UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang 1997/98

FEBRUARY 1998

EUS 203 - REKABENTUK STRUKTUR KAPAL ANGKASA

Masa: [3 jam]

ARAHAN KEPADA CALON:

Sila pastikan bahawa kertas peperiksaan ini mengandungi 17 mukasurat bercetak, EMPAT (4) Lampiran dan ENAM (6) soalan sebelum anda memulakan peperiksaan ini,

Jawab LIMA (5) soalan sahaja.

Tunjukkan kerja pengiraan dengan jelas.

Mesin hitung boleh digunakan.

Agihan markah bagi tiap soalan diberikan di sudut sebelah kanan sebagai peratusan daripada markah keseluruhan yang diperuntukkan bagi soalan berkenaan.

Jawab kesemua soalan dalam Bahasa Malaysia.

Soalan 1

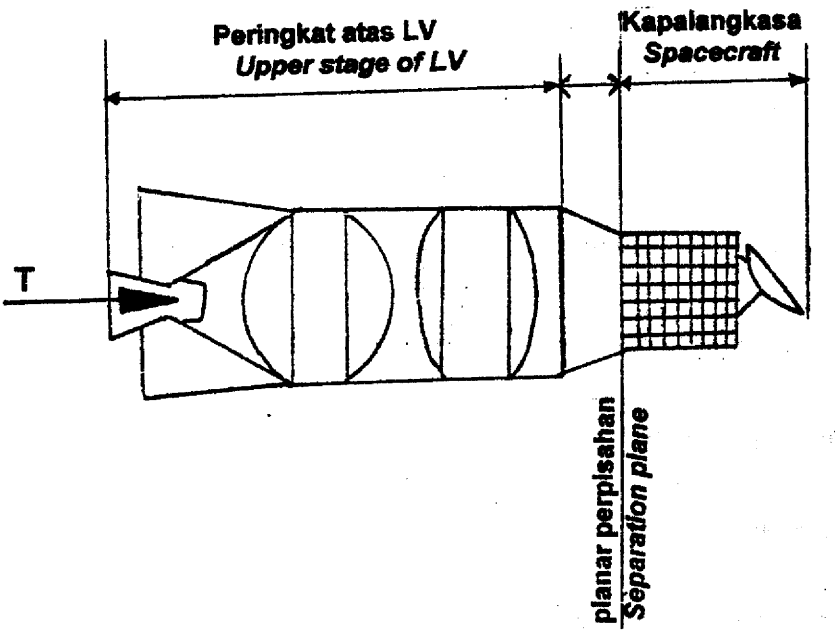
(a) Senaraikan beban utama yang bertindak pada struktur kapal angkasa.
Please state the primary loads acting on spacecraft structures.

(20%)

(b) Apakah yang dimaksudkan dengan beban kritikal untuk rod mudah.
What is mean critical load for a simple rod.

(30%)

(c)



Diberi: di hujung operasi sebelah atas

T	=	Tujah	=	50 kN
M_f	=	Jisim akhir peringkat atas	=	7.0 t.
Mad	=	Jisim penyesuai	=	0.5 t.
M_{sc}	=	Jisim kapal angkasa	=	2.5 t

Takrifkan: Beban statik untuk kapal angkasa pada planar perpisahan.

Given: at the end of upper stage operation

T	=	*Thrust*	=	*50 kN.*
M_f	=	*Final mass of upper stage*	=	*7.0 t.*
Mad	=	*Adapter mass*	=	*0.5 t.*
M_{sc}	=	*Spacecraft mass*	=	*2.5 t*

Define: Static load for spacecraft at the separation plane.

(50%)

Soalan 2

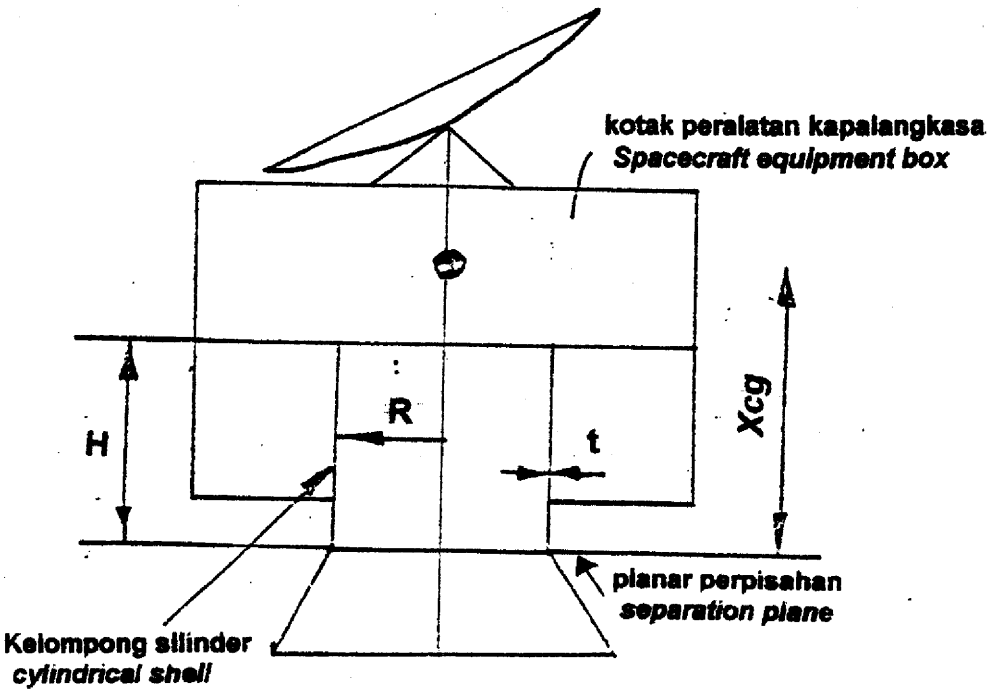
(a) Nyatakan dengan ringkas sumber beban daya statik dan dinamik.
Please briefly state the sources of static and dynamic loads.

(20%)

(b) Bagaimanakah cara menggunakan panel dalam struktur kapal angkasa?
How are panels used in spacecraft structures?

(30%)

(c)



Diberi: Struktur kapal angkasa termasuk kelompang silinder pembawa beban.

Meq	=	Jisim kotak peralatan	=	800 kg.
$X_{c.g.}$	=	Jarak ke pusat graviti	=	2.5 m.
H	=	Ketinggian kelompang	=	2.0 m.
R	=	Jejari kelompang	=	1.0 m.
a_x	=	Pecutan maksima paksi	=	6.0 g.
a_y	=	Pecutan maksima sisi	=	0.5 g.
F.S.	=	Faktor keselamatan	=	1.25
Bahan	=	aloi aluminium 6061 - T6.		

Takrif: Ketebalan kelompang silinder.

Given : spacecraft structure including load carrying cylindrical shell.

Meq	=	*Mass of the equipment box*	=	*800 kg.*
$X_{c.g.}$	=	*The distance to the centre of gravity*	=	*2.5 m.*
H	=	*The height of the shell*	=	*2.0 m.*
R	=	*The radius of the shell*	=	*1.0 m.*
a_x	=	*The maximal axial accelaration*	=	*6.0 g.*
a_y	=	*The maximal lateral accelaration*	=	*0.5 g.*
F.S.	=	*Factor of safety*	=	*1.25*
Material	=	*Aluminium alloy 6061 - T6.*		

Define : The thickness of the cylinderical shell.

(50%)

Soalan 3

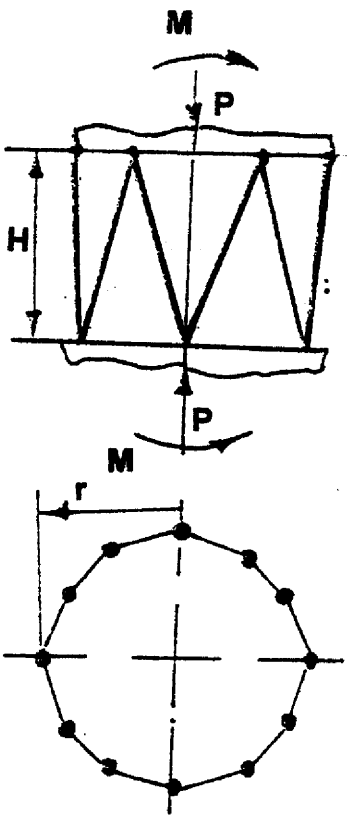
(a) Apakah faktor-faktor utama persekitaran angkasa yang memainkan peranan kepada struktur kapal angkasa?
What are the main factors of the space environment, which are subjected to a spacecraft structure?

(20%)

(b) Apakah yang dimaksudkan sebagai tegasan kritikal dinding nipis monocoque dan kelompang semi-monocoque?
What are the mean critical stresses of thin-walled monocoque and semi-monocoque shells?

(30%)

(c)



Diberi;

Kekuda kapal angkasa mempunyai 12 rod yang serupa.

P = $0.8 \times 10^5 N$ = beban sisi had penerbangan.

M = $0.075 \times 10^5 Nm$ = momen lenturan had penerbangan.

F.S = 1.25 = faktor keselamatan.

R = 0.75m = jejari

H = 1.0m = ketinggian

Rod-rod mempunyai keratan rentas bertiub.

- R = jejari tiub
- t = tebal tiub = 1m

Bahan = aloi aluminium 6061 - T6.

Takrifkan: Jejari tiub (R)

Given;

The spacecraft truss having 12 equal rods

P = $0.8 \times 10^5 N$ = *flight limit axial load*

M = $0.075 \times 10^5 Nm$ = *flight limit bending moment*

F.S = *1.25* = *the factor of safety.*

R = *0.75m* = *radius.*

H = *1.0m* = *height*

The rods have tubular cross - sections.

- *R = radius of the tube*
- *t = thickness of the tube = 1mm*

Material = Aluminium alloy 6061 - T6.

Define: The radius of the tube (R)

Soalan 4

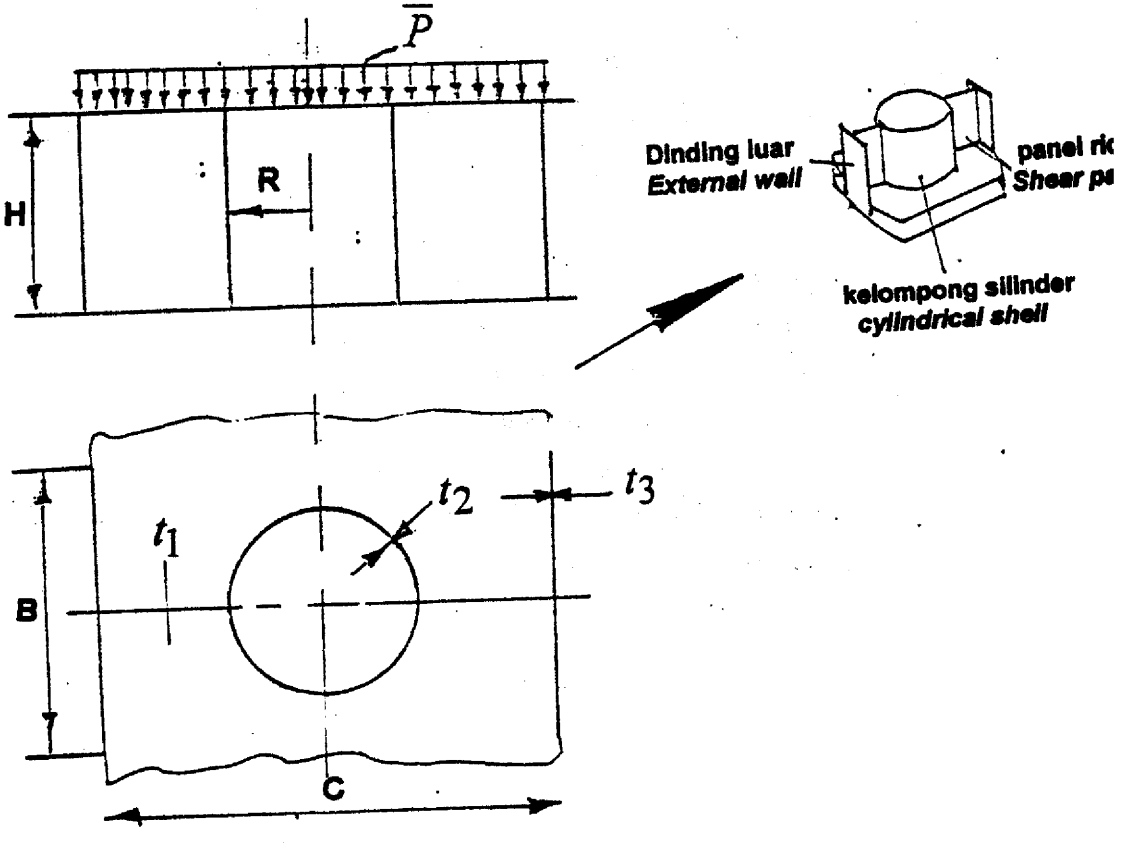
(a) Senaraikan keperluan utama struktur kapal angkasa
Please state the primary requirements to spacecraft structures.

(20%)

(b) Nyatakan langkah kaedah untuk pemilihan keratan rentas rod yang dikenakan beban mampatan.
Please briefly describe the methodical approach in selecting the cross section of rods subjected to compressive loads.

(30%)

(c)



Diberi:- Struktur kapal angkasa termasuk;

- kelompang silinder
- dinding luaran
- panel ricil.

Setiap elemen adalah monocoque.

$\overline{P} = 100kN/m$ = beban besar berunit panjang

Bahan = Aloi aluminium 6061-T6.

B = 1m

C = 1.5 m

R = 0.25 m

H = 1 m

Takrif : Ketebalan setiap elemen yang dinyatakan di atas.

Given:- Spacecraft structure including

- *cylindrical shell*
- *external walls*
- *shear panels*

All elements are monoque

$\overline{P} = 100kN/m$ = *ultimate load per unit of length*

Material = *Aluminium alloy 6061-T6.*

B = 1m

C = 1.5 m

R = 0.25 m

H = 1 m

Define: The thicknesses all mentioned elements.

(50%)

Soalan 5.

(a) Nyatakan kriteria kecekapan bahan struktur. Seterusnya nyatakan dengan terperinci bahan struktur yang lazim digunakan untuk struktur kapal angkasa dan nyatakan sebab-sebabnya.

Please state the structural material efficiency criteria. Also list in detail the structure materials commonly used for spacecraft structures and give the reasons.

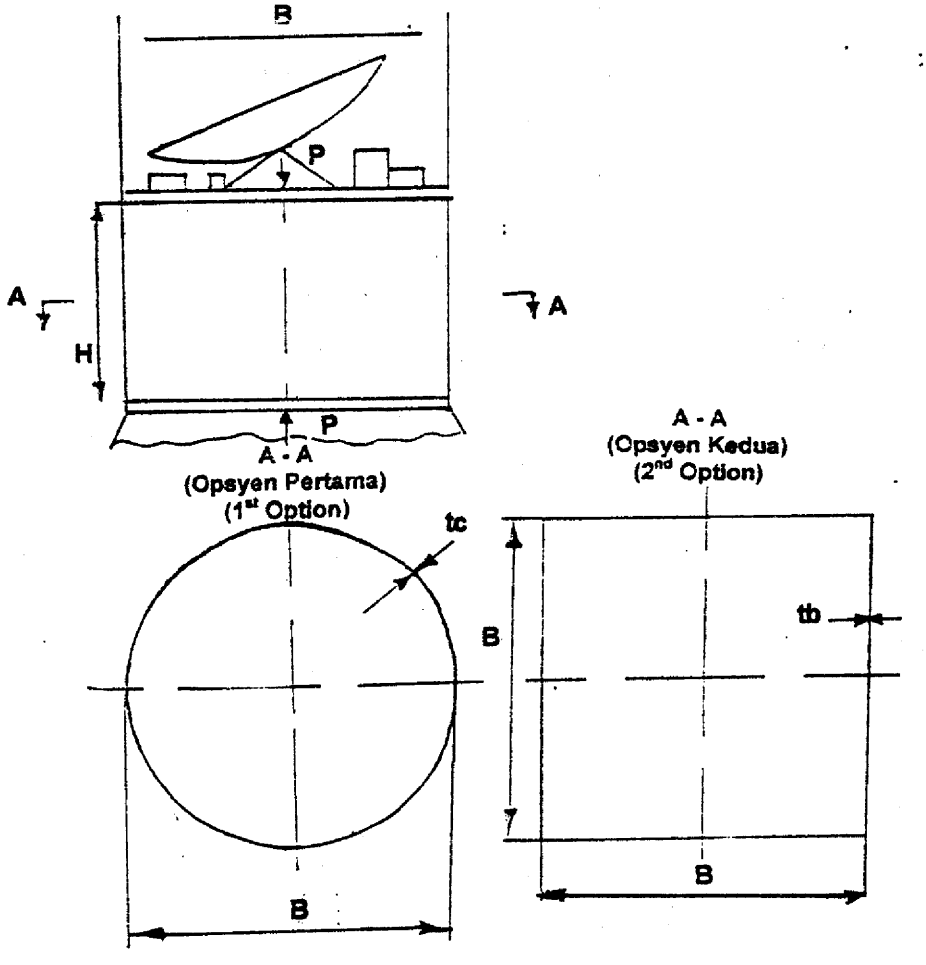
(20%)

(b) Nyatakan dengan ringkas ujian-ujian struktur.

Please briefly describe structural tests.

(30%)

(c)



Diberi: Dua opsyen dinding sisi struktur kapal angkasa.

- silinder
- kekotak

P	=	Beban had penerbangan	=	60 kN
F.S.	=	Faktor keselamatan	=	1.25
H	=	ketinggian dinding	=	1.5 m
B	=	saiz sisi struktur 6061 - 76	=	2m
Bahan	=	Aloi aluminium		

Pilih: Opsyen yang terbaik dengan berdasarkan kriteria jisim.

Given: Two options of the side wall of the spacecraft structure:

- *cylinder*
- *Box*

P	=	*Flight limit load*	=	*60 kN*
F.S.	=	*Factor of safety*	=	*1.25*
H	=	*The height of the wall*	=	*1.5 m*
B	=	*The lateral size of the structure*	=	*2m*

Material = Aluminium alloy 6061 - T6

Select: Better option with respect to mass criterion.

(50%)

Soalan 6

(a) Takrifkan istilah-istilah yang berikut:

(i) beban had penerbangan

(ii) beban rekabentuk

(iii) beban kes terburuk

(iv) rajah rekabentuk

Please define the following terms:

(i) flight limit load

(ii) design load

(iii) worst case loading

(iv) design diagram

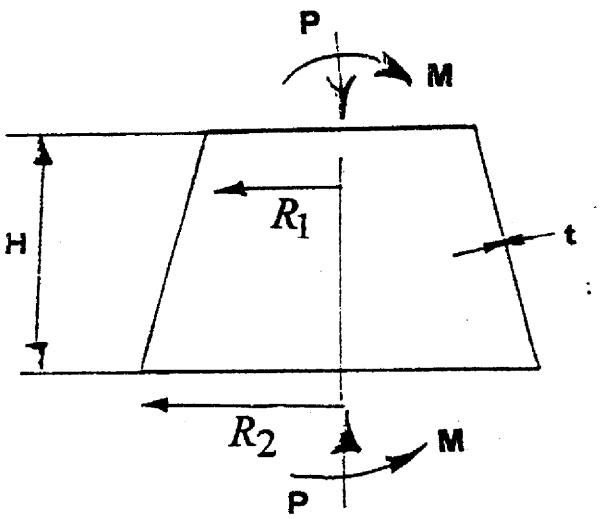
(20%)

(b) Nyatakan kaedah untuk menambahkan keupayaan beban terbawa kelompang yang dikenakan daya mampat yang diketahui.

State the various methods of increasing the loading carrying capability of shells subjected by compressive loads.

(30%)

(c)



Diberi: struktur dinding nipis berkon monocoque.

Beban had penerbangan

- P = 30kN
- M = 2.5 kN.M

Faktor keselamatan = 1.5

H = 1m

$R_1 = 0.75m$

$R_2 = 1m$

Bahan = aloi aluminium 6061 - T6.

Takrif : Ketebalan kelompong.

Given: Thin-walled conical monocoque structure.

Flight limit loads:

- *P = 30kN*
- *M = 2.5 kN.m*

Factor at safety = 1.5

H = 1m

$R_1 = 0.75m$

$R_2 = 1m$

Material = Aluminium alloy 6061 - T6.

Define: The thickness of the shell.

(50%)

Lampiran 1

C.R. Rintangan kekaratan
S.C.C. Retak kekaratan ricih
C.R. Corrosion resistance
S.C.C. stress corrosion cracking

	Ketumpatan *Density* (kg/m^3)	Modulus Young *Young's modulus* $E(GPa)$	Kekuatan alah *Yield strength* $f(MPa)$	$\frac{E}{P}$	$\frac{E^{1/2}}{P}$	$\frac{E^{1/3}}{P}$	$\frac{C_v}{P}$	Perkembangan haba *Thermal expansion* $(\mu m/mK^{-1})$	Kekuatan retakan *Fracture toughness* $(MPa\,m)$	Kekuatan kerotakan *Fatigue strength* $(MPa\,m)$	Komen *Comment*
Aloi aluminium *Aluminium alloy* 6061 . T6 7075 . T6	2800 2700	68 71	276 503	24 26	2.9 3.1	1.5 1.5	98.6 186.3	23.6 23.4	186 24	97 159	*Good C.R.* *Prone to SSC in T6 Form*
Aloi magnesium *Magnesium alloy* A2 31 B ZK 60A. T5	1700	45	220	26	3.9	2.1	129.4	26			*Prone to SCC*
Aloi titanium *Titanium alloys* T1 - 6Al - 4V	4400	110	825	25	2.4	1.1	187.5	9	75	500	
Aloi Beryllium *Beryllium alloys* S 65 A S R 200 E	2000	304	207 345	151	8.7	3.4	103.5	11.5			*Hot pressed steel* *Low fracture toughness*
Aloi besi *Ferrous alloys* INVAR		150	275/415					1.66			*Low expansion* *Ferromagnetic*
Besi bergalvani *Stainless steel* AM350 (SC850) 304I. Ann	7700 7800	200 193	1034 170	26 25	1.84 1.8	0.8 0.7	134.3 21.8	11.9 17.2	40/60	550	*Austenitic*
Komposit *Composites* *KEVLAR 49 0* *(Aramid fibre) 90*	1380 1380	76 5.5	1379 29.6	55 4	6.3 1.7	3.1 1.3	999.3 21.4	-4 57			*Structure members Pressure vessels* *Rocket casings*
Kepingan enoksi grafit *Graphite epoxy* *Sheets* *(undirectional)* GY70.934 *Column ref.* *(See text)*	1620 A	282 B	586 C	174 D	10.4 E	4.0 F	361.7 G	- 11.7 (*Longitunal*) - 29.7(*Transverse*) H	 I	 J	*Sheet*

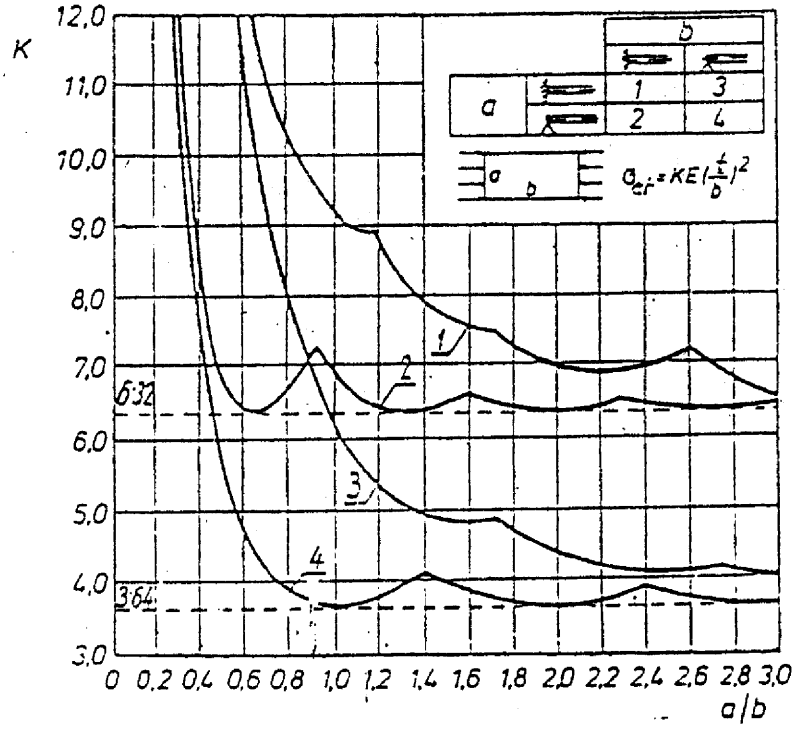
- Modulus lapangan
- Kekuatan lapangan
- *Tensile modulus*
- *Tensile strength*

Sample materials properties

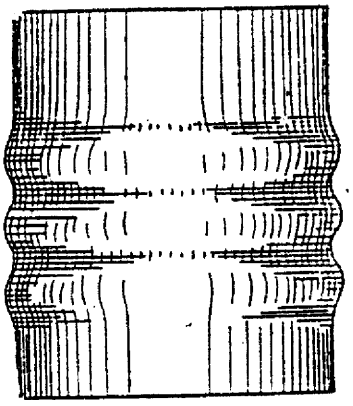
Lampiran 2

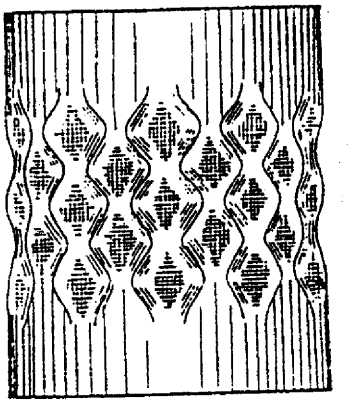
Lengkokan plet: Syarat-syarat sempadan yang mempenganiki.

The Buckling of plates: The influence of the boundary conditions.



Lampiran 3

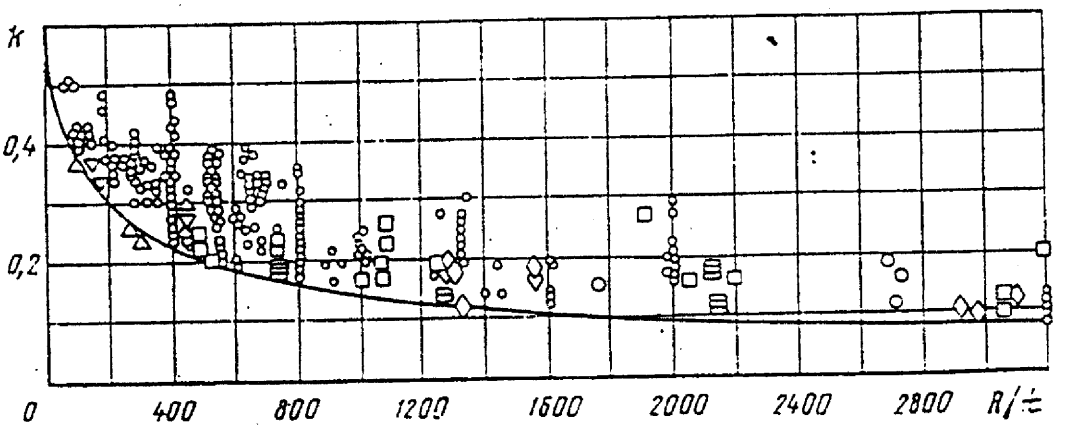




$$\sigma_{cr} = 0.605kE\frac{t}{R}$$

$$k = 1-09\left(1-e^{\emptyset}\right)$$

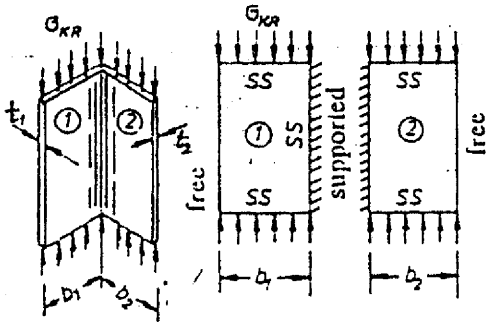
$$\emptyset = \frac{1}{16}\sqrt{\frac{R}{t}}$$



Lampiran 4

Profil lengkokan tempatan dinding nipis.

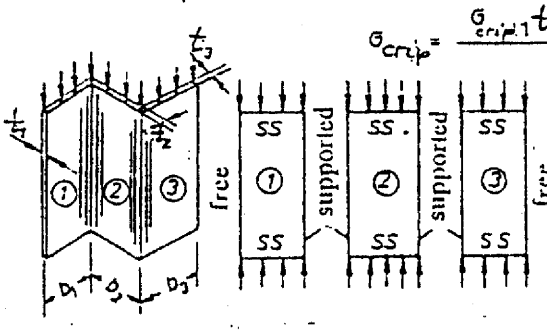
The local buckling of thin-walled profiles.



$$\sigma_{crip} = \frac{\sigma_{crip\,1} t_1 b_1 + \sigma_{crip\,2} t_2 b_2}{t_1 b_1 + t_2 b_2}$$

$$\sigma_{crip\,1} = 0{,}45E\left(\frac{t_1}{b_1}\right)^2$$

$$\sigma_{crip\,2} = 0{,}45E\left(\frac{t_2}{b_2}\right)^2$$



$$\sigma_{crip} = \frac{\sigma_{crip\,1} t_1 b_1 + \sigma_{crip\,2} t_2 b_2 + \sigma_{crip\,3} t_3 b_3}{t_1 b_1 + t_2 b_2 + t_3 b_3}$$

$$\sigma_{crip\,1} = 0{,}45E\left(\frac{t_1}{b_1}\right)^2$$

$$\sigma_{crip\,2} = 3{,}64E\left(\frac{t_2}{b_2}\right)^2$$

$$\sigma_{crip\,3} = 0{,}45E\left(\frac{t_3}{b_3}\right)^2$$

OooOOOooo