COLUMN DESIGN

As it was mentioned earlier, all columns should be designed by considering flexural moments in addition to axial loads.

TS-500:

If $M_d < (N_d \times e_{min})$ then $M_d = N_d \times e_{min}$

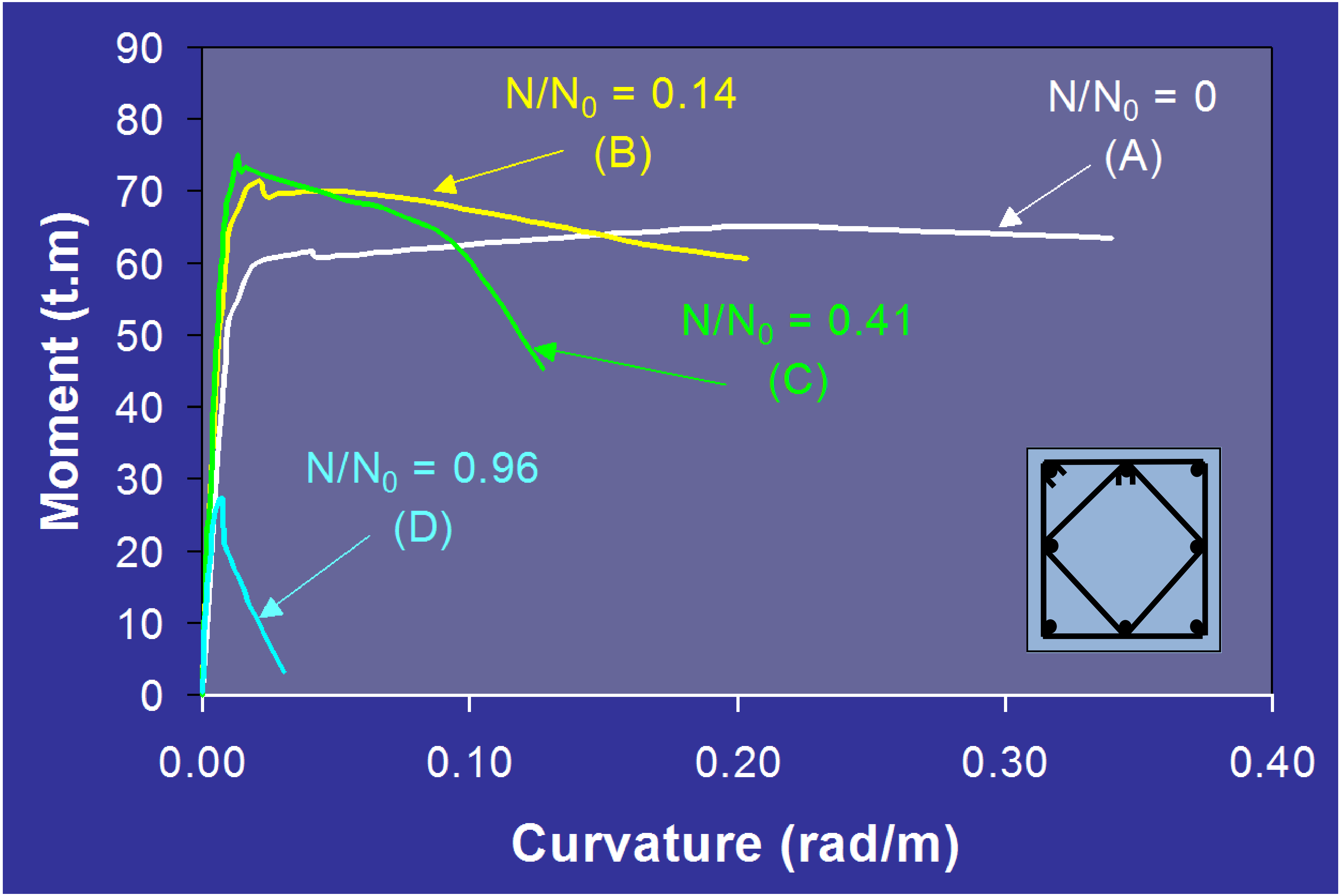
e_{min} = 15 mm + 0.03h

"N_d" is the dimension in the direction of eccentricity
"h" is the dimension in the direction of eccentricity.

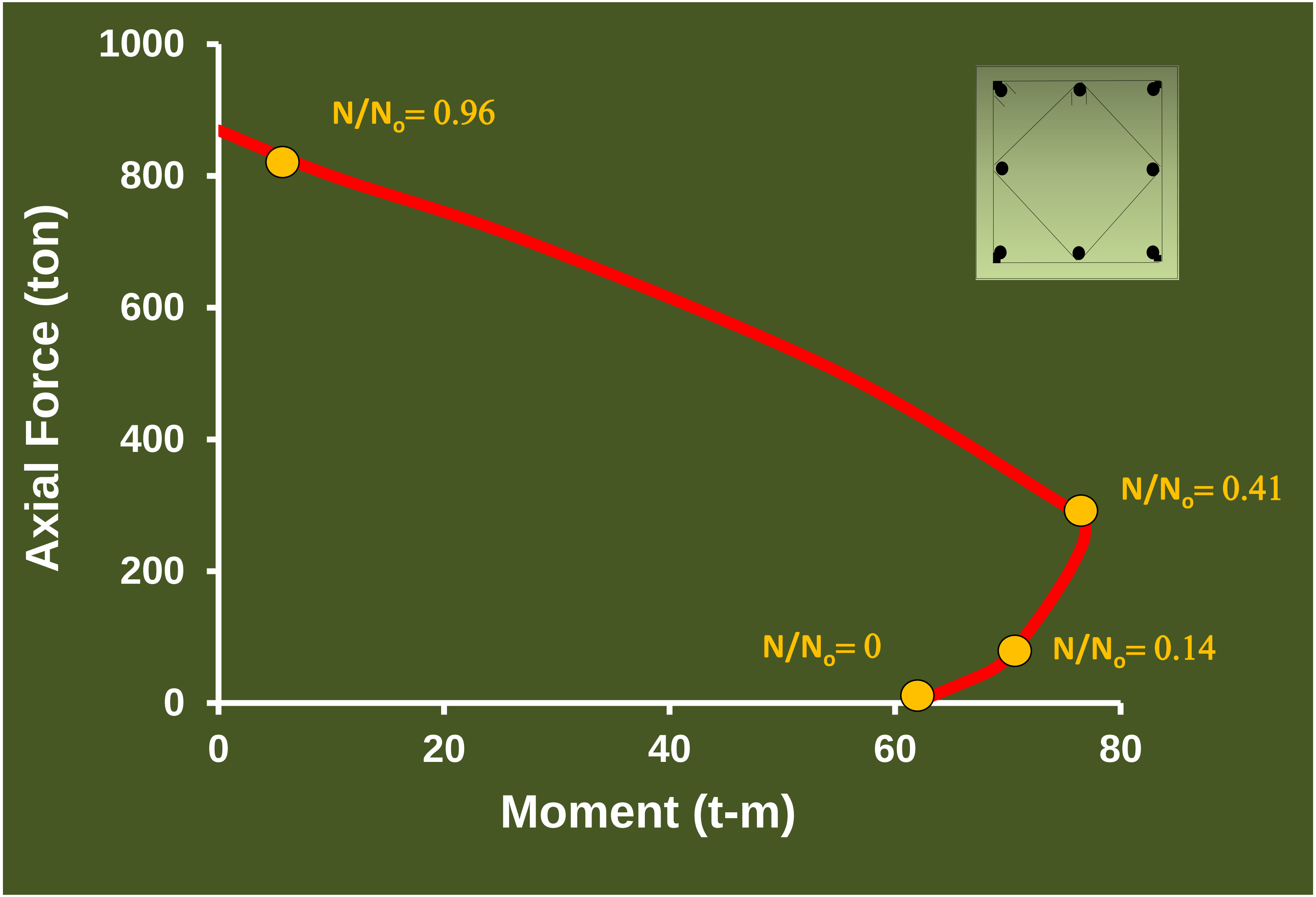
Many of the design codes limit the axial load on the column and specify a minimum eccentricity.

$N_d \leq 0.5 f_{ck} A_c$ (Turkish Seismic Code) or $N_d \leq 0.75 f_{cd} A_c$

$N_d \leq 0.6 f_{ck} A_c$ (TS500-2000) or $N_d \leq 0.90 f_{cd} A_c$



90
80
70
60
50
40
30
20
10
0
Moment (t.m)
N/N_0 = 0.14
(B)
N/N_0 = 0
(A)
N/N_0 = 0.41
(C)
N/N_0 = 0.96
(D)
0.00
0.10
0.20
0.30
0.40
Curvature (rad/m)



Axial Force (ton)
1000
800
600
400
200
0
0
20
40
60
80
Moment (t-m)
N/N_o= 0.96
N/N_o= 0.41
N/N_o= 0.14
N/N_o= 0

Column Design

The structural analysis should be carried on considering all possible load combinations and arrangements. Such an analysis will result in a set of N_d, M'_d values. The designer should design the column for the most critical N_d, M'_d combination found from analysis. The most critical combination can be determined by inspection. If this is not possible, all possibly critical combinations should be considered.

It is very difficult to make recommendations or propose methods for the preliminary design of columns (determining cross-sectional dimensions). At the preliminary design stage, although the axial load on the column can be estimated by considering the gravity loads acting on the **tributary area**, it is very difficult to estimate the moments. Therefore, columns are generally proportioned using experience and intuition. Here, the minimum column dimension will be given using the maximum axial load limit of the Turkish Seismic Code (TSC).

$$\text{Minimum} \quad A_c = \frac{N_d}{0.75 f_{cd}} \geq 75{,}000 \ mm^2$$

When the expected moment on the column is high, like columns in sway frames (unbraced frames) located in seismic zones, the constant in the denominator could be decreased to 0.6 or to 0.5.

In the final design stage, the design moment to be used should include the second order moments. Second order moments can be included by making a non-linear structural analysis which incorporates P-δ effects (moments created by deformations) or the second order moments calculated using approximate methods can be added to the first order moments found from a linear analysis. Second order moments will be discussed later in chapter under the heading "Slenderness Effect".

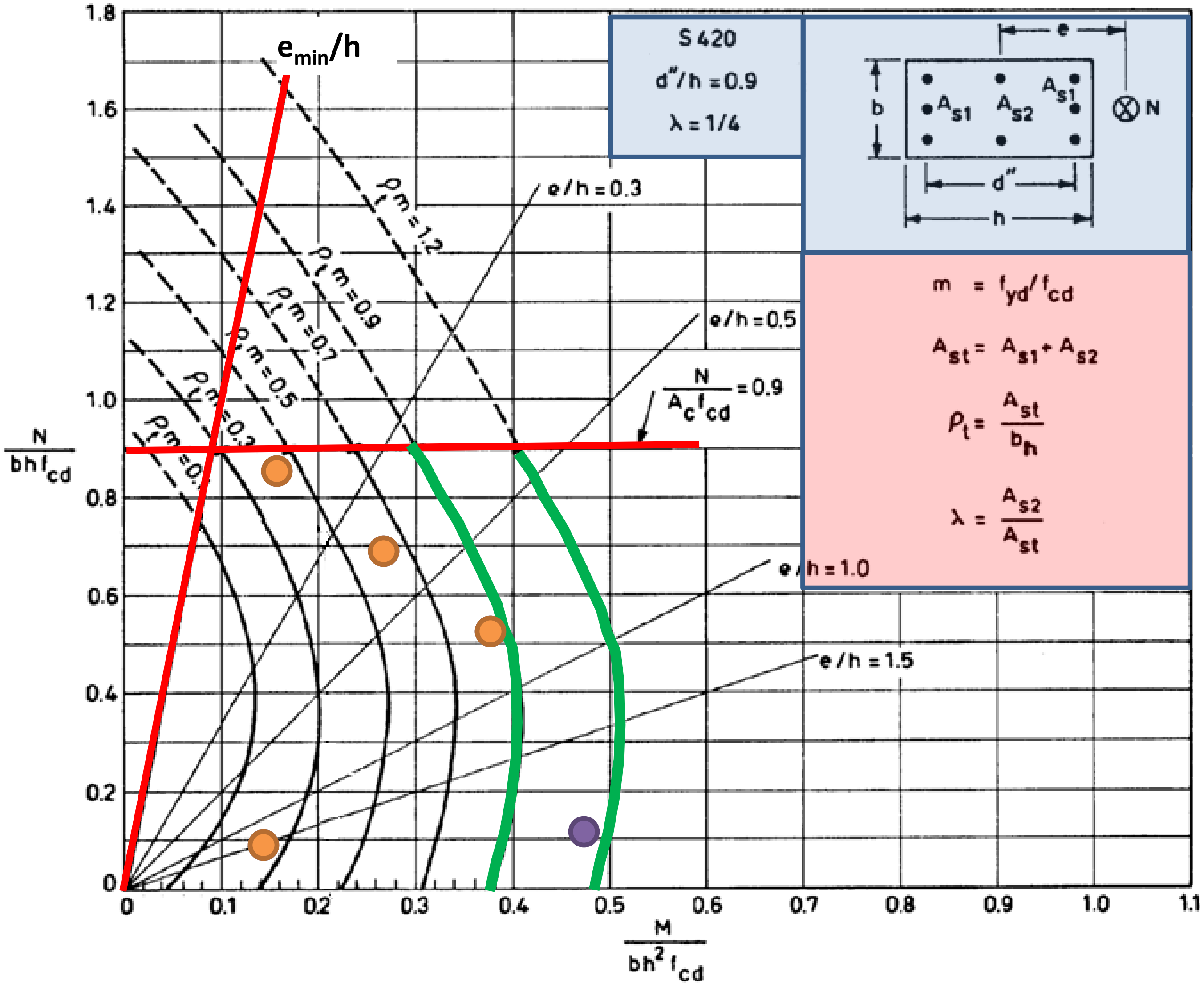
DESIGN CHARTS

Interaction diagrams become very convenient design charts if the coordinates are put in non-dimensional form. This can be made by dividing "N" by "bhf_{cd}"and "M" by "bh^2f_{cd}". Thus $\frac{N}{bhf_{cd}}$ and $\frac{M}{bh^2f_{cd}}$ will be the vertical and horizontal axes, respectively.

Once the diagrams are put in non-dimensional form, the variables are reduced to

- Geometry of the cross-section (rectangular, circular etc.)
- d"/h
- Ratio of longitudinal steel, ρ_t
- Arrangement of steel
- Steel grade

DESIGN CHARTS



Design Charts

In the final design stage, design values for the axial load and moment (including second order effects) are known, N_d and M'_d . Since the dimensions of the column are also known (or assumed), dimensionless values can be calculated, $Nd/(bhf_{cd})$ and $M'_d/(bh^2f_{cd})$.

The design chart can be used with these values. The $\rho_t m$ value corresponding to these points will yield the required longitudinal steel area.

$$A_{st} = \rho_t bh = (\rho_t m)\frac{f_{cd}}{f_{yd}} bh$$

The procedure is extremely simple. It should be noted that “h” is always the dimension of the column in the direction of the eccentricity.

EXAMPLE

Given: Materials used C25, S420 (f_{cd} = 17 MPa, f_{yd} = 365 MPa)
Estimated column load = 1,600 kN (from tributary areas)

Find: Column dimensions

Solution: The column is in a non-sway frame, i.e M'_d is not expected to be too big. Therefore; we will be the following expression to find the approximate size.

$$\text{Minimum} \quad A_c = \frac{N_d}{0.75 f_{cd}} \geq 75{,}000 \; mm^2$$

$$A_c = \frac{1{,}600{,}000}{0.75 \times 17} = 125{,}490 \; mm^2 > 75{,}000 \; mm^2$$

Use 350×400 mm column, A_c=140,000 mm^2.

EXAMPLE

Now, suppose we were given the following design values;

N_d (kN)	M'_d (kN·m)
1,800	180
1,600	230
1,200	200

These values are found from structural analysis considering different load combinations. Second order moments have also been included in values.

Find: The required reinforcement

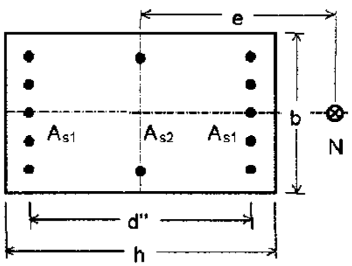
EXAMPLE

N_d (kN)	M'_d (kN·m)
1,800	180
1,600	230
1,200	200

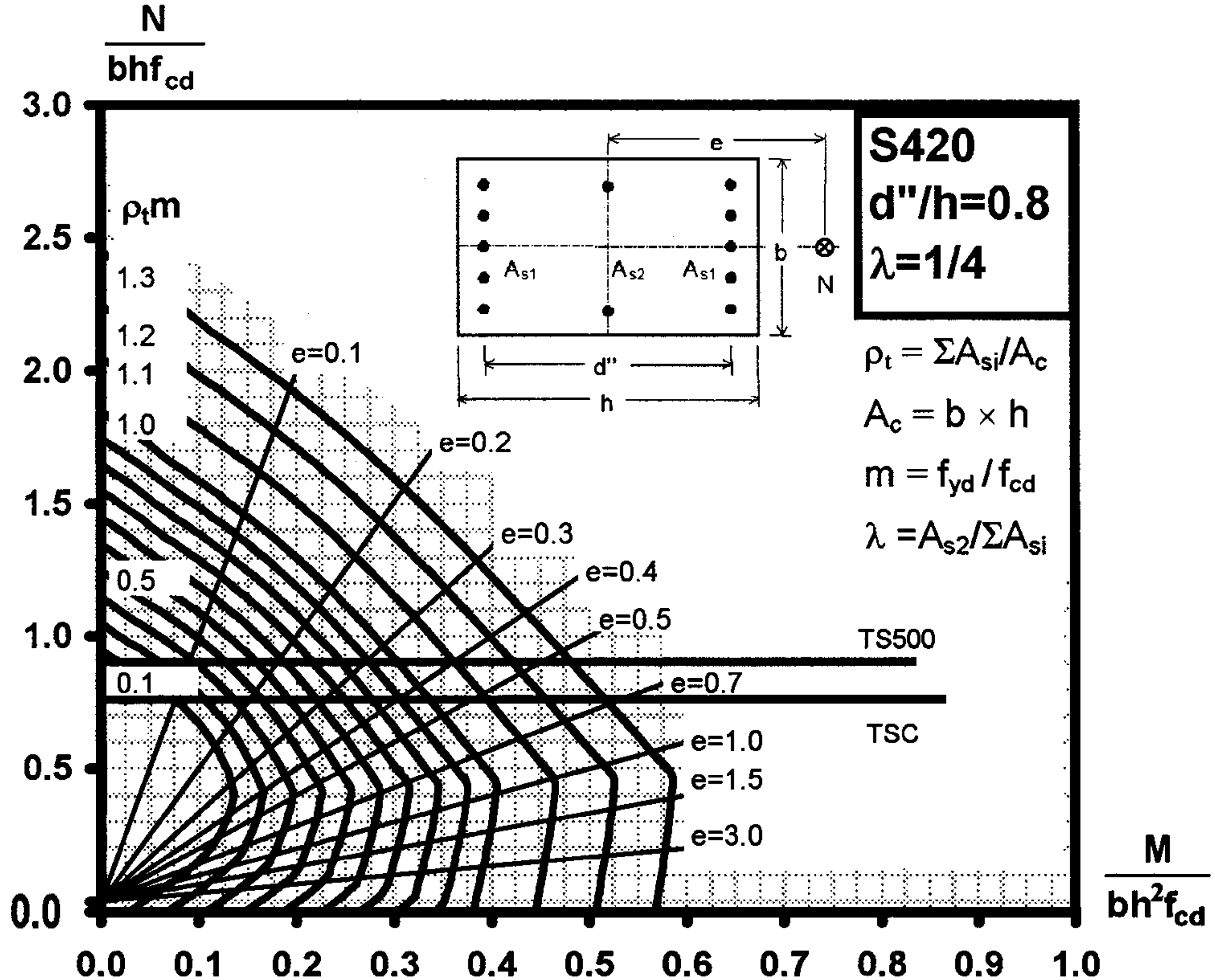
Column: 350×400 mm

Assumed values and Reinforcement Pattern:

d'=35 mm (estimated)
d" = h-2d' = 330 mm



λ= 1/4, d"/h = 0.825



Concrete Grade is C25, Steel grade is S420, hence $m = \frac{f_{yd}}{f_{cd}} = \frac{365}{17} = 21.5$

EXAMPLE

N_d (kN)	M'_d (kN·m)
1,800	180
1,600	230
1,200	200

$\dfrac{N_d}{bhf_{cd}}$	$\dfrac{M'_d}{bh^2f_{cd}}$
0.76	0.19
0.67	0.24
0.50	0.21

$\rho_t m=0.6$
$\rho_t=0.6/(m=21.5)$
$\rho_t= 0.279$
$A_{st}= \rho_t \times b \times h$
$A_{st} = 3,907\ mm^2$
Use 8-ϕ26