Getaran Pilar Jembatan Progo

Lanneke Tristanto

RINGKASAN

Kondisi pilar jembatan Progo dievaluasi dari segi perilaku dinamik dengan mengadakan pengukuran getaran di lapangan.

Analisa teoritik dimodifikasi dengan parameter dinamik sehingga diperoleh tinggi efektif pilar terhadap titik jepit dalam pondasi tiang sumuran.

Titik jepit pondasi dalam arah melintang dan memanjang jembatan menjadi kriteria untuk kondisi stabilitas pilar.

Stabilitas pilar menjadi dasar dalam menentukan cara pengamanan dan perkuatan pilar.

SUMMARY

The Conditions of Progo bridge piers are evaluated based on their dynamic behaviour, which is obtained through vibration measurement on the site.

The theoritical analysis is modified by using the dynamic parameters, revealing the effective pier height to the poin offixity of the bore pile foundation.

The fixity of the foundation in transverse and longitudinal directions is the main criteria in the determining the stability of the piers.

The pier stability is the basic principle for the protection and strengthening recommendation of the piers.

1. PENDAHULUAN

Dalam rangka penelitian kondisi pilar jembatan Progo-Bantar di Jogyakarta, telah dilakukan pengujian pengukuran getaran pada pilar dan bangunan atas jembatan Progo oleh tim Puslitbang Jalan. Data getaran telah digunakan sebagai data masukan dalam analisis kondisi aktual pondasi pilar.

2. METODA PENELITIAN GETARAN

Penggerusan sungai di lokasi pilar-pilar telah menyebabkan terbukanya sambungan pengecoran beton yang semula berada pada ketinggian dasar sungai. Kedalaman gerusan dasar sungai sebesar kurang lebih 6 m (arah Wates) dan 3 m (arah Jogya) telah mengurangi kedalaman terbenamnya pondasi tiang. Getaran pilar dan bangunan atas akibat gaya arus dengan atau tanpa kombinasi beban lalu lintas pada jembatan, telah diukur pada puncak pilar dan tengah bentang dalam tiga arah sumbu ortogonal X, Y dan Z. Pengamatan getaran mengungkapkan besarnya gerakan pilar serta kekakuan pilar yang masing-masing dinyatakan dalam simpangan dinamik (mm) dan frekuensi (Hertz). Berdasarkan frekuensi terukur kemudian dapat diadakan analisis stabilitas pilar dalam arah melintang dan memanjang, yang menyatakan kondisi aktual pilar. Hasil analisis eksperimental tersebut digunakan sebagai kriteria dalam penilaian kondisi getaran pilar.

3. KERANGKA PEMIKIRAN TEORITIK

Dalam perencanaan pondasi tiang umumnya dianggap bahwa susunan tiang secara bersama memikul momen tetapi secara individual memikul beban vertikal dan beban lateral, yang dirumuskan sebagai berikut:

$$V_i = \frac{V}{n} \pm \frac{M_x \cdot Y_i}{\sum(Y_j^2)} \pm \frac{M_y \cdot X_i}{\sum(X_j^2)}$$

$$H_i = \frac{H}{n} \qquad (1)$$

dengan :

Vi = gaya aksial tiang
Hi = gaya lateral tiang
V = beban vertikal pada susunan tiang
M = momen pada susunan tiang
n = jumlah tiang
x,y = jarak tiang terhadap sumbu utama Y,X

Rumus (1) hanya berlaku untuk susunan tiang yang seluruhnya terbenam dalam tanah, sedang dalam kasus jembatan Progo tiang berada sebagian diatas dasar sungai. Dengan menganggap bahwa tanah fiktif antara dasar balok pondasi dan dasar sungai mempunyai modulus elastis E = 0, berat isi = 0 dan sudut geser dalam $\Phi = 0$, perhitungan dengan program 'Piling' dari BMS menghasilkan gaya aksial tiang yang lebih besar dan disesuaikan dengan pengaruh tinggi bebas tiang. Interaksi struktur tiang, gaya geser tiang dan simpangan tiang yang dihitung berdasarkan beban rencana ultimit sesuai Peraturan beban jembatan - bagian 2 dari BMS. Hasil perhitungan kombinasi pembebanan yang mendekati keadaan pengujian getaran kemudian digambar dalam grafik pada Lampiran 1 - 4. Perhitungan tipikal dengan program komputer BMS diuraikan dalam Lampiran 5.

Dari perhitungan pondasi secara teoritik diperoleh data sebagai berikut :

i. titik jepit pondasi yaitu titik dimana momen maksimum dan geser nol
ii. titik tetap pondasi yaitu titik dimana simpangan atau lenturan nol
iii. titik balik yaitu titik dimana momen berubah tanda

Ikhtisar hasil perhitungan teoritik dapat disusun sebagai berikut :

i. titik jepit pondasi berada minimal 8 m diatas dasar tiang sumuran
ii. titik tetap pondasi berada minimal 3.5 m diatas dasar tiang sumuran
iii. titik balik berada pada ketinggian 2 - 6 m diatas dasar sungai

Perhitungan teoritik telah dibuat berdasarkan perkiraan kedalaman gerusan dan gaya aliran sungai sehingga perlu diversifikasi dengan hasil pengamatan getaran pilar.

4. HASIL DAN PEMBAHASAN GETARAN PILAR

Dalam evaluasi getaran dianggap bahwa pilar merupakan struktur kantilever yang terjepit dalam pondasi dan bergetar sebagai bandul dengan derajat kebebasan tunggal. Gaya penggetar dalam pengujian ini berasal dari bangunan atas - beban hidup - beban aliran dan turbulensi. Respon pilar terhadap gaya penggetar adalah lenturan - simpangan pilar yang diukur pada puncak pilar dengan menggunakan alat perekam getaran.

Data rekaman getaran memberikan nilai simpangan dinamik dan frekuensi pilar yang menjadi data masukan untuk analisis dinamik. Cara analisis modal yang digunakan adalah berdasarkan hukum kekekalan energi dalam perumusan sebagai berikut :

$$\frac{1}{2}\int_o^h EI\,(u'')^2\,dx = \frac{1}{2}\,\omega^2 \int_o^h mu^2 dx$$

dengan :

h = tinggi efektif pilar sampai kedalaman jepit (= d+1.2m)
EI = kekakuan inersia pilar terhadap sumbu utama X dan Y
u = fungsi perubahan bentuk pilar dalam mode 1 : u = (x/h)2
m = masa per satuan panjang pilar
w = frekuensi sirkular pilar (= 2 π f)

Masa (berat/gravitasi) dan kekakuan inersia (EI) pilar disusun dalam Tabel 1 sebagai berikut :

Tabel 1. Masa dan kekakuan inersia pilar

Pilar No	Interval (m)	Masa KNd2/m2	EI KNm2.10^6 memanjang-melintang	
1	0 - d d-(d+1.2)	11.31 559.08	149.216 1706.5	1882.74 (8.446)* 17476.25
2	0 - d d-(d+1.2)	11.31 612.3	149.216 1706.5	1882.74 (8.446)* 17476.25
3	0 - d d-(d+1.2)	11.31 559.08	149.216 1706.5	1882.74 (8.446)* 17476.25

Dengan cara uji coba dimana d atau kedalaman jepit tiang variabel antara 10 - 25 m diperoleh nilai frekuensi sirkular yang sesuai dengan frekuensi aktual terukur. Tinggi efektif tiang (h = d + 1.2m tebal balok pondasi) adalah kriteria untuk menentukan stabilitas pondasi. Bila tiang terjepit diatas elevasi dasar pondasi maka pondasi stabil - dan bila tiang terjepit pada elevasi dasar tiang maka pondasi labil. Hasil perhitungan analisis modal disusun dalam grafik Lampiran 1-4.

Dari analisis dinamik eksperimental diperoleh data sebagai berikut :

i. titik jepit pondasi yaitu titik dimana pilar efektif terbenam dalam tanah

ii. integritas kekakuan inersia pilar dalam arah memanjang dan melintang yang tergantung pada kesatuan strukural

Ikhtisar hasil analisis dinamik dapat disusun sebagai berikut :

i. titik jepit pondasi dalam arah memanjang adalah stabil karena berada :

- 11 m diatas elevasi dasar tiang untuk pilar no.1
- 5.2m diatas elevasi dasar tiang untuk pilar no.2
- 7.6m diatas elevasi dasar tiang untuk pilar no.3

ii. titik jepit pondasi dalam arah melintang adalah labil karena berada pada elevasi dasar tiang untuk semua pilar

iii. integritas pondasi dalam arah memanjang didukung oleh kesatuan tiang sumuran yang memberikan kekakuan inersia penuh (149.216 KNm2.10^6 dalam Tabel 1) terhadap sumbu utama bersama

iv. integritas pondasi dalam arah melintang tidak didukung karena tiang sumuran memberikan kekakuan inersia parsial yang merupakan kekakuan inersia terhadap sumbu sendiri dari masing-masing tiang (8.446 KNm2.10^6 * dalam Tabel 1)

5. KESIMPULAN DAN SARAN

5.1. KESIMPULAN

i. Pilar stabil dalam arah memanjang karena merupakan kesatuan yang terikat oleh susunan perletakan bangunan atas jembatan.

ii. Pilar labil dalam arah melintang karena hanya terikat oleh balok pondasi di puncak pilar.

5.2 SARAN

i. Perlu diadakan ikatan melintang tambahan pada semua pilar dengan salah satu cara berikut :

- membuat dua ikatan melintang dengan jarak antar sebesar 5m - 7m pada bagian tiang sumuran yang berada diatas dasar sungai; ikatan dibuat dari batang baja dan wartelmur atau dari beton bertulang
- membuat balok pondasi yang terbenam dalam dasar sungai dan terlindung terhadap penggerusan

ii. Perlu diadakan perlindungan terhadap penggerusan dasar sungai dengan salah satu cara berikut :

- pelantaian dasar sungai di lokasi pilar-pilar
- bangunan pengendali gerusan
- bangunan peredam arus sunagi

6. PUSTAKA

i. Peraturan Beban Jembatan - Bagian 2 - BMS

ii. Program Piling - Lampiran Panduan BMS

iii. Laporan Penelitian Pengaruh Getaran Pada Pilar Jembatan - Puslitbang Jalan - 1991

Penulis :

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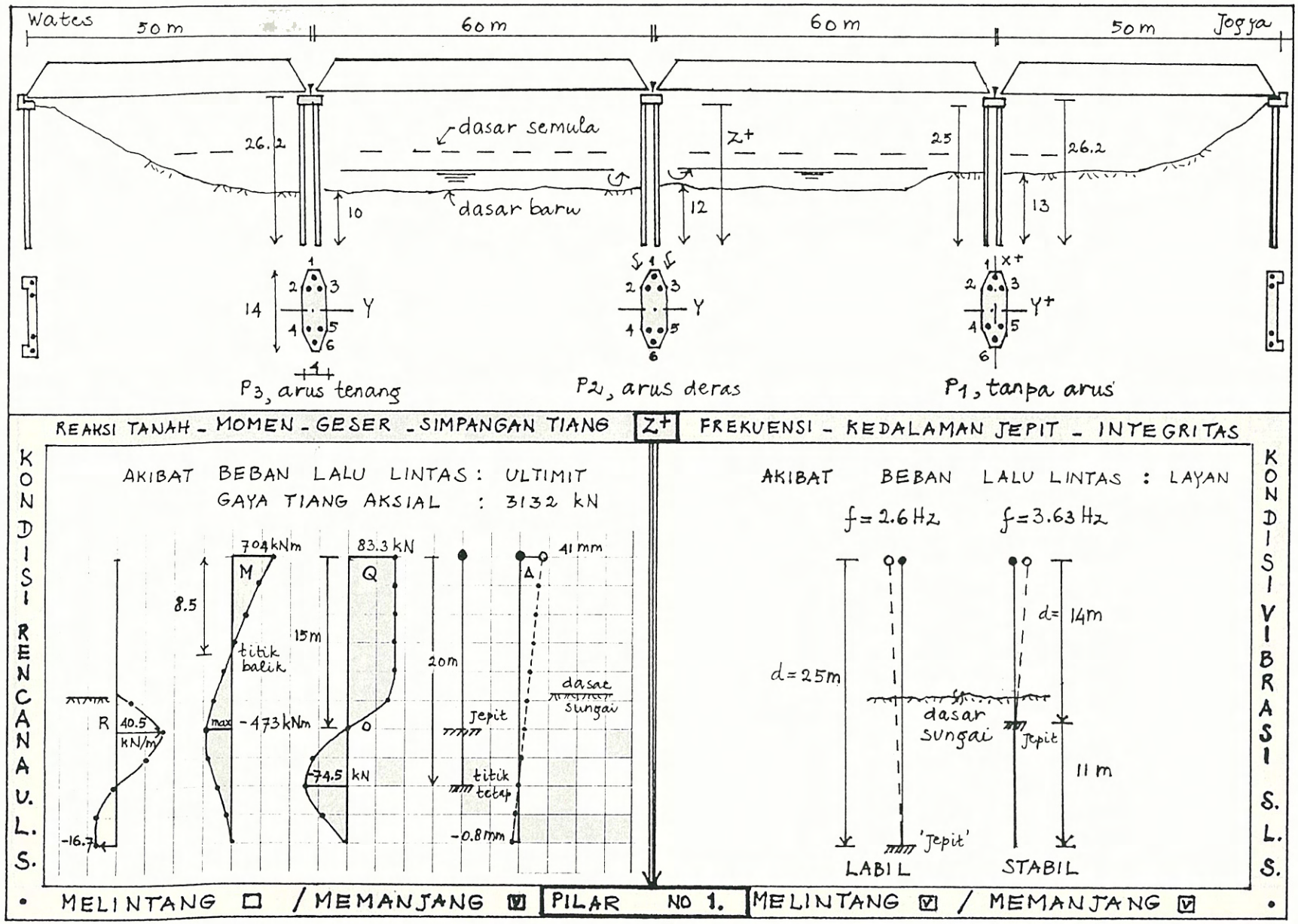
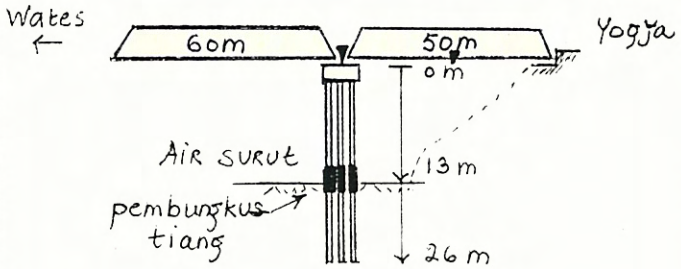
LAMPIRAN 1 :

Pilar no.1 arah Jogya

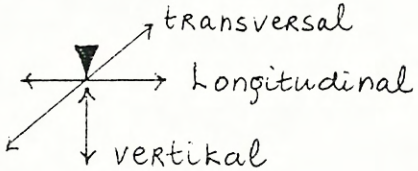


TES GETAR PILAR DAN JEMBATAN (LALU LINTAS ≡ * Rangkaian / satu TRUK)

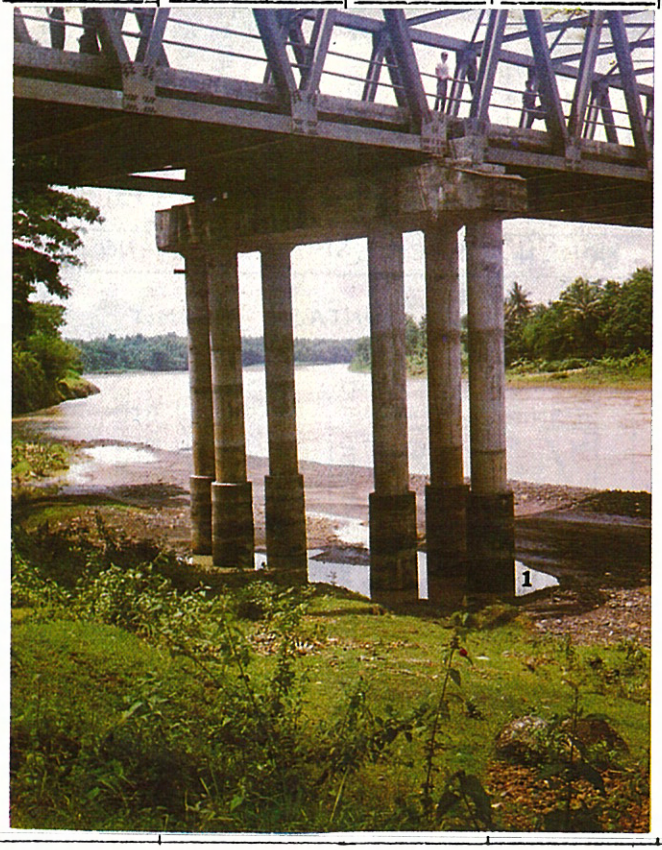
No.	Jembatan	Pondasi	Tinggi Pilar(m) bebas	Tinggi Pilar(m) tertanam	Arah	Frekwensi(Hertz) Pilar	Frekwensi(Hertz) Jembatan	Intensitas Getar Pilar	Intensitas Getar Jembatan	Intensitas Getar Dimensi
1	Progo	Tiang bor	16m	10m	L	3.63	3.33	0.06	0.02	Perpindahan (mm) dinamik
					V	3.48	3.07	0.02	0.42	
					T	2.6	3.07	0.04	0.04	

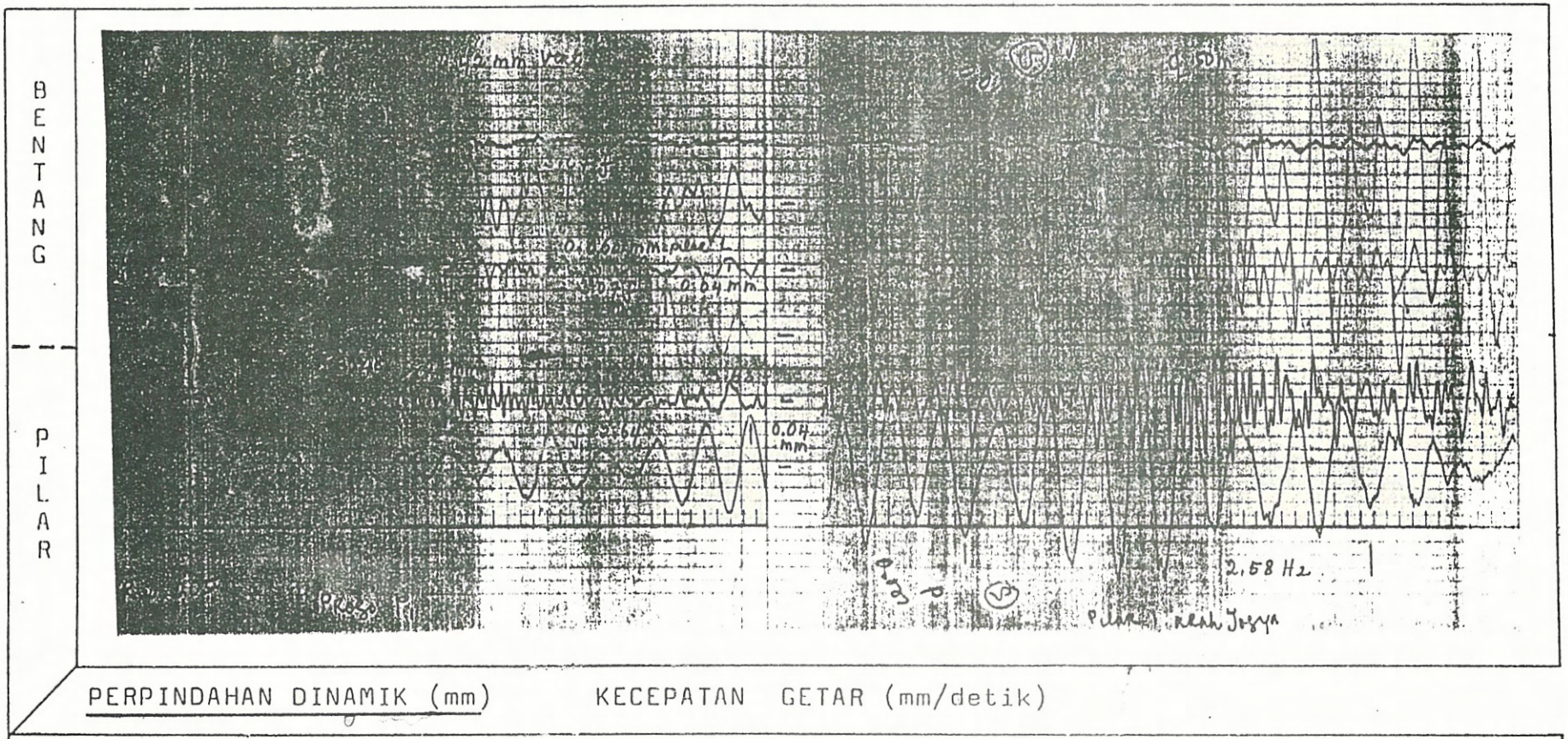


Pilar 1 arah Jogya



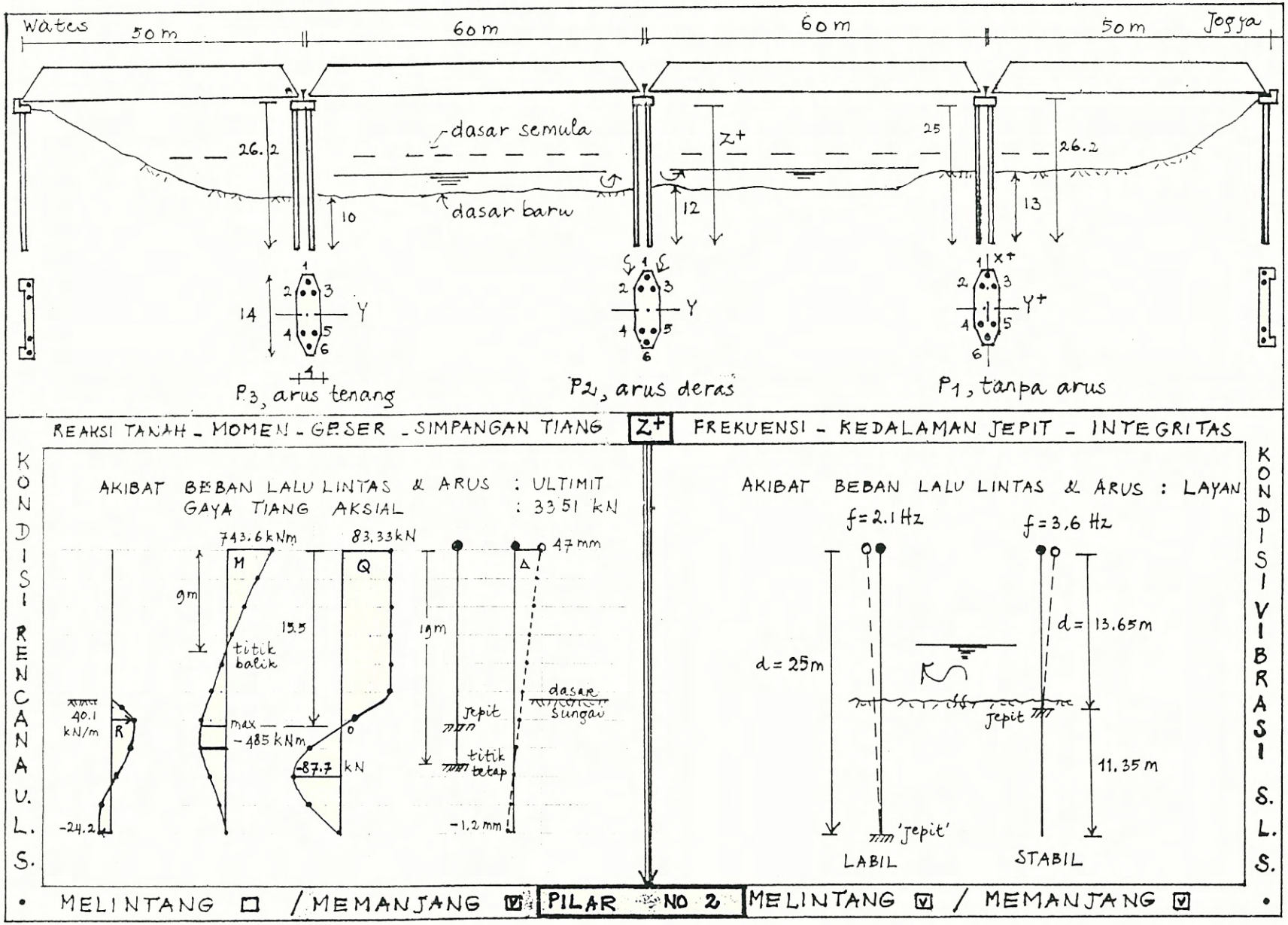
* Rangkaian lalu lintas

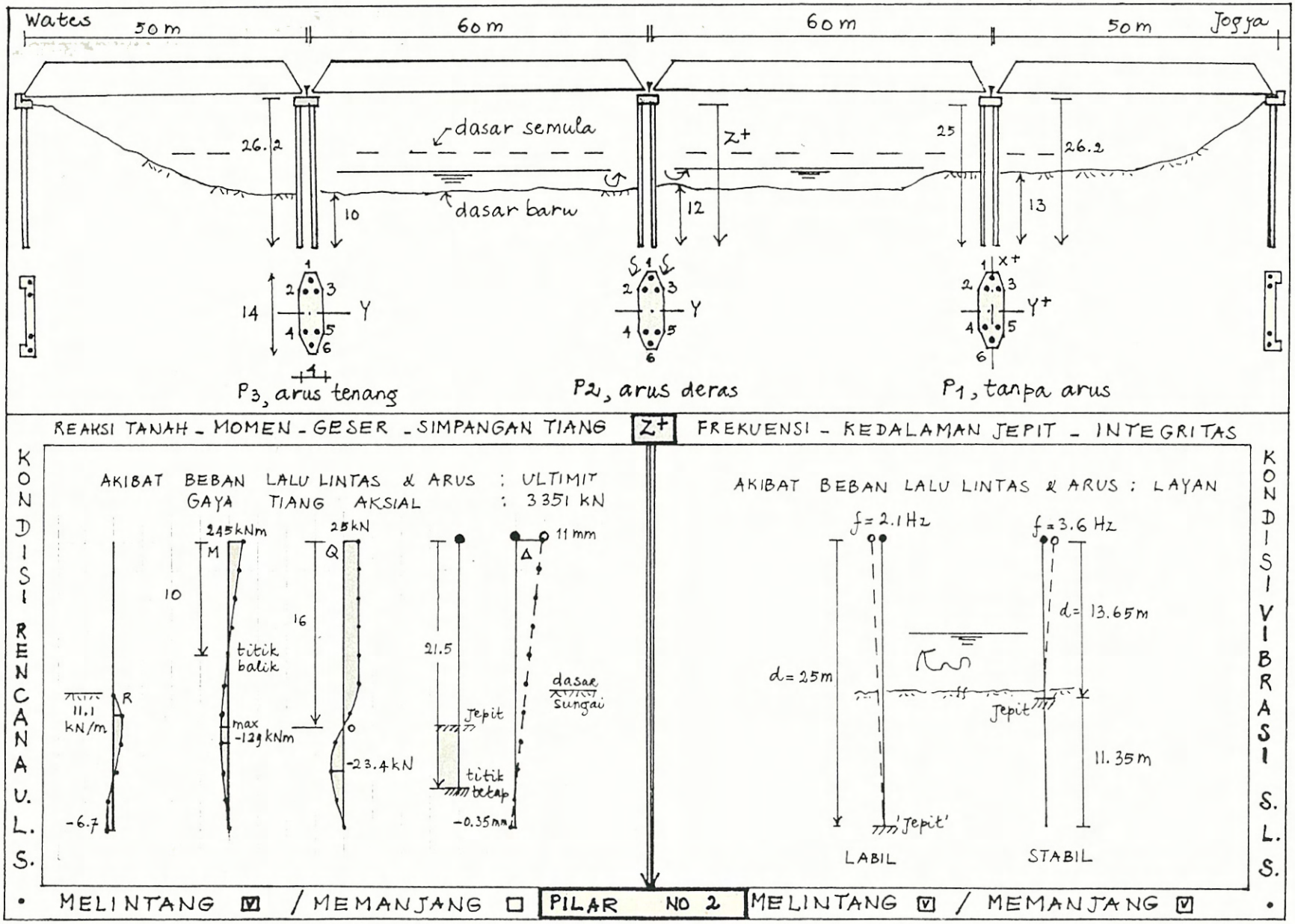




Gambar 1 : Pilar Jembatan Progo (lalu lintas tanpa arus sungai). Pengukuran getar pada pilar no.1 dan bentang no.1 (50 m). Getaran pilar terjadi dalam L -- V -- T -- arah sumbu ontogonal. Getaran bentang terjadi dalam L -- V -- T -- arah sumbu ortogonal. Posisi perekam getar pada puncak pilar dan tengah bentang (50 m)

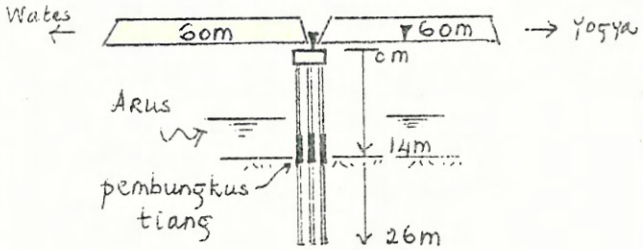
LAMPIRAN 2 :
Pilar no.2 arah Jogya



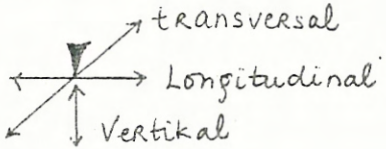

Wates
50 m
60 m
60 m
50 m
Jogja
dasar semula
dasar baru
26.2
10
12
Z+
25
26.2
13
14
Y
X+
Y+
P3, arus tenang
P2, arus deras
P1, tanpa arus
REAKSI TANAH - MOMEN - GESER - SIMPANGAN TIANG
Z+
FREKUENSI - KEDALAMAN JEPIT - INTEGRITAS
KONDISI RENCANA U.L.S.
KONDISI VIBRASI S.L.S.
AKIBAT BEBAN LALU LINTAS & ARUS : ULTIMIT
GAYA TIANG AKSIAL : 3351 kN
245 kNm
25 kN
11 mm
M
Q
Δ
10
16
21.5
titik balik
max -129 kNm
-23.4 kN
Jepit
titik tetap
-0.35 mm
dasar sungai
R
11.1 kN/m
-6.7
AKIBAT BEBAN LALU LINTAS & ARUS : LAYAN
f = 2.1 Hz
f = 3.6 Hz
d = 25 m
d = 13.65 m
11.35 m
Jepit
'Jepit'
LABIL
STABIL
MELINTANG ☑ / MEMANJANG ☐
PILAR NO 2
MELINTANG ☑ / MEMANJANG ☑

TES GETAR PILAR DAN JEMBATAN (LALU LINTAS ≡ *Rangkaian / satu TRUK)

No.	Jembatan	Pondasi	Tinggi Pilar(m) bebas	tertanam
2	Progo	Tiang bor	14 m	12 m

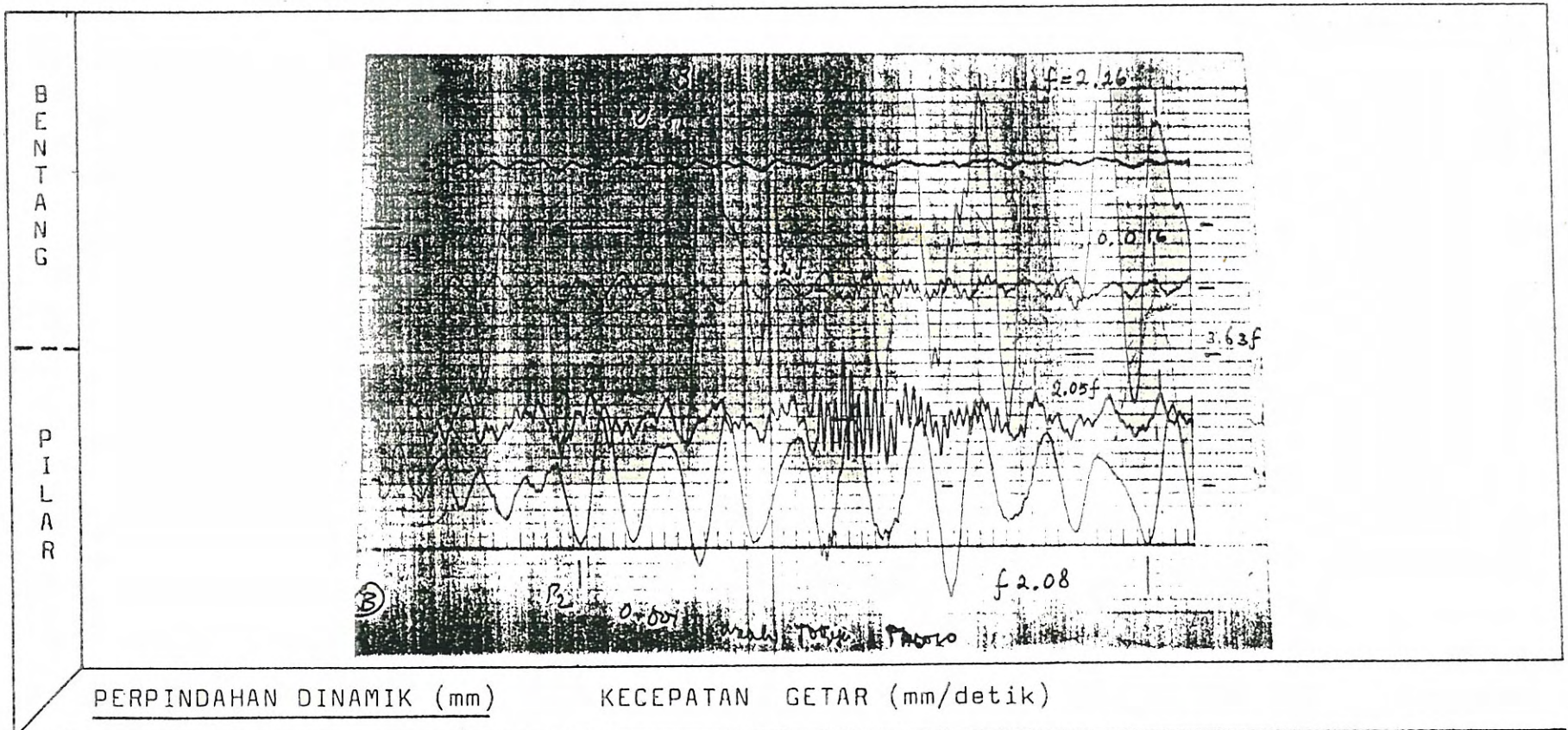


Pilar 2 arah Yogya



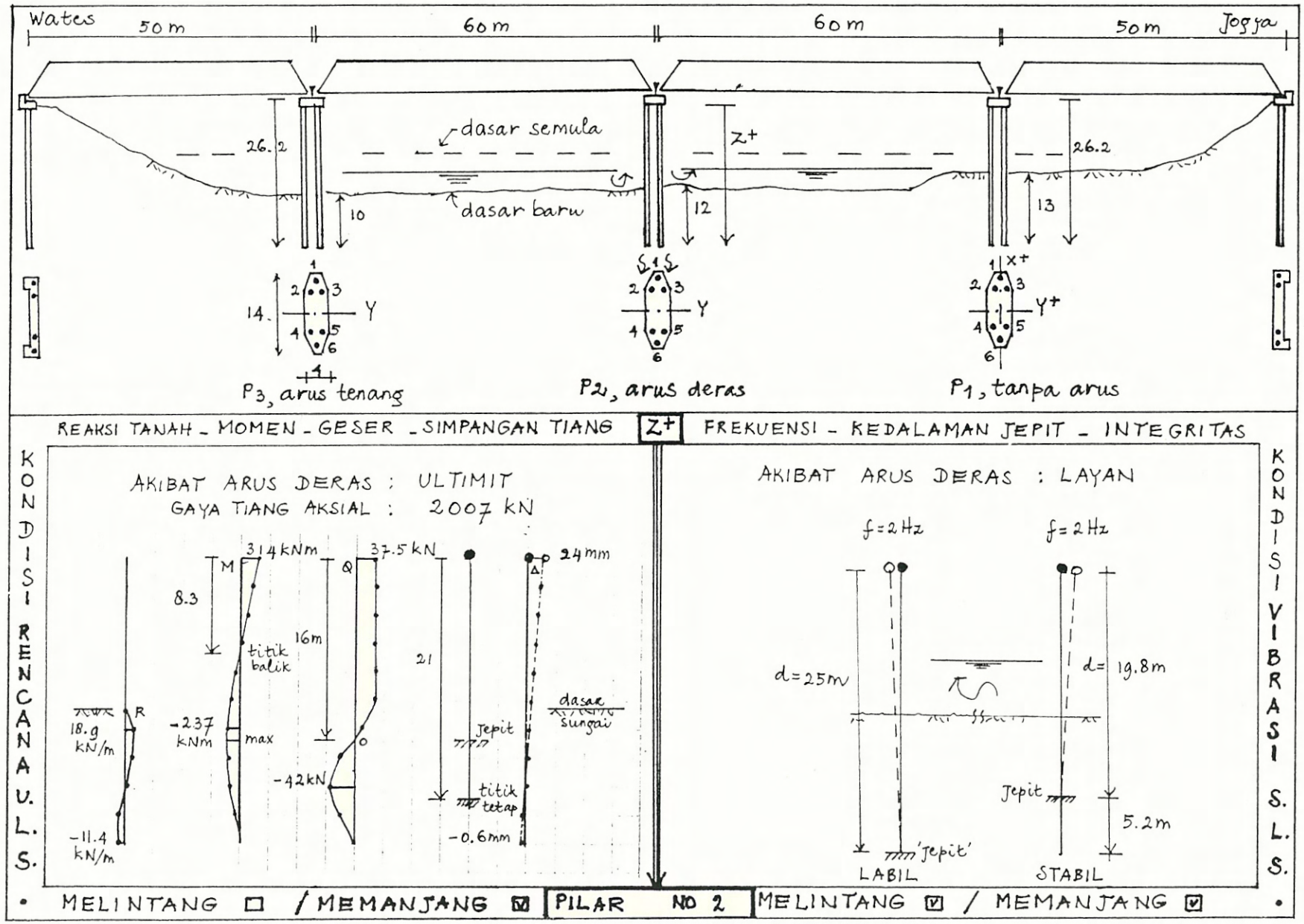
* Rangkaian lalu lintas dengan arus deras

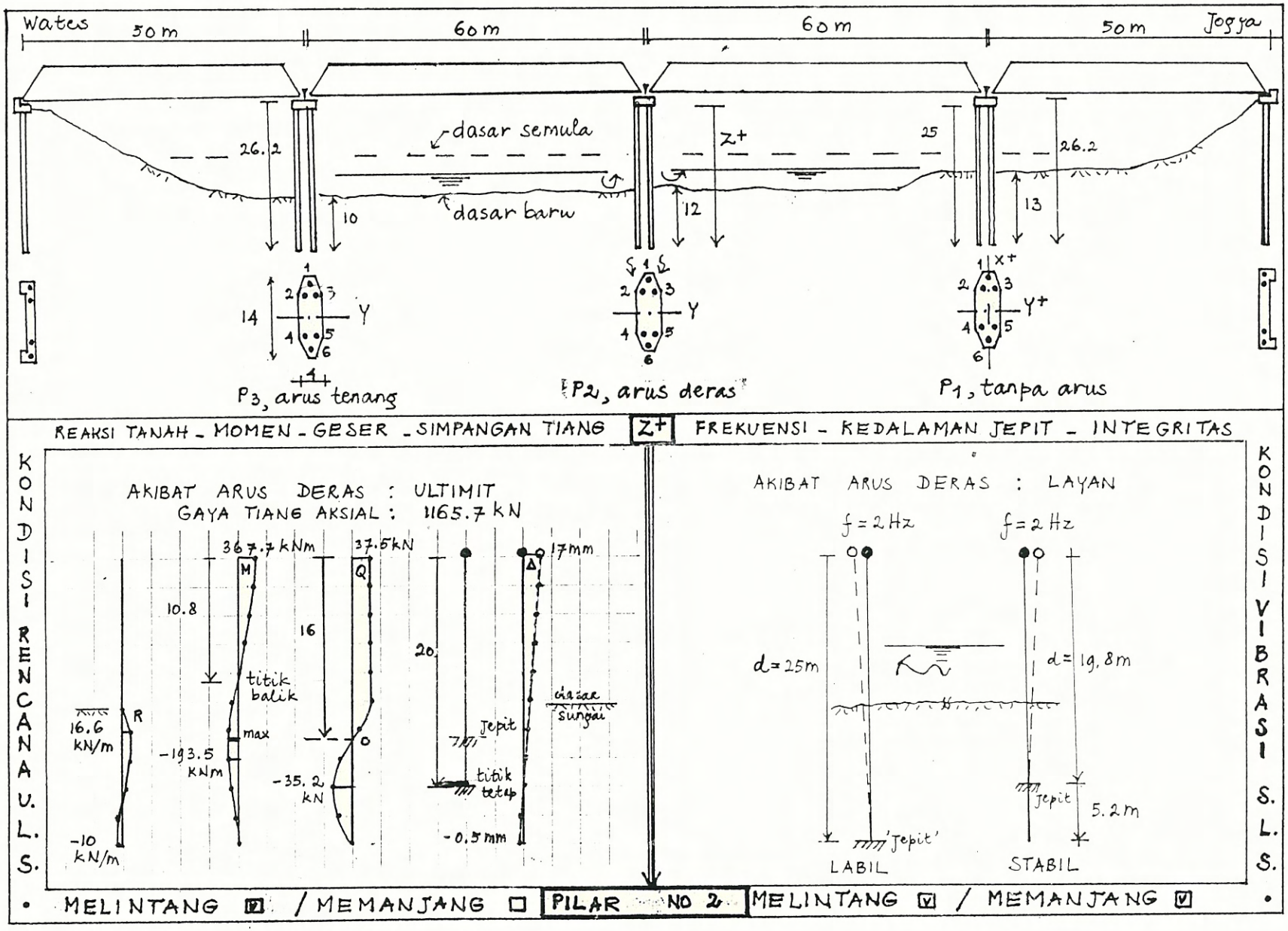
Arah	Frekwensi(Hertz) Pilar	Jembatan	Intensitas Getar Pilar	Jembatan	Dimensi
L	3.63	–	0.016	0.01	Perpindahan (mm) dinamik
V	2.05	2.26	0.011	0.35	
T	2.08	3.20	0.017	0.025	
L					Kecepatan (mm/detik) getar
V					
T					



Gambar 2 : Pilar Jembatan Progo (lalu lintas dengan arus sungai). Pengukuran getar pada pilar no.2 dan bentang no.2 (60 m). Getaran pilar terjadi dalam L -- V -- T -- arah sumbu ortogonal. Getaran bentang terjadi dalam L -- V -- T -- arah sumbu ortogonal. Posisi perekam getar pada puncak pilar dan tengah bentang (60 m)

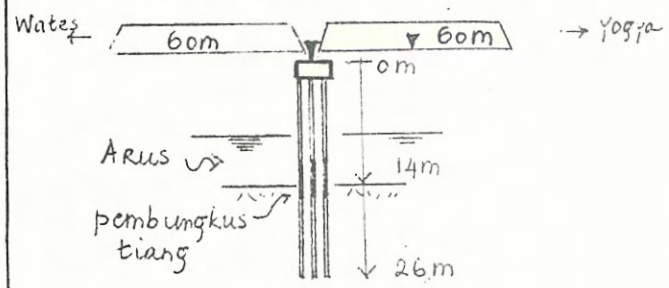
LAMPIRAN 3 :
Pilar no.2 arah Jogya (khusus terhadap arus sungai)



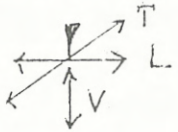

Wates
50 m
60 m
60 m
50 m
Jogja
dasar semula
dasar baru
26.2
10
12
Z+
25
26.2
13
14
Y
X+
Y+
P3, arus tenang
P2, arus deras
P1, tanpa arus
REAKSI TANAH - MOMEN - GESER - SIMPANGAN TIANG
Z+
FREKUENSI - KEDALAMAN JEPIT - INTEGRITAS
KONDISI RENCANA U.L.S.
AKIBAT ARUS DERAS : ULTIMIT
GAYA TIANG AKSIAL : 1165.7 kN
367.7 kNm
37.5 kN
17 mm
10.8
16
20
titik balik
max
-193.5 kNm
-35.2 kN
16.6 kN/m
-10 kN/m
Jepit
titik tetap
-0.5 mm
dasar sungai
AKIBAT ARUS DERAS : LAYAN
f = 2 Hz
f = 2 Hz
d = 25m
d = 19.8m
Jepit
5.2 m
'Jepit'
LABIL
STABIL
KONDISI VIBRASI S.L.S.
MELINTANG ☑ / MEMANJANG ☐
PILAR NO 2
MELINTANG ☑ / MEMANJANG ☑

TES GETAR PILAR DAN JEMBATAN (LALU LINTAS * ≡ Rangkaian / satu TRUK)

No.	Jembatan	Pondasi	Tinggi Pilar(m) bebas	Tinggi Pilar(m) tertanam	Arah	Frekwensi(Hertz) Pilar	Frekwensi(Hertz) Jembatan	Intensitas Getar Pilar	Intensitas Getar Jembatan	Dimensi
3	Progo	Tiang bor	14m	12m	L	2	—	0.008	0	Perpindahan (mm) dinamik
					V	—	2,08	0,001	0,05**	
					T	2	—	0.002	0	
					L					Kecepatan (mm/detik) getar
					V					
					T					

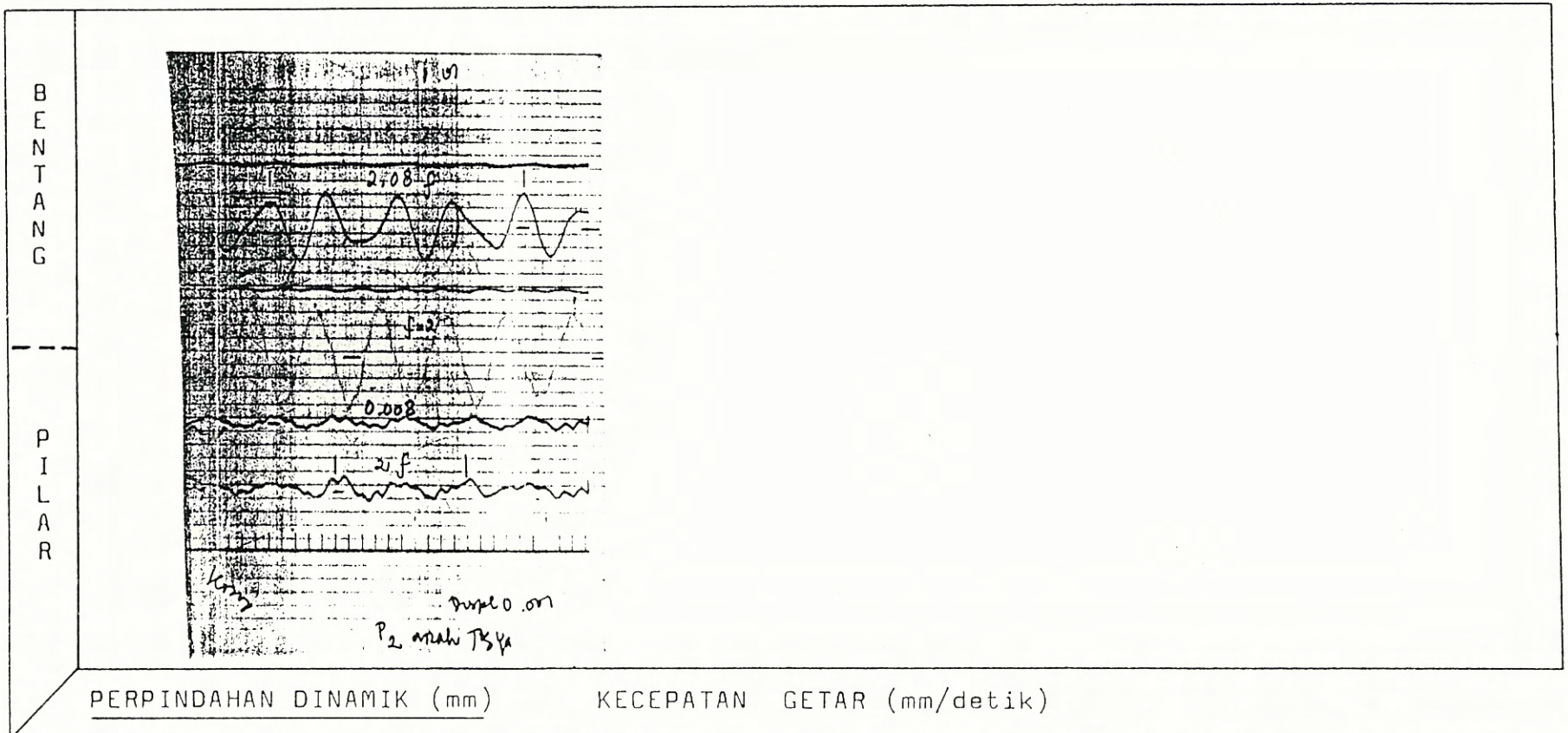


Pilar 2 arah Yogya



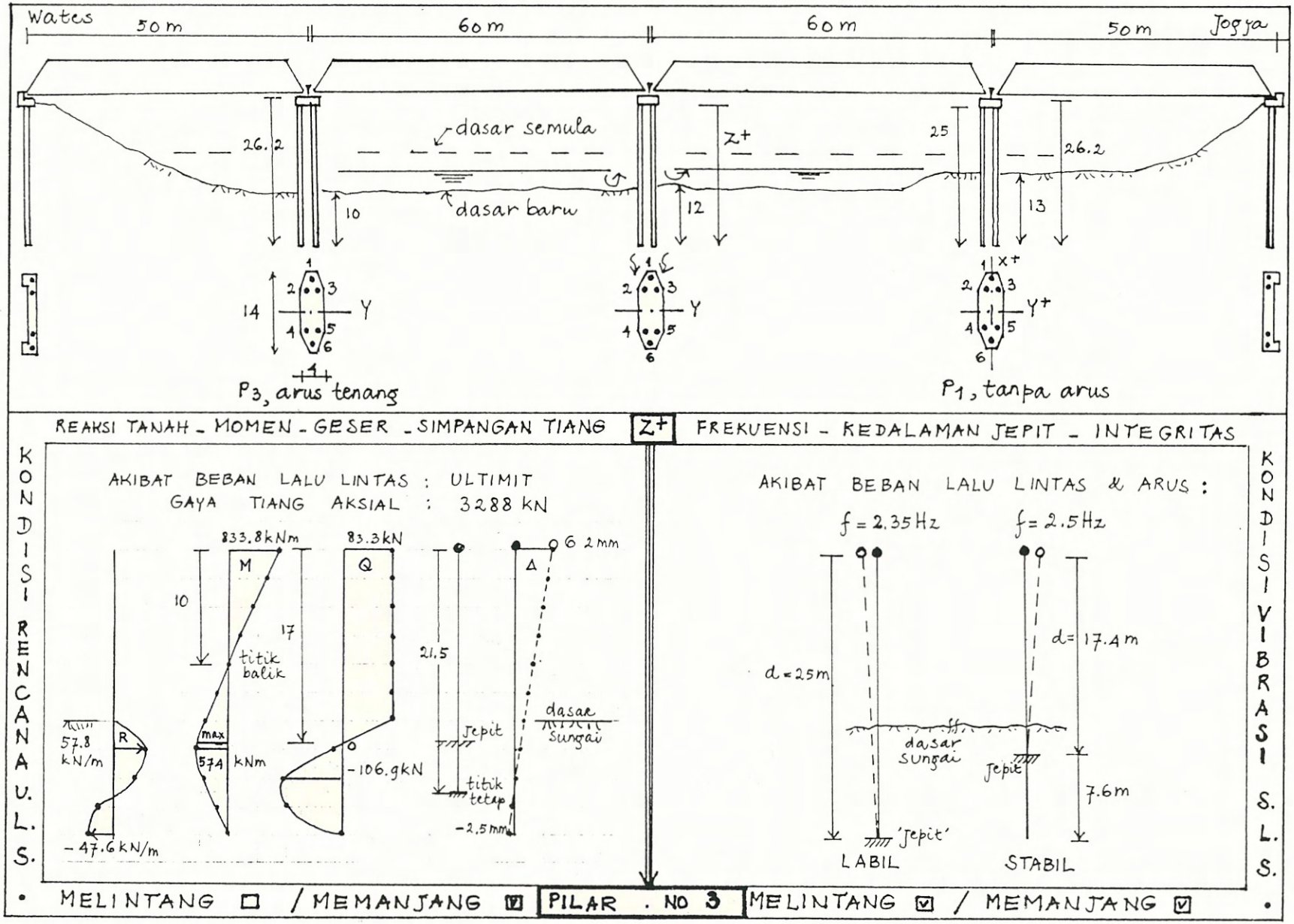
* hanya akibat arus sungai, jembatan kosong

** jembatan bergetar arah vertikal



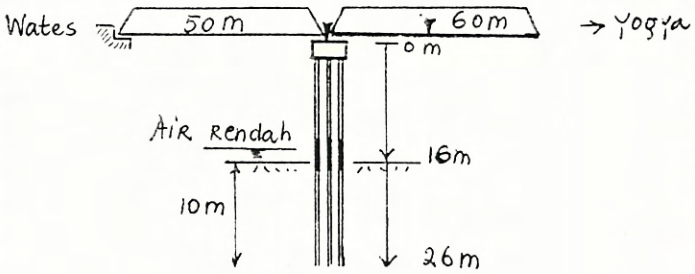
Gambar 3 : Pilar Jembatan Progo (hanya arus sungai). Pengukuran getar pada pilar no.2 dan bentang no.2 (60 m). Getaran pilar terjadi dalam L -- V -- T -- arah sumbu ortogonal Getaran bentang terjadi dalam L -- V -- T -- arah sumbu ortogonal. Posisi perekam getar pada puncak pilar dan tengah bentang (60 m)

LAMPIRAN4 :
Pilar no.3 arah Jogya

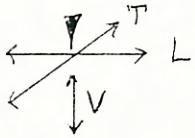


TES GETAR PILAR DAN JEMBATAN (LALU LINTAS ≡ * Rangkaian / satu TRUK)

No.	Jembatan	Pondasi	Tinggi Pilar(m) bebas	tertanam
4	Progo	Tiang bor	1	13 m

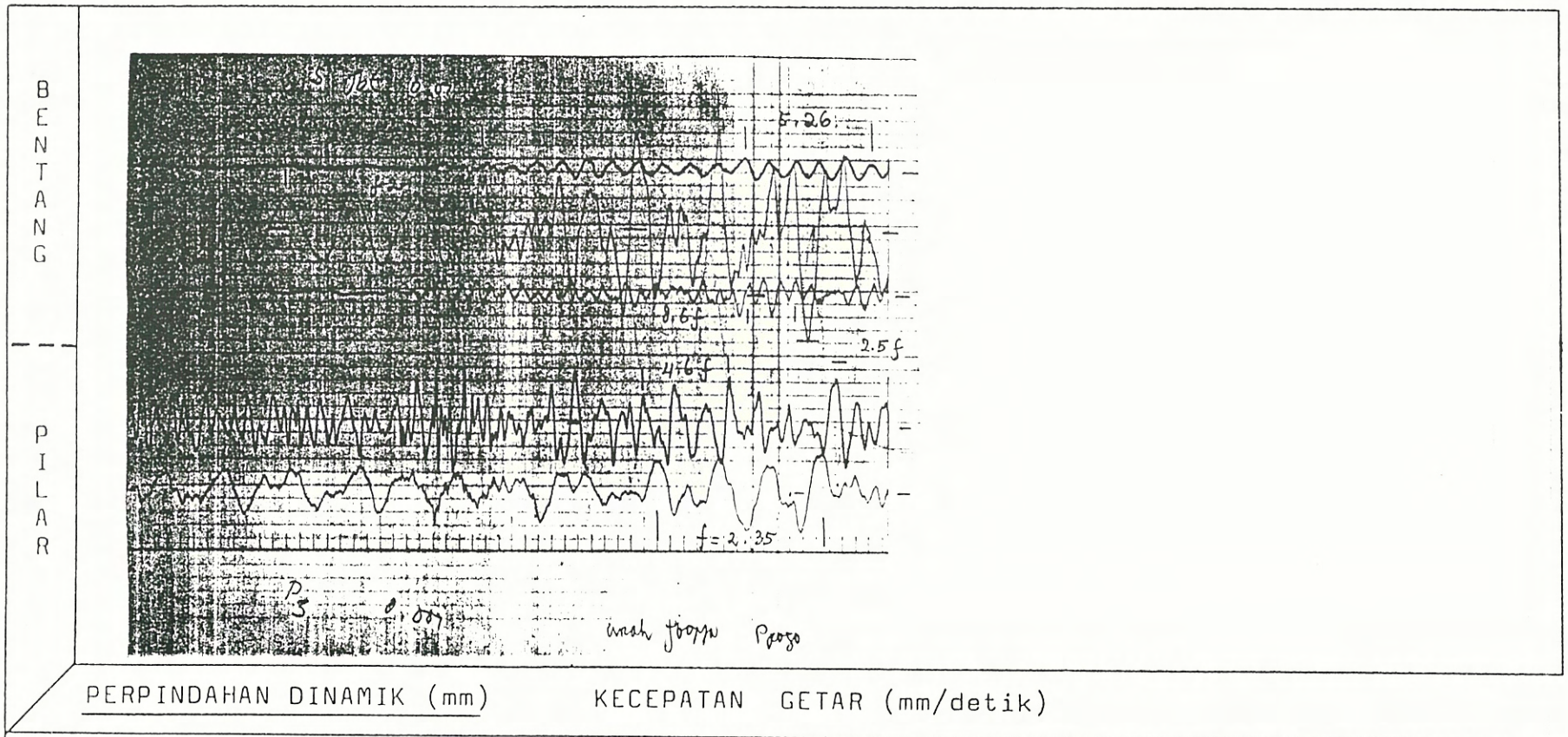


Pilar 3 arah Yogya



* Rangkaian lalu lintas

Arah	Frekwensi(Hertz) Pilar	Jembatan	Intensitas Getar Pilar	Jembatan	Dimensi
L	2,5	5.26	0.020	0.02	Perpindahan (mm) dinamik
V	4.6	2	0.007	0.007	
T	2.35	8.6	0.006	0.006	
L		5		1.25	Kecepatan (mm/detik) getar
V			1.3	2.5	
T	2,7		0.4	1.5	



Gambar 4 : Pilar Jembatan Progo. Pengukuran getar pada pilar no.3 dan bentang no.3 (60 m). Getaran pilar terjadi dalam L -- V -- T -- arah sumbu ortogonal. Getaran bentang terjadi dalam L -- V -- T -- arah sumbu ortogonal. Posisi perekam getar pada puncak pilar dan tengah bentang (60 m)

LAMPIRAN 5

Perhitungan tipikal dengan Program Komputer BMS

'PILAR JEMBATAN PROGO NO.2 ARAH WATES'
'TIANG BOR 13M DIATAS DASAR SUNGAI KN.M'
6 0 0 0
'PROPERTIES'

1	0.04908	0.04908	0.0982	0.7853	1	1	29000000	0.25

'RAKES'
1 'VERTIKAL'
'SOIL PROPERTIES'
'****' 1 0
0 0 'SAND' 0 0
12.999 0
13.0 0 'SAND' 15 10
25.0 30000
'PILES'

1	6.05	0	0	25	0	0	1	1	1	0	'FIX'	'REL'
2	3.55	-1.25	0	25	0	0	1	1	1	0	'FIX'	'REL'
3	3.55	-1.25	0	25	0	0	1	1	1	0	'FIX'	'REL'
4	-3.55	-1.25	0	25	0	0	1	1	1	2	'FIX'	'REL'
5	-3.55	-1.25	0	25	0	0	1	1	1	2	'FIX'	'REL'
6	-6.05	0	0	25	0	0	1	1	1	2	'FIX'	'REL'

'CONTINUE'
'BEBAN SENDIRI NOMINAL DAN ARUS MELINTANG ULTIMATE'

1	0	0	0	225	0	6948	0	2363	0

'CONTINUE'
'BEBAN SENDIRI NOMINAL DAN ARUS MEMANJANG ULTIMATE'

1	0	0	0	0	225	6948	2363	0	0

'END'

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PILAR JEMBATAN PROGO NO.2 ARAH WATES
TIANG BOR 13M DIATAS DASAR SUNGAI KN.M

PILE PROPERTIES
****

No	IRR	ISS	J	A	BR	BS	E	PR
1	.491E-01	.491E-01	.982E-01	.785	1.000	1.000	.290E+08	.250

RAKES
****

RAKE NO. HORIZ. VERT.
1 *** VERTIKAL ***

SOIL PROPERTIES
****

Property No. 1 Soil Surface Z-Coord .000

Z. coord	Elastic Modulus	Soil Type	Cu (clay) Phi (sand)	SoilDensity
.000	.000E+00	SAND	.000	.000
12.999	.000E+00	SAND	.000	.000
13.000	.000E+00	SAND	15 .000	10.000
25.000	.300E+00	SAND	15 .000	10.000

PILE DETAILS
****

NO.	X	Y	Z	LENGTH	ALPHA	GAMMA	RAKE	SEC	SOIL	TOP	BOT
1	6.050	.000	.000	25000	0	0	1	1	1	FIX	REL
2	3.550	-1250	.000	25000	0	0	1	1	1	FIX	REL
3	3.550	1250	.000	25000	0	0	1	1	1	FIX	REL
4	-3550	-1250	.000	25000	0	0	1	1	1	FIX	REL
5	-3550	1250	.000	25000	0	0	1	1	1	FIX	REL
6	-6050	.000	.000	25000	0	0	1	1	1	FIX	REL

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PILAR JEMBATAN PROGO NO.2 ARAH WATES
TIANG BOR 13M DIATAS DASAR SUNGAI KN.M

Load Case 1
BEBAN SENDIRI NOMINAL DAN ARUS MELINTANG ULTIMATE

LOAD	X-ORD	Y-ORD	Z-ORD	FX	FY	FZ	MX	MY	MZ
1	000	000	000	225.0	0	6948.0	0	2363.0	0

GLOBAL DIPLACEMENT AT ORIGIN

X-DEF	Y-DEF	Z-DEF	X-ROT	Y-ROT	Z-ROT
.1711E-01	.0000E+00	.1271E-02	.0000E+00	.1392E-05	.0000E+00

PILE FORCES

PILE	R-SHEAR	S-SHEAR	AXIAL	R-MOMENT	S-MOMENT	TORSION
1	37.500	.000	1150.330	.000	367.715	.000
2	37.500	.000	1153.500	.000	367.715	.000
3	37.500	.000	1153.500	.000	367.715	.000
4	37.500	.000	1162.500	.000	367.715	.000
5	37.500	.000	1162.500	.000	367.715	.000
6	37.500	.000	1165.670	.000	367.715	.000

PILE HEAD DEFLECTIONS

PILE	X-ORD	Y-ORD	Z-ORD	X-DEF	Y-DEF	Z-DEF
1	6.050	.000	.000	.1711E-01	.0000E+00	.1263E-02
2	3.550	-1.250	.000	.1711E-01	.0000E+00	.1266E-02
3	3.550	1.250	.000	.1711E-01	.0000E+00	.1266E-02
4	-3.550	-1.250	.000	.1711E-01	.0000E+00	.1276E-02
5	-3.550	1.250	.000	.1711E-01	.0000E+00	.1276E-02
6	-6.050	.000	.000	.1711E-01	.0000E+00	.1280E-02

COORDINATE AND DEFLECTIONS OF LOAD POINTS

POINT	X-ORD	Y-ORD	Z-ORD	X-DEF	Y-DEF	Z-DEF
1	.000	.000	.000	.1711E-01	.0000E+00	.1271E-02

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PILAR JEMBATAN PROGO NO.2 ARAH WATES
TIANG BOR 13M DIATAS DASAR SUNGAI KN.M

All Piles
Load Case 1
BEBAN SENDIRI NOMINAL DAN ARUS MELINTANG ULTIMATE

MAXIMUM SOIL PRESSURES ..... s-t plane

Pile No	Surface Depth	Axiz Distance	Pressure	Ultimate	Cu(clay) Kp(sand)	Type	Soil No	Density
	25.00	25.00	.00	611.42	1.698	SAND	1	10.00
2	25.00	25.00	.00	611.42	1.698	SAND	1	10.00
3	25.00	25.00	.00	611.42	1.698	SAND	1	10.00
4	25.00	25.00	.00	611.42	1.698	SAND	1	10.00
5	25.00	25.00	.00	611.42	1.698	SAND	1	10.00
6	25.00	25.00	.00	611.42	1.698	SAND	1	10.00

MAXIMUM SOIL PRESSURES ..... r-t plane

Pile No	Surface Depth	Axiz Distance	Pressure	Ultimate	Cu(clay) Kp(sand)	Type	Soil No	Density
1	25.00	25.00	-16.13	611.42	1.698	SAND	1	10.
2	25.00	25.00	-16.13	611.42	1.698	SAND	1	10.
3	25.00	25.00	-16.13	611.42	1.698	SAND	1	10.
4	25.00	25.00	-16.13	611.42	1.698	SAND	1	10.
5	25.00	25.00	-16.13	611.42	1.698	SAND	1	10.
6	25.00	25.00	-16.13	611.42	1.698	SAND	1	10.

Pile No. 4
Load Case 1
BEBAN SENDIRI NOMINAL DAN ARUS MELINTANG ULTIMATE

SOIL AND PILE REACTIONS ..... s-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.00000	.00	00	00	SAND	.00	.00
1.25	.00000	.00	.00	.00	SAND	.00	.00
2.50	.00000	.00	.00	.00	SAND	.00	.00
3.75	.00000	.00	.00	.00	SAND	.00	.00
5.00	.00000	.00	.00	.00	SAND	.00	.00
6.25	.00000	.00	.00	.00	SAND	.00	.00
7.50	.00000	.00	.00	.00	SAND	.00	.00
8.75	.00000	.00	.00	.00	SAND	.00	.00
10.00	.00000	.00	.00	.00	SAND	.00	.00
11.25	.00000	.00	.00	.00	SAND	.00	.00
12.50	.00000	.00	.00	.00	SAND	.00	.00
13.75	.00000	.00	.00	38.21	SAND	.00	.00
15.00	.00000	.00	.00	101.90	SAND	.00	.00
16.25	.00000	.00	.00	165.59	SAND	.00	.00
17.50	.00000	.00	.00	229.28	SAND	.00	.00
18.75	.00000	.00	.00	292.97	SAND	.00	.00
20.00	.00000	.00	.00	356.66	SAND	.00	.00
21.25	.00000	.00	.00	420.35	SAND	.00	.00
22.50	.00000	.00	.00	484.04	SAND	.00	.00
23.75	.00000	.00	.00	547.73	SAND	.00	.00
25.00	.00000	.00#	.00	611.42	SAND	.00	.00

SOIL AND PILE REACTIONS ..... r-t plane melintang

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.01692	.00	.00	00	SAND	37.50	367.71
1.25	.01675	.00	.00	.00	SAND	37.50	320.84
2.50	.01623	.00	.00	.00	SAND	37.50	273.96
3.75	.01541	.00	.00	.00	SAND	37.50	227.09
5.00	.01434	.00	.00	.00	SAND	37.50	180.21
6.25	.01307	.00	.00	.00	SAND	37.50	133.34
7.50	.01166	.00	.00	.00	SAND	37.50	86.46
8.75	.01015	.00	.00	.00	SAND	37.50	39.59
10.00	.00860	.00	.00	.00	SAND	37.50	-7.29
11.25	.00705	.00	.00	.00	SAND	37.50	-54.16
12.50	.00557	.00	.00	.00	SAND	37.50	-101.04
13.75	.00419	8.08	6.46	38.21	SAND	29.42	-147.91
15.00	.00298	16.61	13.29	101.90	SAND	12.81	-184.69
16.25	.00197	18.54	14.83	165.59	SAND	-5.74	-200.69
17.50	.00117	15.66	12.53	229.28	SAND	-21.40	-193.52
18.75	.00058	10.11	8.09	292.97	SAND	-31.51	-166.77
20.00	.00017	3.65	2.92	356.66	SAND	-35.16	-127.38
21.25	-.00010	-2.62	-2.10	420.35	SAND	-32.54	-83.43
22.50	-.00028	-8.41	-6.73	484.04	SAND	-24.13	-42.76
23.75	-.00041	-14.05	-11.24	547.73	SAND	-10.08	-12.59
25.00	-.00052	-10.08#	-16.13	611.42	SAND	.00	.02

Pile No. 5
Load Case 1
BEBAN SENDIRI NOMINAL DAN ARUS MELINTANG ULTIMATE

SOIL AND PILE REACTIONS ..... s-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.00000	.00	00	00	SAND	.00	.00
1.25	.00000	.00	.00	.00	SAND	.00	.00
2.50	.00000	.00	.00	.00	SAND	.00	.00
3.75	.00000	.00	.00	.00	SAND	.00	.00
5.00	.00000	.00	.00	.00	SAND	.00	.00
6.25	.00000	.00	.00	.00	SAND	.00	.00
7.50	.00000	.00	.00	.00	SAND	.00	.00
8.75	.00000	.00	.00	.00	SAND	.00	.00
10.00	.00000	.00	.00	.00	SAND	.00	.00
11.25	.00000	.00	.00	.00	SAND	.00	.00
12.50	.00000	.00	.00	.00	SAND	.00	.00
13.75	.00000	.00	.00	38.21	SAND	.00	.00
15.00	.00000	.00	.00	101.90	SAND	.00	.00
16.25	.00000	.00	.00	165.59	SAND	.00	.00
17.50	.00000	.00	.00	229.28	SAND	.00	.00
18.75	.00000	.00	.00	292.97	SAND	.00	.00
20.00	.00000	.00	.00	356.66	SAND	.00	.00
21.25	.00000	.00	.00	420.35	SAND	.00	.00
22.50	.00000	.00	.00	484.04	SAND	.00	.00
23.75	.00000	.00	.00	547.73	SAND	.00	.00
25.00	.00000	.00#	.00	611.42	SAND	.00	.00

SOIL AND PILE REACTIONS ..... r-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.01692	.00	.00	00	SAND	37.50	367.71
1.25	.01675	.00	.00	.00	SAND	37.50	320.84
2.50	.01623	.00	.00	.00	SAND	37.50	273.96
3.75	.01541	.00	.00	.00	SAND	37.50	227.09
5.00	.01434	.00	.00	.00	SAND	37.50	180.21
6.25	.01307	.00	.00	.00	SAND	37.50	133.34
7.50	.01166	.00	.00	.00	SAND	37.50	86.46
8.75	.01015	.00	.00	.00	SAND	37.50	39.59
10.00	.00860	.00	.00	.00	SAND	37.50	-7.29
11.25	.00705	.00	.00	.00	SAND	37.50	-54.16
12.50	.00557	.00	.00	.00	SAND	37.50	-101.04
13.75	.00419	8.08	6.46	38.21	SAND	29.42	-147.91
15.00	.00298	16.61	13.29	101.90	SAND	12.81	-184.69
16.25	.00197	18.54	14.83	165.59	SAND	-5.74	-200.69
17.50	.00117	15.66	12.53	229.28	SAND	-21.40	-193.52
18.75	.00058	10.11	8.09	292.97	SAND	-31.51	-166.77
20.00	.00017	3.65	2.92	356.66	SAND	-35.16	-127.38
21.25	-.00010	-2.62	-2.10	420.35	SAND	-32.54	-83.43
22.50	-.00028	-8.41	-6.73	484.04	SAND	-24.13	-42.76
23.75	-.00041	-14.05	-11.24	547.73	SAND	-10.08	-12.59
25.00	-.00052	-10.08#	-16.13	611.42	SAND	.00	.02

Pile No. 6
Load Case 1
BEBAN SENDIRI NOMINAL DAN ARUS MELINTANG ULTIMATE

SOIL AND PILE REACTIONS ..... s-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.00000	.00	00	00	SAND	.00	.00
1.25	.00000	.00	.00	.00	SAND	.00	.00
2.50	.00000	.00	.00	.00	SAND	.00	.00
3.75	.00000	.00	.00	.00	SAND	.00	.00
5.00	.00000	.00	.00	.00	SAND	.00	.00
6.25	.00000	.00	.00	.00	SAND	.00	.00
7.50	.00000	.00	.00	.00	SAND	.00	.00
8.75	.00000	.00	.00	.00	SAND	.00	.00
10.00	.00000	.00	.00	.00	SAND	.00	.00
11.25	.00000	.00	.00	.00	SAND	.00	.00
12.50	.00000	.00	.00	.00	SAND	.00	.00
13.75	.00000	.00	.00	38.21	SAND	.00	.00
15.00	.00000	.00	.00	101.90	SAND	.00	.00
16.25	.00000	.00	.00	165.59	SAND	.00	.00
17.50	.00000	.00	.00	229.28	SAND	.00	.00
18.75	.00000	.00	.00	292.97	SAND	.00	.00
20.00	.00000	.00	.00	356.66	SAND	.00	.00
21.25	.00000	.00	.00	420.35	SAND	.00	.00
22.50	.00000	.00	.00	484.04	SAND	.00	.00
23.75	.00000	.00	.00	547.73	SAND	.00	.00
25.00	.00000	.00#	.00	611.42	SAND	.00	.00

SOIL AND PILE REACTIONS ..... r-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.01692	.00	.00	00	SAND	37.50	367.71
1.25	.01675	.00	.00	.00	SAND	37.50	320.84
2.50	.01623	.00	.00	.00	SAND	37.50	273.96
3.75	.01541	.00	.00	.00	SAND	37.50	227.09
5.00	.01434	.00	.00	.00	SAND	37.50	180.21
6.25	.01307	.00	.00	.00	SAND	37.50	133.34
7.50	.01166	.00	.00	.00	SAND	37.50	86.46
8.75	.01015	.00	.00	.00	SAND	37.50	39.59
10.00	.00860	.00	.00	.00	SAND	37.50	-7.29
11.25	.00705	.00	.00	.00	SAND	37.50	-54.16
12.50	.00557	.00	.00	.00	SAND	37.50	-101.04
13.75	.00419	8.08	6.46	38.21	SAND	29.42	-147.91
15.00	.00298	16.61	13.29	101.90	SAND	12.81	-184.69
16.25	.00197	18.54	14.83	165.59	SAND	-5.74	-200.69
17.50	.00117	15.66	12.53	229.28	SAND	-21.40	-193.52
18.75	.00058	10.11	8.09	292.97	SAND	-31.51	-166.77
20.00	.00017	3.65	2.92	356.66	SAND	-35.16	-127.38
21.25	-.00010	-2.62	-2.10	420.35	SAND	-32.54	-83.43
22.50	-.00028	-8.41	-6.73	484.04	SAND	-24.13	-42.76
23.75	-.00041	-14.05	-11.24	547.73	SAND	-10.08	-12.59
25.00	-.00052	-10.08#	-16.13	611.42	SAND	.00	.02

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TIANG BOR 13M DIATAS DASAR SUNGAI KN.M

Load Case 2
BEBAN SENDIRI NOMINAL DAN ARUS MEMANJANG ULTIMATE

LOAD	X-ORD	Y-ORD	Z-ORD	FX	FY	FZ	MX	MY	MZ
1	000	000	000	0	225.0	6948.0	2363.0	0	0

GLOBAL DIPLACEMENT AT ORIGIN

X-DEF	Y-DEF	Z-DEF	X-ROT	Y-ROT	Z-ROT
.0000E+00	.2443E-01	.1271E-02	.7460E-03	.0000E+00	.0000E+00

PILE FORCES

PILE	R-SHEAR	S-SHEAR	AXIAL	R-MOMENT	S-MOMENT	TORSION
1	.000	37.500	1158.000	-314.041	.000	.000
2	.000	37.500	308.551	-314.041	.000	.000
3	.000	37.500	2007.449	-314.041	.000	.000
4	.000	37.500	308.551	-314.041	.000	.000
5	.000	37.500	2007.449	-314.041	.000	.000
6	.000	37.500	1158.000	-314.041	.000	.000

PILE HEAD DEFLECTIONS

PILE	X-ORD	Y-ORD	Z-ORD	X-DEF	Y-DEF	Z-DEF
1	6.050	.000	.000	.0000E+00	2443E-01	.1271E-02
2	3.550	-1.250	.000	.0000E+00	2443E-01	.3387E-03
3	3.550	1.250	.000	.0000E+00	2443E-01	.2204E-02
4	-3.550	-1.250	.000	.0000E+00	2443E-01	.3387E-03
5	-3.550	1.250	.000	.0000E+00	2443E-01	.2204E-02
6	-6.050	.000	.000	.0000E+00	2443E-01	.1271E-02

CORDINATES AND DEFLECTIONS OF LOAD POINTS

POINT	X-ORD	Y-ORD	Z-ORD	X-DEF	Y-DEF	Z-DEF
1	.000	.000	.000	.0000E+00	.2443E-01	.1271E-02

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PILAR JEMBATAN PROGO NO.2 ARAH WATES
TIANG BOR 13M DIATAS DASAR SUNGAI KN.M.

All Piles
Load Case 2
BEBAN SENDIRI NOMINAL DAN ARUS MEMANJANG ULTIMATE

MAXIMUM SOIL PRESSURES ..... s-t plane

Pile No	Surface Depth	Axiz Distance	Pressure	Ultimate	Cu(clay) Kp(sand)	Type	Soil	Density
1	25.00	25.00	-18.26	611.42	1.698	SAND	1	10.00
2	25.00	25.00	-18.26	611.42	1.698	SAND	1	10.00
3	25.00	25.00	-18.26	611.42	1.698	SAND	1	10.00
4	25.00	25.00	-18.26	611.42	1.698	SAND	1	10.00
5	25.00	25.00	-18.26	611.42	1.698	SAND	1	10.00
6	25.00	25.00	-18.26	611.42	1.698	SAND	1	10.00

MAXIMUM SOIL PRESSURES ..... r-t plane

Pile No	Surface Depth	Axiz Distance	Pressure	Ultimate	Cu(clay) Kp(sand)	Type	Soil	Density
1	25.00	25.00	.00	611.42	1.698	SAND	1	10.
2	25.00	25.00	.00	611.42	1.698	SAND	1	10.
3	25.00	25.00	.00	611.42	1.698	SAND	1	10.
4	25.00	25.00	.00	611.42	1.698	SAND	1	10.
5	25.00	25.00	.00	611.42	1.698	SAND	1	10.
6	25.00	25.00	.00	611.42	1.698	SAND	1	10.

Pile No. 4
Load Case 2
BEBAN SENDIRI NOMINAL DAN ARUS MEMANJANG ULTIMATE

SOIL AND PILE REACTIONS ..... s-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.02406	.00	.00	00	SAND	37.50	314.04
1.25	.02301	.00	.00	.00	SAND	37.50	267.17
2.50	.02166	.00	.00	.00	SAND	37.50	220.29
3.75	.02008	.00	.00	.00	SAND	37.50	173.42
5.00	.01830	.00	.00	.00	SAND	37.50	126.54
6.25	.01638	.00	.00	.00	SAND	37.50	79.67
7.50	.01438	.00	.00	.00	SAND	37.50	32.79
8.75	.01234	.00	.00	.00	SAND	37.50	-14.08
10.00	.01031	.00	.00	.00	SAND	37.50	-60.96
11.25	.00835	.00	.00	.00	SAND	37.50	-107.83
12.50	.00651	.00	.00	.00	SAND	37.50	-154.71
13.75	.00484	9.33	7.47	38.21	SAND	28.17	-201.58
15.00	.00339	18.93	15.14	101.90	SAND	9.24	-236.79
16.25	.00220	20.75	16.60	165.59	SAND	-11.51	-248.34
17.50	.00127	17.09	13.67	229.28	SAND	-28.60	-233.95
18.75	.00060	10.49	8.39	292.97	SAND	-39.09	-298.20
20.00	.00014	3.05	2.44	356.66	SAND	-42.14	-149.33
21.25	-.00015	-4.00	-3.20	420.35	SAND	-38.14	-96.66
22.50	-.00034	-10.34	-8.27	484.04	SAND	-27.79	-48.99
23.75	-.00048	-16.38	-13.10	547.73	SAND	-11.42	-14.25
25.00	-.00059	-11.42#	-18.26	611.42	SAND	.00	.02

SOIL AND PILE REACTIONS ..... r-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.00000	.00	00	00	SAND	.00	.00
1.25	.00000	.00	.00	.00	SAND	.00	.00
2.50	.00000	.00	.00	.00	SAND	.00	.00
3.75	.00000	.00	.00	.00	SAND	.00	.00
5.00	.00000	.00	.00	.00	SAND	.00	.00
6.25	.00000	.00	.00	.00	SAND	.00	.00
7.50	.00000	.00	.00	.00	SAND	.00	.00
8.75	.00000	.00	.00	.00	SAND	.00	.00
10.00	.00000	.00	.00	.00	SAND	.00	.00
11.25	.00000	.00	.00	.00	SAND	.00	.00
12.50	.00000	.00	.00	.00	SAND	.00	.00
13.75	.00000	.00	.00	38.21	SAND	.00	.00
15.00	.00000	.00	.00	101.90	SAND	.00	.00
16.25	.00000	.00	.00	165.59	SAND	.00	.00
17.50	.00000	.00	.00	229.28	SAND	.00	.00
18.75	.00000	.00	.00	292.97	SAND	.00	.00
20.00	.00000	.00	.00	356.66	SAND	.00	.00
21.25	.00000	.00	.00	420.35	SAND	.00	.00
22.50	.00000	.00	.00	484.04	SAND	.00	.00
23.75	.00000	.00	.00	547.73	SAND	.00	.00
25.00	.00000	.00#	.00	611.42	SAND	.00	.00

Pile No. 5
Load Case 2
BEBAN SENDIRI NOMINAL DAN ARUS MEMANJANG ULTIMATE

SOIL AND PILE REACTIONS ..... s-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.02406	.00	.00	00	SAND	37.50	314.04
1.25	.02301	.00	.00	.00	SAND	37.50	267.17
2.50	.02166	.00	.00	.00	SAND	37.50	220.29
3.75	.02008	.00	.00	.00	SAND	37.50	173.42
5.00	.01830	.00	.00	.00	SAND	37.50	126.54
6.25	.01638	.00	.00	.00	SAND	37.50	79.67
7.50	.01438	.00	.00	.00	SAND	37.50	32.79
8.75	.01234	.00	.00	.00	SAND	37.50	-14.08
10.00	.01031	.00	.00	.00	SAND	37.50	-60.96
11.25	.00835	.00	.00	.00	SAND	37.50	-107.83
12.50	.00651	.00	.00	.00	SAND	37.50	-154.71
13.75	.00484	9.33	7.47	38.21	SAND	28.17	-201.58
15.00	.00339	18.93	15.14	101.90	SAND	9.24	-236.79
16.25	.00220	20.75	16.60	165.59	SAND	-11.51	-248.34
17.50	.00127	17.09	13.67	229.28	SAND	-28.60	-233.95
18.75	.00060	10.49	8.39	292.97	SAND	-39.09	-298.20
20.00	.00014	3.05	2.44	356.66	SAND	-42.14	-149.33
21.25	-.00015	-4.00	-3.20	420.35	SAND	-38.14	-96.66
22.50	-.00034	-10.34	-8.27	484.04	SAND	-27.79	-48.99
23.75	-.00048	-16.38	-13.10	547.73	SAND	-11.42	-14.25
25.00	-.00059	-11.42#	-18.26	611.42	SAND	.00	.02

SOIL AND PILE REACTIONS ..... r-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.00000	.00	00	00	SAND	.00	.00
1.25	.00000	.00	.00	.00	SAND	.00	.00
2.50	.00000	.00	.00	.00	SAND	.00	.00
3.75	.00000	.00	.00	.00	SAND	.00	.00
5.00	.00000	.00	.00	.00	SAND	.00	.00
6.25	.00000	.00	.00	.00	SAND	.00	.00
7.50	.00000	.00	.00	.00	SAND	.00	.00
8.75	.00000	.00	.00	.00	SAND	.00	.00
10.00	.00000	.00	.00	.00	SAND	.00	.00
11.25	.00000	.00	.00	.00	SAND	.00	.00
12.50	.00000	.00	.00	.00	SAND	.00	.00
13.75	.00000	.00	.00	38.21	SAND	.00	.00
15.00	.00000	.00	.00	101.90	SAND	.00	.00
16.25	.00000	.00	.00	165.59	SAND	.00	.00
17.50	.00000	.00	.00	229.28	SAND	.00	.00
18.75	.00000	.00	.00	292.97	SAND	.00	.00
20.00	.00000	.00	.00	356.66	SAND	.00	.00
21.25	.00000	.00	.00	420.35	SAND	.00	.00
22.50	.00000	.00	.00	484.04	SAND	.00	.00
23.75	.00000	.00	.00	547.73	SAND	.00	.00
25.00	.00000	.00#	.00	611.42	SAND	.00	.00

Pile No. 6
Load Case 2
BEBAN SENDIRI NOMINAL DAN ARUS MEMANJANG ULTIMATE

SOIL AND PILE REACTIONS ..... s-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.02406	.00	.00	00	SAND	37.50	314.04
1.25	.02301	.00	.00	.00	SAND	37.50	267.17
2.50	.02166	.00	.00	.00	SAND	37.50	220.29
3.75	.02008	.00	.00	.00	SAND	37.50	173.42
5.00	.01830	.00	.00	.00	SAND	37.50	126.54
6.25	.01638	.00	.00	.00	SAND	37.50	79.67
7.50	.01438	.00	.00	.00	SAND	37.50	32.79
8.75	.01234	.00	.00	.00	SAND	37.50	-14.08
10.00	.01031	.00	.00	.00	SAND	37.50	-60.96
11.25	.00835	.00	.00	.00	SAND	37.50	-107.83
12.50	.00651	.00	.00	.00	SAND	37.50	-154.71
13.75	.00484	9.33	7.47	38.21	SAND	28.17	-201.58
15.00	.00339	18.93	15.14	101.90	SAND	9.24	-236.79
16.25	.00220	20.75	16.60	165.59	SAND	-11.51	-248.34
17.50	.00127	17.09	13.67	229.28	SAND	-28.60	-233.95
18.75	.00060	10.49	8.39	292.97	SAND	-39.09	-298.20
20.00	.00014	3.05	2.44	356.66	SAND	-42.14	-149.33
21.25	-.00015	-4.00	-3.20	420.35	SAND	-38.14	-96.66
22.50	-.00034	-10.34	-8.27	484.04	SAND	-27.79	-48.99
23.75	-.00048	-16.38	-13.10	547.73	SAND	-11.42	-14.25
25.00	-.00059	-11.42#	-18.26	611.42	SAND	.00	.02

SOIL AND PILE REACTIONS ..... r-t plane

Axis	Lateral	---------- SOIL ----------				---- PILE -----	
Distance	Displ	Reaction	Pressure	Ultimate	Type	Shear	Moment
.00	.00000	.00	00	00	SAND	.00	.00
1.25	.00000	.00	.00	.00	SAND	.00	.00
2.50	.00000	.00	.00	.00	SAND	.00	.00
3.75	.00000	.00	.00	.00	SAND	.00	.00
5.00	.00000	.00	.00	.00	SAND	.00	.00
6.25	.00000	.00	.00	.00	SAND	.00	.00
7.50	.00000	.00	.00	.00	SAND	.00	.00
8.75	.00000	.00	.00	.00	SAND	.00	.00
10.00	.00000	.00	.00	.00	SAND	.00	.00
11.25	.00000	.00	.00	.00	SAND	.00	.00
12.50	.00000	.00	.00	.00	SAND	.00	.00
13.75	.00000	.00	.00	38.21	SAND	.00	.00
15.00	.00000	.00	.00	101.90	SAND	.00	.00
16.25	.00000	.00	.00	165.59	SAND	.00	.00
17.50	.00000	.00	.00	229.28	SAND	.00	.00
18.75	.00000	.00	.00	292.97	SAND	.00	.00
20.00	.00000	.00	.00	356.66	SAND	.00	.00
21.25	.00000	.00	.00	420.35	SAND	.00	.00
22.50	.00000	.00	.00	484.04	SAND	.00	.00
23.75	.00000	.00	.00	547.73	SAND	.00	.00
25.00	.00000	.00#	.00	611.42	SAND	.00	.00

Total Run time 1m. 04.1s