Isowall U.K. Limited.
91-93 Pirbright Road,
Southfields,
London SW18 5ND
Telephone: 01-874 1184/5/6
01-874 7667/8/9
Telex: 845931

Isowall Commercial Coolrooms

Industrial Coldstores

Structural Insulating Panels

Directors:
B.A. Russell, M.Inst.R. (Managing)
D. Epstein, F.C.A., M.I.D.M.
M.R. Young, B.Ec. (Australia)

Isowall INT'L

LLOYD'S REGISTER OF SHIPPING NOTED 20/5/87 LONDON

A. PRODUCT DESCRIPTION

Isowall Panels are structural sandwich laminates utilising a core of self extinguishing grade polystyrene foam. Facings, as standard, are steel but other materials, such as aluminium, are available.

In bonding, the skins act in tension and compression and the foam core assists in distributing the sheet forces making the panel act as a composite whole.

The skins are stressed under heat and pressure and permanently bonded to the insulating core of expanded polystyrene foam with a polyurethane adhesive. The panels are manufactured and trimmed to a size by an automatic, continuous press to machine tolerances. Panels are formed, as standard, 1.20m. wide and any transportable length. Other widths can be cut as required.

D. Properties of Panel Components:

Steel

Property	Imperial	Metric
Weight	1.01 lbs./sq.ft.	4.93 Kg./sq.m.
Thickness	0.0247 ins.	0.063 cm.
Elastic Modulus	$3x10^7$ lbs./sq.ins.	$211x10^4$ Kg./sq.cm.
Buckling Stress	9000 lbs./sq.ins.	633 Kg./sq.cm.
Tension Stress	24000 lbs./sq.ins.	1687 Kg./sq.cm.
Coeficient of Thermal Expansion	$64x10^{-7}$in./in./F°	$11.5x10^{-6}$cm./cm./C°

Polystyrene Foam

Property	Imperial	Metric
Density	1.25 lbs./cu.ft.	20.02 Kg./cu.m.
Thickness	2 to 10 ins.	5 to 25 cm.
Elastic Modulus	200 lbs./sq.ins.	14.06 Kg./sq.cm.
Shear Modulus	300 lbs./sq.ins.	21.09 Kg./sq.cm.
Shear Stress	20 lbs./sq.ins.	1.41 Kg./sq.cm.
K Factor	0.23 BTU/sq.ft.h.in°F	2.85 KCal/m².h.cm°C
Stable Temperature Range	180°F/-180°F	82°C/-118°C

U Factor

Imperial BTU/ft².h.°F

2"	3"	4"	6"	8"	10"
0.115	0.077	0.058	0.038	0.029	0.023

Metric KCal/m².h.°C

5cm	7.5cm	10cm	15cm	20cm	25cm
0.57	0.38	0.285	0.19	0.143	0.114

Chart No.4

a) Imperial values of length in Feet

Load lb.	Core Thickness	2"	3"	4"	6"	8"	10"
5	Deflection	(17.37)	(23.11)	28.38	37.55	45.70	53.76
	Core shear	38.4	57.6	76.8	115.2	153.6	192.0
	Wrinkling	19.11	23.41	(27.03)	(33.11)	(38.23)	(42.74)
10	Deflection	(12.56)	16.92	20.94	28.0	34.3	40.5
	Core shear	19.2	28.8	38.4	57.6	76.8	96.0
	Wrinkling	13.52	(16.55)	(19.11)	(23.41)	(27.03)	(30.22)
20	Deflection	(8.53)	11.74	14.71	20.01	24.78	29.46
	Core shear	9.6	14.4	19.2	28.8	38.4	48.0
	Wrinkling	9.56	(11.71)	(13.52)	(16.55)	(19.11)	(21.37)
30	Deflection	6.52	(9.12)	11.55	15.96	19.95	23.85
	Core shear	(6.4)	9.6	12.8	19.2	25.6	32.0
	Wrinkling	7.80	9.56	(11.04)	(13.52)	(15.61)	(17.45)
40	Deflection	5.26	7.46	(9.54)	13.34	16.82	20.21
	Core shear	(4.8)	(7.2)	9.6	14.4	19.2	24.0
	Wrinkling	6.76	8.28	9.56	(11.71)	(13.52)	(15.11)
50	Deflection	4.40	6.30	8.11	11.46	14.56	17.58
	Core shear	(3.84)	(5.8)	(7.7)	11.5	15.4	19.2
	Wrinkling	6.04	7.40	8.55	(10.47)	(12.09)	(13.52)
60	Deflection	3.77	5.44	7.05	10.05	12.84	15.56
	Core shear	(3.2)	(4.8)	(6.4)	9.6	12.8	16.0
	Wrinkling	5.52	6.76	7.80	(9.56)	(11.04)	(12.34)

The control values of span are those typed in ( )

C. Panel Weights:

Panel weights can be obtained by adding facing and core weights together.

For this purpose a steel finish (standard) has been taken.

Imperial

Core Thickness ins.	Core Weight lbs./sq.ft.	Finish Weight lbs./sq.ft.	Total Weight lbs./sq.ft.
2	0.208	2.02	2.228
3	0.312	2.02	2.332
4	0.417	2.02	2.437
6	0.625	2.02	2.645
8	0.833	2.02	2.853
10	1.042	2.02	3.062

Metric

Core Thickness cm.	Core Weight Kg./sq.m.	Finish Weight Kg./sq.m.	Total Weight Kg./sq.m.
5	1.001	9.86	10.861
7.5	1.502	9.86	11.362
10	2.002	9.86	11.862
15	3.003	9.86	12.863
20	4.004	9.86	13.864
25	5.005	9.86	14.865

D. Modes of Failure and Formulae:

Legend

q = uniform weight lbs./ft. or Kg./m.

L = length ft. or m.

E_f = modulus of elasticity of steel lbs./sq.in. or Kg./sq.cm.

G = shear modulus of core lbs./sq.in. or Kg./sq.cm.

b = width of loading ins. or cm.

t = skin thickness ins. or cm.

c = core thickness ins. or cm.

S_s = core shear stress lbs./sq.in. or Kg./sq.cm.

S_B = buckling stress steel lbs./ sq.in. or Kg./sq.cm.

β = 0.76

E_o = modulus of elasticity of core lbs./sq.in. or Kg./sq.cm.

y = thermal deflection ins. or cm.

K = difference in thermal expansion of the faces

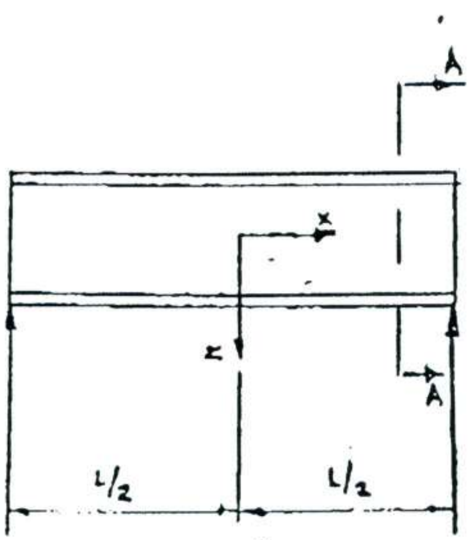
α = coefficient of thermal expansion of face in./in./ F or cm./cm./ C

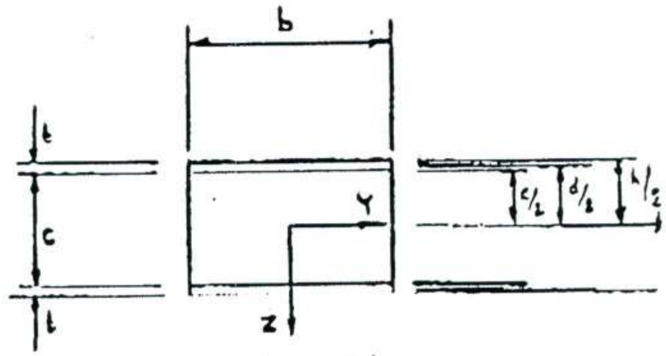
Δt = difference in temperature of faces F or C

d = distance between neutral axis of both faces in. or cm.

N.B.

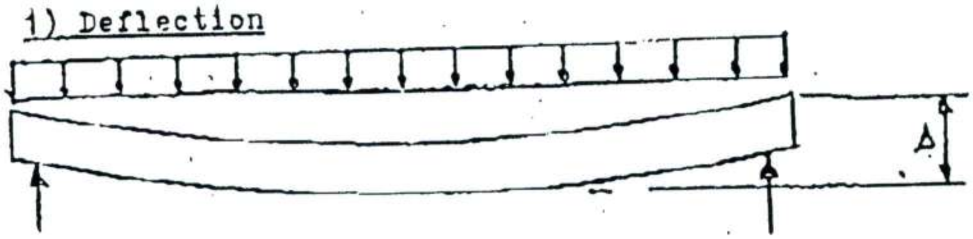
When using the equations check thoroughly for compatibility of units used.





Section AA

1) Deflection



Control by $\Delta = \frac{L}{240}$

$$\Delta = \Delta_1 + \Delta_2 = \frac{5qL^4}{384D} + \frac{qL^2}{8AG}$$

based on

(a) Central bending deflection $\Delta_1 = \frac{5qL^4}{384D}$

where $D = E_f I$

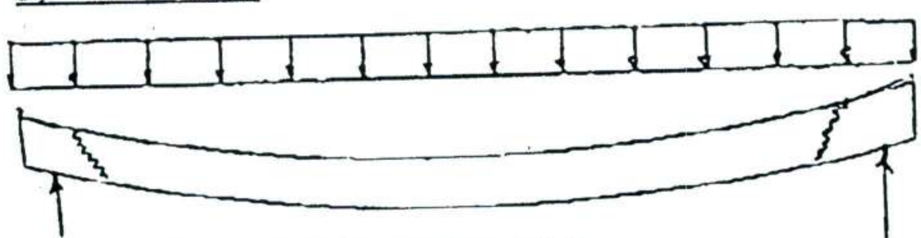
$I = \frac{btd^2}{2}$

$d = c + t$

(b) Central shear deflection $\Delta_2 = \frac{qL^2}{8AG}$

where $A = \frac{bd^2}{c}$

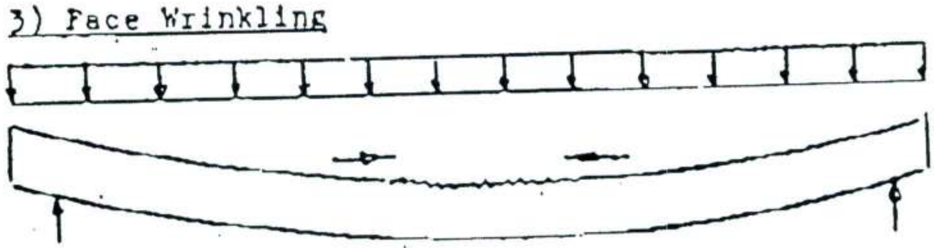
2) Core Shear



Control by a safety factor of 5

$$S_s = \frac{qL}{2bc}$$

3) Face Wrinkling



Control by a safety factor of 2

$$S_B = B\sqrt[3]{E_f \times E_o \times G}$$

and $S_B = \frac{oL^2}{8ctb}$

4) Face Tension

The allowable stress in tension of steel is always greater than the buckling stresses therefore this mode of failure will not control.

5) Thermal Bowing

Control by $\frac{L}{240}$

$$y = \frac{KL^2}{8d}$$

where $K = \alpha \Delta t$

6) Axial Compressive Buckling

Control against local buckling stress

$$P = \frac{P_E}{1 + \frac{P_E}{AG}}$$

where $P_E = \frac{\pi^2 D_1}{L^2}$

$$A = \frac{bd^2}{c}$$

$$D_1 = \frac{E_f btd^2}{2}$$

E. Sample Calculations:

1) Deflection Imperial

$$\Delta ft. = \frac{lb./ft.\times ft.^{4}\times(144)}{lb./in^2\times in\times in\times in\times in^2} + \frac{lb/ft\times ft.^2}{in\times in^2/in\times lb./in^2}$$

$$\Delta = \frac{L}{240} = \frac{5qL^4\times 144}{384\times 3\times 10^7\times \frac{bt(c+t)^2}{2}} + \frac{qL^2}{\frac{8b(c+t)^2}{c}\times 300}$$

Take a 6in. panel, 12in. wide and 20lbs./ft.
assume that the span is 20 ft.

$$\Delta = \frac{20}{240} = \frac{5\times 20\times 20^4\times 144}{384\times 3\times 10^7\times \frac{12\times 0.0247\times(6.0247)^2}{2}} + \frac{20\times 20^2}{\frac{8\times 12\times 300\times(6.0247)^2}{6}}$$

$$\Delta = 0.0833333 = 0.0371801 + 0.0459174$$

2) Deflection Metric

$$\Delta m. = \frac{Kg/cm\times cm^{4}\times(10^4)}{Kg/cm^2\times cm\times cm\times cm\times cm^2} + \frac{Kg/m\times m^2}{cm/cm\times cm^2\times Kg/cm^2}$$

Take a 15cm. panel, 100cm. wide and 100Kg/m
assume that the span is 6m

$$\Delta = \frac{6}{240} = \frac{5\times 100\times 6^4\times 10^4}{384\times 211\times 10^4\times \frac{100\times 0.063\times(15.063)^2}{2}} + \frac{100\times 6^2}{\frac{8\times 100\times(15.063)^2\times 2}{15}}$$

$$\Delta = 0.025 = 0.0113704 + 0.014106$$

3) Core Shear Imperial

$$S_s\,lb/in^2 = \frac{lb/ft\times ft}{in\times in}$$

Take a 6in. panel, 12in. wide and 20lb/ft.
assume that the panel length is controlled by a safety factor of 5 therefore S_s = 20/5 = 4

$$4 = \frac{20\times L}{2\times 12\times 6}$$

$$L = 28.8ft.$$

4) Core Shear Metric

$S_s = \frac{kg/m \times m}{cm \times cm} = Kg/cm^2$

Take a 15cm. panel, 100cm. wide and 100 Kg/m.
Assume that the panel length is controlled by a safety factor of 5 therefore $S_s = 1.41/5$

$\frac{1.41}{5} = \frac{100 \times L}{2 \times 100 \times 15}$

$L = 8.46$ m.

5) Face Wrinkling Imperial

$S_B = \sqrt[3]{lb/in^2 \times lb/in^2 \times lb/in^2} = lb/in^2$

$S_B = 0.76 \sqrt[3]{3 \times 10^7 \times 200 \times 300}$

$S_B \simeq 9000$

$S_B = \frac{lb/ft \times ft^2 \times (12)}{in \times in \times in} = lb/in^2$

Take a 6in panel and 20lb/ft.
Assume that we control by a safety factor of 2
therefore $S_B = 4500$

$4500 = \frac{20 \times L^2 \times 12}{8 \times 6 \times 0.0247 \times 12}$

$L = \sqrt{900 \times 2 \times 6 \times 0.0247} = 16.33$ ft.

6) Face Wrinkling Metric

$S_B \simeq 633\ Kg/cm^2$

$S_B = \frac{Kg/m \times m^2 \times (100)}{cm \times cm \times cm} = Kg/cm^2$

Take a 15 cm. panel and 100 Kg/m
Assume that we control by a safety factor of 2
therefore $S_B = 633/2$

$\frac{633}{2} = \frac{100 \times L^2 \times 100}{8 \times 15 \times 0.063 \times 100}$

$L = \sqrt{6.33 \times 4 \times 15 \times 0.063} = 4.89$ m.

7) Thermal Bowing Imperial

For thin skins d ≏ o

$$y = \frac{in/in \times F' \times F' \times ft^2 \times (144)}{in} = in$$

$$\frac{L\times12}{240} = y = \frac{\alpha \Delta t L^2 \times 144}{8c}$$

Take a 6in. panel and t at 110F

$$\frac{L\times12}{240} = \frac{64\times10^{-7}\times110\times L^2\times144}{8\times6}$$

$$L = \frac{1}{8\times10^{-7}\times110\times2\times240} = 23.67\ ft.$$

8) Thermal Bowing Metric

$$y = \frac{cm/cm \times C' \times C' \times m^2 \times (10^4)}{cm}$$

$$\frac{L\times100}{240} = y = \frac{\alpha \Delta t L^2 \times 10^4}{8c}$$

Take a 15cm. panel and t at 60C

$$\frac{L\times100}{240} = \frac{11.5\times10^{-6}\times60\times L^2\times10^4}{8\times15}$$

$$L = \frac{5}{6\times11.5\times10^{-2}} = 7.25\ m.$$

9) Axial Compressive Load Buckling Imperial

$$D_1 = lb/in^2 \times in \times in \times in = lb/in$$

$$P_E = \frac{lb/in^2}{ft^2 \times (144)} = lb.$$

$$P = \frac{lb}{\frac{lb}{\frac{in \times in^2 \times lb}{in \times in^2}}} = lb.$$

Take a 20ft. high column and 6in. thick

$$D_1 = \frac{3\times10^7\times12\times0.0247\times(6.0247)^2}{2}$$

$$D_1 = 16.14\times10^7\ lb/in^2$$

$$P_E = \frac{^2\times16.14\times10^7}{20\times20\times144} = 27677\ lb.$$

$$AG = \frac{12\times(6.0247)^2\times300}{6} = 21778$$

$$P = \frac{27677}{\dots} = 12187\ lb.$$

24-09-93 17:28 M R YOUNG ID=44 306 6317251 P.10

Use a safety factor of 5
Therefore $P = 2437$ lb/ft.

10) Axial Compressive Load Buckling Metric

$$D_1 = Kg/cm^2 \times cm \times cm \times cm^2 = Kg/cm^2$$

$$P_E = \frac{Kg/cm^2}{m^2 \times (10^4)} = Kg$$

$$P = \frac{Kg}{\dfrac{Kg}{\dfrac{60 \times cm^2 \times Kg}{cm \quad \times cm^2}}} = Kg$$

Take a 6m. high column of panel 15cm thick

$$D_1 = \frac{211 \times 10^4 \times 100 \times 0{,}063 \times (15.063)^2}{2} = 1508050600 \ Kg/cm^2$$

$$P_E = \frac{15.08 \times 10^8 \times {}^2}{6 \times 6 \times 10^4} = 41400 \ Kg$$

$$AG = \frac{100 \times (15.063)^2}{15} \times 21.09 = 31901$$

$$P = \frac{41400}{1 + \dfrac{41400}{31901}} = 18018 \ Kg.$$

Use a safety factor of 5
Therefore $P = 3603.6$ Kg/m.

F. Results, Charts and Graphs

The calculations sampled above were completed for a full range of values and the results obtained are first charted and then graphed below.

Charts 1,2 &3 show the individual values obtained for,deflection,core shear andface wrinkling respectfully. Chart 4 shows these compared with one another to show more clearly the actual control factor.

Charts 5 & 6 show the values obtained for thermal bowing and column buckling.

The graphs allow other values to be predicted.

Chart No.1

Theoretical length determined by deflection of $\frac{L}{240}$

a) Imperial, values of length in Feet.

c	Theory load in lbs./ft². 5	10	20	30	40	50	60
2"	17.37	12.56	8.53	6.52	5.26	4.40	3.77
3"	23.11	16.92	11.74	9.12	7.46	6.30	5.44
4"	28.38	20.94	14.71	11.55	9.54	8.11	7.05
6"	37.55	28.0	20.01	15.96	13.34	11.46	10.05
8"	45.70	34.3	24.78	19.95	16.82	14.56	12.84
10"	53.76	40.5	29.46	23.85	20.21	17.58	15.56

b) Metric, values of length in Metres.

c	Theory load in Kg./m². 25	50	100	150	200	250	300
5cm	5.19	3.74	2.53	1.93	1.55	1.29	1.11
7.5cm	6.91	5.05	3.49	2.70	2.21	1.86	1.61
10cm	8.46	6.24	4.37	3.42	2.82	2.39	2.07
15cm	11.24	8.37	5.97	4.74	3.95	3.40	2.97
20cm	13.77	10.31	7.43	5.96	5.01	4.33	3.81
25cm	16.10	12.11	8.79	7.10	6.01	5.22	4.61

Chart No.6

Theoretical column buckling load per unit width with a safety factor of 5.

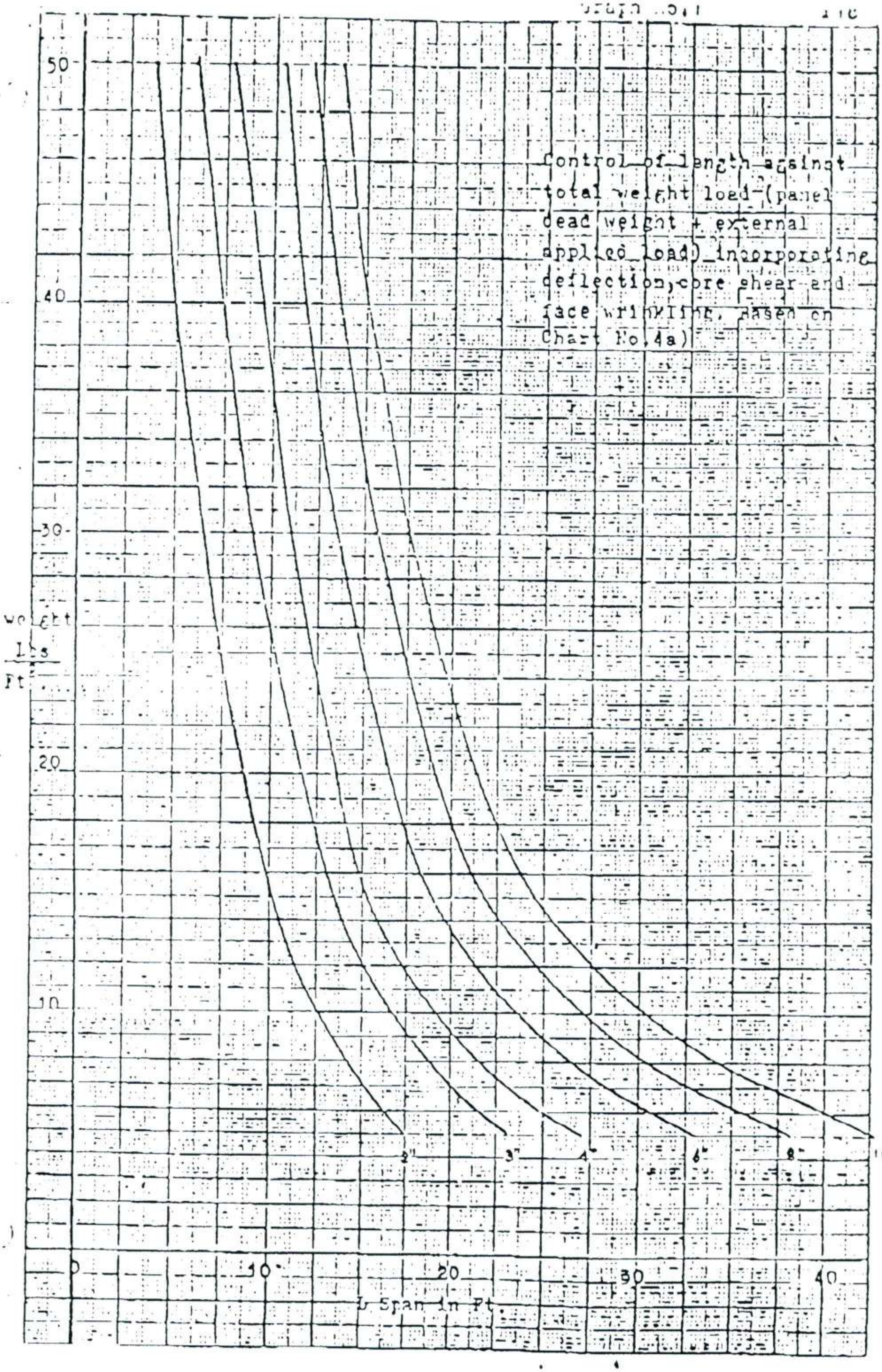
NB Control and check against local buckling stress.

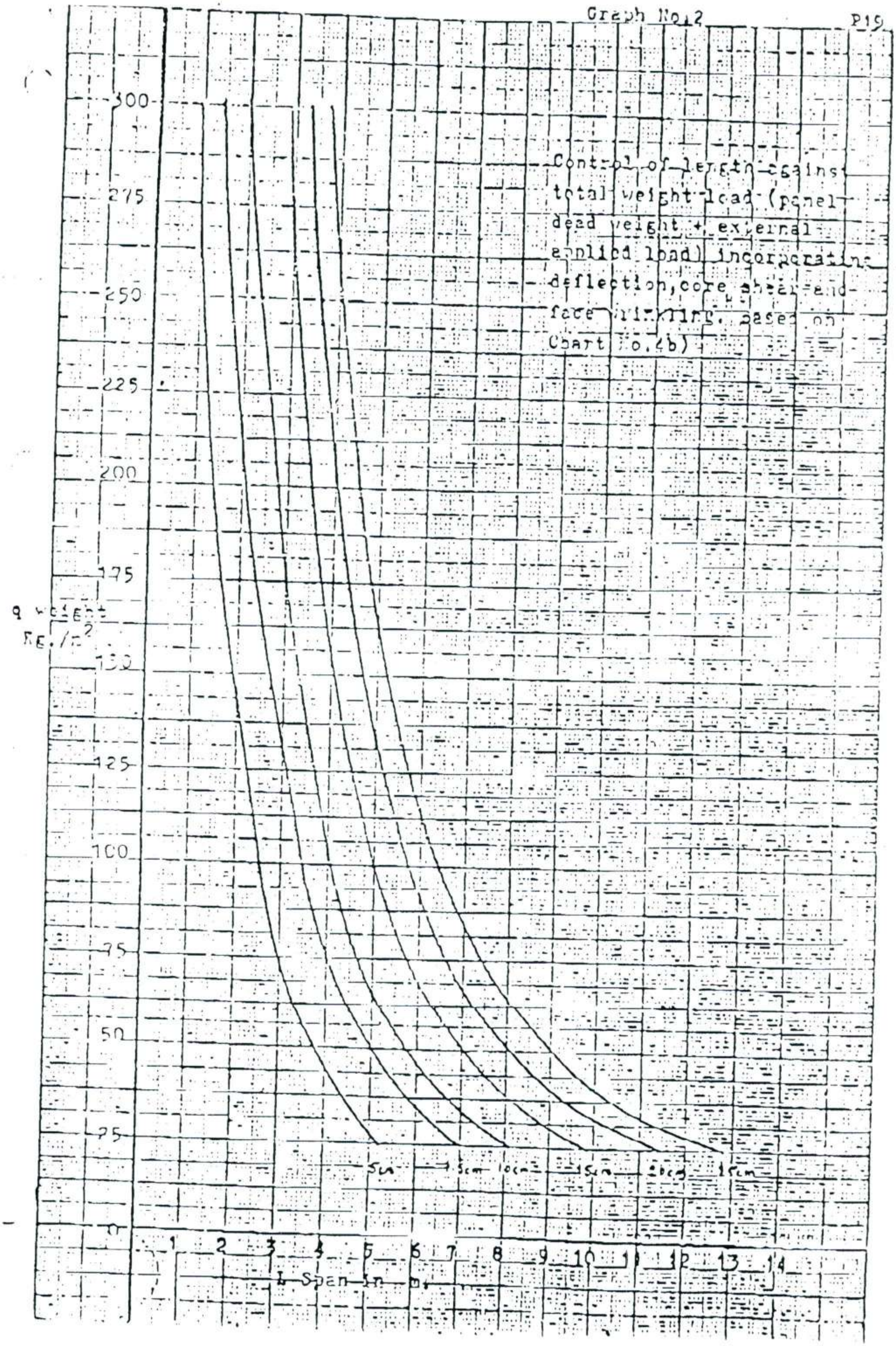
a) Imperial, load in lbs/ft (width).

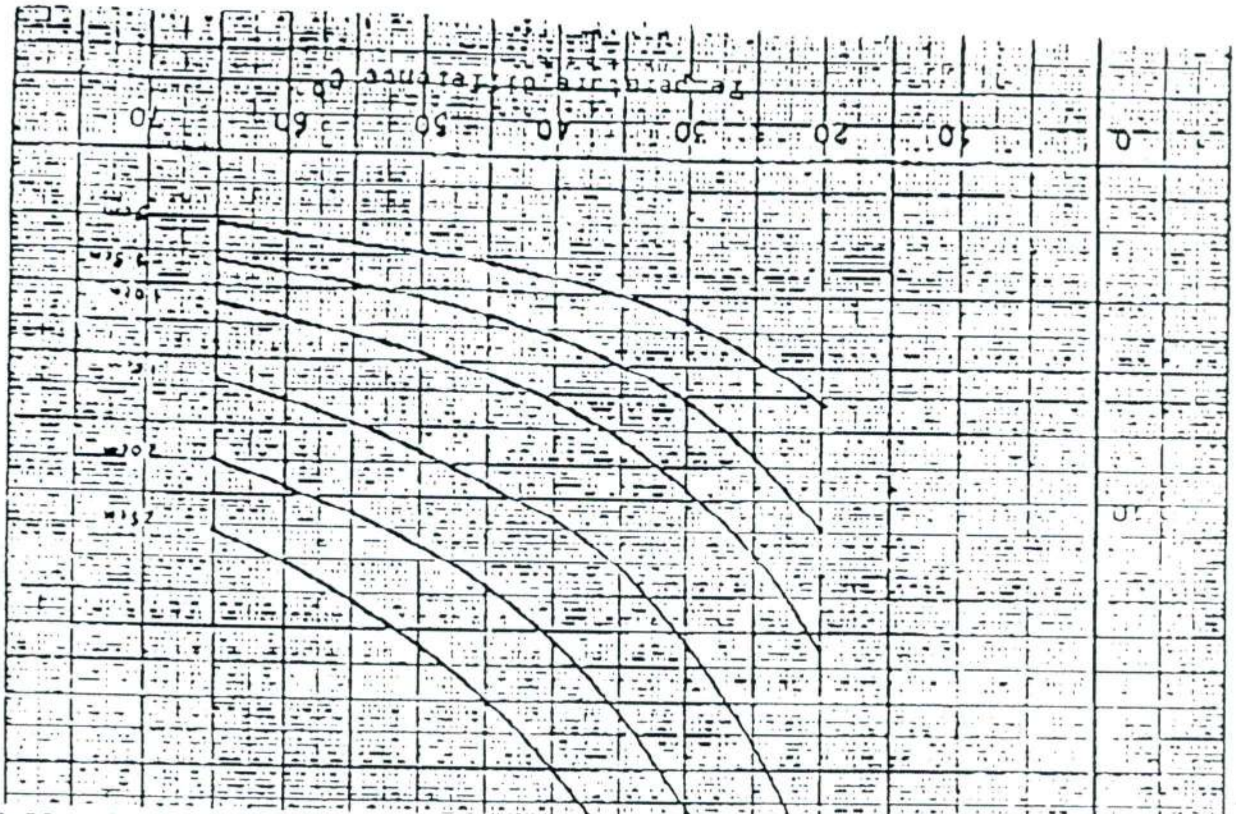
c	Theory height of column ft. 8	12	14	16	18	20	24
2"	1071	783	684	588	507	439	335
3"	1754	1402	1240	1094	965	853	672
4"	2452	2046	1847	1661	1491	1337	1080
6"	3669	3394	3143	2897	2660	2437	2042
8"	5295	4780	4495	4207	3921	3645	3133
10"	6727	6184	5876	5556	5234	4915	4307

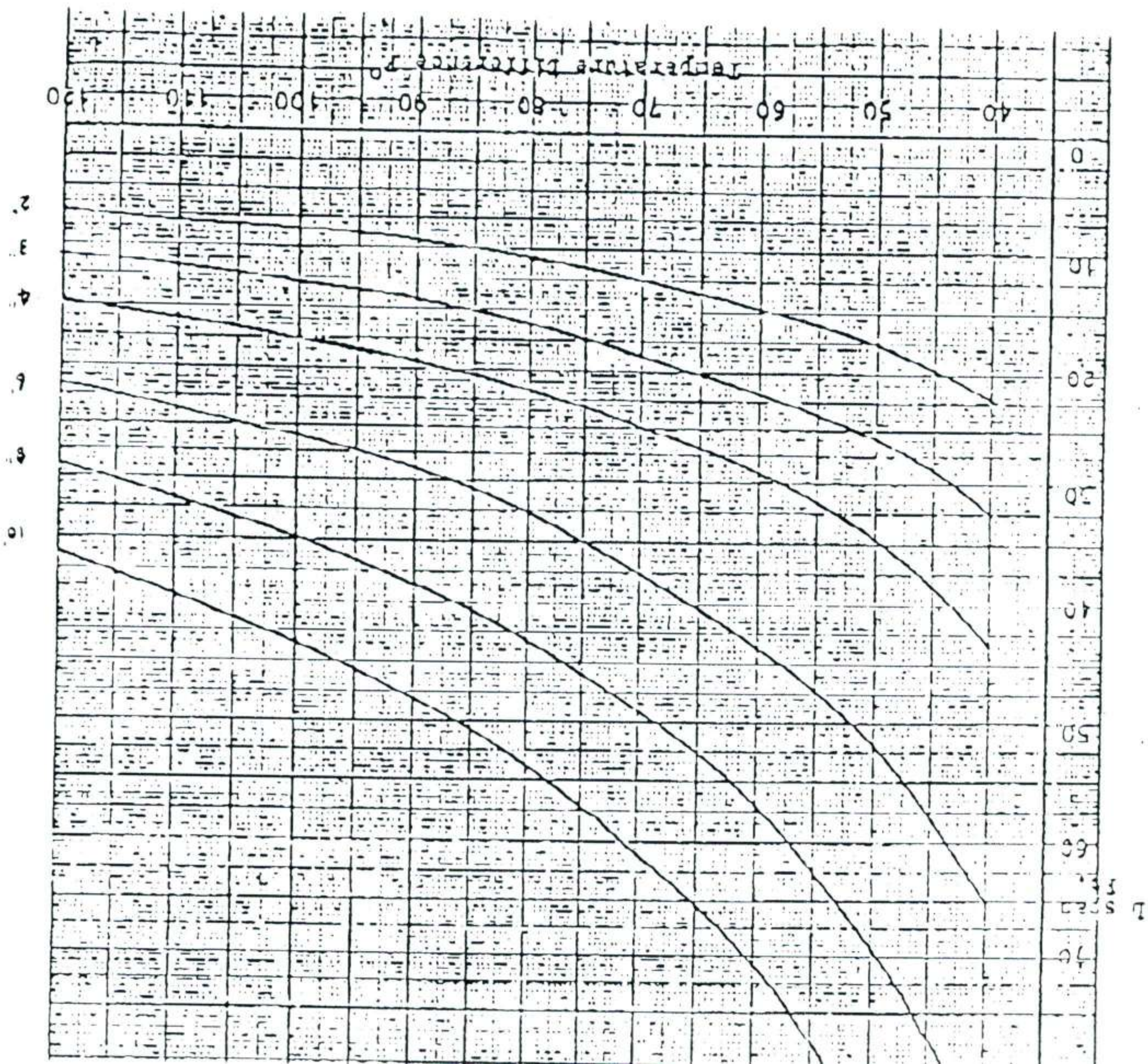
b) Metric, load in Kg./m (width).

c	Theory height of column m. 2.5	3.5	4	5	5.5	6	7.5
5cm	1534	1210	1066	830	735	653	469
7.5cm	2530	2110	1909	1553	1401	1266	94[illegible]
10cm	3557	3065	2821	2369	2166	1981	1522
15cm	5627	5054	1752	4135	3872	3603	2894
20cm	7713	7094	6754	6057	5713	5379	4460
25cm	9810	9157	8791	8021	7632	7246	6152


Control of length against total weight load (panel dead weight + external applied load) incorporating deflection, core shear and face wrinkling. Based on Chart No. 4a)
50
40
30
20
10
weight
Lbs
Ft
2"
3"
4"
6"
8"
10"
0
10
20
30
40
L Span in Ft.


Graph No.2
P19
Control of length against total weight load (panel dead weight + external applied load) incorporating deflection, core shear and face wrinkling, based on Chart No.4b)
q weight kg./m²
L Span in m.
300
275
250
225
200
175
125
100
75
50
25
5cm
7.5cm
10cm
15cm
1 2 3 4 5 6 7 8 9 10 11 12 13 14





Isowall

Isowall

PERFORMANCE DATA

Design loading for panels*

The recommended spans are based on the following criteria.

1. face wrinkling with a safety factor of 2
2. deflection of 1/240 of span or
3. core shear with a safety factor of 5

All uniform loads are rounded to the next lowest value.

BS 6399: Part 1. 1984 states that the following loads are appropriate to the support of walk-on ceilings and similar structures with access.

0.25kN/m² uniformly distributed over the whole area or the area supported and a concentrated load of 0.9kN so placed as to produce maximum stresses on the affected members.

Table 3

Maximum uniform loads (kg/m²) for spans (including weight of panel)*

core material	panel weight kg/m²	core thickness mm	span m 2	3	4	5	6	7	8	9	10	11	12
HD POLYSTYRENE	10.05	50	173	94	50	29	18	12					
	10.55	75	260	173	96	58	37	25	17	13			
	11.05	100	347	231	151	93	61	42	29	22	16	12	
	11.55	125	433	289	203	130	89	61	44	32	24	19	15
	12.05	150	520	434	244	166	108	80	61	45	34	27	21
	12.55	175	607	404	285	102	127	93	71	56	45	35	28
	13.05	200		462	325	208	145	108	87	64	52	43	36
	13.55	225		520	366	234	163	120	92	72	59	48	41
	14.05	250		678	407	260	187	133	102	80	65	54	45
SD POLYSTYRENE	9.84	50	122	77	43	26	16	11					
	10.24	75	183	122	80	50	33	23	16	12			
	10.64	100	246	163	110	70	49	30	27	20	15	12	
	11.04	125	308	204	137	88	61	45	34	27	22	18	14
	11.44	150	367	245	165	105	73	54	41	33	26	22	18
	11.84	175	429	285	102	123	85	63	48	38	31	25	21
	12.24	200		326	220	141	98	72	55	43	35	29	24
	12.64	225		367	247	158	110	81	62	49	40	33	27
	13.04	250		408	274	176	122	90	69	54	44	38	30
STYROFOAM	10.54	50	[illegible]	[illegible]	[illegible]	[illegible]	18	12		[illegible]	[illegible]	[illegible]	[illegible]
	11.29	75	[illegible]	[illegible]	[illegible]	[illegible]	38	26	18	[illegible]	[illegible]	[illegible]	[illegible]
	12.04	100	[illegible]	[illegible]	[illegible]	[illegible]	64	43	30	22	17	[illegible]	[illegible]
	12.79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	94	64	48	[illegible]	25	[illegible]	[illegible]
	13.64	150	[illegible]	[illegible]	[illegible]	[illegible]	128	88	63	[illegible]	35	[illegible]	[illegible]
	14.29	175	[illegible]	[illegible]	[illegible]	[illegible]	164	115	83	[illegible]	47	[illegible]	[illegible]
	15.04	200	[illegible]	[illegible]	[illegible]	[illegible]	204	144	105	78	59	[illegible]	[illegible]
	16.70	225	[illegible]	[illegible]	[illegible]	[illegible]	239	175	128	[illegible]	73	67	[illegible]
	16.54	250	[illegible]	[illegible]	[illegible]	[illegible]	266	106	160	115	89	69	[illegible]

Table 4

Properties of expanded and extruded polystyrene

property/unit	expanded polystyrene HD	SD	styrofoam LB	LT
Nominal density (kg/m³)	20	15	30	28
Compressive modulus (N/mm²)	4.5	2.1	12	12
Compressive strength at 10% (kN/m²)	110	70	300	300
Shear strength (N/mm²)	0.17	0.12	0.25	0.25
Shear modulus (N/mm²)	3.77	2.48	4.5	4.5
Water vapour resistivity (MNs/gm)	200	146	520/832	520/832
Thermal conductivity (W/mK)	0.034	0.037	0.027	0.024

Chill store using 12m long 'walk-on' ceiling panels.