

Design Charts For Prestressed Concrete Slabs

by Paul F. Csagoly†

Introduction

Gustave Magnel in his book "Prestressed Concrete" (1948) had already approached the problem of designing prestressed concrete slabs by graphical charts. Unfortunately, the designer using Magnel's method must prepare the charts for each individual case. The author, applying Magnel's idea of the limiting curves has succeeded in preparing permanent charts which are based upon different parameters. The eight charts included in this paper may be used either to satisfy certain requirements or give the most economical solution.

Notation:

f'_c = 28 day strength of concrete in ksi

h = total depth of slab in inches

e = eccentricity of prestressing force in inches

M_D = moment at time of prestressing in ft.k./ft.

M_L = live load moment in ft.k./ft.

M_L^* = alternating live load moment in ft.k./ft.

$k = (-M_L^*/M_L)$ maximum allowed

$c = 1 - \text{loss \%}/100$ (parameter)

$$D = f'_c h^2 / 10 M_L \text{ (parameter)}$$

$$n = 0.0848 \text{ for pretensioned,}$$

$$0.0424 \text{ for post-tensioned}$$

For a given thickness of the slab and breaking strength of the concrete, the most economical solution generally is when a certain minimum amount of prestressing force is decreasing the tensile stress at the bottom fibre (for positive moment) to an allowable maximum. On this basis, it becomes possible to form limiting curves in the terms of M_D/M_L , e/h and D . The area enclosed by the curves of the same D is the geometrical place of the possible solutions. The upper straight lines represent the limit for top compression, the lower curves the limit for top tension, respectively. The limit for bottom compression is never reached; therefore the lines representing this case are omitted from the charts.

In the case of live load moments with alternating signs, such as for continuous slabs, the conditions should satisfy the following equation: $-M_L^*/M_L \leq k$, as given to each D line in the charts. This represents the maximum bottom compression for M_L^* . For top tension, from M_L^* , figures should satisfy the equation:

†Structural Engineer
The Shawinigan Engineering Company
Limited, Montreal, Canada

$$\text{(equation 1)} \quad \frac{M_D}{M_L} \geq - \frac{(M_L + M_L^*) - 6 \frac{e}{h} (M_L - M_L^*)}{2M_L} - 10 nD \frac{e}{h}$$

The required initial prestressing force is given by the equation:

$$\text{(equation 2)} \quad P_i = \frac{12}{ch(6 \frac{e}{h} + 1)} [6(M_D + M_L) - nh^2 f'_c]$$

The charts are based on the "Tentative Recommendations for Prestressed Concrete" by the ACI-ASCE Committee 323. Allowable stresses were:

initial concrete compression: $0.600 f'_c$
 final concrete compression: $0.450 f'_c$
 tension: pretensioned: $0.085 f'_c$
 post-tensioned: $0.042 f'_c$

Examples

1. total loss: 20%

pretensioned

minimum protection: $\frac{3}{4}$ "

$M_D = + 5.07$ ft.k

$M_L = +14.50$ ft.k

$$\frac{M_D}{M_L} = \frac{5.07}{14.50} = 0.350$$

Try for minimum thickness:

from chart: $D_{min} = 1.24$

use: $f'_c = 6.0$ ksi, $h = 5.5$ in.

$$D_{usable} = f'_c h^2 / 10M_L =$$

$$6.0 (5.5)^2 / 145 = 1.252$$

from chart: $e/h_{max.} = 0.35$

$$e = (5.5) (.35) = 1.93$$

Protection = $h/2 - e =$

$$2.75 - 1.93 = .82 \text{ in.}$$

Then using equation (2):

$$P_i = \frac{12}{.80 (5.5) (2.11 + 1)} [6 (5.07 + 14.5) - .0848 (5.5)^2 6]$$

$$P_i = 89.5 \text{ k/ft.}$$

2. Same as above, except $h = 7.0$ in. is given.

$$\frac{e}{h_{max}} = \frac{h/2 - \text{protection}}{h}$$

$$= \frac{3.50 - .75}{7.00} = .393$$

from chart: $D_{usable \text{ max}} = 1.60$

$$f'_c = \frac{D (10M_L)}{h^2} = \frac{1.6 (145)}{49} =$$

4.73 ksi; use 5000 psi concrete

Then using equation (2):

$$P_i = \frac{12}{ch(6 \frac{e}{h} + 1)} [6 (M_D + M_L) - nh^2 f'_c]$$

$$P_i = \frac{12}{.80 (7) (2.36 + 1)} [6 (5.07 + 14.50) - .0848 (49) 5]$$

$$P_i = 61.8 \text{ k/ft.}$$

3. Same as example 1, except:

$M_L^* = -3.60$ ft.k

$$- \frac{M_L^*}{M_L} = \frac{3.60}{14.5} = 0.248$$

Try for minimum thickness:

from chart: $D_{min} = 1.400$

use: $f'_c = 6.0$ ksi, $h = 6.0$ ksi

then $D_{usable} = f'_c h^2 / 10M_L = 1.489$

$$\text{from equation (1)} \quad \frac{M_D}{M_L} =$$

$$- \frac{(M_L + M_L^*) - 6 \frac{e}{h} (M_L - M_L^*)}{2M_L}$$

$$- 10 nD \frac{e}{h}$$

$$\frac{e}{h_{max}} = 0.293$$

Then using equation (2):

$$P_i = \frac{12}{ch(6 \frac{e}{h} + 1)} [6 (M_D + M_L) - nh^2 f'_c]$$

$$P_i = \frac{12}{.80 (6) (1.76 + 1)} [6 (5.07 + 14.50) - .0848 (36) 6]$$

$$P_i = 90.1 \text{ k/ft.}$$















