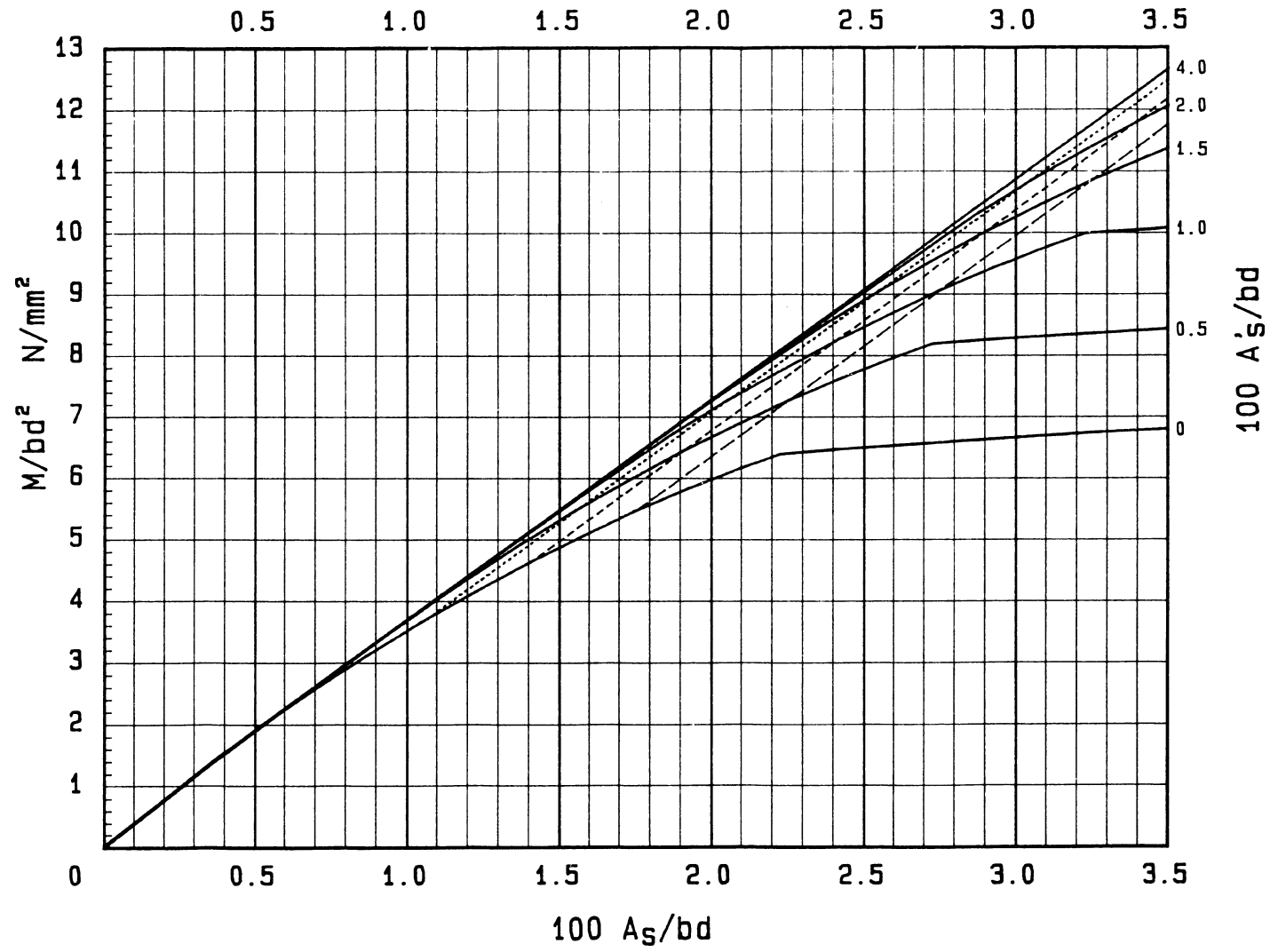
- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - . - . - (dash-dot line)



| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d'/d | 0.20 |

Doubly reinforced beams

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - - - - - (dash-dot line)

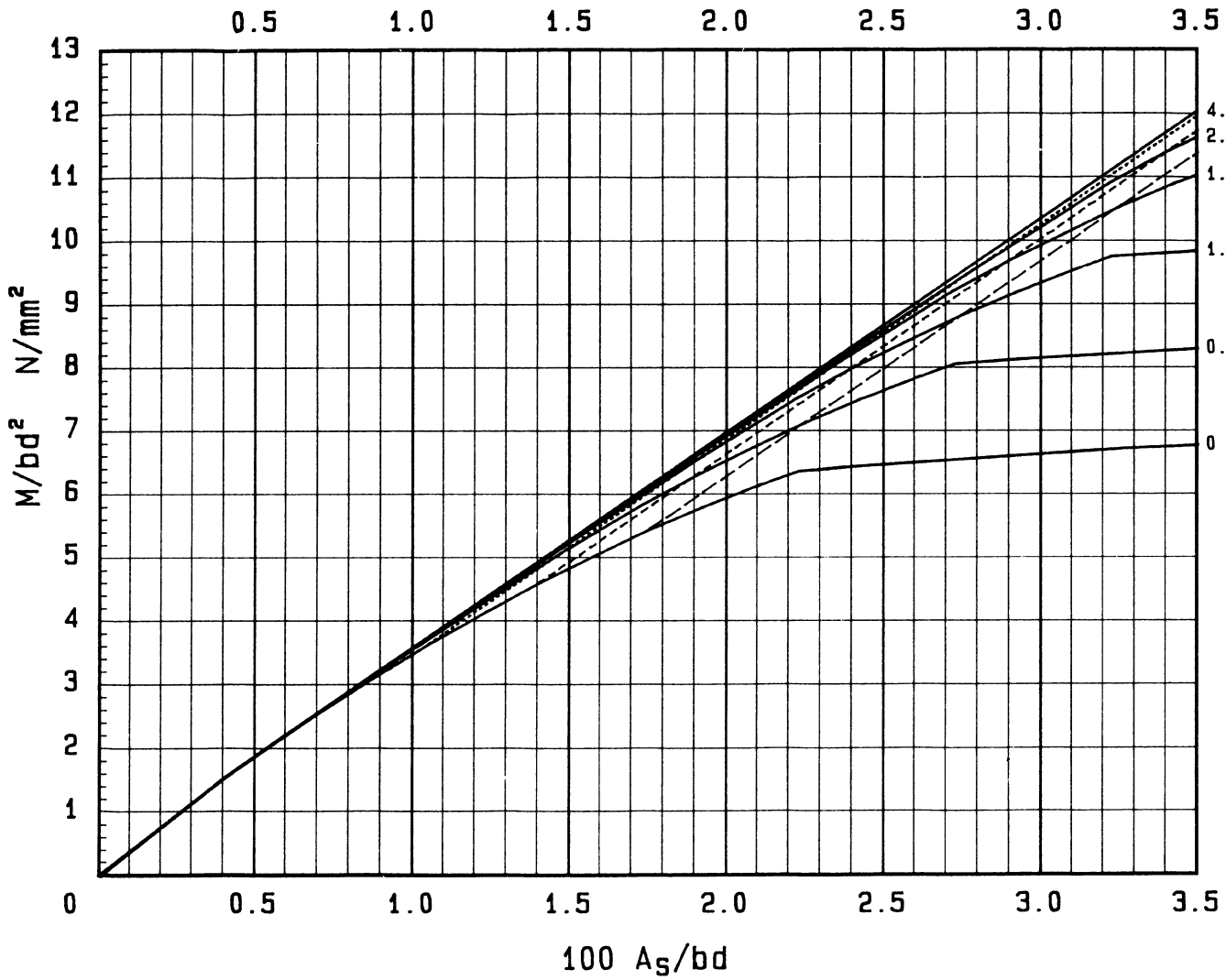


| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d'/d | 0.10 |

Doubly reinforced beams

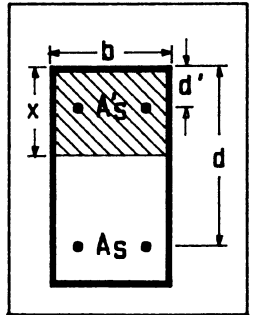
Chart No. 9

Chart No. 10



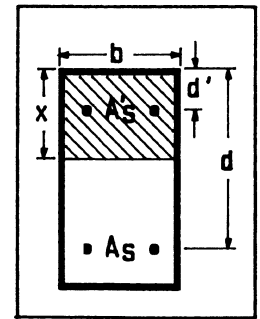
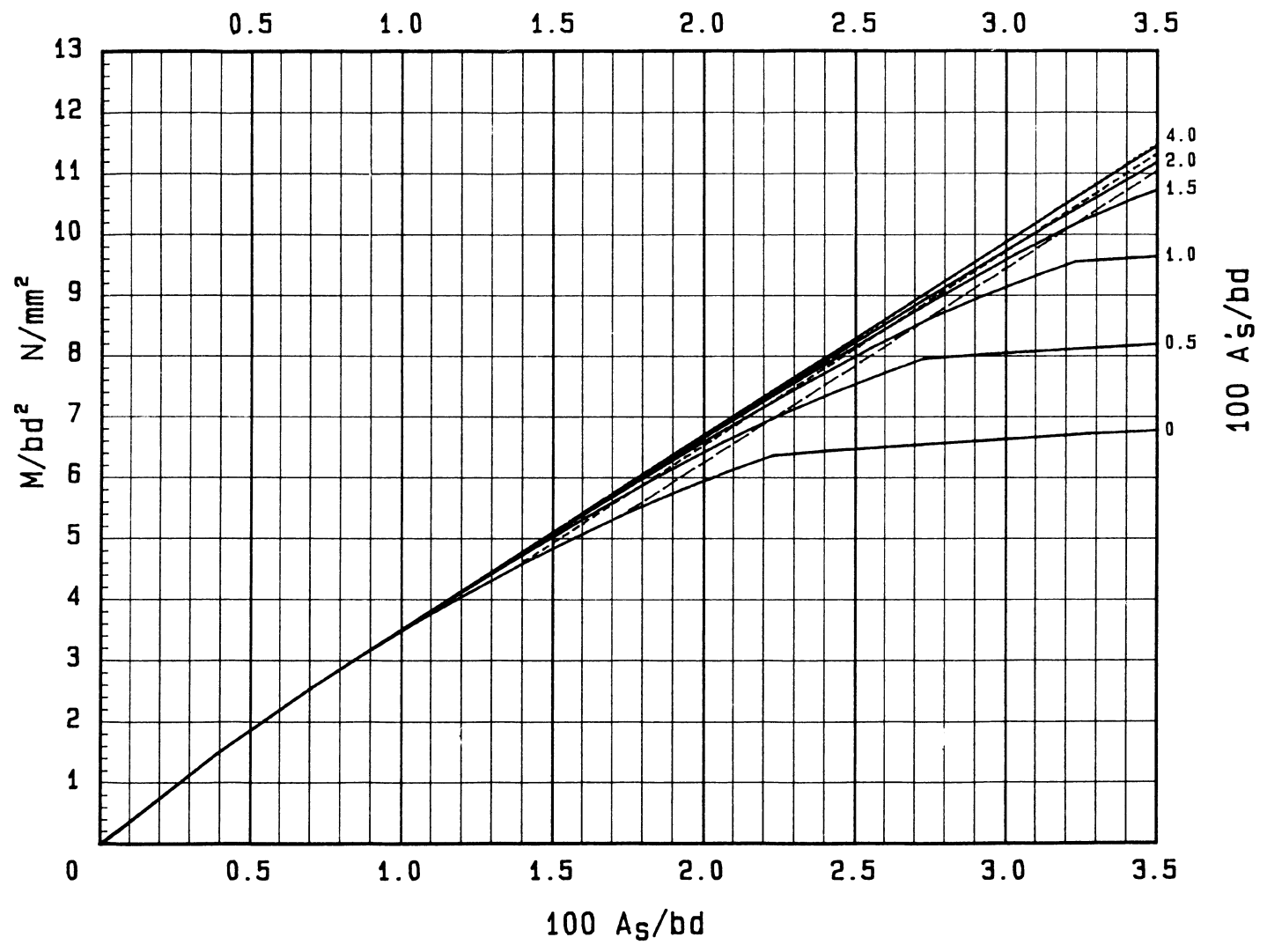
Doubly reinforced beams

$x/d = 0.3$
 $x/d = 0.4$
 $x/d = 0.5$ - - -



| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d'/d | 0.15 |

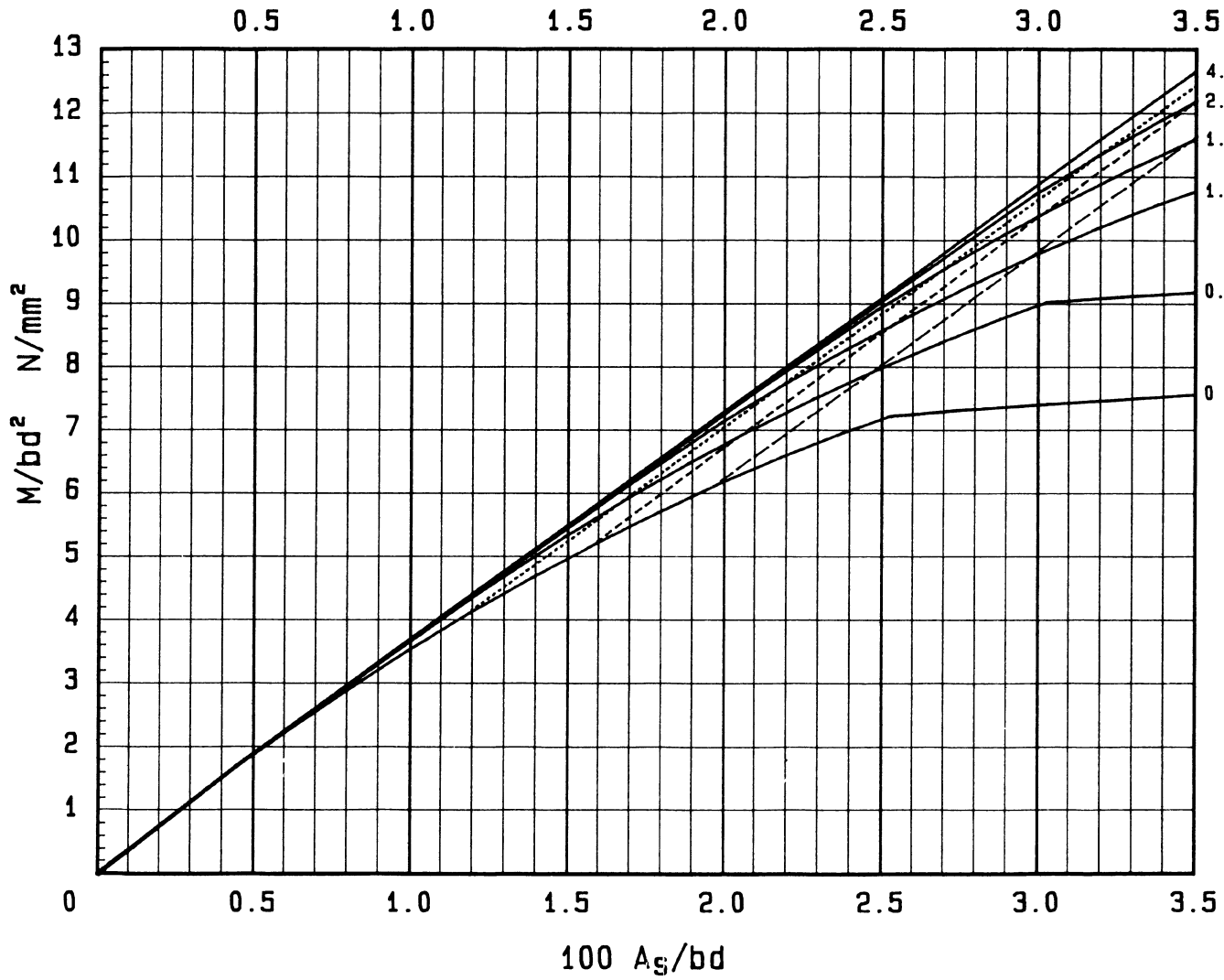
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- $x/d = 0.5$ - - - - - (dash-dot line)



Doubly reinforced beams

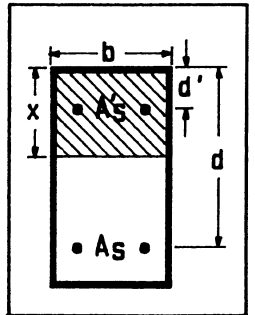
Chart No. 11

Chart No. 12



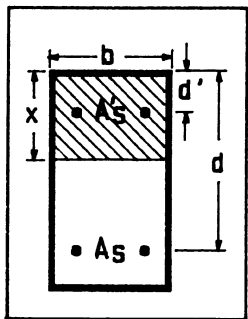
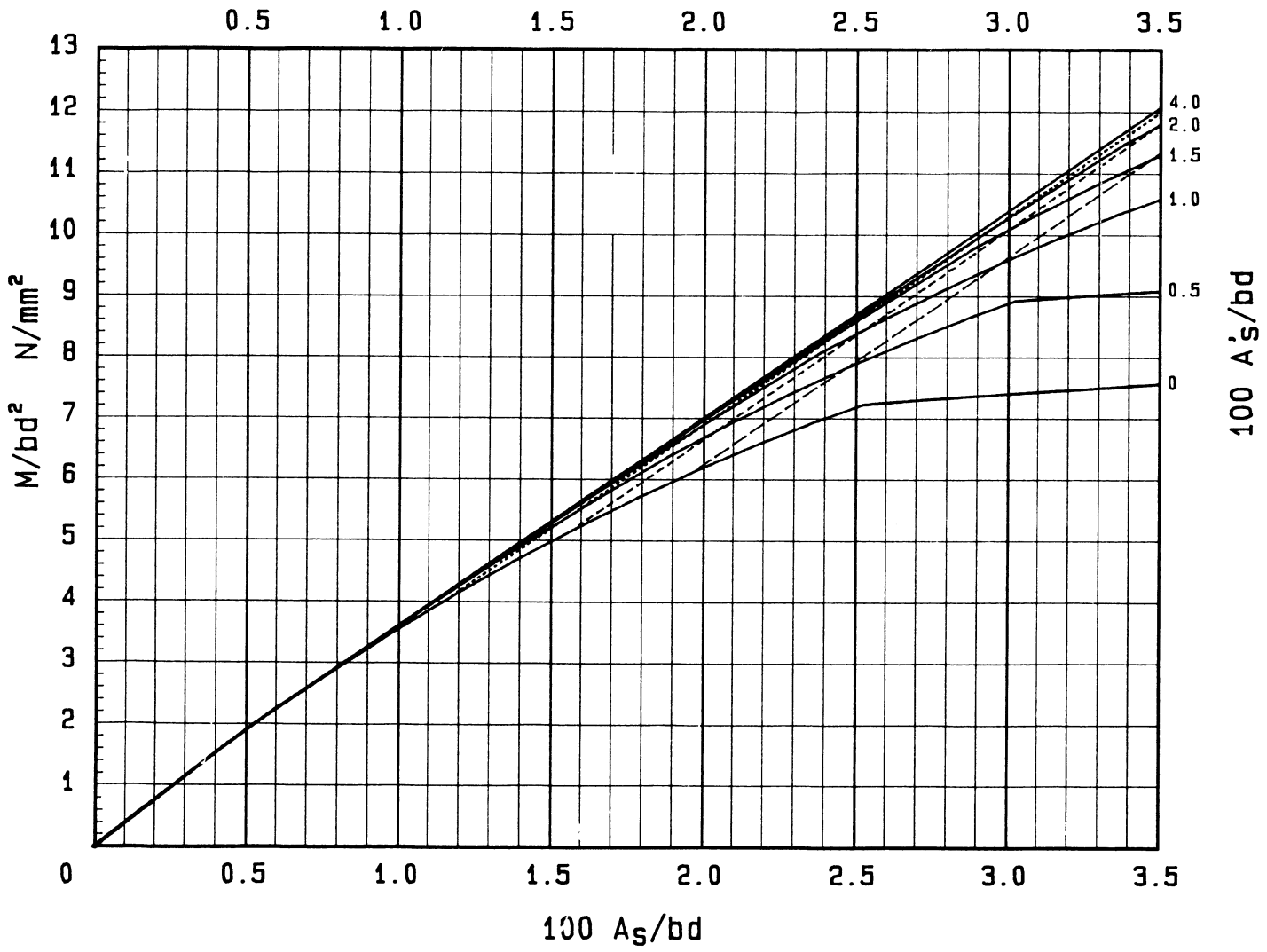
Doubly reinforced beams

$x/d = 0.3$
 $x/d = 0.4$
 $x/d = 0.5$ - - -



| | |
|----------|------|
| f_{cu} | 40 |
| f_y | 460 |
| d'/d | 0.10 |

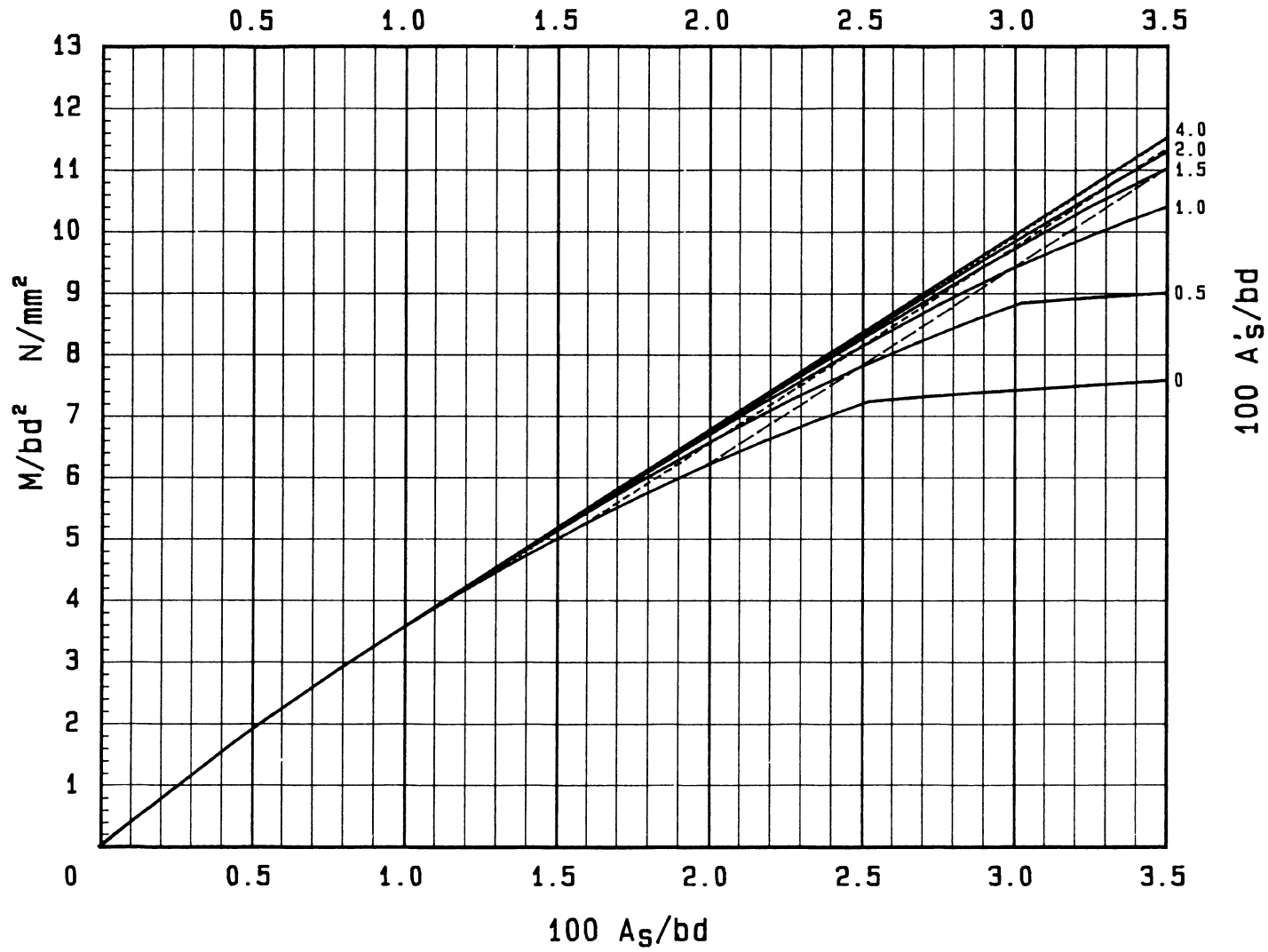
- $x/d = 0.3$ (dotted line)
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- $x/d = 0.5$ - - - - - (dash-dot line)



Doubly reinforced beams

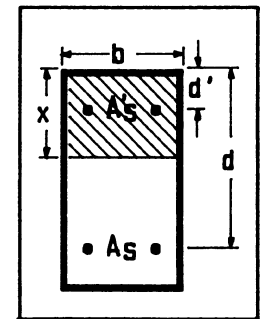
Chart No. 13

Chart No. 14



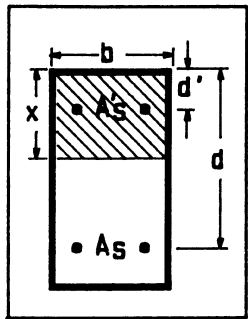
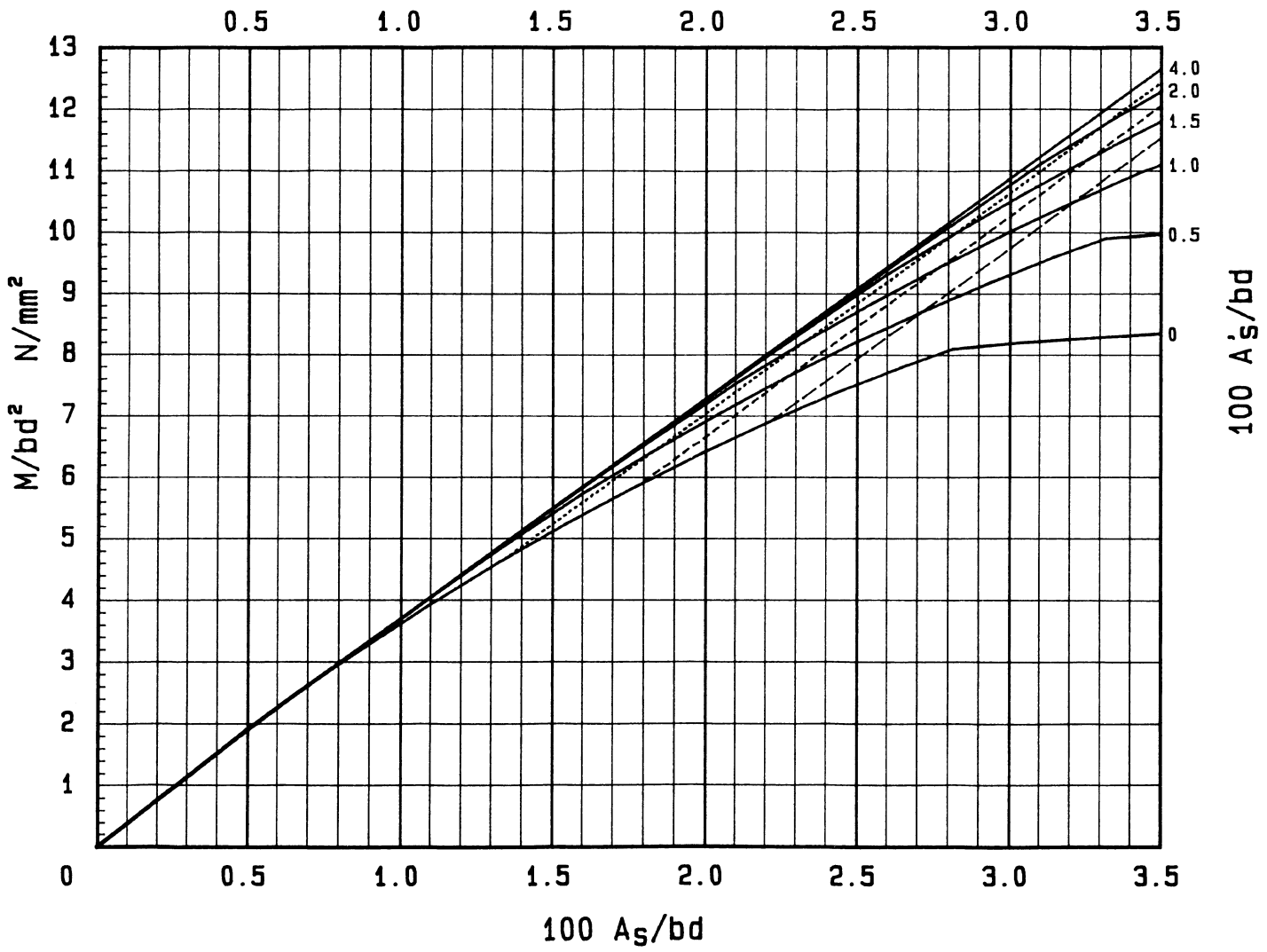
Doubly reinforced beams

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - . - . - (dash-dot line)



| | |
|----------|------|
| f_{cu} | 40 |
| f_y | 460 |
| d'/d | 0.20 |

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - - - - - (dash-dot line)

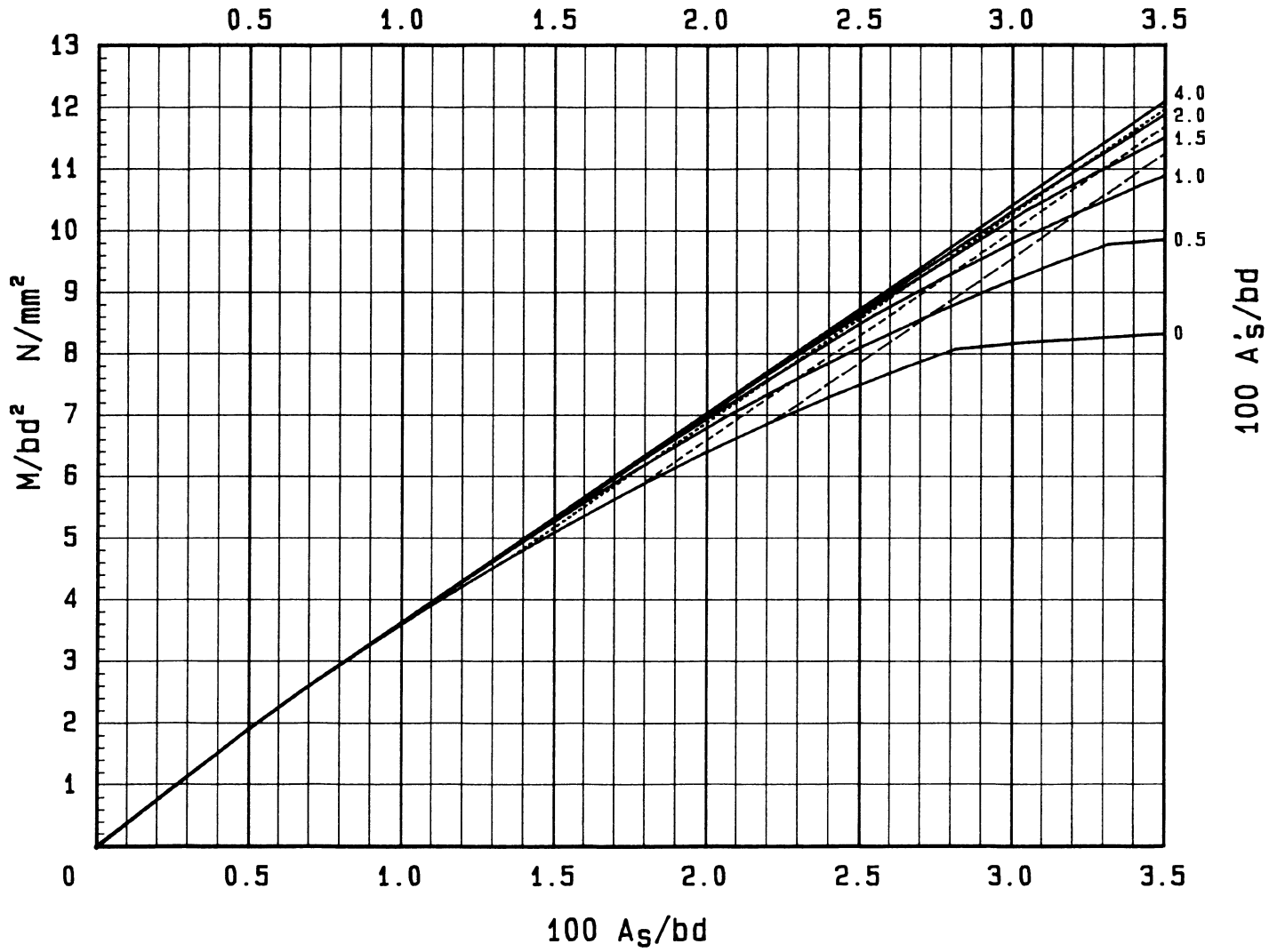


| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d'/d | 0.10 |

Doubly reinforced beams

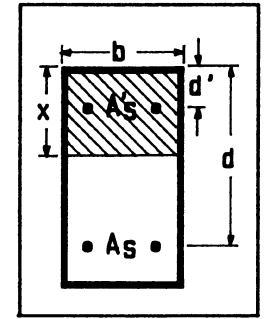
Chart No. 15

Chart No. 16



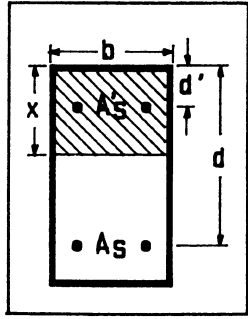
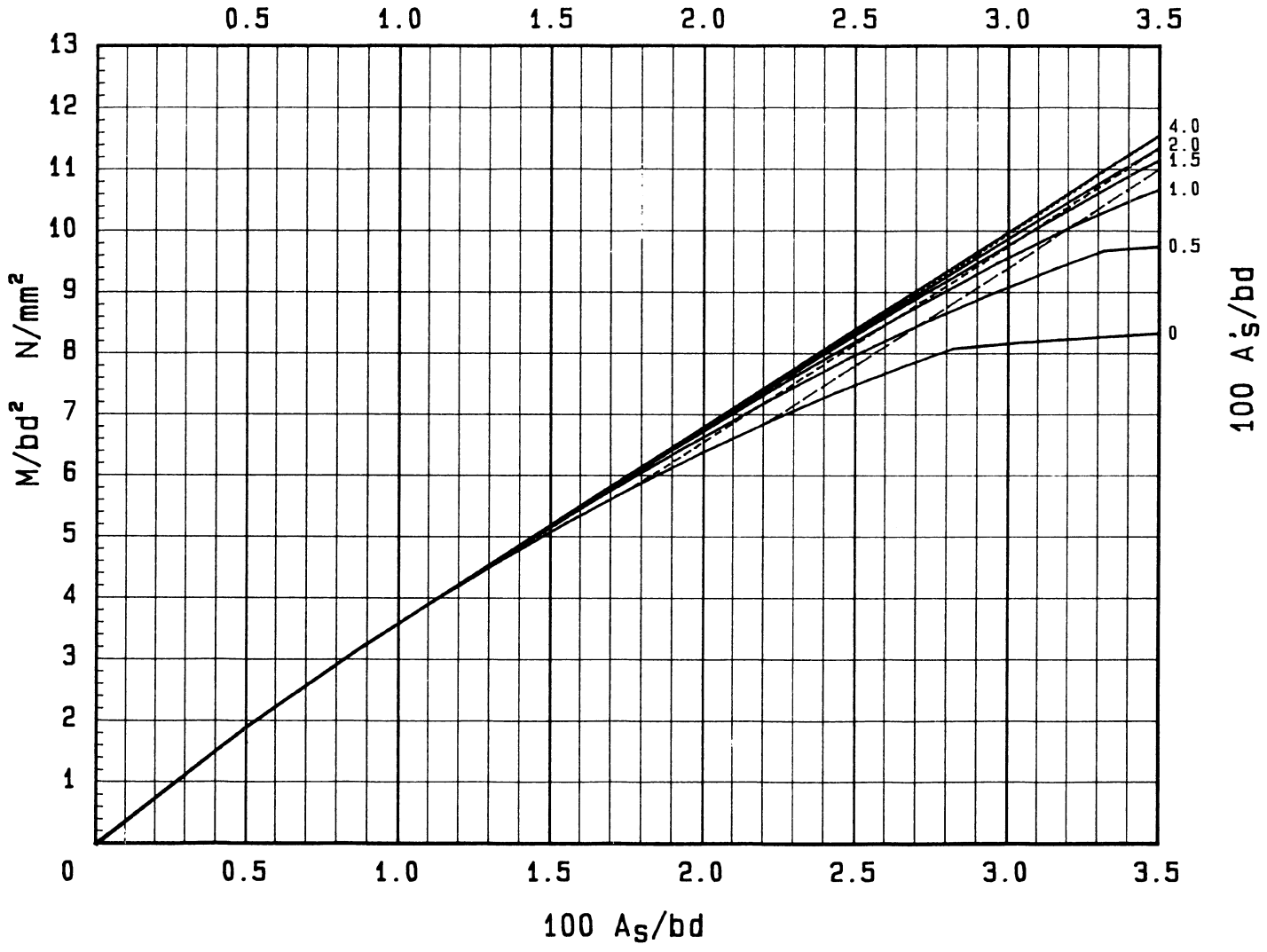
Doubly reinforced beams

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - . - . - (dash-dot line)



| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d'/d | 0.15 |

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - (dashed line)
- $x/d = 0.5$ - - - - (dash-dot line)

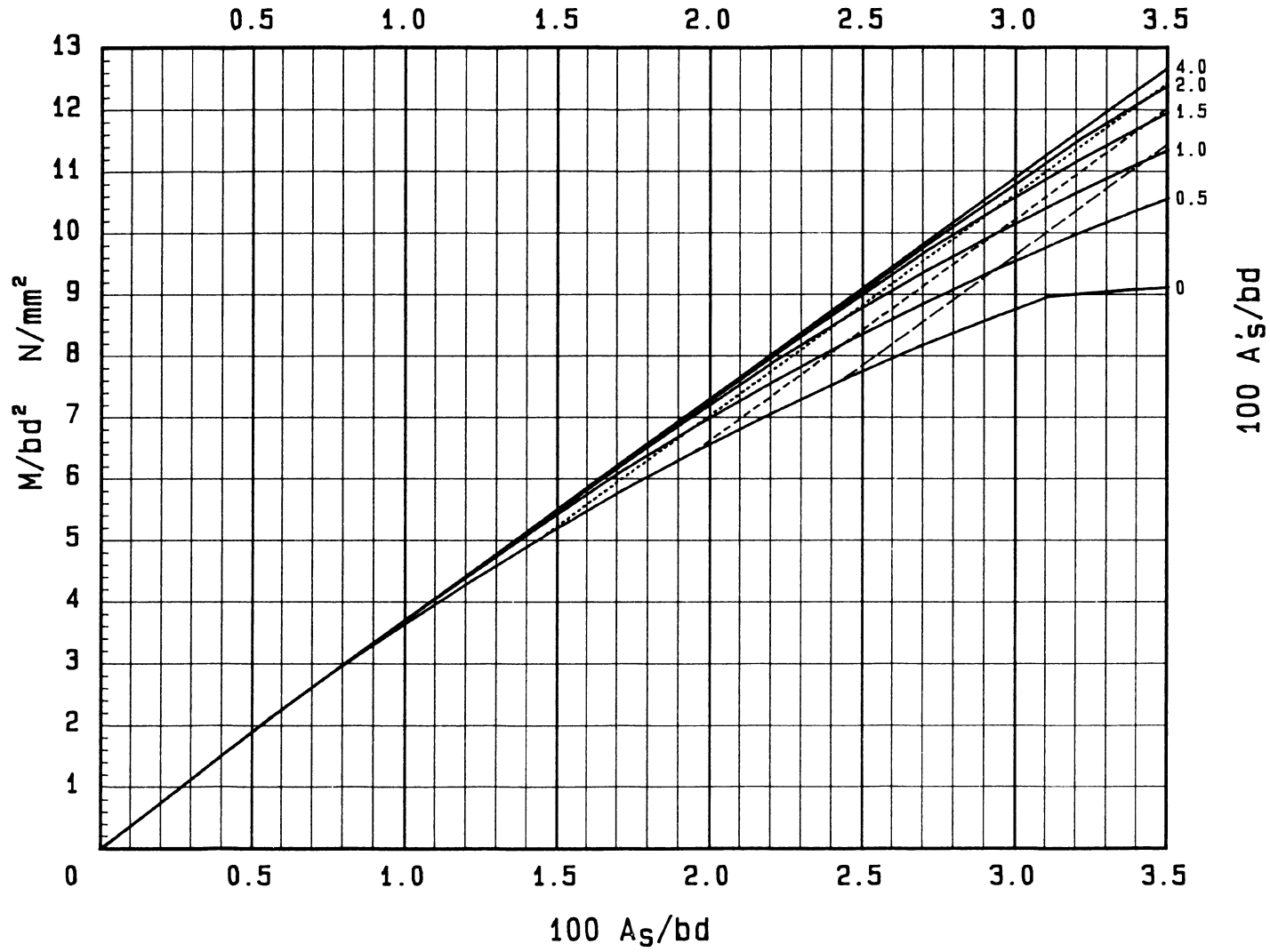


| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d'/d | 0.20 |

Doubly reinforced beams

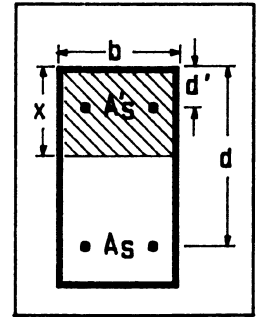
Chart No. 17

Chart No. 18



Doubly reinforced beams

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - - (dashed line)
- $x/d = 0.5$ - . - . - (dash-dot line)



| | |
|----------|------|
| f_{cu} | 50 |
| f_y | 460 |
| d'/d | 0.10 |

- $x/d = 0.3$ (dotted line)
- $x/d = 0.4$ - - - - (dashed line)
- $x/d = 0.5$ - - - - (dash-dot line)

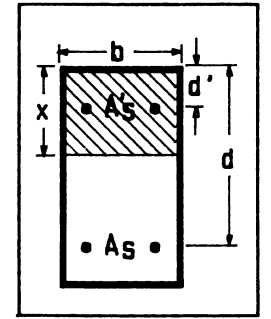
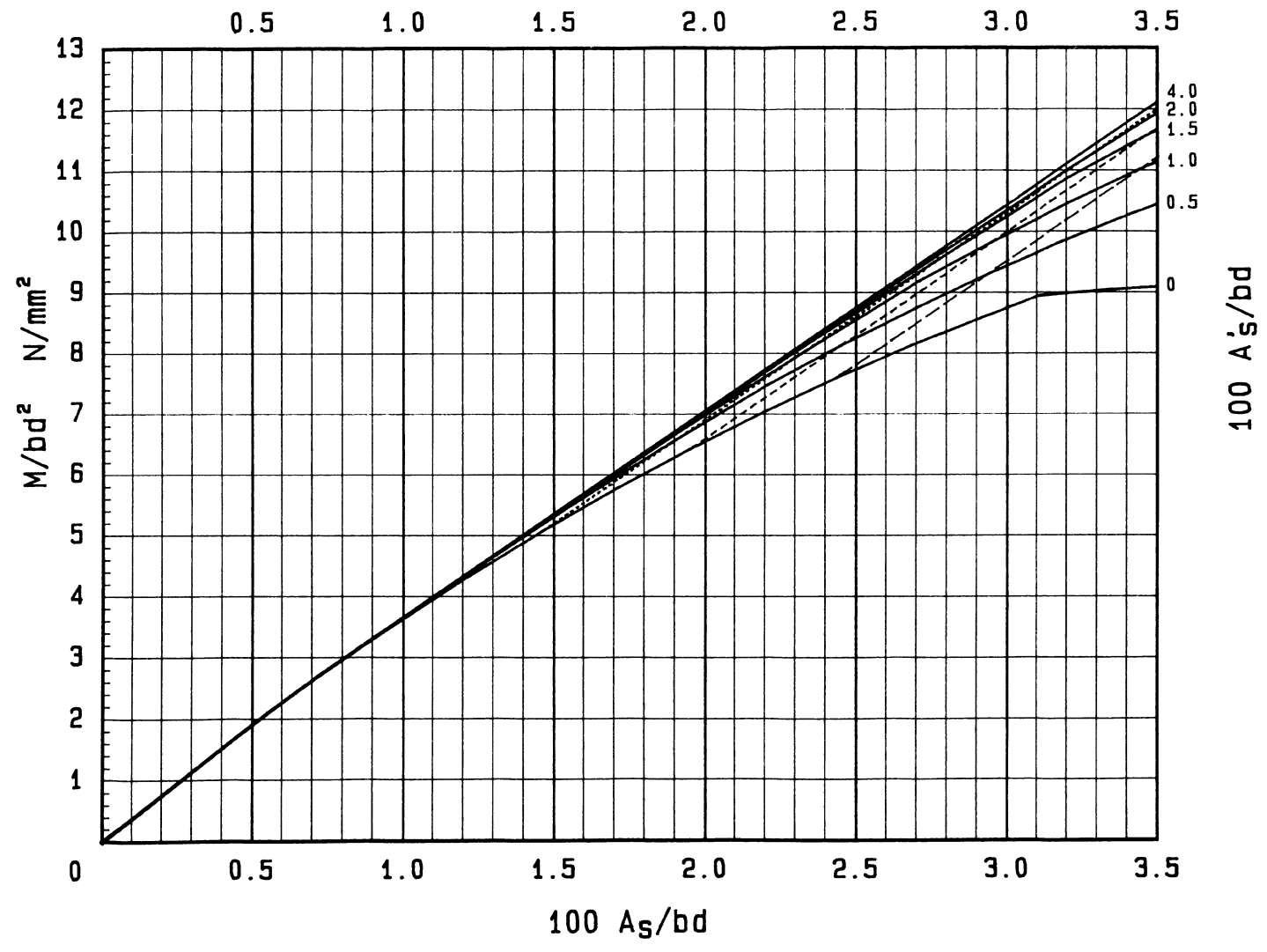
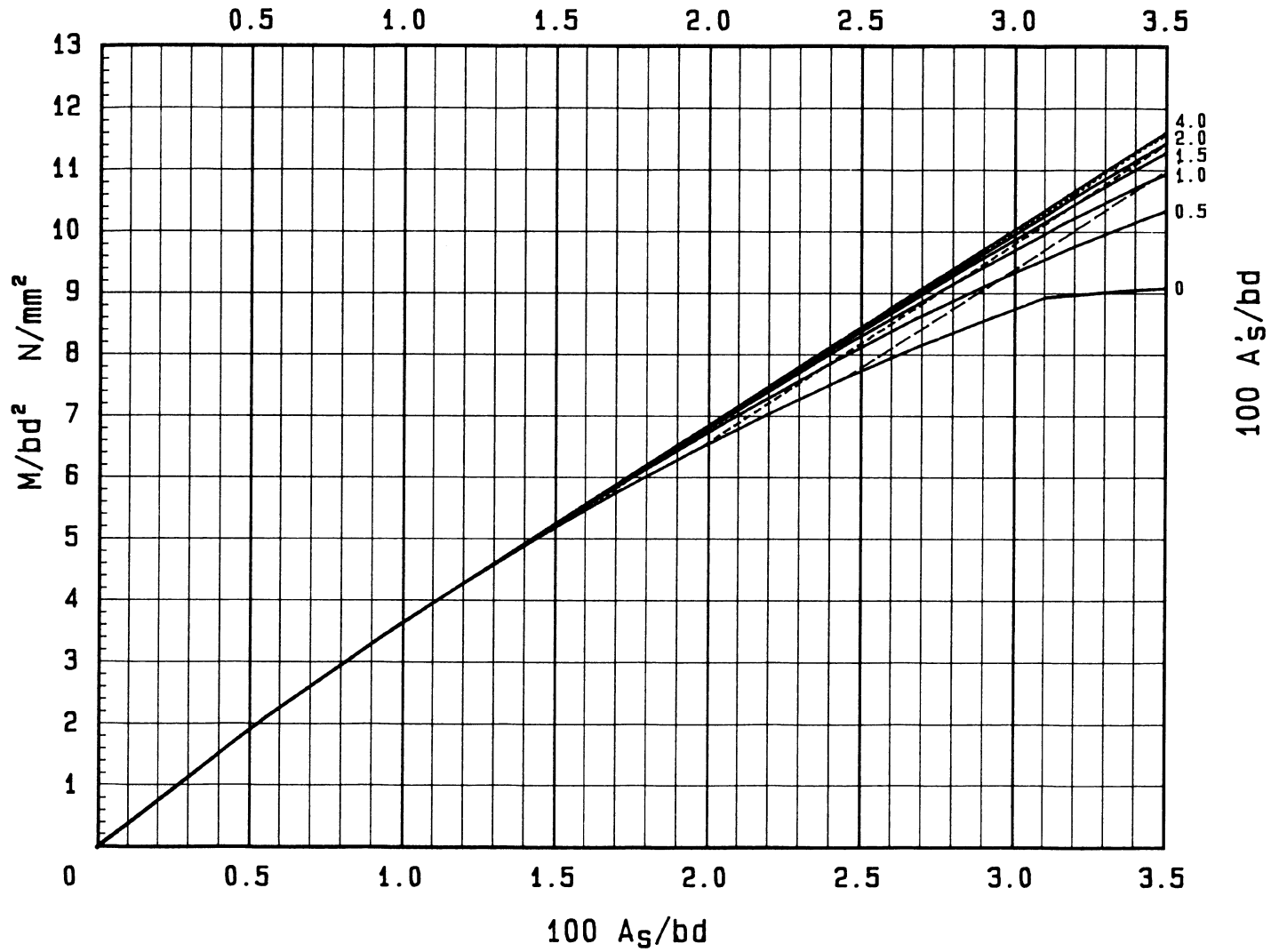


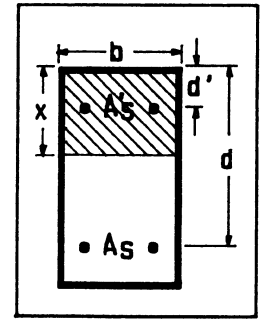
Chart No. 19

Doubly reinforced beams

Chart No. 20

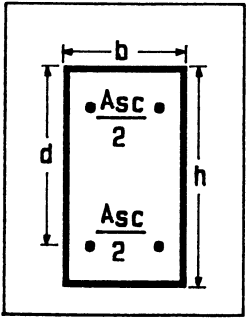
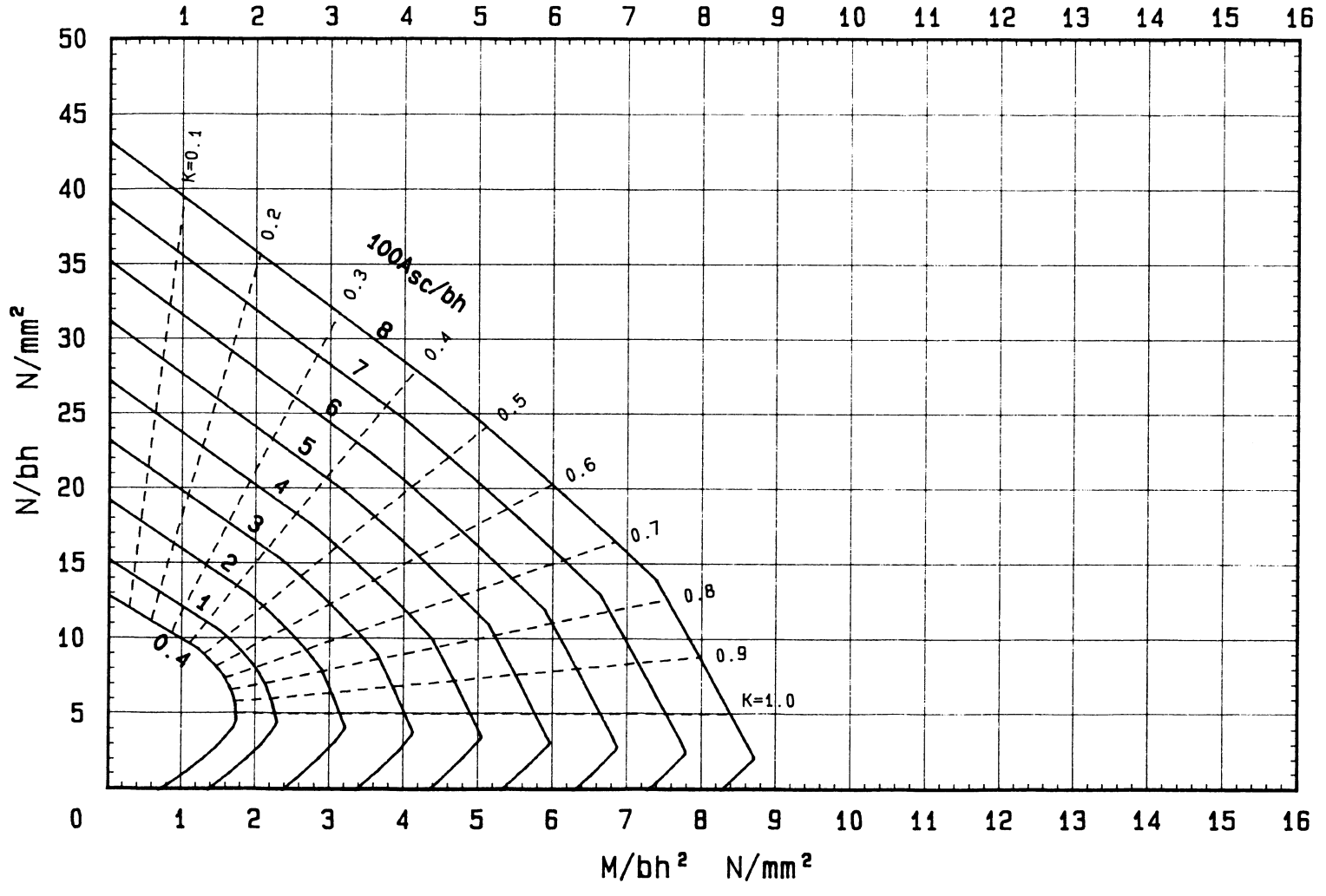


$x/d = 0.3$
 $x/d = 0.4$
 $x/d = 0.5$



| | |
|----------|------|
| f_{cu} | 50 |
| f_y | 460 |
| d'/d | 0.20 |

Doubly reinforced beams

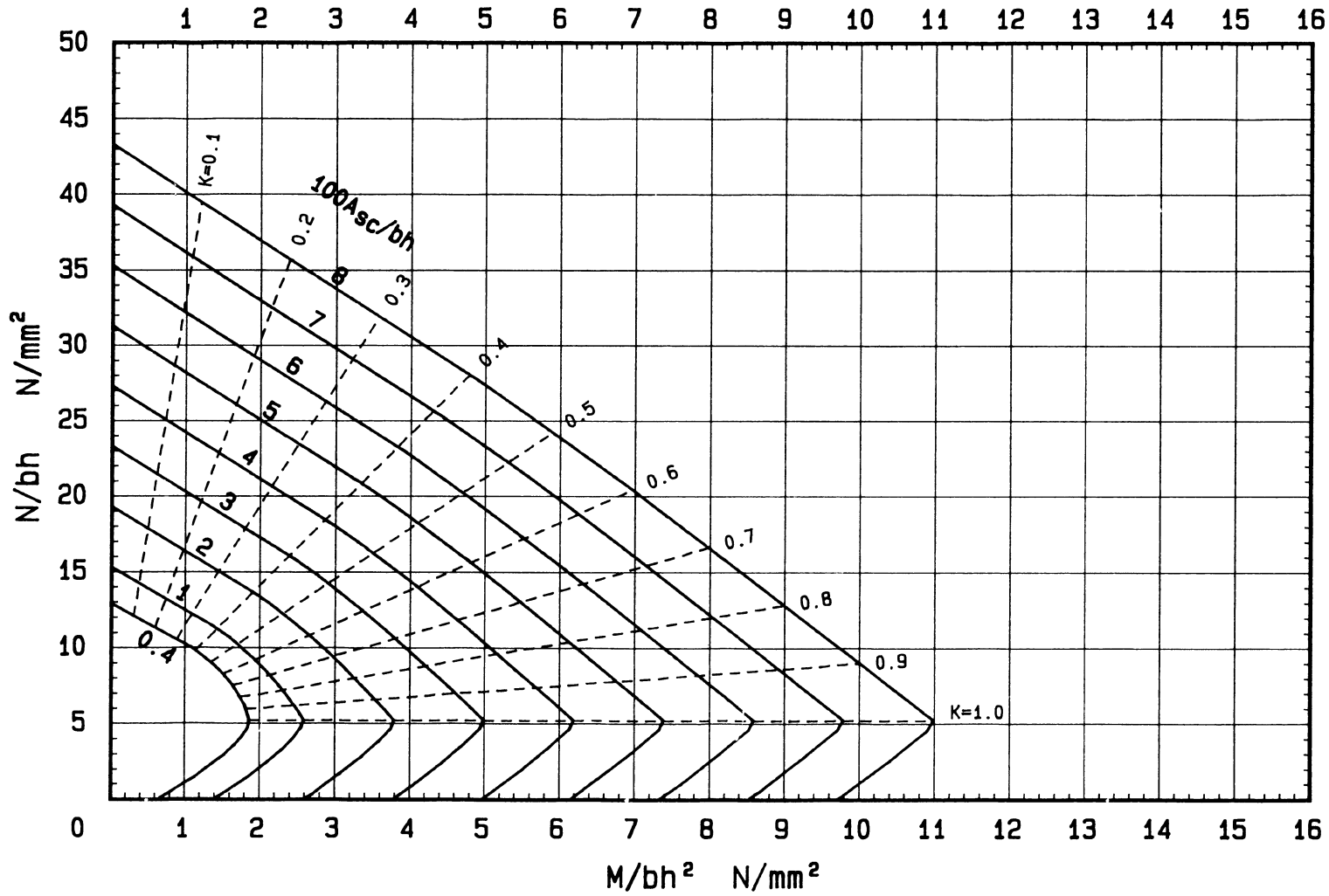


| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d/h | 0.75 |

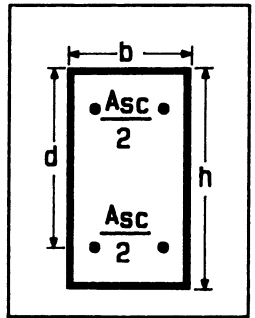
Rectangular columns

Chart No.21

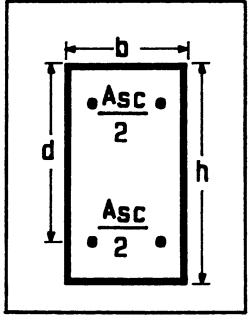
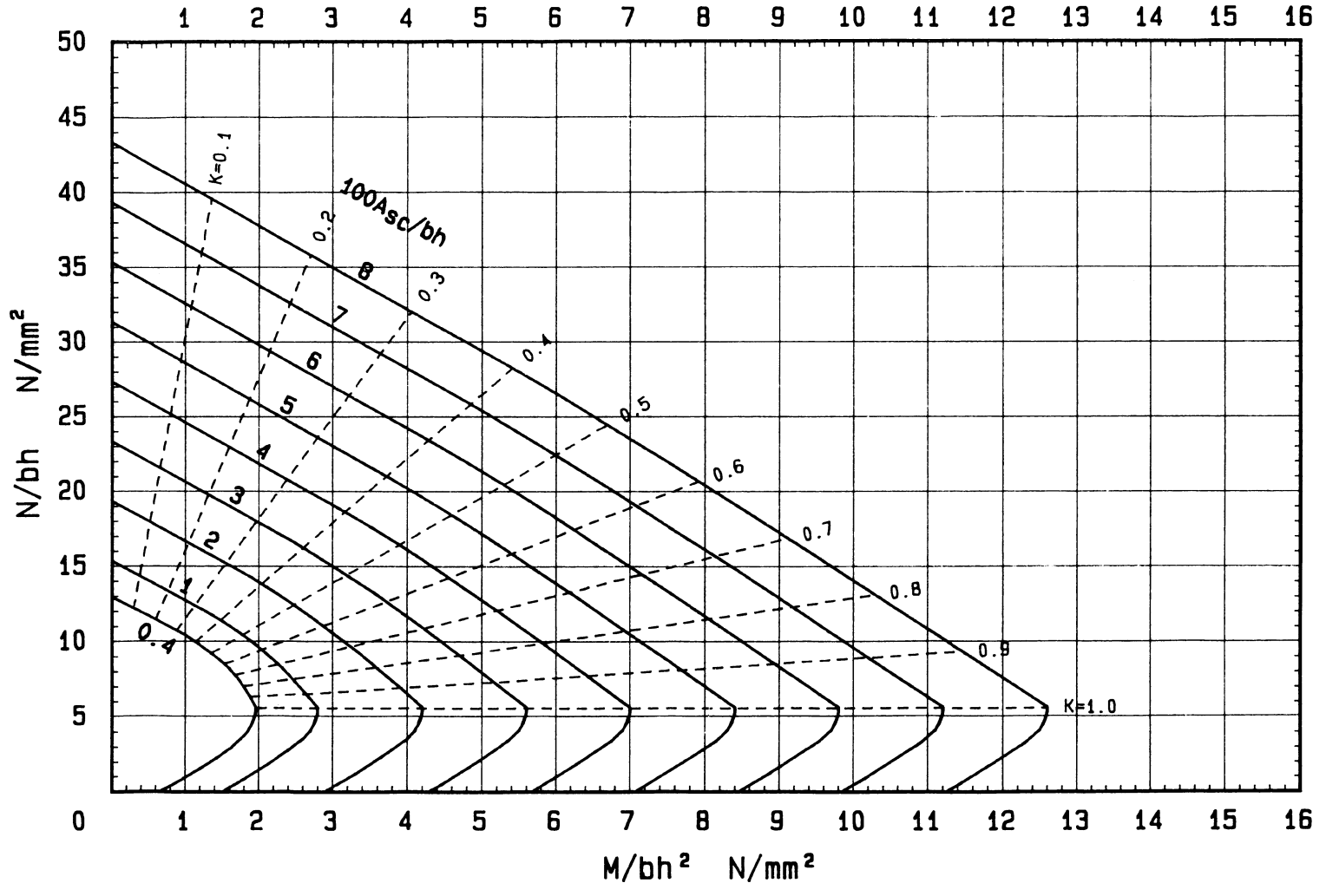
Chart No. 22



Rectangular columns



| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d/h | 0.80 |

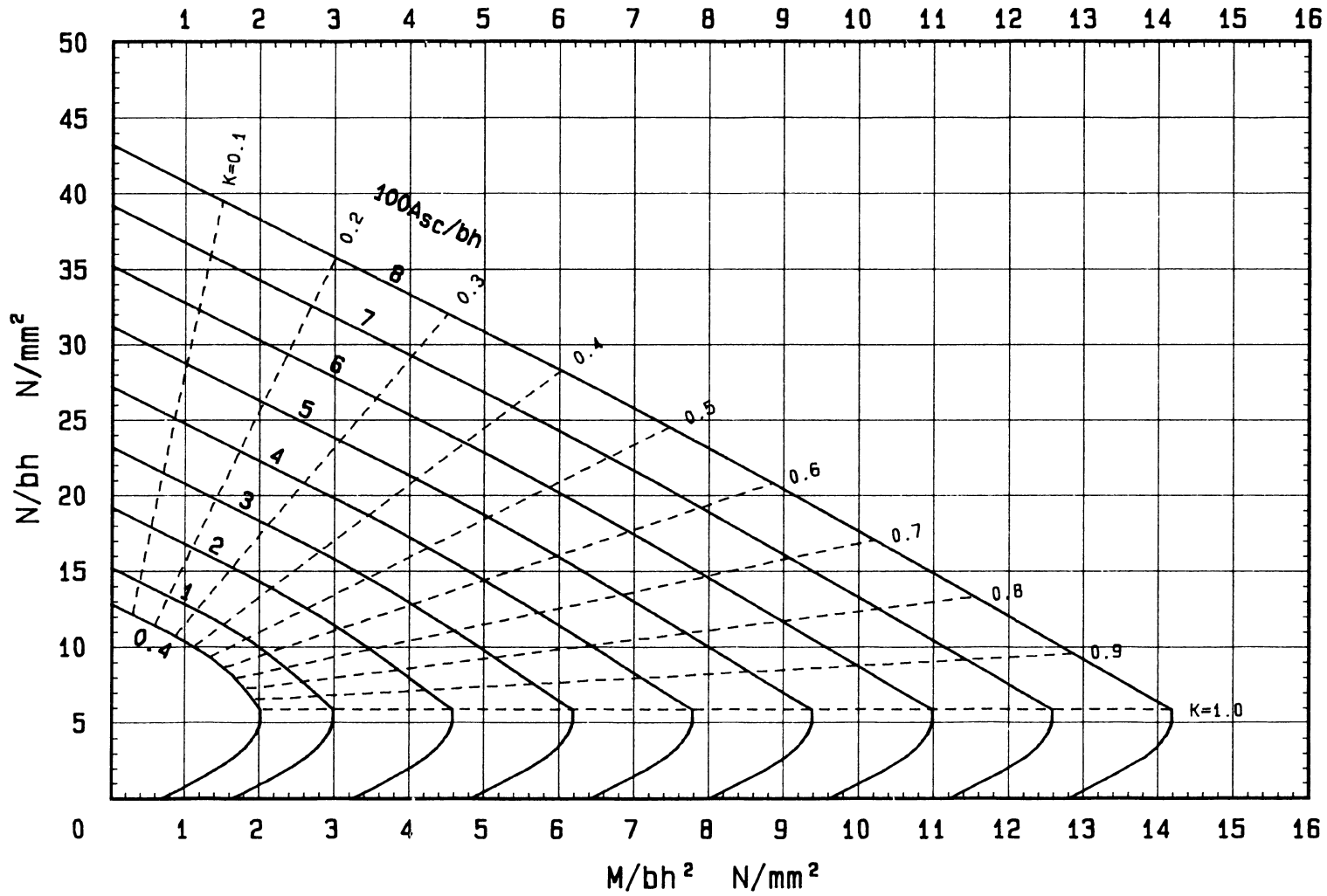


| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d/h | 0.85 |

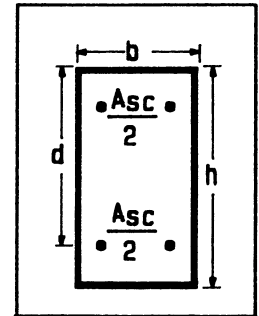
Rectangular columns

Chart No. 23

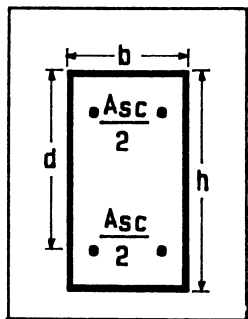
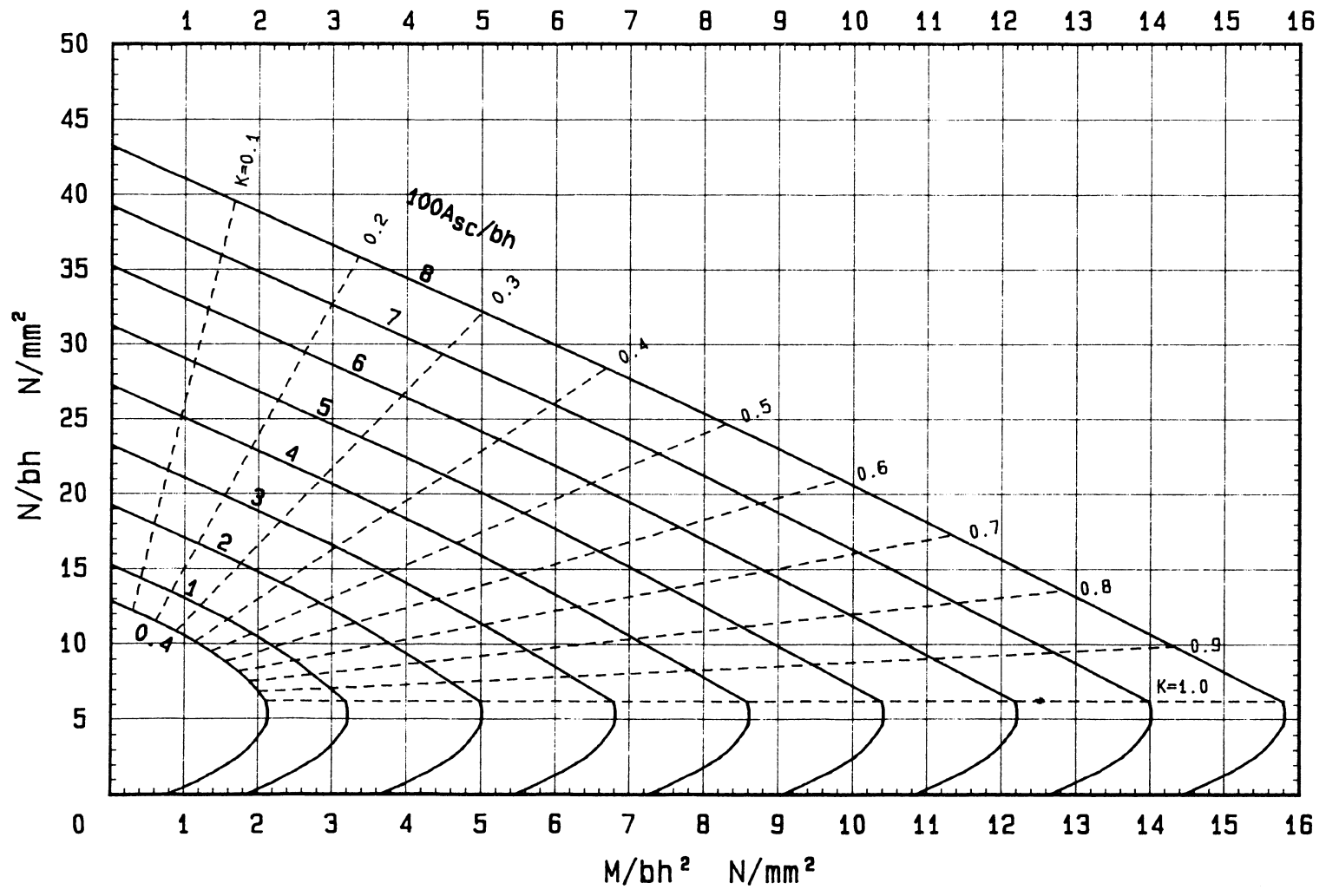
Chart No. 24



Rectangular columns



| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d/h | 0.90 |

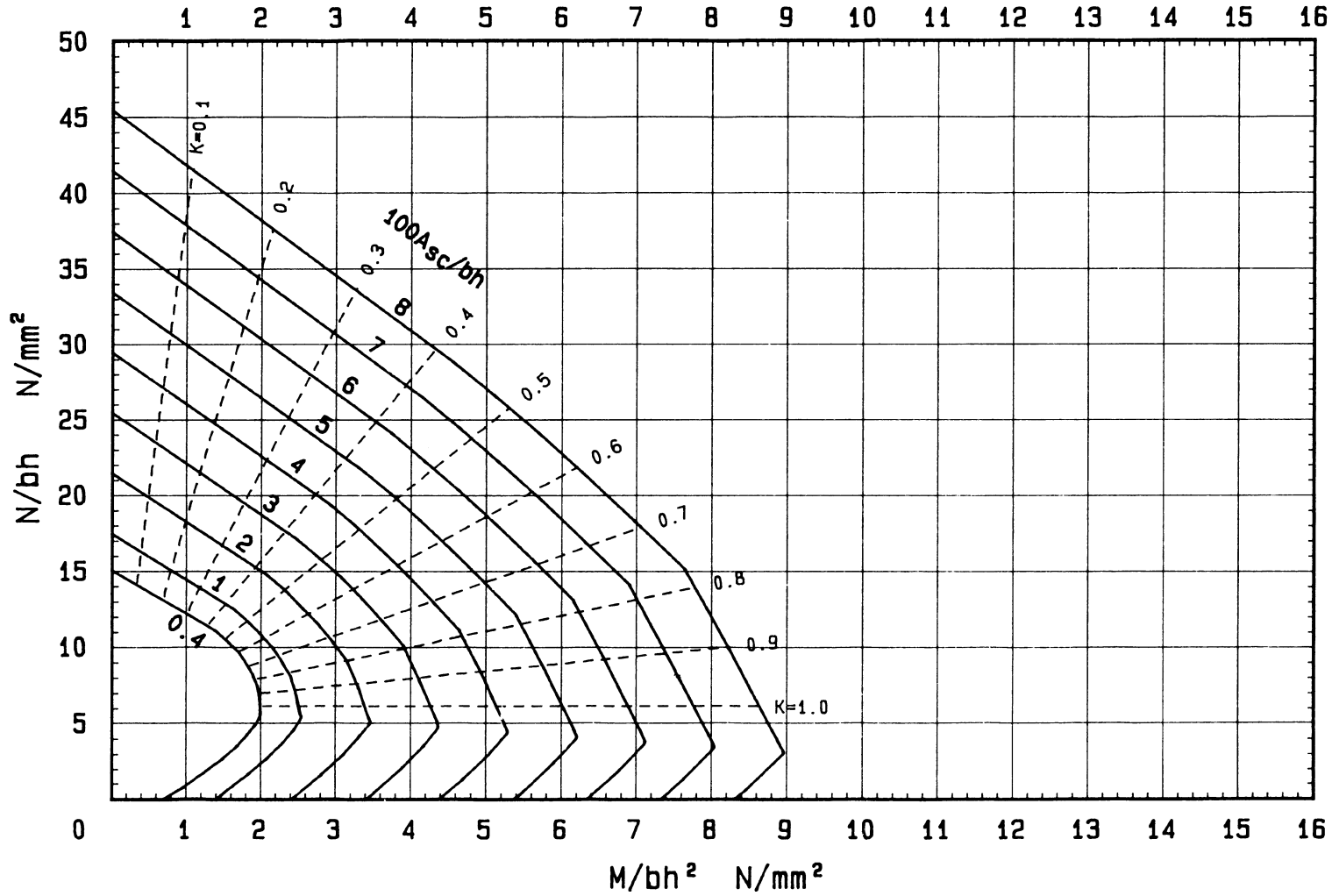


| | |
|----------|------|
| f_{cu} | 25 |
| f_y | 460 |
| d/h | 0.95 |

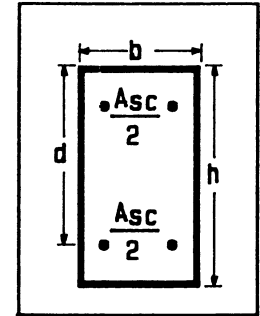
Rectangular columns

Chart No. 25

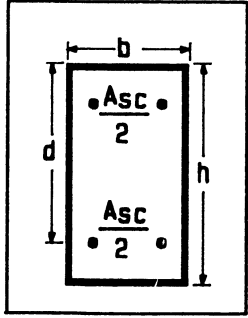
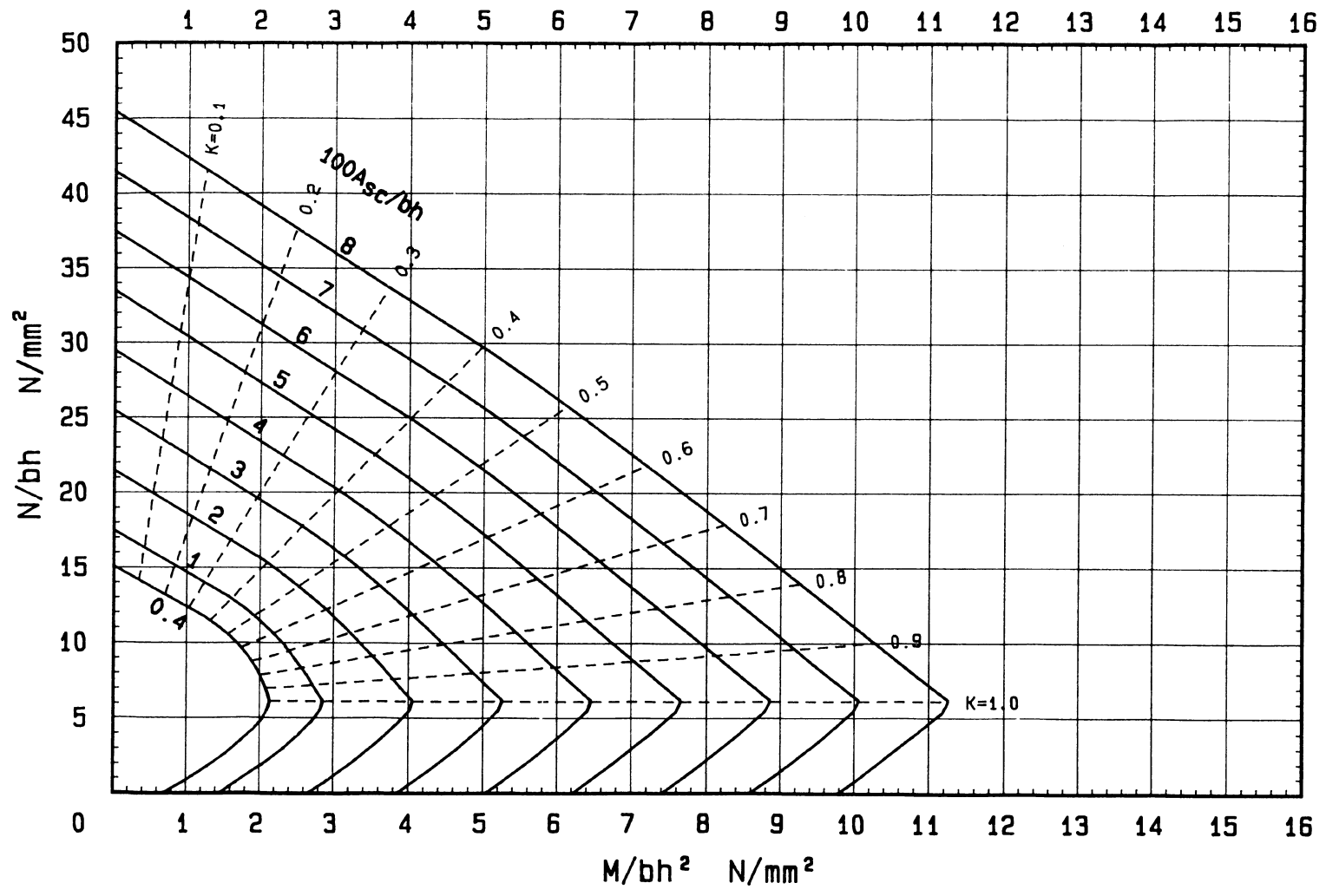
Chart No. 26



Rectangular columns



| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d/h | 0.75 |

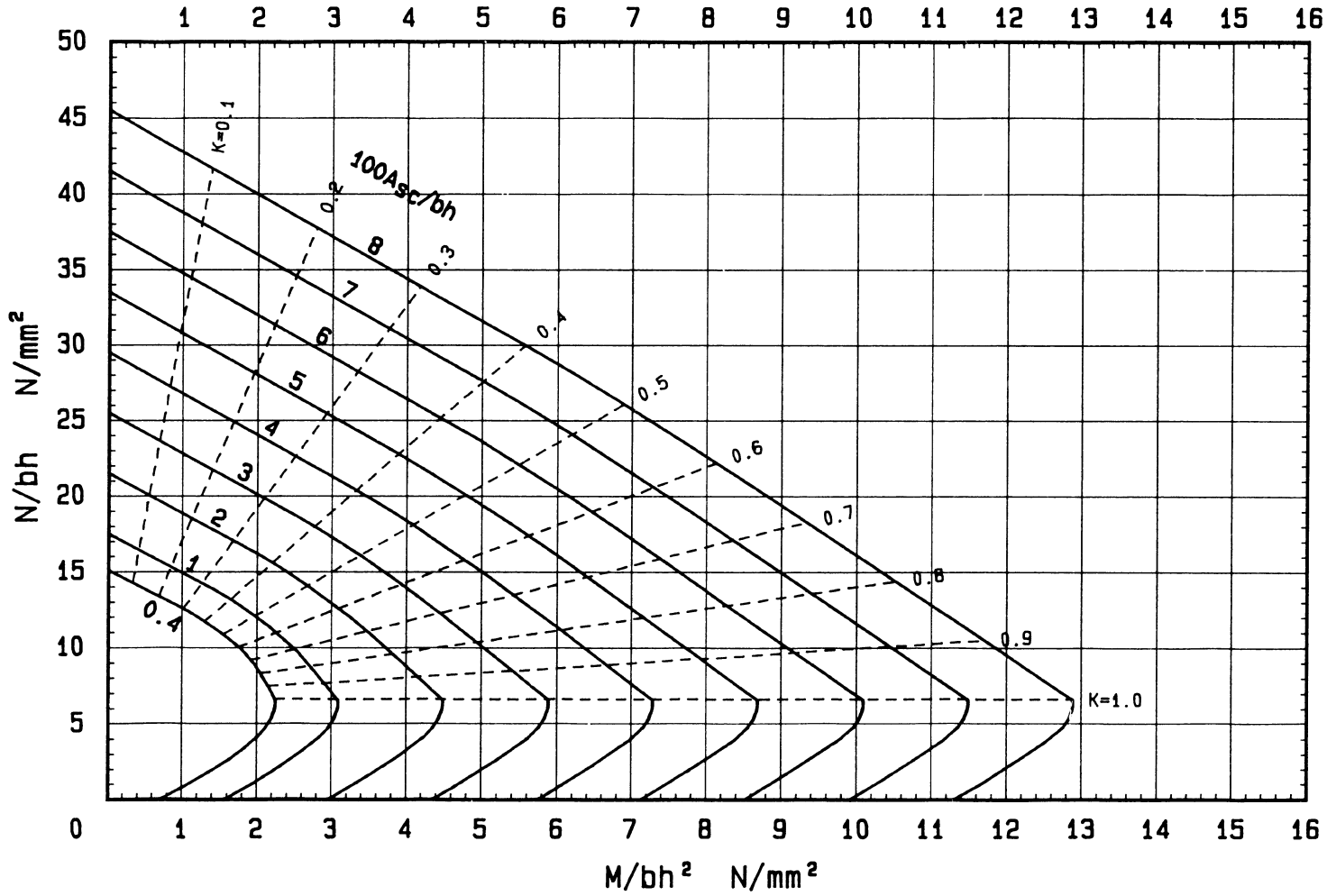


| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d/h | 0.80 |

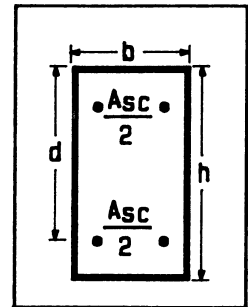
Rectangular columns

Chart No. 27

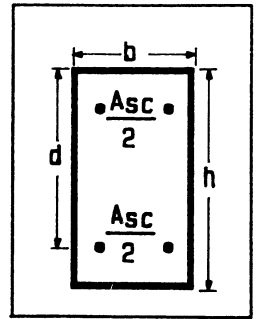
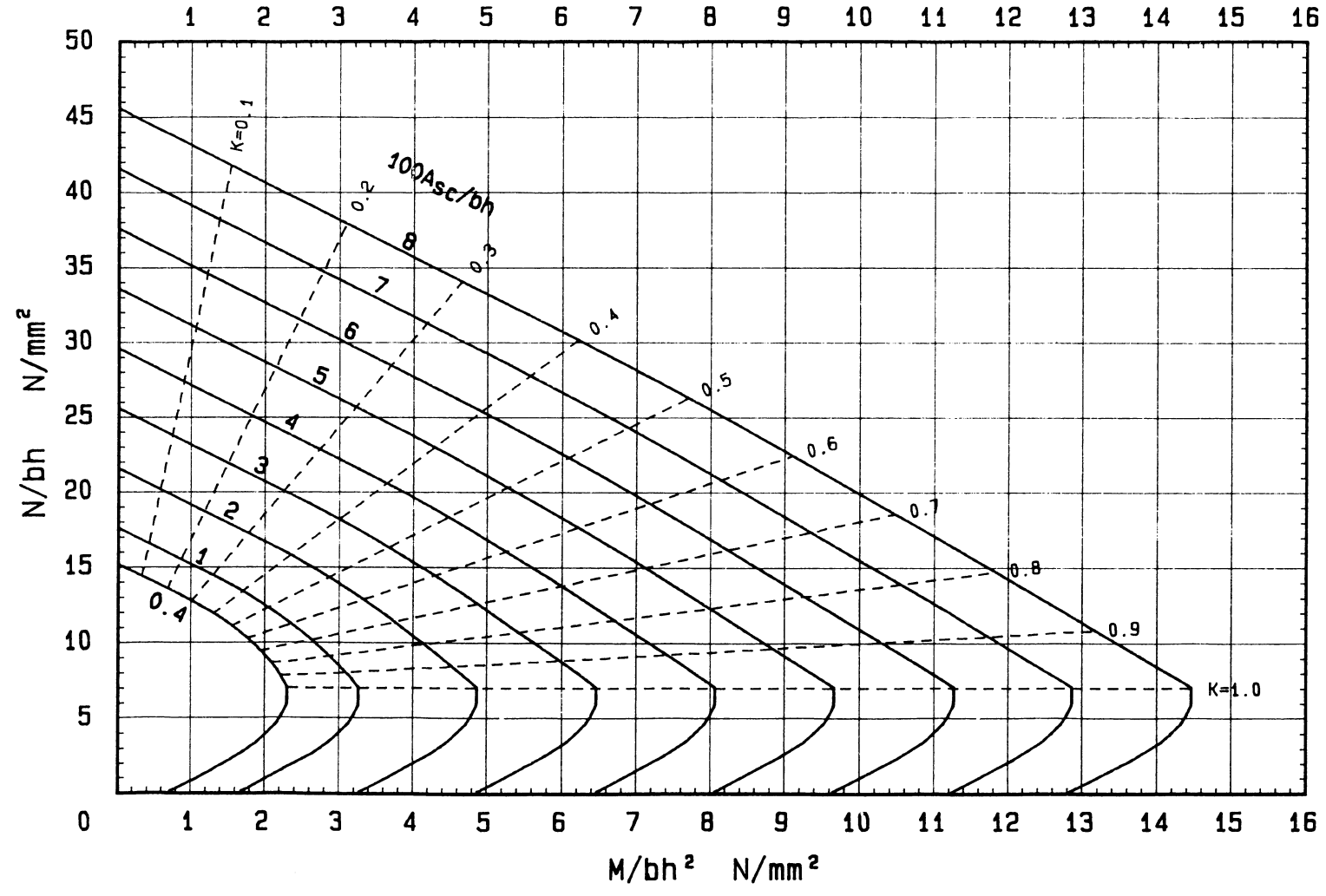
Chart No. 28



Rectangular columns



| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d/h | 0.85 |

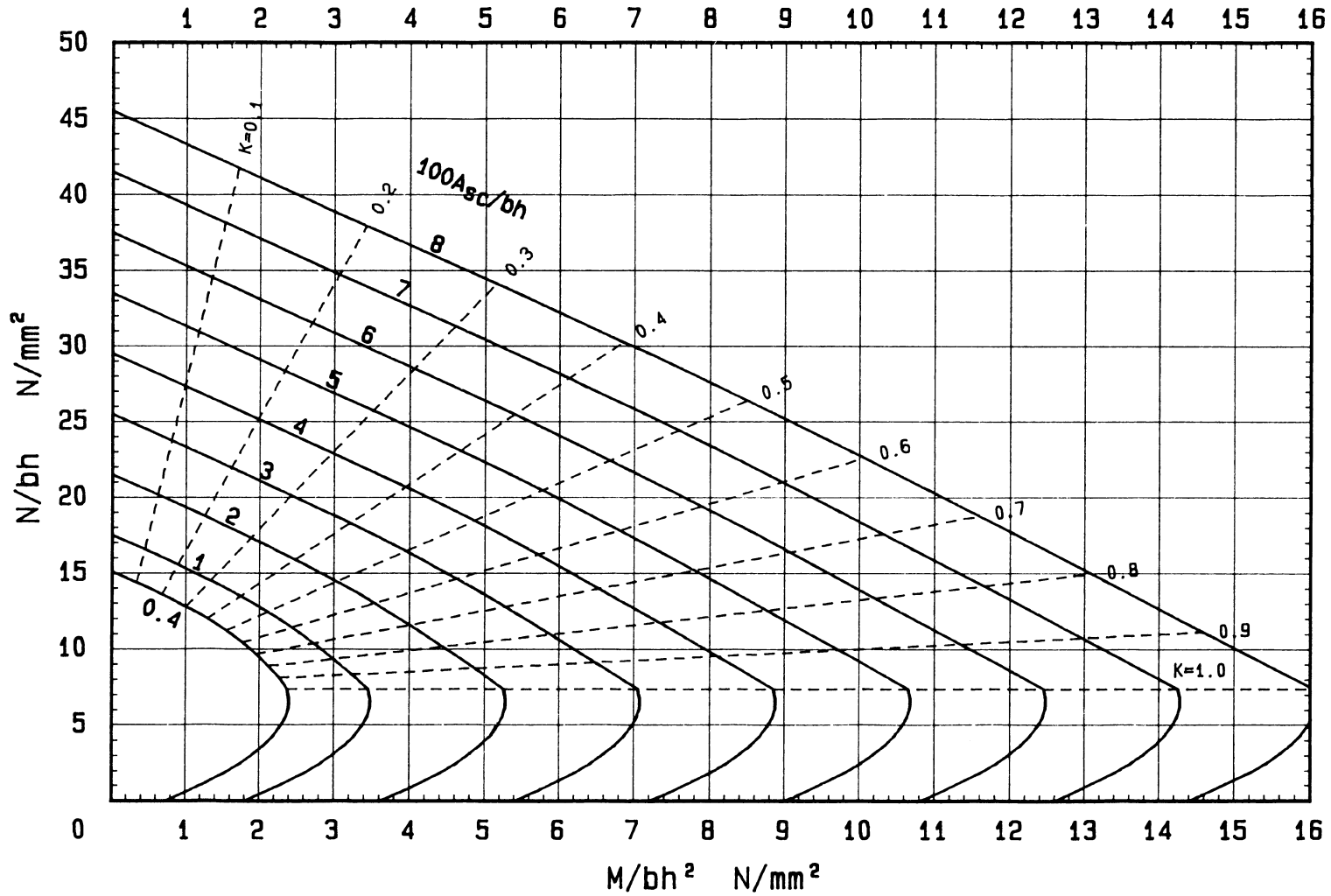


| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d/h | 0.90 |

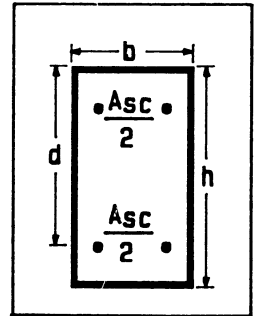
Rectangular columns

Chart No. 29

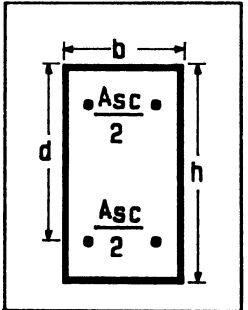
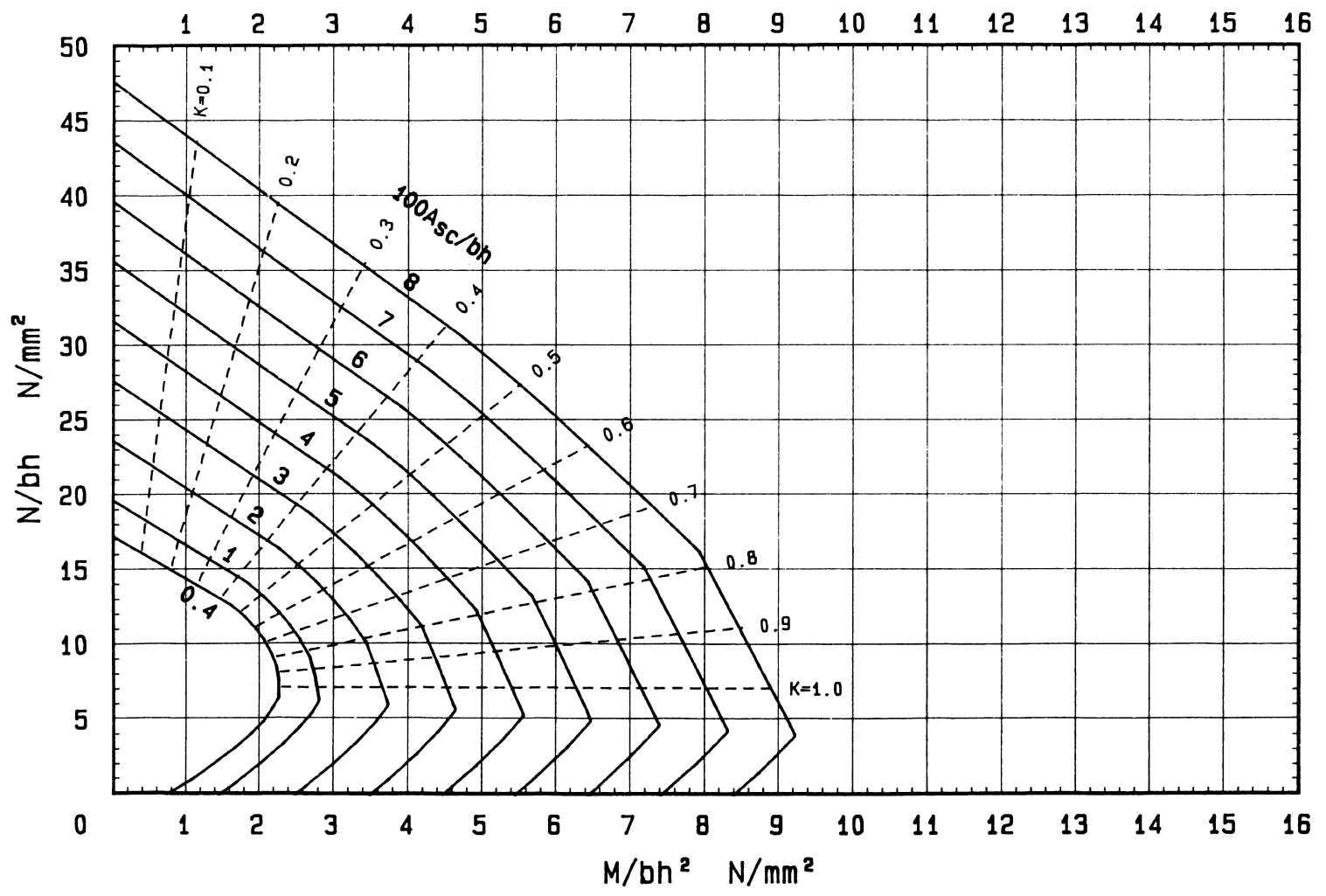
Chart No. 30



Rectangular columns



| | |
|----------|------|
| f_{cu} | 30 |
| f_y | 460 |
| d/h | 0.95 |

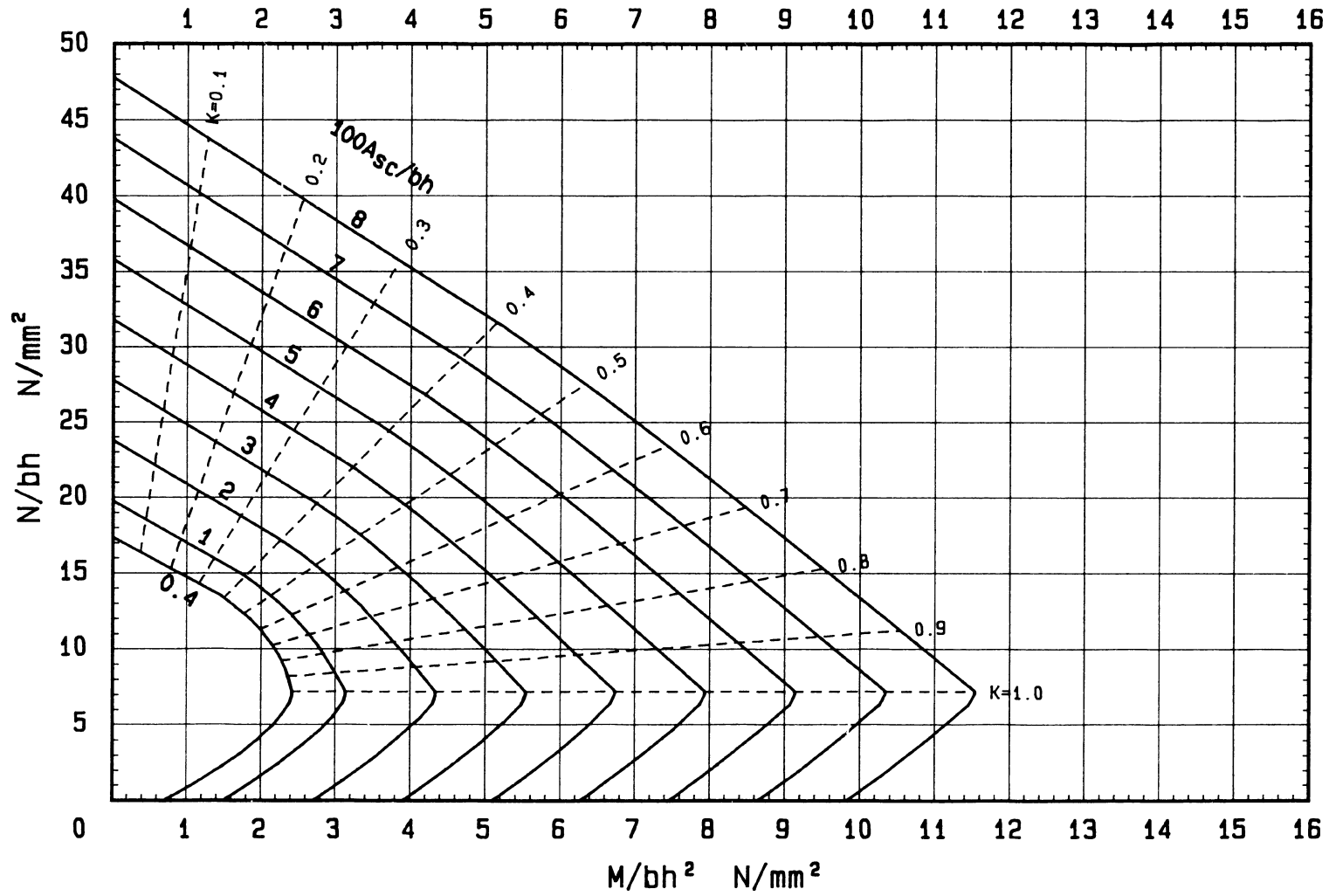


| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d/h | 0.75 |

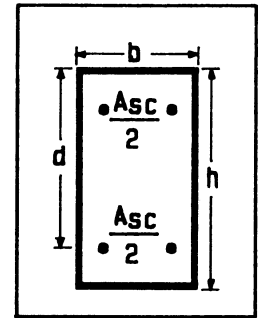
Rectangular columns

Chart No. 31

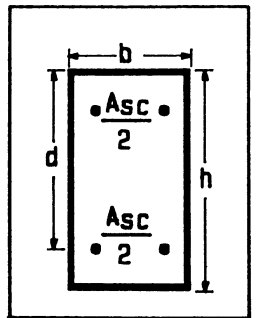
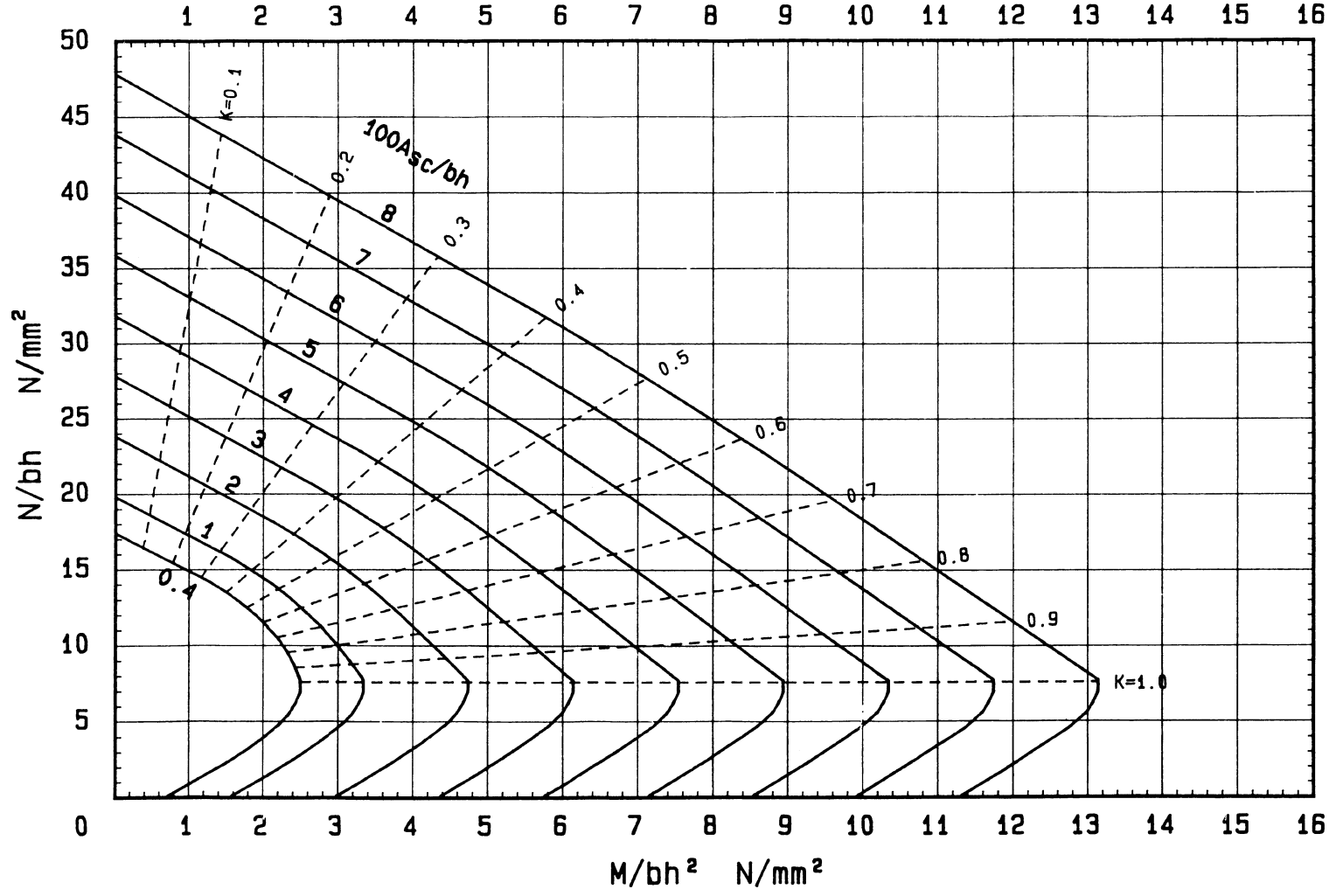
Chart No. 32



Rectangular columns



| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d/h | 0.80 |

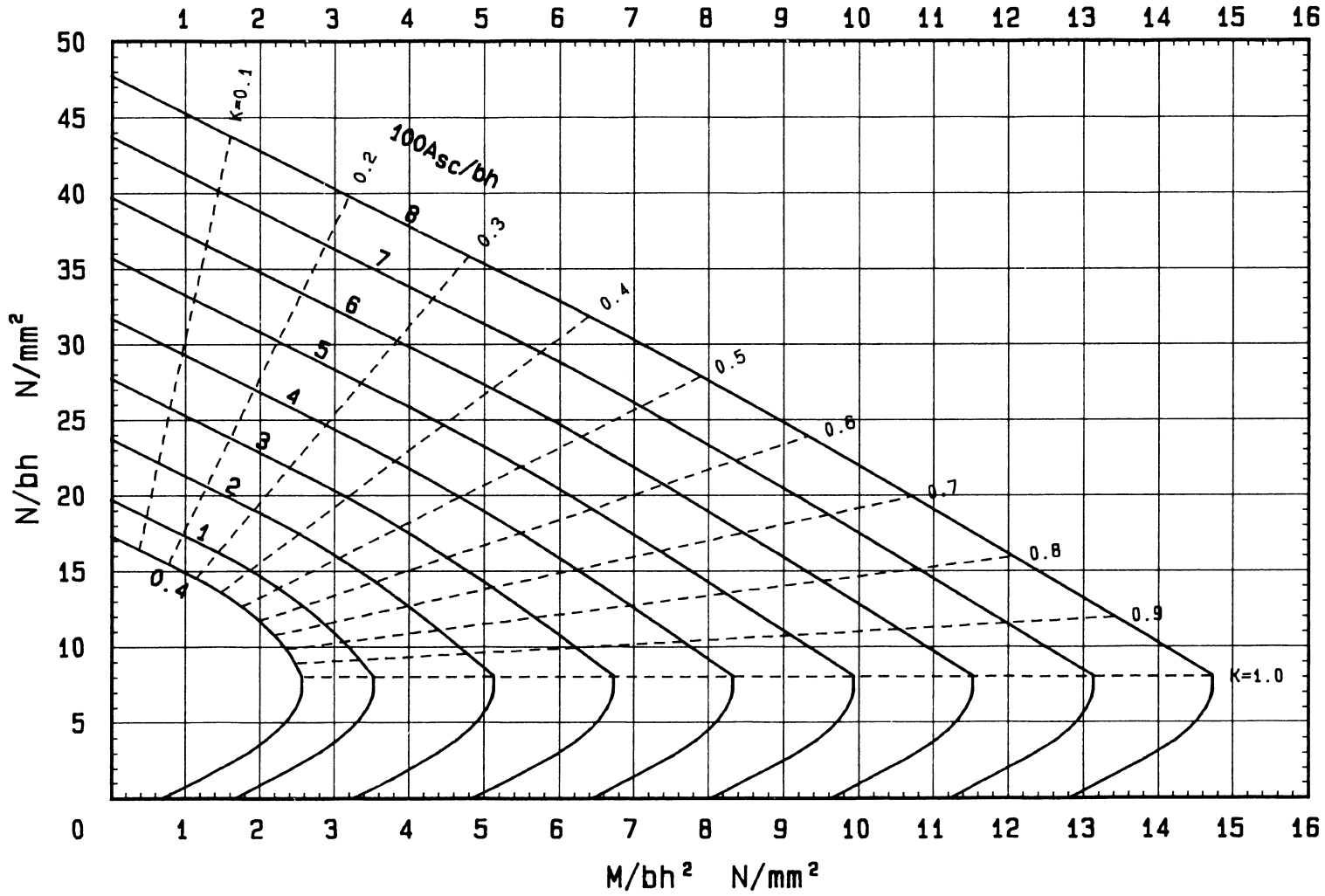


| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d/h | 0.85 |

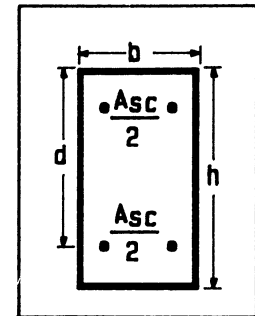
Rectangular columns

Chart No. 33

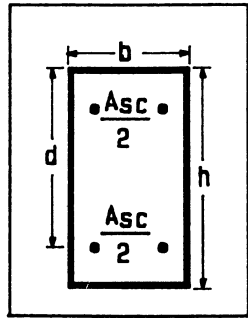
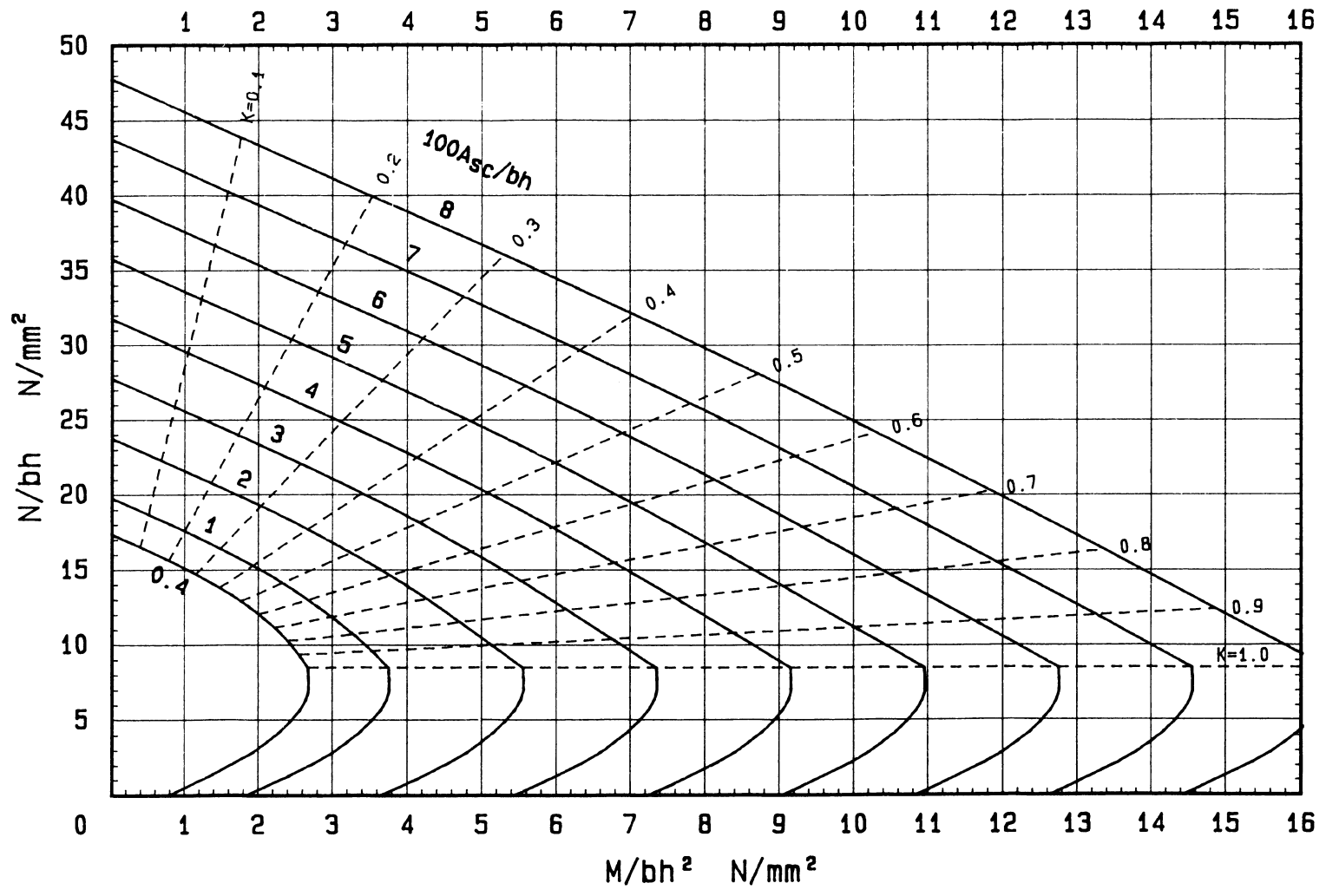
Chart No. 34



Rectangular columns



| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d/h | 0.90 |

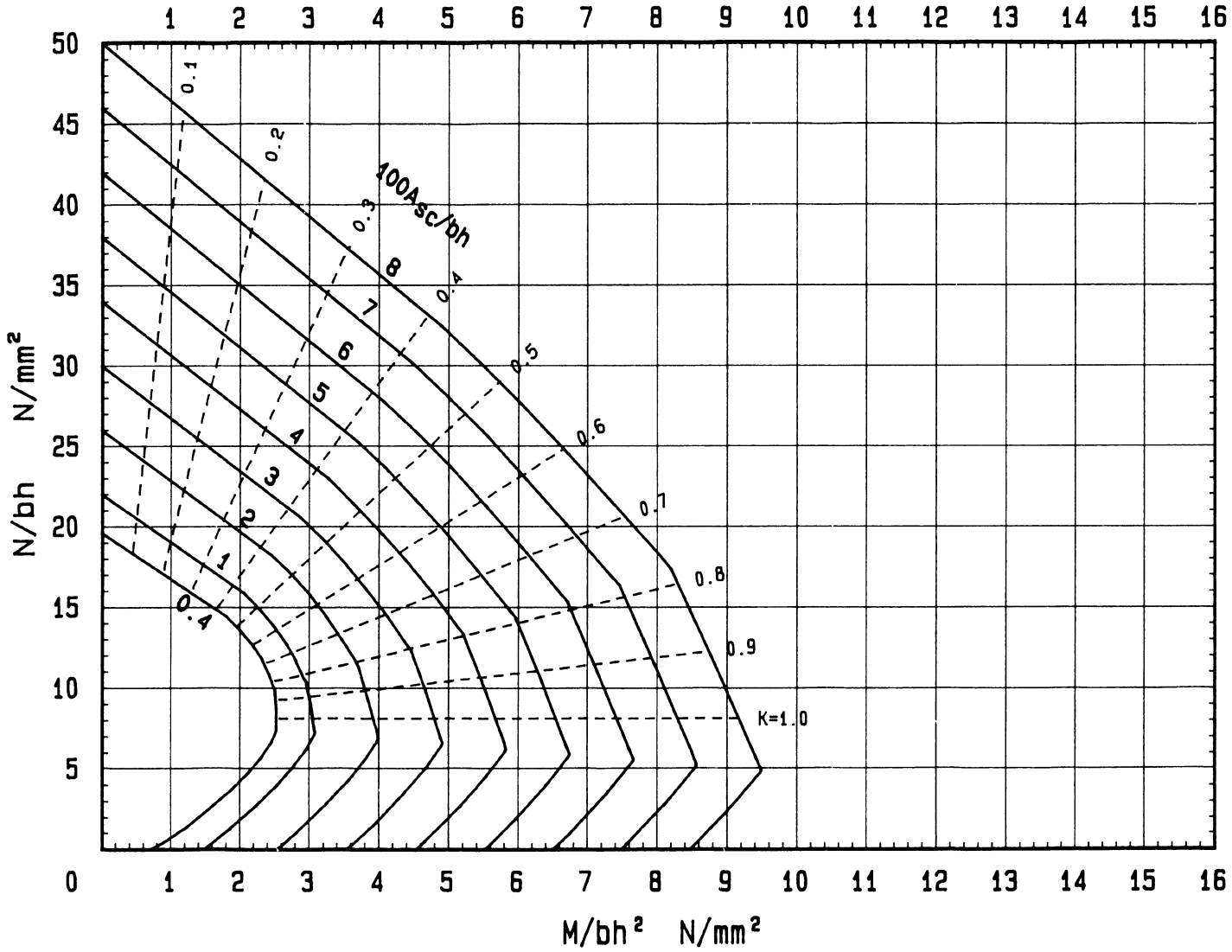


| | |
|----------|------|
| f_{cu} | 35 |
| f_y | 460 |
| d/h | 0.95 |

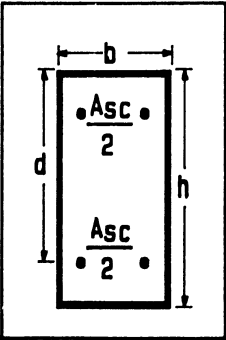
Rectangular columns

Chart No. 35

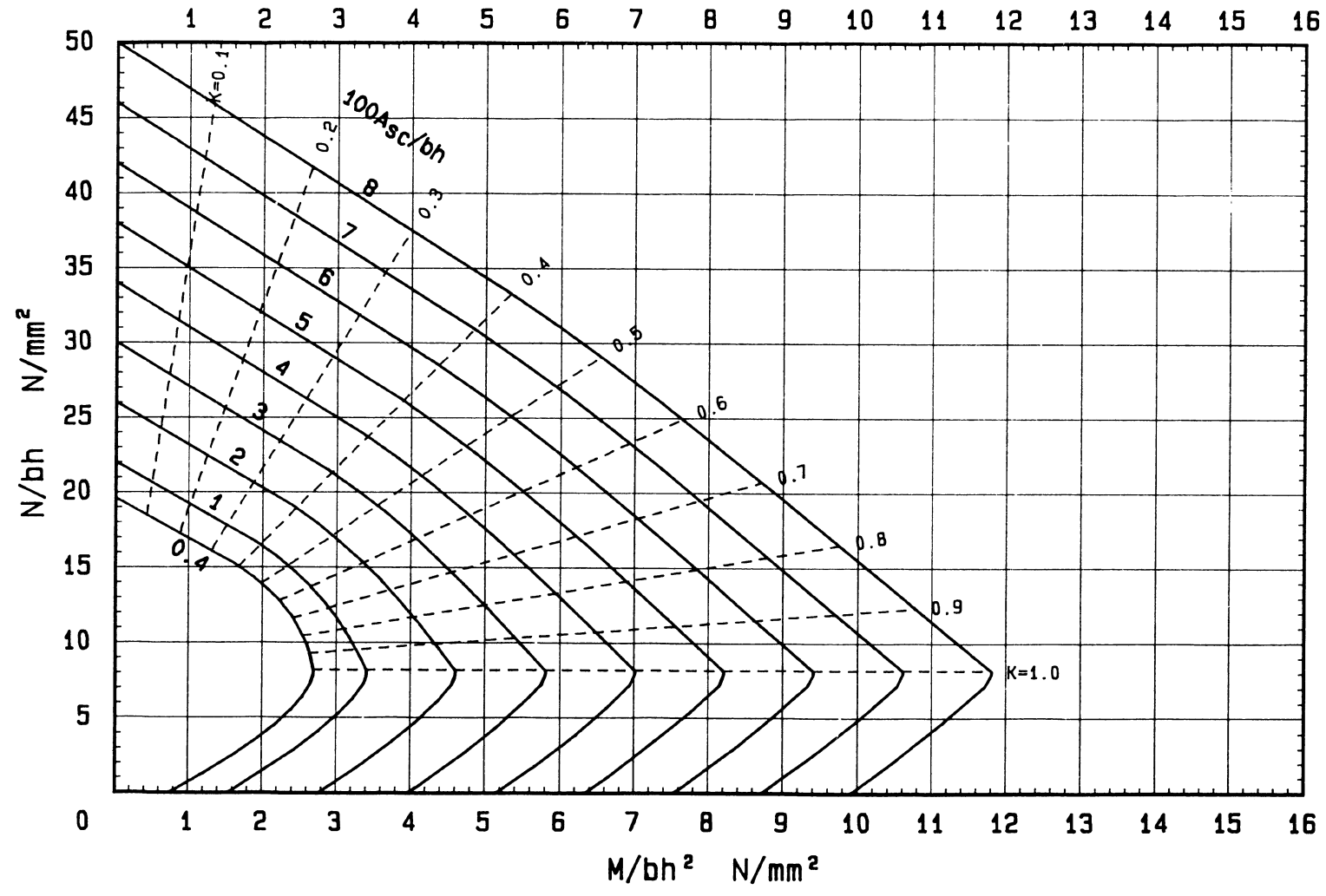
Chart No. 36



Rectangular columns



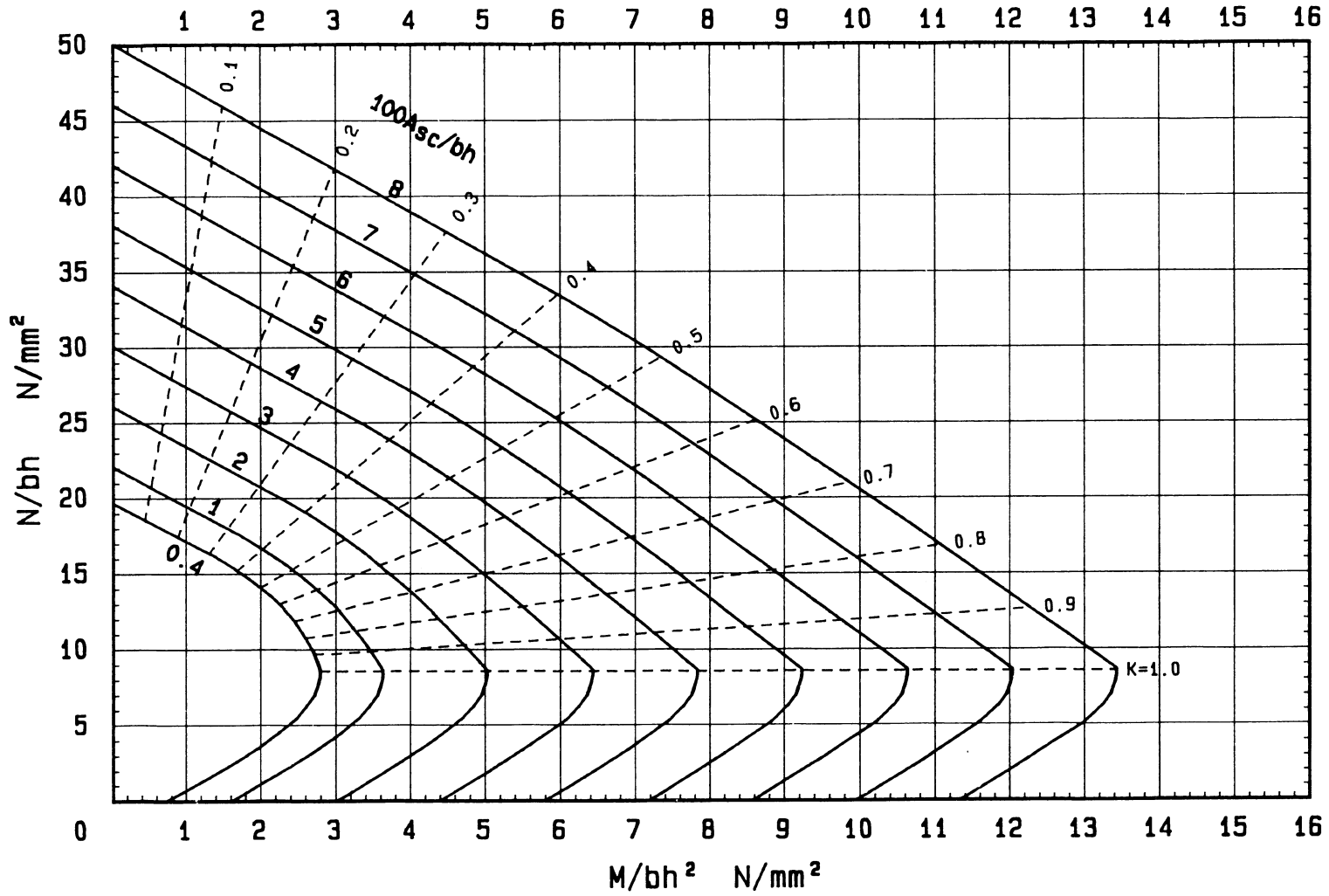
| | |
|----------|------|
| f_{cu} | 40 |
| f_y | 460 |
| d/h | 0.75 |



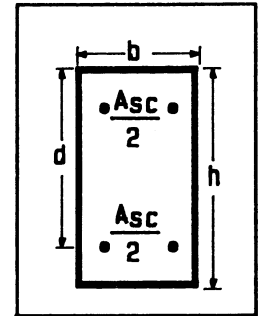
Rectangular columns

Chart No. 37

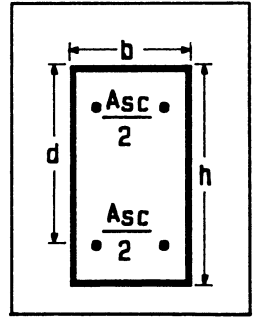
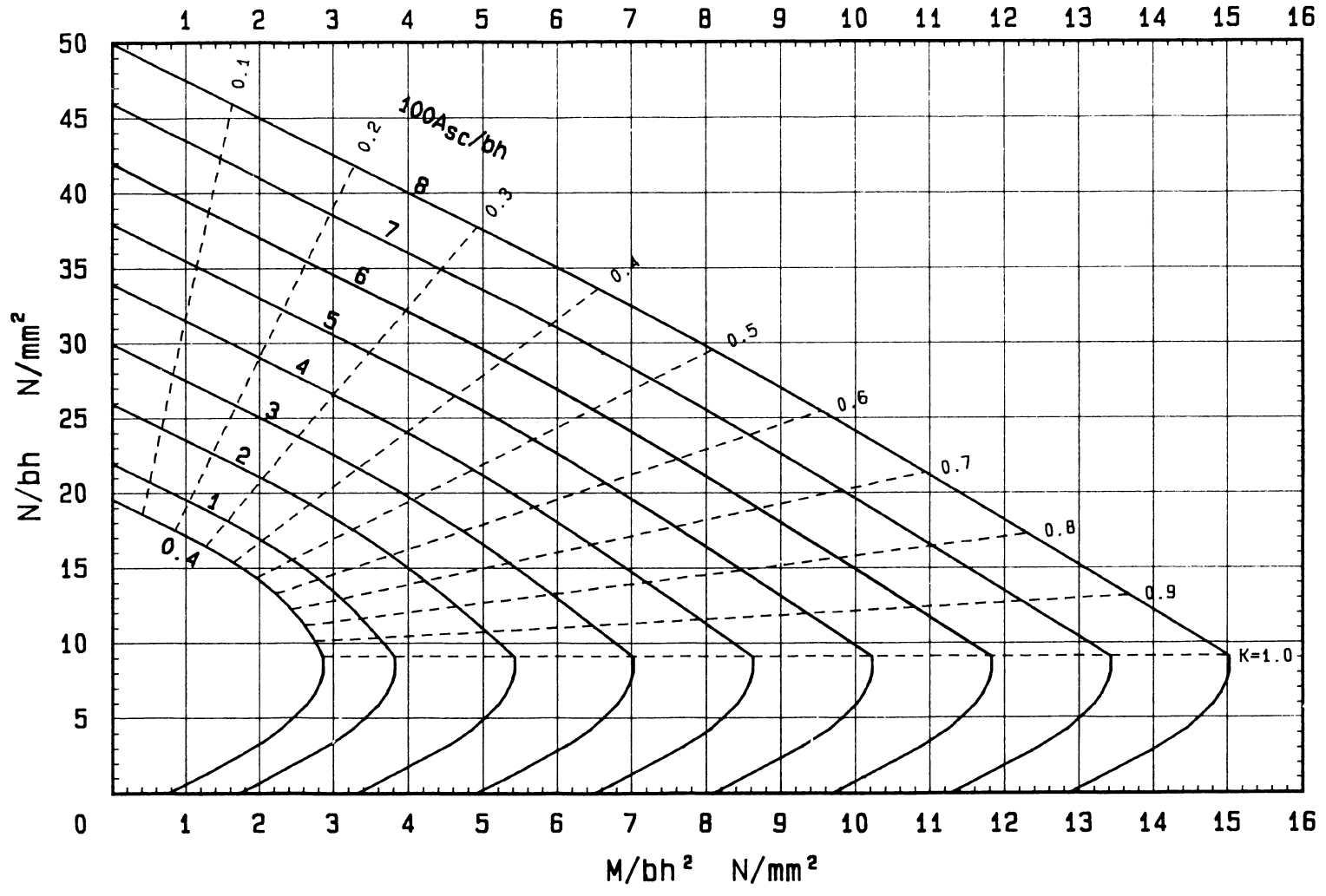
Chart No. 38



Rectangular columns



| | |
|----------|------|
| f_{cu} | 40 |
| f_y | 460 |
| d/h | 0.85 |

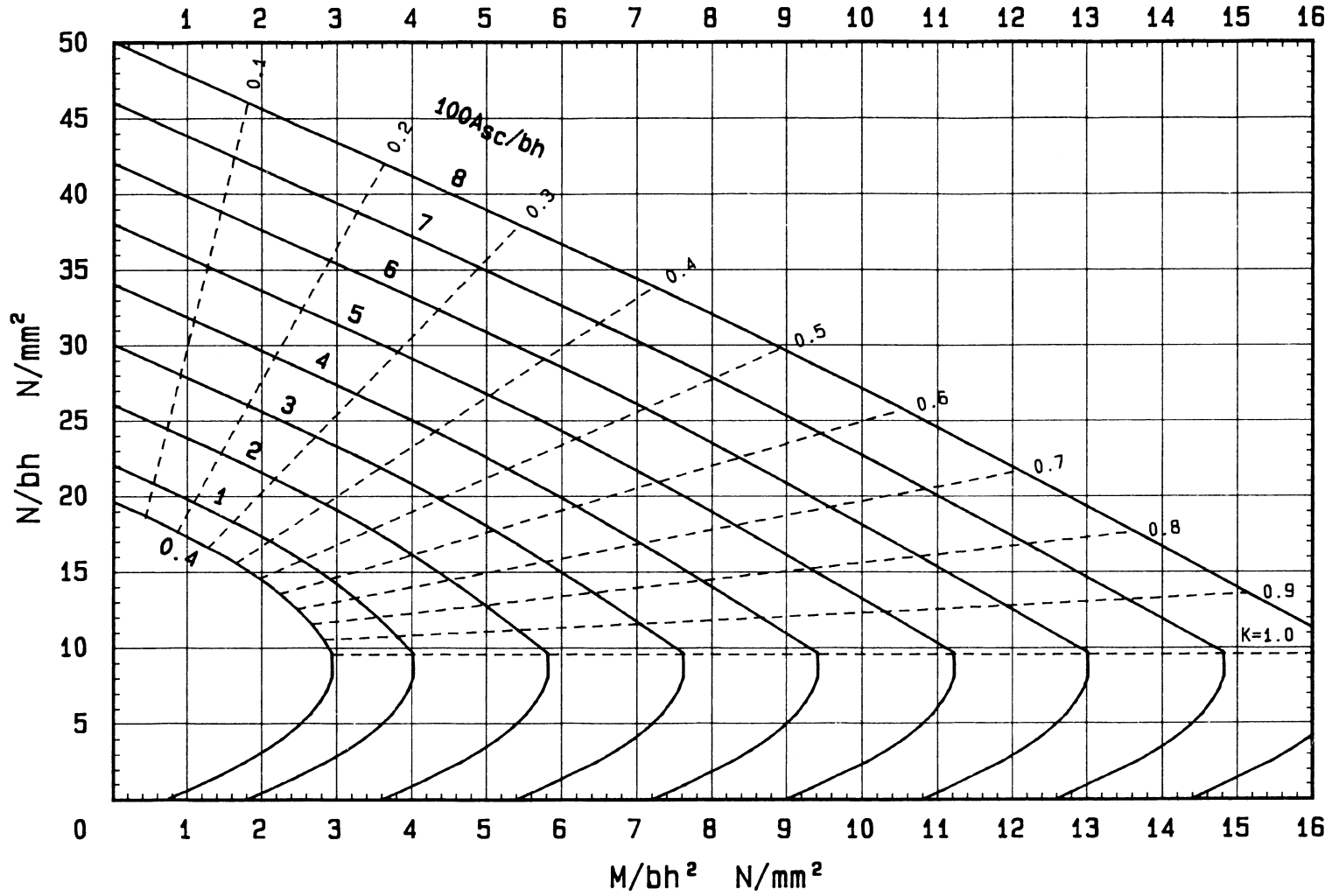


| | |
|----------|------|
| f_{cu} | 40 |
| f_y | 460 |
| d/h | 0.90 |

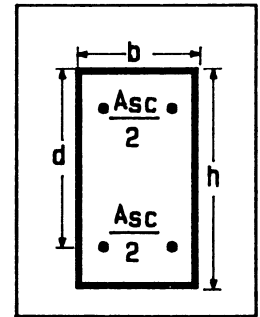
Rectangular columns

Chart No. 39

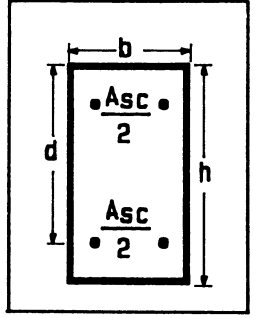
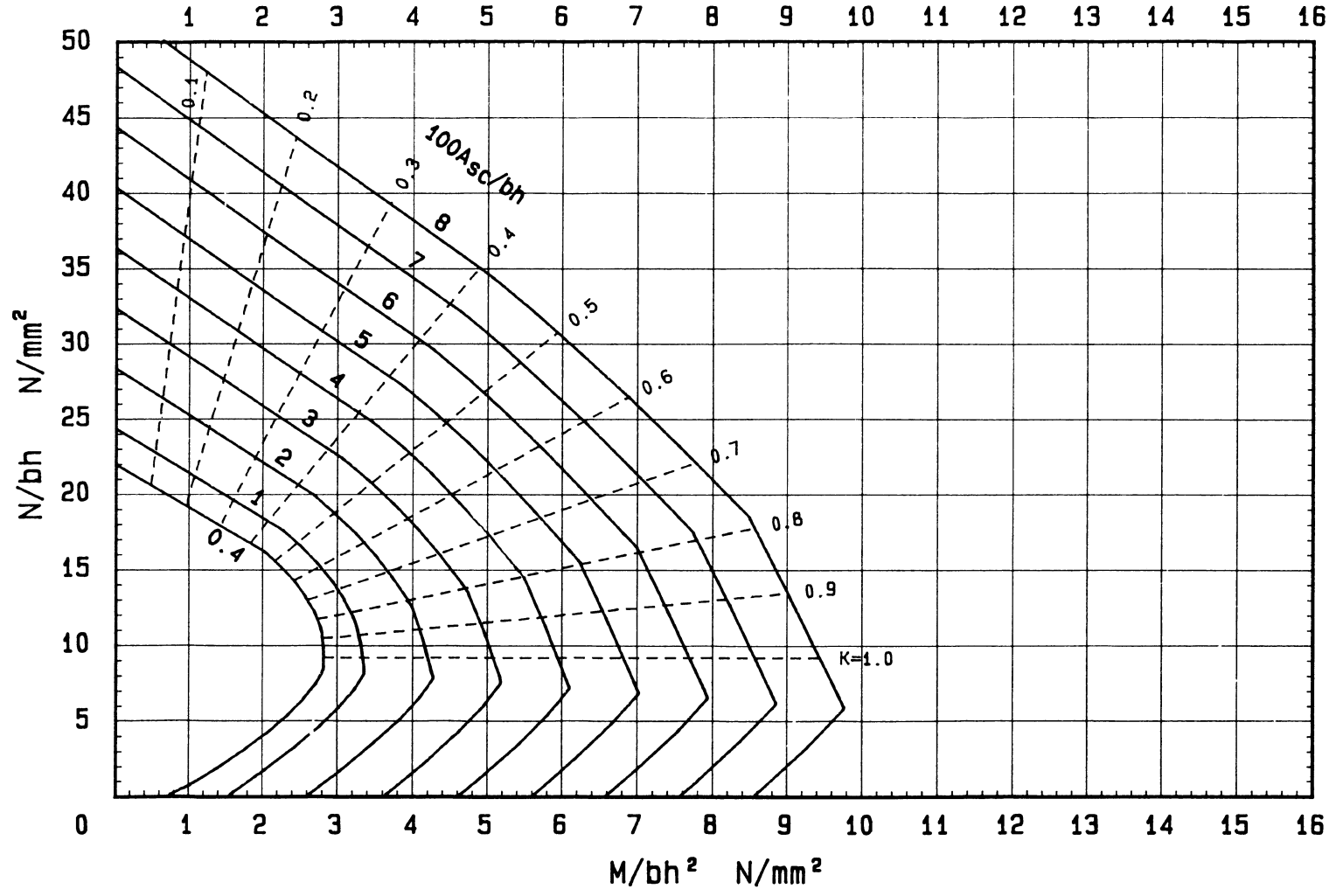
Chart No. 40



Rectangular columns



| | |
|----------|------|
| f_{cu} | 40 |
| f_y | 460 |
| d/h | 0.95 |

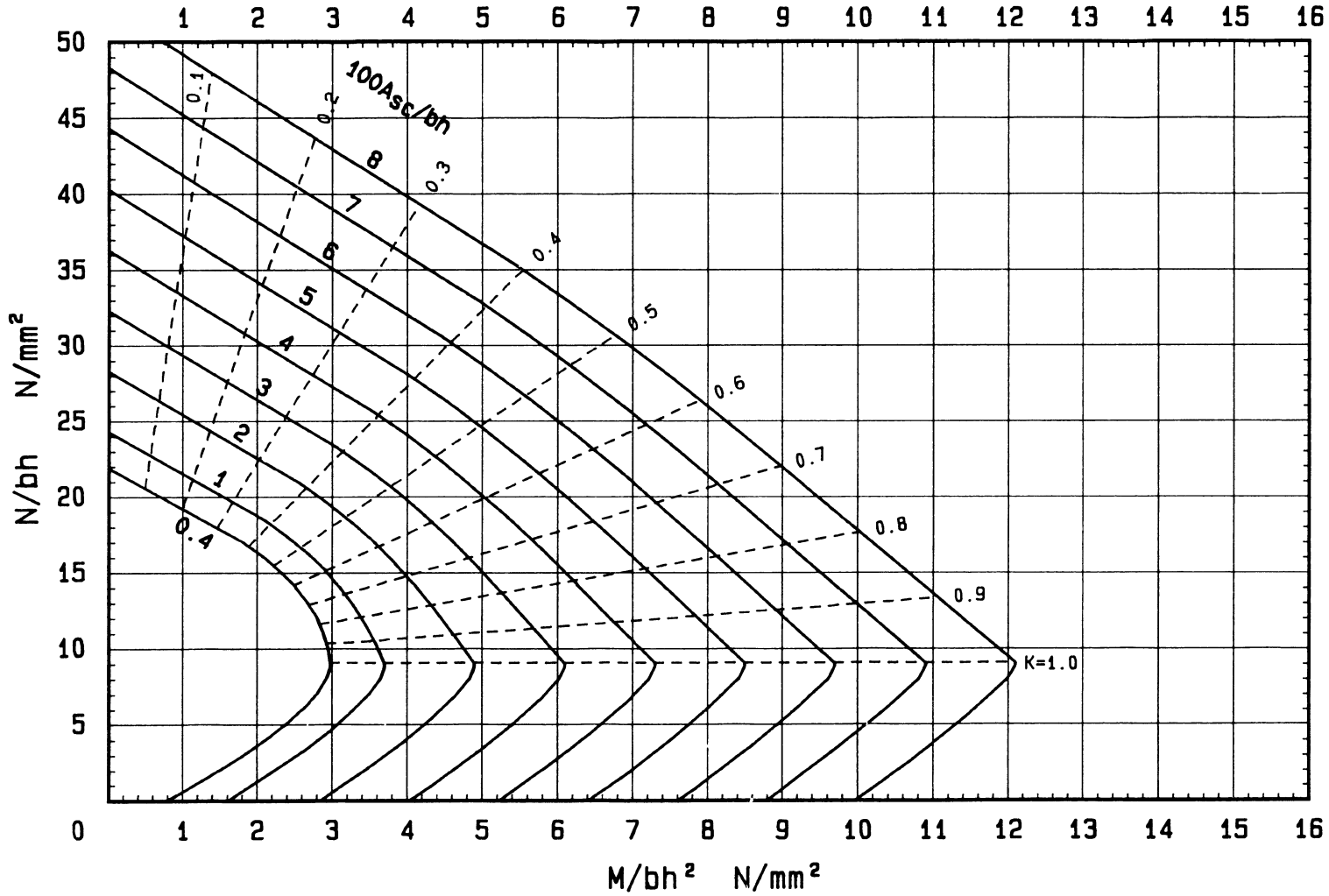


| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d/h | 0.75 |

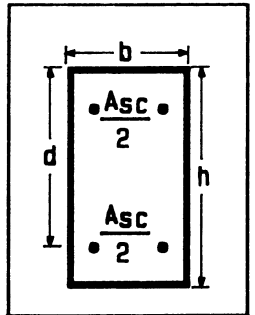
Rectangular columns

Chart No. 41

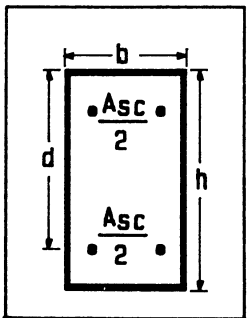
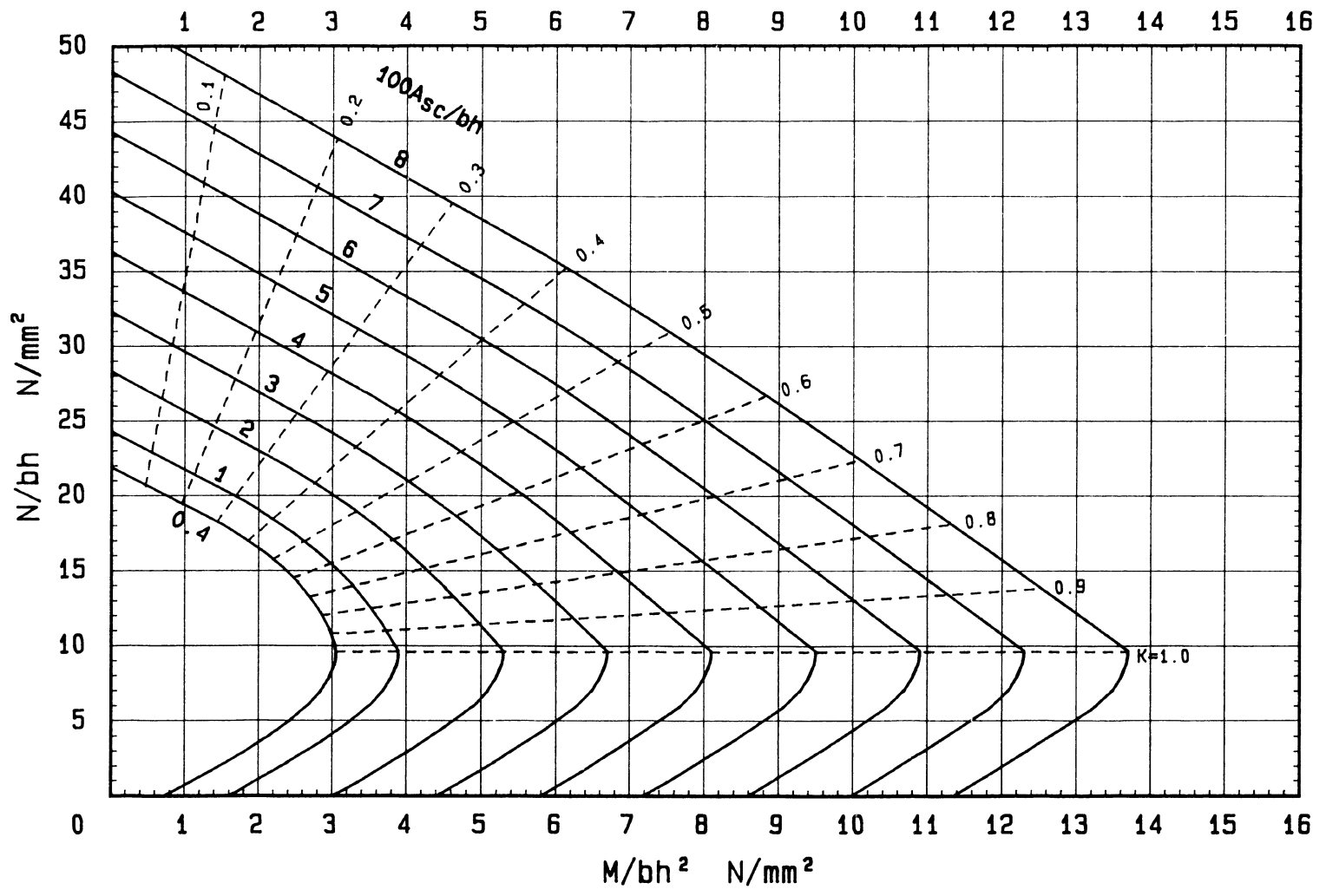
Chart No. 42



Rectangular columns



| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d/h | 0.80 |

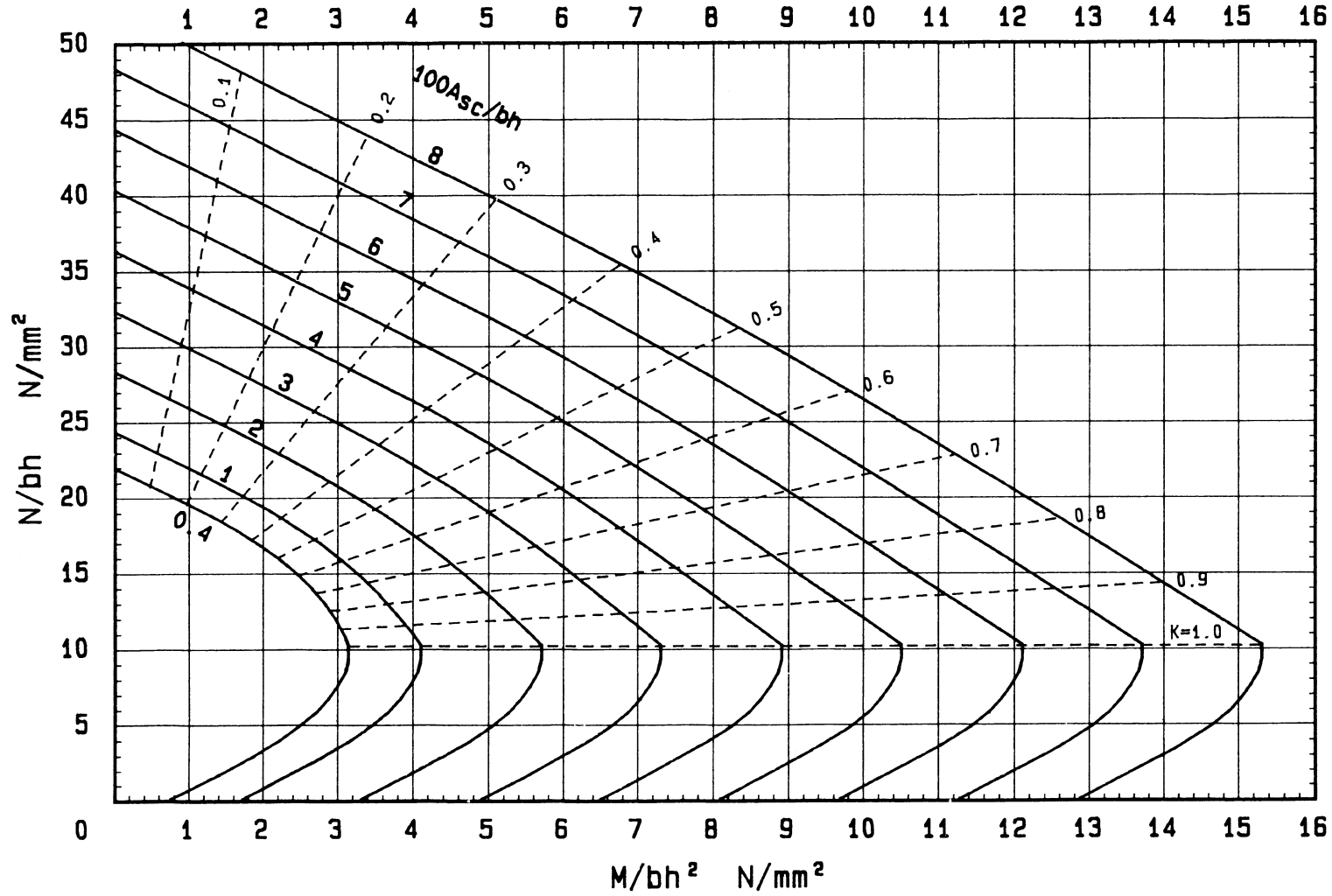


| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d/h | 0.85 |

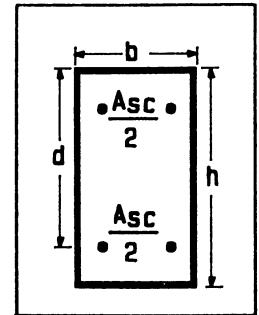
Rectangular columns

Chart No. 43

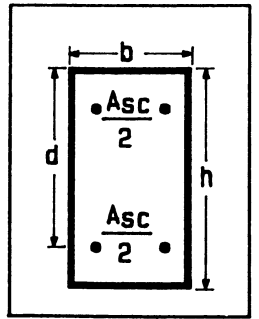
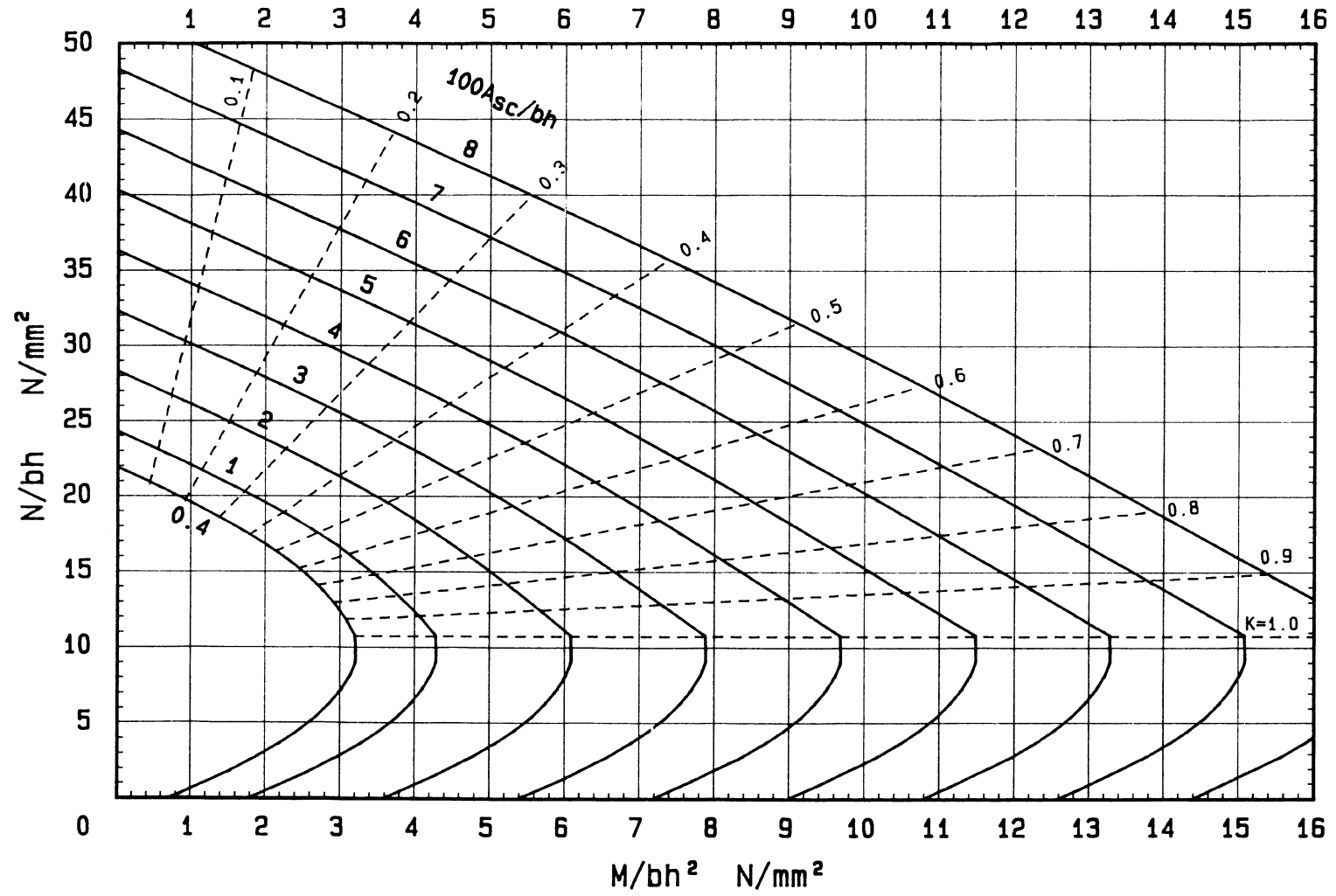
Chart No. 44



Rectangular columns



| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d/h | 0.90 |

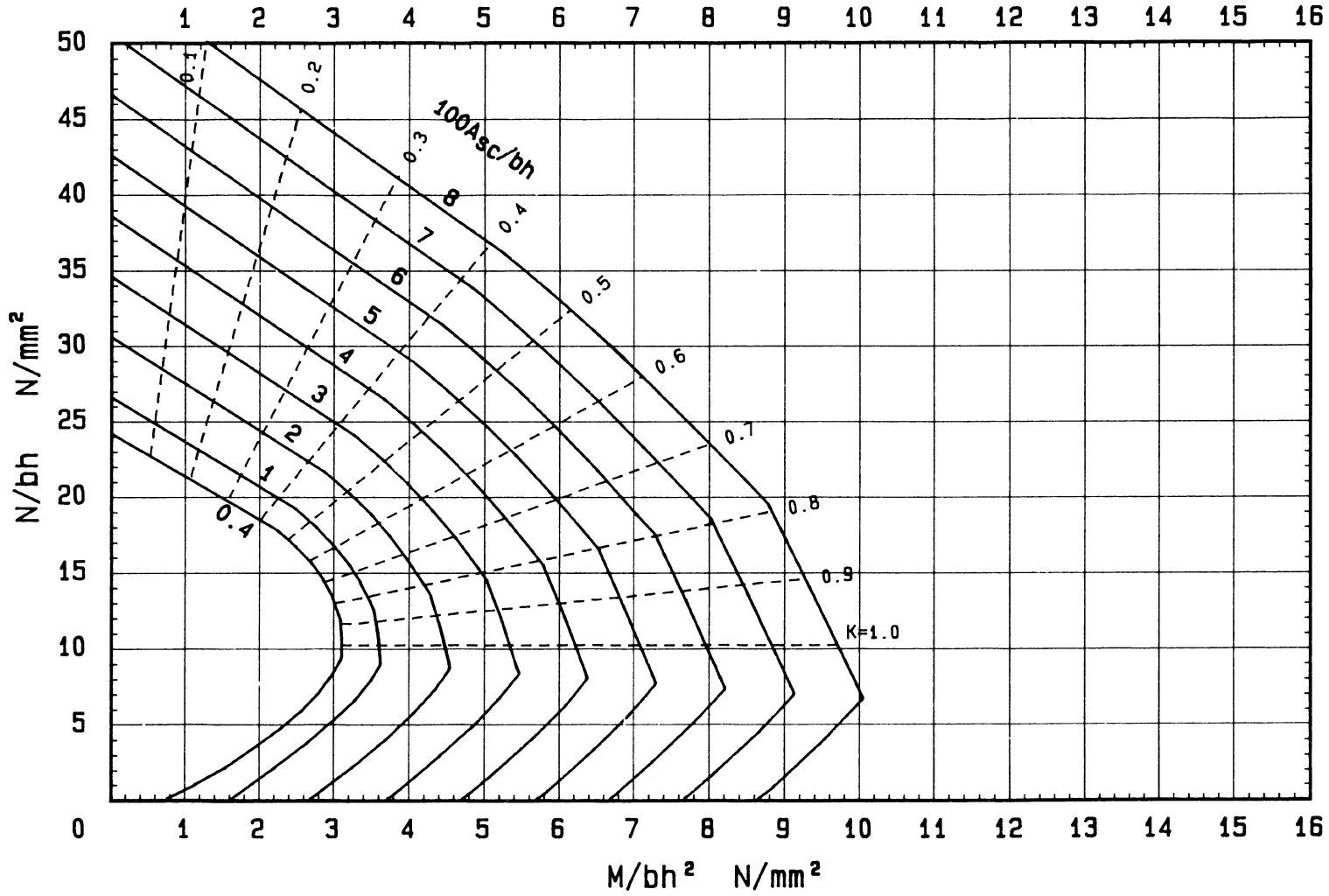


| | |
|----------|------|
| f_{cu} | 45 |
| f_y | 460 |
| d/h | 0.95 |

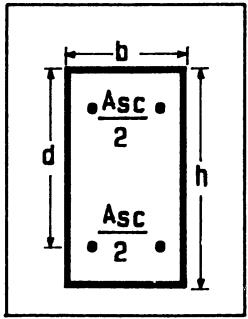
Rectangular columns

Chart No. 45

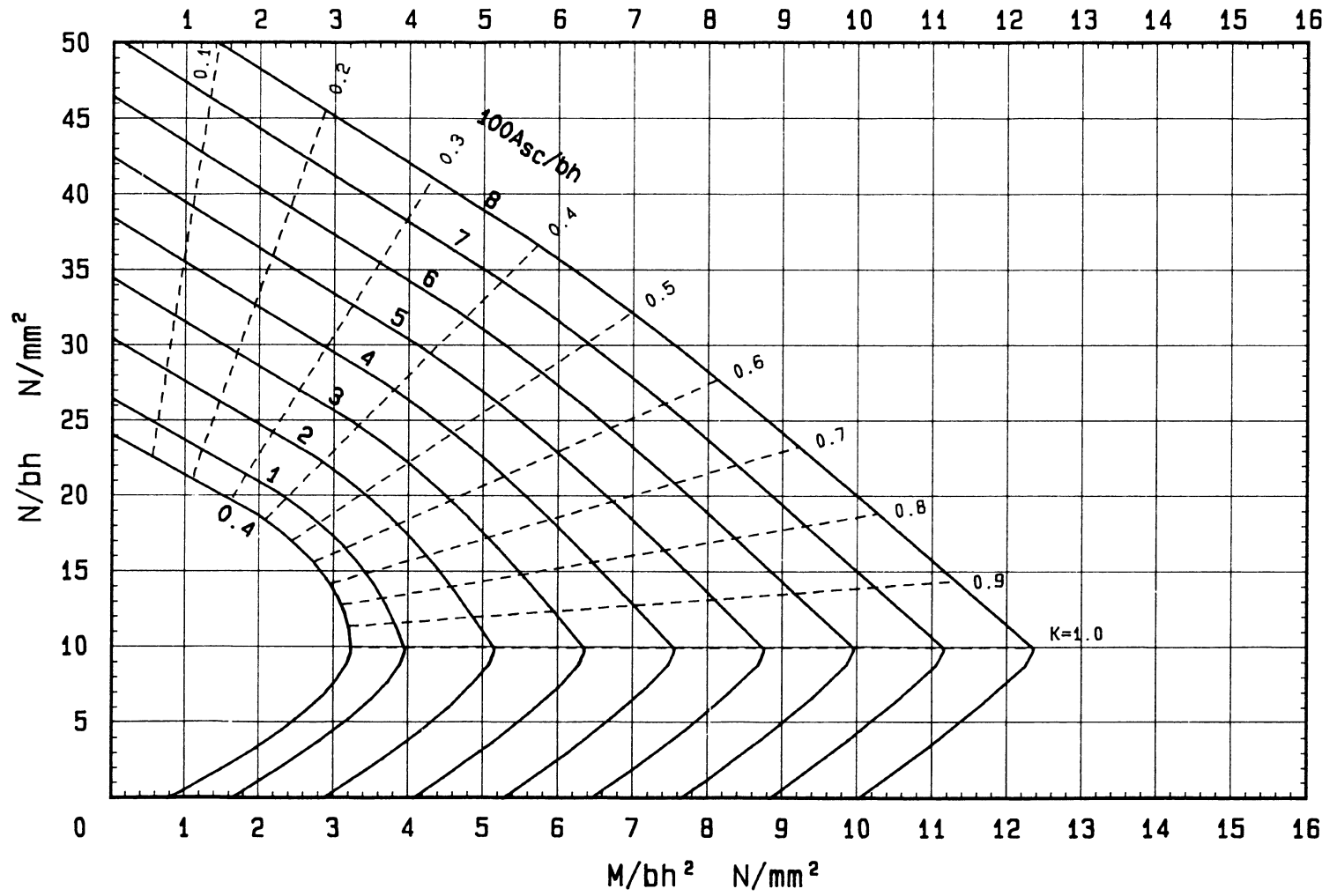
Chart No. 46



Rectangular columns



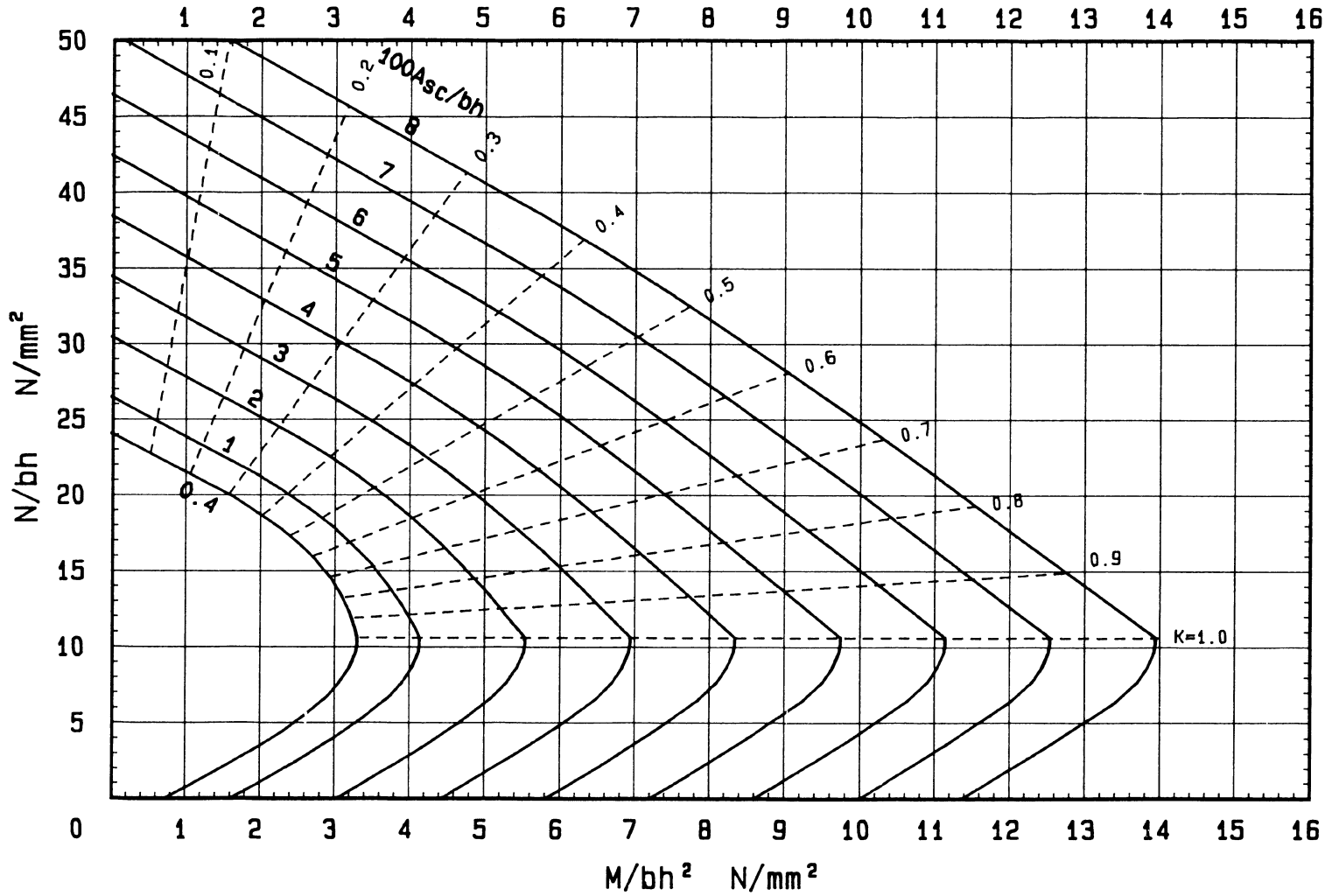
| | |
|----------|------|
| f_{cu} | 50 |
| f_y | 460 |
| d/h | 0.75 |



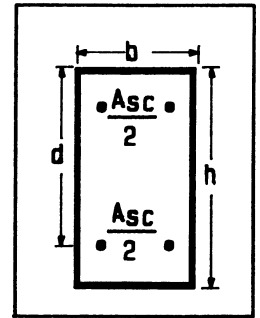
Rectangular columns

Chart No. 47

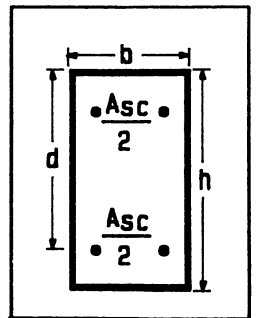
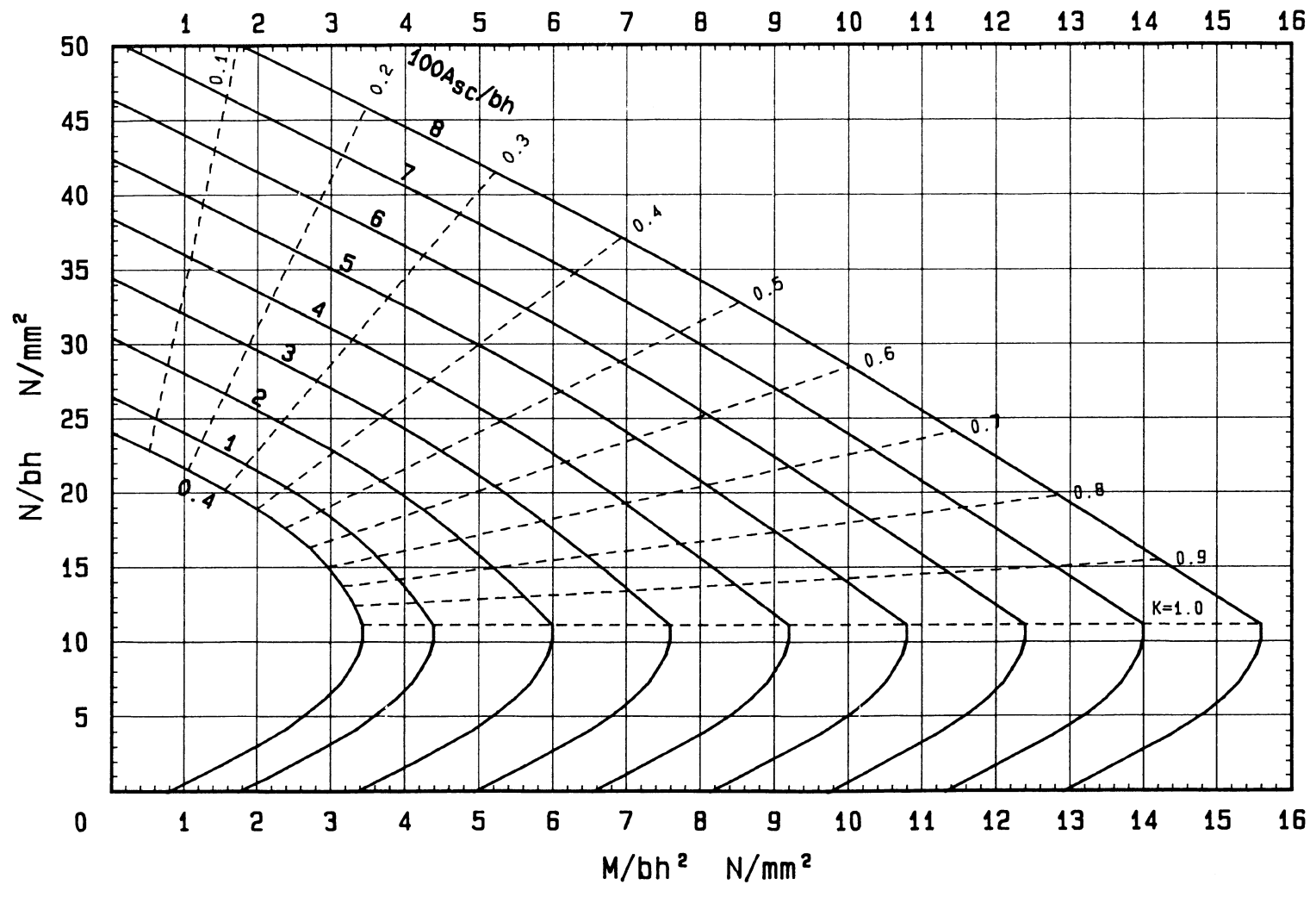
Chart No. 48



Rectangular columns



| | |
|----------|------|
| f_{cu} | 50 |
| f_y | 460 |
| d/h | 0.85 |

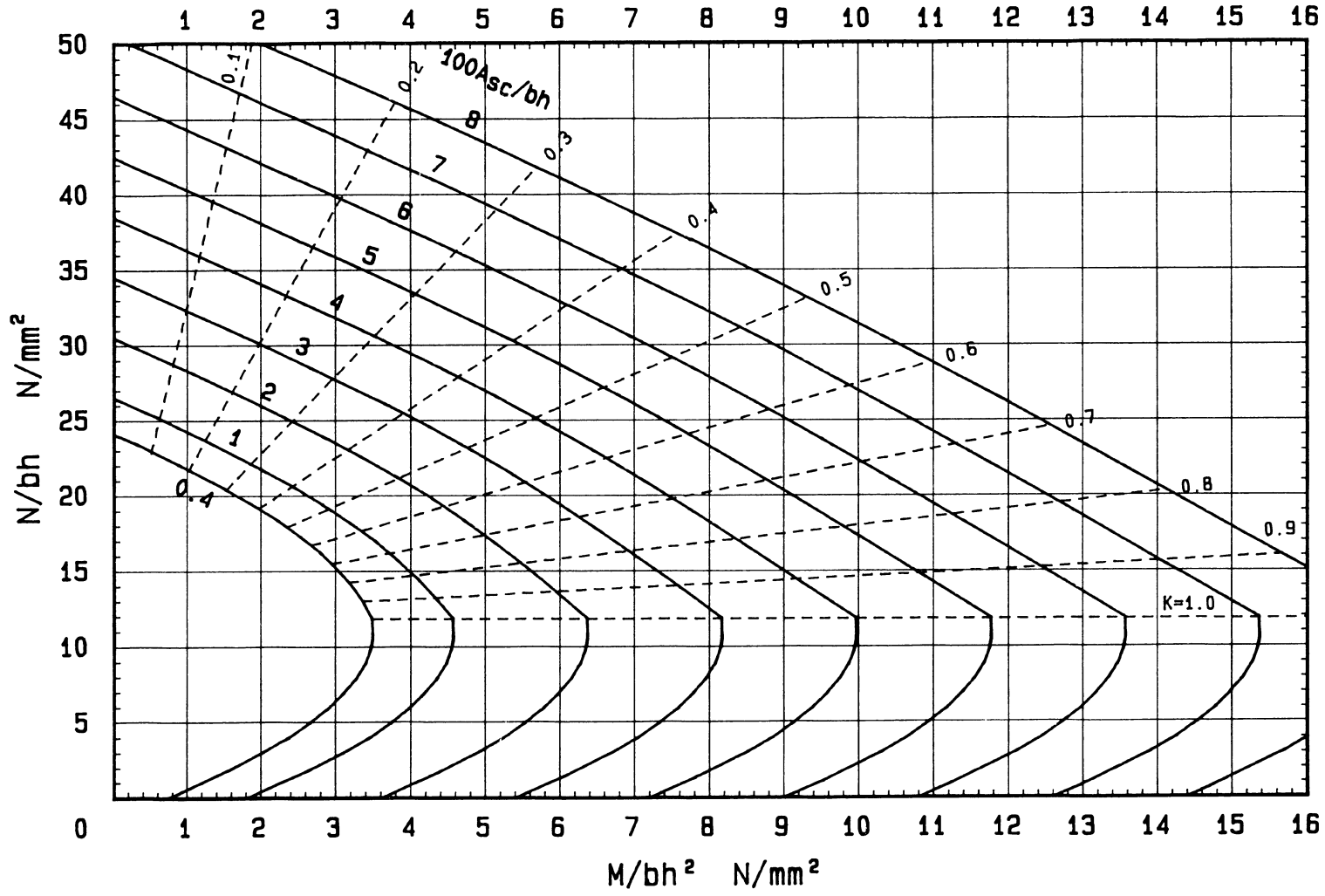


| | |
|----------|------|
| f_{cu} | 50 |
| f_y | 460 |
| d/h | 0.90 |

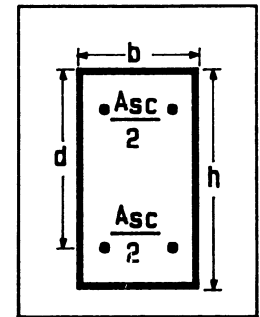
Rectangular columns

Chart No. 49

Chart No. 50



Rectangular columns



| | |
|----------|------|
| f_{cu} | 50 |
| f_y | 460 |
| d/h | 0.95 |

Appendix A Notes on the derivation of the design charts

All the charts have been derived using the assumptions given in 3.4.4.1 of BS 8110-1:1985 for the analysis of cross sections. These assumptions are shown diagrammatically in Figure 1 to Figure 3. Figure 2 shows the stress-strain curves assumed for the concrete and Figure 3 the stress-strain relationship for the reinforcement at the ultimate limit state. In deriving the charts from these stress-strain curves, γ_m has been taken as 1.5 and 1.15 for concrete and reinforcement, respectively. For rectangular cross sections where the neutral axis remains within the section, expressions can easily be derived to give the total compressive force developed in the concrete and the position of the centroid of this force at failure. These are as follows.

Concrete compressive force at failure is given by:

$$\frac{0.45 f_{cu} b x}{0.0035} \left(0.0035 - \frac{\epsilon_0}{3} \right) = k_1 b x$$

Distance from compressive face of section to centroid of concrete compressive force is given by:

$$\left[\frac{(2 - \epsilon_0/0.0035)^2 + 2}{4(3 - \epsilon_0/0.0035)} \right] x = k_2 x$$

These expressions were used in the production of all the design charts for rectangular cross sections. For rectangular column cross sections where the eccentricity of the load is sufficiently small to cause the neutral axis to lie outside the section, the result obtained from the expressions is reduced to allow for the effect of the part of the parabola lying outside the section.

The figures from which the charts were drawn were produced by solution of the equations for equilibrium of moments and forces for successive values of neutral axis depth. For a doubly reinforced rectangular cross section with the neutral axis within the section, these equations are as follows.

Equilibrium of axial forces, N , is given by:

$$N = k_1 b x + A_s' f_{sc} + A_s f_{st}$$

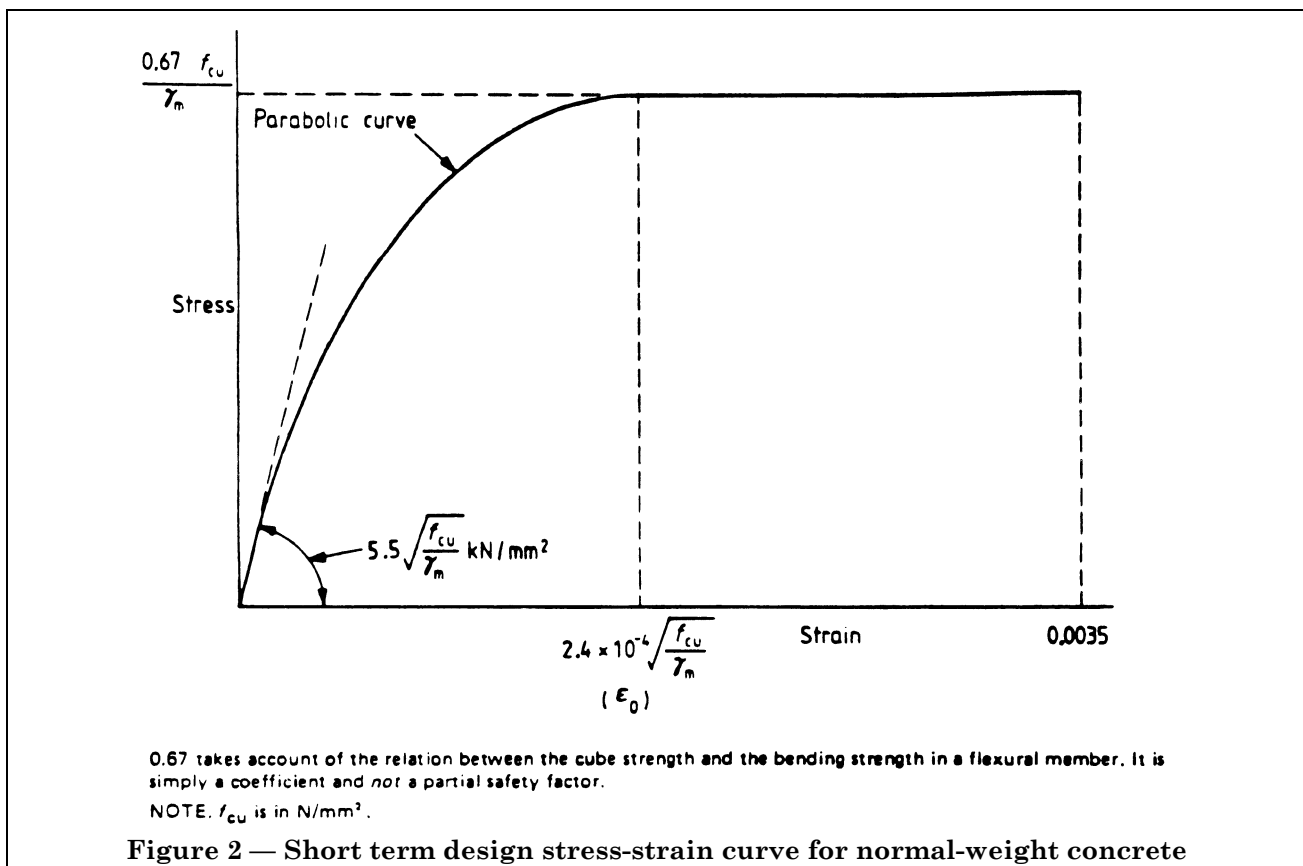
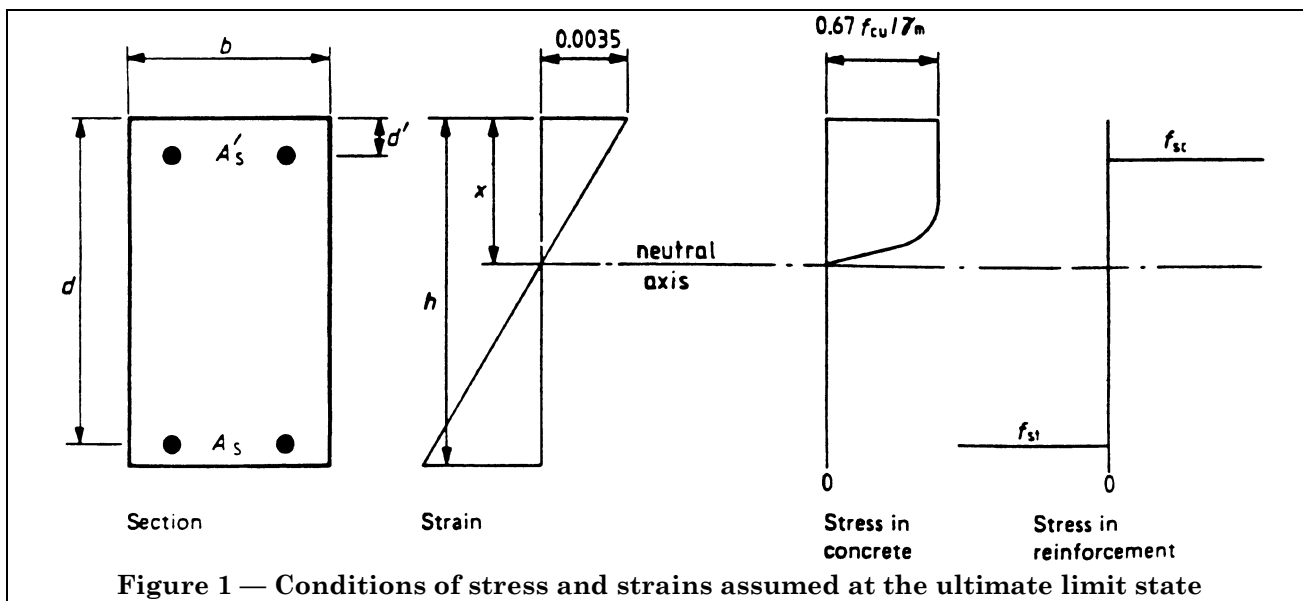
Equilibrium of moments, M , is given by:

$$M = k_1 b x (h/2 - k_2 x) + A_s' f_{sc} (h/2 - d') + A_s f_{st} (h/2 - d)$$

For the beam charts, areas of tension steel and moments were calculated for specified areas of compression steel and neutral axis depth. For the column charts, moments and axial loads were calculated for specified steel areas and neutral axis depths.

Three assumptions of a minor nature have been introduced in the production of the charts in addition to those given in BS 8110-1.

- a) No solutions have been produced for situations where $x < d'$. For the beam charts the first point calculated is for $x = d'$. This point was joined to the origin by a straight line. This is conservative.
- b) Where compression reinforcement is present the full area of concrete in compression has still been assumed active, thus no reduction has been made in the calculations for the concrete displaced by the reinforcement.
- c) There should, rigorously, be a slight deviation from a smooth curve of the interaction diagrams for columns in the region of low moments. This arises where the neutral axis lies just outside the section and part of the parabolic section of the stress-strain curve is curtailed. The curves have been "smoothed" in this region. The error introduced is negligible.



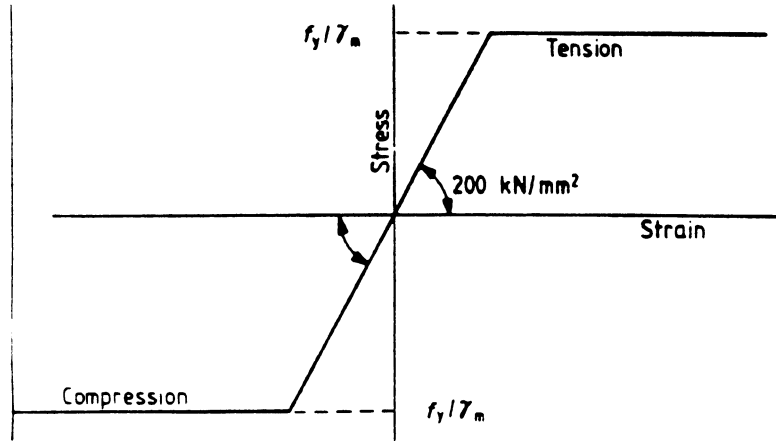


Figure 3 — Short term design stress-strain curve for reinforcement

Appendix B Design example

NOTE The use of each type of chart is illustrated by an example.

B.1 Singly reinforced beams

Design the cross section of a slab for the ultimate moment given. Design details:

$$f_{cu} = 25 \text{ N/mm}^2;$$

$$f_y = 250 \text{ N/mm}^2;$$

$$h = 160 \text{ mm};$$

cover = 30 mm to main reinforcement;

$$M \text{ per metre width} = 27.6 \text{ kN m.}$$

Assume 16 mm bars

Therefore

$$d = 160 - \left[\frac{30 + 16}{2} \right]$$

$$= 122 \text{ mm}$$

$$\frac{M}{bd^2} = \frac{27.6 \times 10^6}{1000 \times 122^2}$$

$$= 1.86 \text{ N/mm}^2 \text{ per metre width}$$

From Chart No. 1

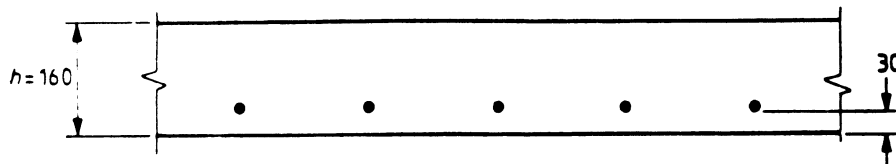
$$\frac{100 A_s}{bd} = 0.94$$

Therefore

$$A_s = \frac{0.94 \times 1000 \times 122}{100}$$

$$= 1145 \text{ mm}^2 \text{ per metre width}$$

Therefore a suitable solution is to use 16 mm bars at 175 mm centres (i.e. 1 150 mm² per metre width).



B.2 Doubly reinforced beams

Design the centre cross section of a rectangular beam to comply with the following requirements at the ultimate limit state.

Design details:

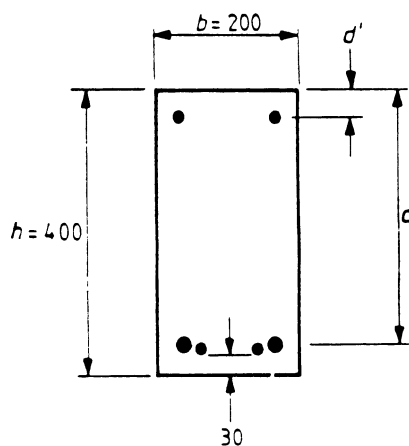
$$f_{cu} = 40 \text{ N/mm}^2;$$

$$f_y = 460 \text{ N/mm}^2;$$

$$M = 127 \text{ kN m};$$

cover = 30 mm to main reinforcement.

The critical cross section under consideration is given below and the bending moment at the ultimate limit state has been obtained by redistribution involving a reduction equal to 30 % of the numerically largest moment given by the elastic maximum moments diagram for the beam.



Assume 10 mm bars for compression reinforcement and 25 mm bars for tension reinforcement.

$$\frac{d'}{d} = \frac{35}{357.5} \approx 0.10 \text{ therefore use Chart No. 18}$$

$$M/bd^2 = 4.97$$

A reduction of 30 % due to redistribution requires that the neutral axis depth should be limited such that $x/d \leq 0.3$. Thus a solution must be sought on or to the left of the line marked $x/d = 0.3$ on Chart No. 18. A suitable solution is:

$$100 A_s/bd = 1.42;$$

$$100 A_s'/bd = 0.3 \text{ (by interpolation).}$$

$$\text{Therefore } A_s = 1\,015 \text{ mm}^2$$

$$\text{and } A_s' = 214 \text{ mm}^2$$

Therefore reinforcement to be provided

$$A_s: 2 \text{ No. } 20 + 2 \text{ No. } 16 \text{ (area } 1\,030 \text{ mm}^2)$$

A'_s : 2 No. 12 (area 226 mm²)

The use of 12 mm compression reinforcement means that d'/d is now 0.101 thus the use of Chart No. 18 is still justified.

B.3 Rectangular columns

Design the cross section of a rectangular column to comply with the following requirements at the ultimate limit state.

Design details:

$$f_{cu} = 50 \text{ N/mm}^2;$$

$$f_y = 460 \text{ N/mm}^2;$$

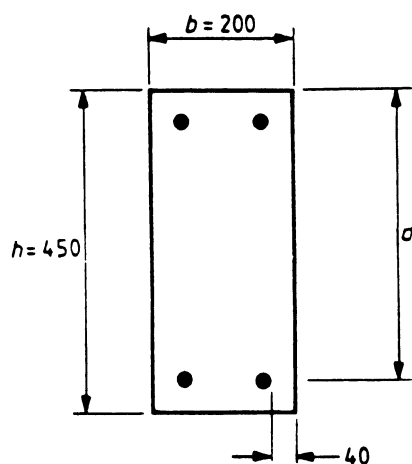
cover = 40 mm to main reinforcement;

$M = 91.2 \text{ kN m}$ about major axis

0 kN m about minor axis

$$N = 2\,460 \text{ kN}$$

The cross section of the column is as follows:



Assume 32 mm bars

$\frac{d}{h} = \frac{394}{450} \approx 0.88$ therefore use Chart No. 49 where

$$d/h = 0.90$$

$$M/bh^2 = 2.25$$

$$N/bh = 27.4$$

From Chart No. 49

$$100 A_{sc}/bh = 2.6$$

Therefore $A_{sc} = 2\,340 \text{ mm}^2$

Therefore a suitable solution is to use 4 No. 32 mm cold worked bars (i.e. 3 220 mm²).

Publications referred to

BS 8110, *Structural use of concrete.*

BS 8110-1, *Code of practice for design and construction.*

BS 8110-2, *Code of practice for special circumstances.*

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