BAB V

PENUTUP

5.1. Kesimpulan

Berdasarkan hasil analisis dan pembahasan yang telah diuraikan sebelumnya, maka diperoleh beberapa kesimpulan sebagai berikut :

1. Hasil identifikasi parameter modal dengan menggunakan metode simulasi numerik pada struktur frame yaitu frekuensi alami struktur (ω_n) untuk *mode number* satu, dua, tiga masing-masing = 2,3328 ; 8,3092 ;17,0662 rad/s, periode getar (T) masing-masing = 2,6934 ; 0,7562 ; 0,2682 *second* dan Mode getar (ϕ) pada masing-masing *mode number* yaitu mode 1 = 1,0000 ; 1,8665 ; 2,4050 , mode 2 = 1,0000 ; 0,4227 ; -1,3861 dan mode 3 = 1,0000 ; -0,5281 ; 0,5401 sedangkan pada struktur kantilever yaitu frekuensi alami struktur (ω_n) = 2,2115 rad/s ; periode getar (T) = 2,8411 *second* dan Mode getar (ϕ) = *mode* 1 = 1.
2. Hasil identifikasi parameter modal dengan menggunakan metode FDD pada struktur frame yaitu frekuensi alami struktur (ω_n) untuk *mode number* satu,dua dan tiga masing-masing = 2,4544; 8,5903 ; 16,5670 rad/s , periode getar (T) untuk *mode number* satu,dua dan tiga masing – masing = 2,5610; 0,7317; 0,3794 second sedangkan pada struktur kantilever yaitu frekuensi alami struktur (ω_n) =2,1476 rad/s dan periode getar (T) = 2,9269 *second.*

3. Perbandingan hasil identifikasi parameter modal antara motode simulasi numerik dan metode FDD yaitu untuk frekuensi alami struktur (ω_n) pada struktur *frame* sebesar 5,21 % untuk *mode number* satu ; 3,38 % untuk *mode number* dua dan 3,01 % untuk *mode number* tiga. Sedangkan pada struktur kantilever sebesar 2,98 %. Untuk Periode getar (T) pada struktur *frame* sebesar 5,17 % untuk *mode number* satu ; 3,35 % untuk *mode number* dua dan 2,96 % untuk *mode number* tiga. Sedangkan pada struktur kantilever sebesar 2,93 %. Hasil perbandingan ini mengindikasikan bahwa metode FDD yang dikembangkan oleh Brincker dengan mengikuti program Schanke (2015) dapat digunakan sebagai salah satu metode untuk mengidentifikasi parameter modal struktur.

5.2. Saran

Sesuai dengan hasil pembahasan dalam penelitian ini maka disarankan :

1. Perlu dilakukan penelitian lanjutan pada struktur bangunan *existing* untuk mengidentifikasi parameter modal.
2. Perlu dilakukan penelitian lanjutan tentang identifikasi kerusakan struktur dan atau monitoring kesehatan struktur dengan memanfaatkan analisis parameter modal sebagaimana dilakukan pada penelitian ini.

DAFTAR PUSTAKA

Arfiadi,Y., 1996,*Pengembangan Program Bantu untuk Analisis Struktur dengan Menggunakan Matlab*, Laporan Penelitian, Program Studi Teknik Sipil Fakultas Teknik, Universitas Atma Jaya Yogjakarta, Yogjakarta.

Arfiadi,Y., 2016a, *Analisis Struktur dengan Program Matlab dan FreMat*, Cahaya Atma Pustaka, Kelompok Penerbit Universitas Atma Jaya Yogjakarta, Yogjakarta.

Arfiadi,Y., 2016b, *Bahan Kuliah Dinamika Struktur Lanjut*, Program Studi Magister Teknik Sipil, Universitas Atma Jaya Yogjakarta, Yogjakarta.

Brincker,R., Ventura,C., Andersen,P., 2000, *Damping Estimation By Frequency Domain Decomposition*, In Proc. Of the International Modal Analysis Conference (IMAC), San Antonio, Texas.

Brincker,R., 2014, *Some Elements of Operational Modal Analysis*, Journal of Shock and Vibration Vol.2014, Article ID 325839.

Chopra,A.K.,1995, *Dynamics Of Structures : Theory And Applications To Earthquake Engineering*,Prentice – Hall,Inc. A.Simon & Schuster Company, United State Of America.

Chen,X.,Omenzetter,P., Beskhyroum,S., 2014, *Ambient vibration testing,system identification and modal updating of a multiple-span elevated bridge*, Proceedings of the 9th International Conference on Structural Dynamic, Porto, Portugal

Peeters,B., De Roeck,G., 1999, *Stochastic System Identification; Uncertainly of the Estimated Modal Prameters*, Proceedings of The International Modal Analysis Conference,pp.231-237, Kissimmee,Florida,USA.

Peeters,B., 2000, *System Identification and Damage Detection in Civil Engineering*, PhD Thesis, Department of Civil Engineering, Katholicke Universiteit Leuven, Leuvel, Belgium.

Rainieri,C., Fabbrocino,G., 2014, *Operational Modal Analysis of Civil Engineering Structures*, Springer,1st edition

Schanke, A.S., 2015, Operational Modal Analysis of Large Bridges, *Master Thesis*, Norwegian University of Science and Technology.

Widjajakusuma,J., Limbunan,F.,2013, Studi Simulasi Numerik Kesehatan Jembatan Rangka Warren Dengan Uji Vibrasi, *Konferensi Nasional Teknik Sipil 7*, Universitas Sebelas Maret, Surakarta.

LAMPIRAN 1
INPUT DAN OUTPUT – MATLAB
PADA STRUKTUR FRAME
(METODE SIMULASI NUMERIK)

INPUT DATA MATLAB
PADA MODEL STRUKTUR FRAME

```
%----data coordinat
n1=coor(0,0)
n2=coor(0.5,0)
n3=coor(0,0.3)
n4=coor(0.5,0.3)
n5=coor(0,0.6)
n6=coor(0.5,0.6)
n7=coor(0,0.9)
n8=coor(0.5,0.9)
%----material properties
E=2e8    %--kN/m^2--modulus elastisitas

A1=0.25*(22/7)*(0.008^2) %---Luas Penampang---m2
I1=((22/7)*(0.008^4))/64  %--- Moment Inersia
rho1=7850   %---massa jenis baja (kg/m^3)
[L1,T1]=memf(n1,n3)  %--menghitung L (Panjang) dan T
(transformasi)
k1=klf(E,A1,I1,L1)  %--k lokal
K1=kg(k1,T1)    %--K global
m1=mlf(rho1,A1,L1)
M1=mg(m1,T1)
ID1=[0 0 0 13 1 2]   %-- vektor tujuan

A2=A1 %---Luas Penampang---m2
I2=I1  %--- Moment Inersia
rho2=rho1   %---massa jenis baja (kg/m^3)
[L2,T2]=memf(n2,n4)  %--menghitung L (Panjang) dan T
(transformasi)
k2=klf(E,A2,I2,L2)  %--k lokal
K2=kg(k2,T2)    %--K global
m2=mlf(rho2,A2,L2)
M2=mg(m2,T2)
ID2=[0 0 0 13 3 4]   %-- vektor tujuan

A3=A1 %---Luas Penampang---m2
I3=I1  %--- Moment Inersia
rho3=rho1   %---massa jenis baja (kg/m^3)
[L3,T3]=memf(n3,n4)  %--menghitung L (Panjang) dan T
(transformasi)
k3=klf(E,A3,I3,L3)  %--k lokal
K3=kg(k3,T3)    %--K global
m3=mlf(rho3,A3,L3)
M3=mg(m3,T3)
ID3=[13 1 3 13 3 4]   %-- vektor tujuan

A4=A1 %---Luas Penampang---m2
I4=I1  %--- Moment Inersia
rho4=rho1   %---massa jenis baja (kg/m^3)
[L4,T4]=memf(n3,n5)  %--menghitung L (Panjang) dan T
(transformasi)
k4=klf(E,A4,I4,L4)  %--k lokal
K4=kg(k4,T4)    %--K global
```

```
m4=mlf(rho4,A4,L4)
M4=mg(m4,T4)
ID4=[13 1 3 14 5 6]   %-- vektor tujuan

A5=A1 %---Luas Penampang---m2
I5=I1  %--- Moment Inersia
rho5=rho1   %---massa jenis baja (kg/m^3)
[L5,T5]=memf(n4,n6)  %--menghitung L (Panjang) dan T
(transformasi)
k5=klf(E,A5,I5,L5)  %--k lokal
K5=kg(k5,T5)    %--K global
m5=mlf(rho5,A5,L5)
M5=mg(m5,T5)
ID5=[13 3 4 14 7 8]   %-- vektor tujuan

A6=A1 %---Luas Penampang---m2
I6=I1  %--- Moment Inersia
rho6=rho1   %---massa jenis baja (kg/m^3)
[L6,T6]=memf(n5,n6)  %--menghitung L (Panjang) dan T
(transformasi)
k6=klf(E,A6,I6,L6)  %--k lokal
K6=kg(k6,T6)    %--K global
m6=mlf(rho6,A6,L6)
M6=mg(m6,T6)
ID6=[14 5 6 14 7 8]   %-- vektor tujuan

A7=A1 %---Luas Penampang---m2
I7=I1  %--- Moment Inersia
rho7=rho1   %---massa jenis baja (kg/m^3)
[L7,T7]=memf(n5,n7)  %--menghitung L (Panjang) dan T
(transformasi)
k7=klf(E,A7,I7,L7)  %--k lokal
K7=kg(k7,T7)    %--K global
m7=mlf(rho7,A7,L7)
M7=mg(m7,T7)
ID7=[14 5 6 15 9 10]   %-- vektor tujuan

A8=A1 %---Luas Penampang---m2
I8=I1  %--- Moment Inersia
rho8=rho1   %---massa jenis baja (kg/m^3)
[L8,T8]=memf(n6,n8)  %--menghitung L (Panjang) dan T
(transformasi)
k8=klf(E,A8,I8,L8)  %--k lokal
K8=kg(k8,T8)    %--K global
m8=mlf(rho8,A8,L8)
M8=mg(m8,T8)
ID8=[14 7 8 15 11 12]   %-- vektor tujuan

A9=A1 %---Luas Penampang---m2
I9=I1  %--- Moment Inersia
rho9=rho1   %---massa jenis baja (kg/m^3)
[L9,T9]=memf(n7,n8)  %--menghitung L (Panjang) dan T
(transformasi)
k9=klf(E,A9,I9,L9)  %--k lokal
K9=kg(k9,T9)    %--K global
m9=mlf(rho9,A9,L9)
```

```
M9=mg(m9,T9)
ID9=[15 9 10 15 11 12]   %-- vektor tujuan

%----Degree of freedom
dof=15

K=assf(K1,ID1,dof);
K=K+assf(K2,ID2,dof);
K=K+assf(K3,ID3,dof);
K=K+assf(K4,ID4,dof);
K=K+assf(K5,ID5,dof);
K=K+assf(K6,ID6,dof);
K=K+assf(K7,ID7,dof);
K=K+assf(K8,ID8,dof);
K=K+assf(K9,ID9,dof)

M=assf(M1,ID1,dof);
M=M+assf(M2,ID2,dof);
M=M+assf(M3,ID3,dof);
M=M+assf(M4,ID4,dof);
M=M+assf(M5,ID5,dof);
M=M+assf(M6,ID6,dof);
M=M+assf(M7,ID7,dof);
M=M+assf(M8,ID8,dof);
M=M+assf(M9,ID9,dof)

nc=12 %--- Jumlah Gaya dalam arah selain gaya lateral
nl=3 %--- Jumlah Gaya dalam arah lateral
Klat=kcon(K,nc,nl)
Mlat=mcon(M,nc,nl)

%----frekuensi alami
[eigv,eigval]=eig(Mlat\Klat)
[wo,worder]=sort(sqrt(diag(eigval)))

%----mode shape

for i = 1:3
    mode(:,i)=eigv(:,i)/eigv(1,i)
end
mode1=[mode(3,3);mode(2,3);mode(1,3)]
mode2=[mode(3,2);mode(2,2);mode(1,2)]
mode3=[mode(3,1);mode(2,1);mode(1,1)]

%--matriks redaman c
T1=2*pi/wo(1)   %---waktu getar
T2=2*pi/wo(2)
T3=2*pi/wo(3)

rd=0.02 %--rasio redaman 2%
ak=rd*T1/pi
am=rd*4*pi/T1

Ck=ak*Klat   %--redaman sebanding kekakuan
Cm=am*Mlat     %--redaman sebanding massa
Cr=Ck+Cm    %--redaman Rayleigh
```

```
eo=[-0.2879;-0.6605;-0.2616]

n=size(Klat)
n=n(1)  %--ukuran DOF atau n=2
N=2*n   %--ukuran state vector

%--State space Eq
A=[zeros(n,n) eye(n);-inv(Mlat)*Klat -inv(Mlat)*Cr]
E=[zeros(n,1);inv(Mlat)*eo]

%--Y=X
Cy=eye(N)
Dy=zeros(N,1)

syst1=ss(A,E,Cy,Dy);

%----dikenakan getaran random sebanyak 1000000
t1=0:0.01:10000;
iu1=randn(1,length(t1))';

[y1,t1,z1]=lsim(syst1,iu1,t1);    %%simulasi
%plot(t1,y1)
plot(t1,y1(:,1),'-k')   %% plot perpindahan lantai 1
xlabel('waktu (detik)')
ylabel('Perpindahan (m)')

y1max=(max(abs(y1(:,1))))
%y2max=(max(abs(y1(:,2))))    %%%%---perpindahan max

I0=[1;1;1]
acc3lantai=-[inv(Mlat)*Klat inv(Mlat)*Cr]*z1'-I0*iu1';
    %-[inv(M)*Klat inv(M)*C]*z1'-I0*iu1';

save acc3lantai.mat
```

OUTPUT PARAMETER MODAL – MATLAB
PADA STRUKTUR FRAME

```
>> clear all
>> frame3lantai

n1 =
     0     0

n2 =
    0.5000         0

n3 =
         0    0.3000

n4 =
    0.5000    0.3000

n5 =
         0    0.6000

n6 =
    0.5000    0.6000

n7 =
         0    0.9000

n8 =
    0.5000    0.9000

E =
   200000000

A1 =
   5.0286e-05

I1 =
   2.0114e-10

rho1 =
        7850

L1 =
    0.3000

T1 =
     0     1     0     0     0     0
    -1     0     0     0     0     0
     0     0     1     0     0     0
     0     0     0     0     1     0
     0     0     0    -1     0     0
     0     0     0     0     0     1
```

```
k1 =
   1.0e+04 *

    3.3524         0         0   -3.3524         0         0
         0    0.0018    0.0003         0   -0.0018    0.0003
         0    0.0003    0.0001         0   -0.0003    0.0000
   -3.3524         0         0    3.3524         0         0
         0   -0.0018   -0.0003         0    0.0018   -0.0003
         0    0.0003    0.0000         0   -0.0003    0.0001

K1 =
   1.0e+04 *

    0.0018         0   -0.0003   -0.0018         0   -0.0003
         0    3.3524         0         0   -3.3524         0
   -0.0003         0    0.0001    0.0003         0    0.0000
   -0.0018         0    0.0003    0.0018         0    0.0003
         0   -3.3524         0         0    3.3524         0
   -0.0003         0    0.0000    0.0003         0    0.0001

mm =

  140.0000         0         0   70.0000         0         0
         0  126.0000    6.6000         0   54.0000   -3.9000
         0    6.6000    0.3600         0    3.9000   -0.2700
   70.0000         0         0  140.0000         0         0
         0   54.0000    3.9000         0  156.0000  -22.0000
         0   -3.9000   -0.2700         0  -22.0000    0.3600

m =

    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

m1 =

    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

M =

    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001
```

```
M1 =

    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001


ID1 =
     0     0     0    13     1     2

A2 =
   5.0286e-05

I2 =
   2.0114e-10

rho2 =
        7850
L2 =
    0.3000

T2 =

     0     1     0     0     0     0
    -1     0     0     0     0     0
     0     0     1     0     0     0
     0     0     0     0     1     0
     0     0     0    -1     0     0
     0     0     0     0     0     1

k2 =

   1.0e+04 *

    3.3524         0         0   -3.3524         0         0
         0    0.0018    0.0003         0   -0.0018    0.0003
         0    0.0003    0.0001         0   -0.0003    0.0000
   -3.3524         0         0    3.3524         0         0
         0   -0.0018   -0.0003         0    0.0018   -0.0003
         0    0.0003    0.0000         0   -0.0003    0.0001

K2 =

   1.0e+04 *

    0.0018         0   -0.0003   -0.0018         0   -0.0003
         0    3.3524         0         0   -3.3524         0
   -0.0003         0    0.0001    0.0003         0    0.0000
   -0.0018         0    0.0003    0.0018         0    0.0003
         0   -3.3524         0         0    3.3524         0
   -0.0003         0    0.0000    0.0003         0    0.0001
```

```
mm =

  140.0000         0         0   70.0000         0         0
         0  126.0000    6.6000         0   54.0000   -3.9000
         0    6.6000    0.3600         0    3.9000   -0.2700
   70.0000         0         0  140.0000         0         0
         0   54.0000    3.9000         0  156.0000  -22.0000
         0   -3.9000   -0.2700         0  -22.0000    0.3600


m =

    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

m2 =

    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001
M =

    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

M2 =

    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

ID2 =
     0     0     0    13     3     4

A3 =
   5.0286e-05

I3 =
   2.0114e-10

rho3 =
        7850
```

```
L3 =
    0.5000

T3 =

     1     0     0     0     0     0
     0     1     0     0     0     0
     0     0     1     0     0     0
     0     0     0     1     0     0
     0     0     0     0     1     0
     0     0     0     0     0     1

k3 =
   1.0e+04 *

    2.0114         0         0   -2.0114         0         0
         0    0.0004    0.0001         0   -0.0004    0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
   -2.0114         0         0    2.0114         0         0
         0   -0.0004   -0.0001         0    0.0004   -0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000

K3 =
   1.0e+04 *

    2.0114         0         0   -2.0114         0         0
         0    0.0004    0.0001         0   -0.0004    0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
   -2.0114         0         0    2.0114         0         0
         0   -0.0004   -0.0001         0    0.0004   -0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000

mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000   11.0000         0   54.0000   -6.5000
         0   11.0000    1.0000         0    6.5000   -0.7500
   70.0000         0         0  140.0000         0         0
         0   54.0000    6.5000         0  156.0000  -22.0000
         0   -6.5000   -0.7500         0  -22.0000    1.0000

m =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

m3 =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005
```

```
M =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

M3 =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

ID3 =
    13     1     3    13     3     4

A4 =
   5.0286e-05

I4 =
   2.0114e-10

rho4 =
        7850
L4 =
    0.3000

T4 =
     0     1     0     0     0     0
    -1     0     0     0     0     0
     0     0     1     0     0     0
     0     0     0     0     1     0
     0     0     0    -1     0     0
     0     0     0     0     0     1

k4 =
   1.0e+04 *
    3.3524         0         0   -3.3524         0         0
         0    0.0018    0.0003         0   -0.0018    0.0003
         0    0.0003    0.0001         0   -0.0003    0.0000
   -3.3524         0         0    3.3524         0         0
         0   -0.0018   -0.0003         0    0.0018   -0.0003
         0    0.0003    0.0000         0   -0.0003    0.0001

K4 =
   1.0e+04 *
    0.0018         0   -0.0003   -0.0018         0   -0.0003
         0    3.3524         0         0   -3.3524         0
   -0.0003         0    0.0001    0.0003         0    0.0000
   -0.0018         0    0.0003    0.0018         0    0.0003
         0   -3.3524         0         0    3.3524         0
   -0.0003         0    0.0000    0.0003         0    0.0001
```

```
mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000    6.6000         0   54.0000   -3.9000
         0    6.6000    0.3600         0    3.9000   -0.2700
   70.0000         0         0  140.0000         0         0
         0   54.0000    3.9000         0  156.0000  -22.0000
         0   -3.9000   -0.2700         0  -22.0000    0.3600


m =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

m4 =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

M =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

M4 =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

ID4 =
    13     1     3    14     5     6

A5 =
   5.0286e-05

I5 =
   2.0114e-10

rho5 =
        7850

L5 =
    0.3000
```

```
T5 =
     0     1     0     0     0     0
    -1     0     0     0     0     0
     0     0     1     0     0     0
     0     0     0     0     1     0
     0     0     0    -1     0     0
     0     0     0     0     0     1

k5 =
   1.0e+04 *
    3.3524         0         0   -3.3524         0         0
         0    0.0018    0.0003         0   -0.0018    0.0003
         0    0.0003    0.0001         0   -0.0003    0.0000
   -3.3524         0         0    3.3524         0         0
         0   -0.0018   -0.0003         0    0.0018   -0.0003
         0    0.0003    0.0000         0   -0.0003    0.0001

K5 =
   1.0e+04 *
    0.0018         0   -0.0003   -0.0018         0   -0.0003
         0    3.3524         0         0   -3.3524         0
   -0.0003         0    0.0001    0.0003         0    0.0000
   -0.0018         0    0.0003    0.0018         0    0.0003
         0   -3.3524         0         0    3.3524         0
   -0.0003         0    0.0000    0.0003         0    0.0001

mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000    6.6000         0   54.0000   -3.9000
         0    6.6000    0.3600         0    3.9000   -0.2700
   70.0000         0         0  140.0000         0         0
         0   54.0000    3.9000         0  156.0000  -22.0000
         0   -3.9000   -0.2700         0  -22.0000    0.3600

m =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

m5 =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001
M =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001
```

```
M5 =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

ID5 =
    13     3     4    14     7     8

A6 =
   5.0286e-05

I6 =
   2.0114e-10

rho6 =
     7850

L6 =
    0.5000

T6 =
     1     0     0     0     0     0
     0     1     0     0     0     0
     0     0     1     0     0     0
     0     0     0     1     0     0
     0     0     0     0     1     0
     0     0     0     0     0     1

k6 =
   1.0e+04 *
    2.0114         0         0   -2.0114         0         0
         0    0.0004    0.0001         0   -0.0004    0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
   -2.0114         0         0    2.0114         0         0
         0   -0.0004   -0.0001         0    0.0004   -0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000

K6 =
   1.0e+04 *
    2.0114         0         0   -2.0114         0         0
         0    0.0004    0.0001         0   -0.0004    0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
   -2.0114         0         0    2.0114         0         0
         0   -0.0004   -0.0001         0    0.0004   -0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000

mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000   11.0000         0   54.0000   -6.5000
         0   11.0000    1.0000         0    6.5000   -0.7500
   70.0000         0         0  140.0000         0         0
         0   54.0000    6.5000         0  156.0000  -22.0000
         0   -6.5000   -0.7500         0  -22.0000    1.0000
```

```
m =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

m6 =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

M =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

M6 =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

ID6 =
    14     5     6    14     7     8

A7 =
   5.0286e-05

I7 =
   2.0114e-10

rho7 =
        7850

L7 =
    0.3000

T7 =
     0     1     0     0     0     0
    -1     0     0     0     0     0
     0     0     1     0     0     0
     0     0     0     0     1     0
     0     0     0    -1     0     0
     0     0     0     0     0     1
```

```
k7 =
   1.0e+04 *
    3.3524         0         0   -3.3524         0         0
         0    0.0018    0.0003         0   -0.0018    0.0003
         0    0.0003    0.0001         0   -0.0003    0.0000
   -3.3524         0         0    3.3524         0         0
         0   -0.0018   -0.0003         0    0.0018   -0.0003
         0    0.0003    0.0000         0   -0.0003    0.0001

K7 =
   1.0e+04 *
    0.0018         0   -0.0003   -0.0018         0   -0.0003
         0    3.3524         0         0   -3.3524         0
   -0.0003         0    0.0001    0.0003         0    0.0000
   -0.0018         0    0.0003    0.0018         0    0.0003
         0   -3.3524         0         0    3.3524         0
   -0.0003         0    0.0000    0.0003         0    0.0001

mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000    6.6000         0   54.0000   -3.9000
         0    6.6000    0.3600         0    3.9000   -0.2700
   70.0000         0         0  140.0000         0         0
         0   54.0000    3.9000         0  156.0000  -22.0000
         0   -3.9000   -0.2700         0  -22.0000    0.3600
m =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

m7 =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001

M =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

M7 =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001
```

```
ID7 =
    14     5     6    15     9    10
A8 =
   5.0286e-05
I8 =
   2.0114e-10
rho8 =
        7850
L8 =
    0.3000
T8 =
     0     1     0     0     0     0
    -1     0     0     0     0     0
     0     0     1     0     0     0
     0     0     0     0     1     0
     0     0     0    -1     0     0
     0     0     0     0     0     1

k8 =
   1.0e+04 *
    3.3524         0         0   -3.3524         0         0
         0    0.0018    0.0003         0   -0.0018    0.0003
         0    0.0003    0.0001         0   -0.0003    0.0000
   -3.3524         0         0    3.3524         0         0
         0   -0.0018   -0.0003         0    0.0018   -0.0003
         0    0.0003    0.0000         0   -0.0003    0.0001

K8 =
   1.0e+04 *
    0.0018         0   -0.0003   -0.0018         0   -0.0003
         0    3.3524         0         0   -3.3524         0
   -0.0003         0    0.0001    0.0003         0    0.0000
   -0.0018         0    0.0003    0.0018         0    0.0003
         0   -3.3524         0         0    3.3524         0
   -0.0003         0    0.0000    0.0003         0    0.0001

mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000    6.6000         0   54.0000   -3.9000
         0    6.6000    0.3600         0    3.9000   -0.2700
   70.0000         0         0  140.0000         0         0
         0   54.0000    3.9000         0  156.0000  -22.0000
         0   -3.9000   -0.2700         0  -22.0000    0.3600
m =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001
m8 =
    0.0395         0         0    0.0197         0         0
         0    0.0355    0.0019         0    0.0152   -0.0011
         0    0.0019    0.0001         0    0.0011   -0.0001
    0.0197         0         0    0.0395         0         0
         0    0.0152    0.0011         0    0.0440   -0.0062
         0   -0.0011   -0.0001         0   -0.0062    0.0001
```

```
M =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

M8 =
    0.0355         0   -0.0019    0.0152         0    0.0011
         0    0.0395         0         0    0.0197         0
   -0.0019         0    0.0001   -0.0011         0   -0.0001
    0.0152         0   -0.0011    0.0440         0    0.0062
         0    0.0197         0         0    0.0395         0
    0.0011         0   -0.0001    0.0062         0    0.0001

ID8 =
    14     7     8    15    11    12
A9 =
   5.0286e-05
I9 =
   2.0114e-10
rho9 =
        7850
L9 =
    0.5000
T9 =
     1     0     0     0     0     0
     0     1     0     0     0     0
     0     0     1     0     0     0
     0     0     0     1     0     0
     0     0     0     0     1     0
     0     0     0     0     0     1
k9 =
   1.0e+04 *
    2.0114         0         0   -2.0114         0         0
         0    0.0004    0.0001         0   -0.0004    0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
   -2.0114         0         0    2.0114         0         0
         0   -0.0004   -0.0001         0    0.0004   -0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
K9 =
   1.0e+04 *
    2.0114         0         0   -2.0114         0         0
         0    0.0004    0.0001         0   -0.0004    0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
   -2.0114         0         0    2.0114         0         0
         0   -0.0004   -0.0001         0    0.0004   -0.0001
         0    0.0001    0.0000         0   -0.0001    0.0000
mm =
  140.0000         0         0   70.0000         0         0
         0  126.0000   11.0000         0   54.0000   -6.5000
         0   11.0000    1.0000         0    6.5000   -0.7500
   70.0000         0         0  140.0000         0         0
         0   54.0000    6.5000         0  156.0000  -22.0000
         0   -6.5000   -0.7500         0  -22.0000    1.0000
```

```
m =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

m9 =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

M =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

M9 =
    0.0658         0         0    0.0329         0         0
         0    0.0592    0.0052         0    0.0254   -0.0031
         0    0.0052    0.0005         0    0.0031   -0.0004
    0.0329         0         0    0.0658         0         0
         0    0.0254    0.0031         0    0.0733   -0.0103
         0   -0.0031   -0.0004         0   -0.0103    0.0005

ID9 =
    15     9    10    15    11    12
dof =
    15
K =
   1.0e+04 *
 Columns 1 through 8

    6.7051         0   -0.0003    0.0001   -3.3524         0         0         0
         0    0.0001         0         0         0         0         0         0
   -0.0003         0    6.7050   -0.0001         0    0.0000   -3.3524         0
    0.0001         0   -0.0001    0.0001         0         0         0    0.0000
   -3.3524         0         0         0    6.7051    0.0001   -0.0004    0.0001
         0         0    0.0000         0    0.0001    0.0001   -0.0001    0.0000
         0         0   -3.3524         0   -0.0004   -0.0001    6.7051   -0.0001
         0         0         0    0.0000    0.0001    0.0000   -0.0001    0.0001
         0         0         0         0   -3.3524         0         0         0
         0         0         0         0         0    0.0000         0         0
         0         0         0         0         0         0   -3.3524         0
         0         0         0         0         0         0         0    0.0000
         0    0.0003   -0.0003         0         0   -0.0003         0   -0.0003
         0         0    0.0003    0.0003         0    0.0000         0    0.0000
         0         0         0         0         0    0.0003         0    0.0003
```

```
Columns 9 through 15
         0         0         0         0         0         0         0
         0         0         0         0    0.0003         0         0
         0         0         0         0   -0.0003    0.0003         0
         0         0         0         0         0    0.0003         0
   -3.3524         0         0         0         0         0         0
         0    0.0000         0         0   -0.0003    0.0000    0.0003
         0         0   -3.3524         0         0         0         0
         0         0         0    0.0000   -0.0003    0.0000    0.0003
    3.3528    0.0001   -0.0004    0.0001         0         0         0
    0.0001    0.0001   -0.0001    0.0000         0   -0.0003    0.0003
   -0.0004   -0.0001    3.3528   -0.0001         0         0         0
    0.0001    0.0000   -0.0001    0.0001         0   -0.0003    0.0003
         0         0         0         0    0.0072   -0.0036         0
         0   -0.0003         0   -0.0003   -0.0036    0.0072   -0.0036
         0    0.0003         0    0.0003         0   -0.0036    0.0036

M =
  Columns 1 through 8
    0.1382         0    0.0305   -0.0031    0.0197         0         0         0
         0    0.0001         0         0         0         0         0         0
    0.0305         0    0.1589   -0.0107         0   -0.0001    0.0197         0
   -0.0031         0   -0.0107    0.0007         0         0         0   -0.0001
    0.0197         0         0         0    0.1382    0.0052    0.0254   -0.0031
         0         0   -0.0001         0    0.0052    0.0007    0.0031   -0.0004
         0         0    0.0197         0    0.0254    0.0031    0.1523   -0.0103
         0         0         0   -0.0001   -0.0031   -0.0004   -0.0103    0.0007
         0         0         0         0    0.0197         0         0         0
         0         0         0         0         0   -0.0001         0         0
         0         0         0         0         0         0    0.0197         0
         0         0         0         0         0         0         0   -0.0001
         0    0.0062   -0.0019    0.0043         0    0.0011         0    0.0011
         0         0   -0.0011   -0.0011         0    0.0043         0    0.0043
         0         0         0         0         0   -0.0011         0   -0.0011

  Columns 9 through 15
         0         0         0         0         0         0         0
         0         0         0         0    0.0062         0         0
         0         0         0         0   -0.0019   -0.0011         0
         0         0         0         0    0.0043   -0.0011         0
    0.0197         0         0         0         0         0         0
         0   -0.0001         0         0    0.0011    0.0043   -0.0011
         0         0    0.0197         0         0         0         0
         0         0         0   -0.0001    0.0011    0.0043   -0.0011
    0.0987    0.0052    0.0254   -0.0031         0         0         0
    0.0052    0.0006    0.0031   -0.0004         0    0.0011    0.0062
    0.0254    0.0031    0.1128   -0.0103         0         0         0
   -0.0031   -0.0004   -0.0103    0.0006         0    0.0011    0.0062
         0         0         0         0    0.3564    0.0305         0
         0    0.0011         0    0.0011    0.0305    0.3564    0.0305
         0    0.0062         0    0.0062         0    0.0305    0.2853
nc =
    12
nl =
     3
Klat =
   48.2439  -34.1344    7.2695
  -34.1344   51.8534  -22.8368
    7.2695  -22.8368   16.2819
Mlat =
    0.2879    0.0692   -0.0192
    0.0692    0.6605    0.0482
   -0.0192    0.0482    0.2616
eigv =
   -0.7979    0.5680    0.3120
    0.4214    0.2401    0.5824
   -0.4309   -0.7873    0.7506
```

```
eigval =
  291.2563         0         0
         0   69.0429         0
         0         0    5.4421
wo =
    2.3328
    8.3092
   17.0662
worder =
     3
     2
     1
mode =
    1.0000
   -0.5281
    0.5401
mode =
    1.0000    1.0000
   -0.5281    0.4227
    0.5401   -1.3861
mode =
    1.0000    1.0000    1.0000
   -0.5281    0.4227    1.8665
    0.5401   -1.3861    2.4054
mode1 =
    2.4054
    1.8665
    1.0000
mode2 =
   -1.3861
    0.4227
    1.0000
mode3 =
    0.5401
   -0.5281
    1.0000
T1 =
    2.6934
T2 =
    0.7562
T3 =
    0.3682
rd =
    0.0200
ak =
    0.0171
am =
    0.0933
Ck =
    0.8272   -0.5853    0.1246
   -0.5853    0.8891   -0.3916
    0.1246   -0.3916    0.2792
Cm =
    0.0269    0.0065   -0.0018
    0.0065    0.0616    0.0045
   -0.0018    0.0045    0.0244
```

```
Cr =
    0.8541   -0.5788    0.1229
   -0.5788    0.9507   -0.3871
    0.1229   -0.3871    0.3036
eo =
   -0.2879
   -0.6605
   -0.2616
n =
     3     3
n =
     3
N =
     6
A =
         0         0         0    1.0000         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    1.0000
 -189.4301  151.1184  -40.7719   -3.3414    2.5912   -0.6991
   75.5915 -102.9121   44.2068    1.2961   -1.8579    0.7580
  -55.6580  117.3980  -73.3991   -0.9543    2.0130   -1.3519
E =
         0
         0
         0
   -0.8576
   -0.8438
   -0.9075
Cy =
     1     0     0     0     0     0
     0     1     0     0     0     0
     0     0     1     0     0     0
     0     0     0     1     0     0
     0     0     0     0     1     0
     0     0     0     0     0     1
Dy =
     0
     0
     0
     0
     0
     0
y1max =
    0.1455
I0 =
     1
     1
     1

>>
```

LAMPIRAN 2
INPUT DAN OUTPUT – MATLAB
PADA STRUKTUR KANTILEVER
(METODE SIMULASI NUMERIK)

INPUT DATA MATLAB
PADA STRUKTUR KANTILEVER

```
K=[0.965485714]
M=[0.197408]
eo=[-0.197408]
n=size(K)
n=n(1)  %--ukuran DOF atau n=1
N=2*n   %--ukuran state vector

[eigv,eigval]=eig(M\K)
[wo,worder]=sort(sqrt(diag(eigval)))
for i = 1:1
    mode(:,i)=eigv(:,i)/eigv(1,i)
end
mode1=[mode(1,1)]

%--matriks redaman c
T1=2*pi/wo(1)   %---waktu getar

rd=0.02 %--rasio redaman 2%
ak=rd*T1/pi
am=rd*4*pi/T1

Ck=ak*K   %--redaman sebanding kekakuan
Cm=am*M     %--redaman sebanding massa
Cr=Ck+Cm    %--redaman Rayleigh

%--State space Eq
A=[zeros(n,n) eye(n);-inv(M)*K -inv(M)*Cr]
E=[zeros(n,1);inv(M)*eo]

%--Y=X
Cy=eye(N)
Dy=zeros(N,1)

syst1=ss(A,E,Cy,Dy);

t1=0:0.01:100;
iu1=randn(1,length(t1))';

[y1,t1,z1]=lsim(syst1,iu1,t1);    %%simulasi

I0=[1]
acc_minkantilever=-[inv(M)*K inv(M)*Cr]*z1'-I0*iu1';

save acc_minkantilever.mat
```

OUTPUT PARAMETER MODAL – MATLAB
PADA STRUKTUR KANTILEVER

```
K =
    0.9655
M =
    0.1974
eo =
   -0.1974
n =
     1     1
n =
     1
N =
     2
eigv =
     1
eigval =
    4.8908
wo =
    2.2115
worder =
     1
mode =
     1
mode1 =
     1
T1 =
    2.8411
rd =
    0.0200
ak =
    0.0181
am =
    0.0885
Ck =
    0.0175
Cm =
    0.0175
Cr =
    0.0349
A =
         0    1.0000
   -4.8908   -0.1769
E =
     0
    -1
Cy =
     1     0
     0     1
Dy =
     0
     0
I0 =
     1
>>
```

LAMPIRAN 3
OUTPUT – METODE FDD
PADA STRUKTUR FRAME

OUTPUT PARAMETER MODAL – METODE FDD PADA STRUKTUR FRAME

```
NFFT =
        1024
>> freq
freq =
  Columns 1 through 8
         0    0.6136    1.2272    1.8408    2.4544    3.0680    3.6816    4.2951
  Columns 9 through 16
    4.9087    5.5223    6.1359    6.7495    7.3631    7.9767    8.5903    9.2039
  Columns 17 through 24
    9.8175   10.4311   11.0447   11.6583   12.2718   12.8854   13.4990   14.1126
  Columns 25 through 32
   14.7262   15.3398   15.9534   16.5670   17.1806   17.7942   18.4078   19.0214
  Columns 33 through 40
   19.6350   20.2485   20.8621   21.4757   22.0893   22.7029   23.3165   23.9301
  Columns 41 through 48
   24.5437   25.1573   25.7709   26.3845   26.9981   27.6117   28.2252   28.8388
  Columns 49 through 56
   29.4524   30.0660   30.6796   31.2932   31.9068   32.5204   33.1340   33.7476
  Columns 57 through 64
   34.3612   34.9748   35.5884   36.2019   36.8155   37.4291   38.0427   38.6563
  Columns 65 through 72
   39.2699   39.8835   40.4971   41.1107   41.7243   42.3379   42.9515   43.5651
  Columns 73 through 80
   44.1786   44.7922   45.4058   46.0194   46.6330   47.2466   47.8602   48.4738
  Columns 81 through 88
   49.0874   49.7010   50.3146   50.9282   51.5418   52.1553   52.7689   53.3825
  Columns 89 through 96
   53.9961   54.6097   55.2233   55.8369   56.4505   57.0641   57.6777   58.2913
  Columns 97 through 104
   58.9049   59.5185   60.1320   60.7456   61.3592   61.9728   62.5864   63.2000
  Columns 105 through 112
   63.8136   64.4272   65.0408   65.6544   66.2680   66.8816   67.4952   68.1087
  Columns 113 through 120
   68.7223   69.3359   69.9495   70.5631   71.1767   71.7903   72.4039   73.0175
  Columns 121 through 128
   73.6311   74.2447   74.8583   75.4719   76.0854   76.6990   77.3126   77.9262
  Columns 129 through 136
   78.5398   79.1534   79.7670   80.3806   80.9942   81.6078   82.2214   82.8350
  Columns 137 through 144
   83.4486   84.0621   84.6757   85.2893   85.9029   86.5165   87.1301   87.7437
  Columns 145 through 152
   88.3573   88.9709   89.5845   90.1981   90.8117   91.4253   92.0388   92.6524
  Columns 153 through 160
   93.2660   93.8796   94.4932   95.1068   95.7204   96.3340   96.9476   97.5612
  Columns 161 through 168
   98.1748   98.7884   99.4020  100.0155  100.6291  101.2427  101.8563  102.4699
  Columns 169 through 176
  103.0835  103.6971  104.3107  104.9243  105.5379  106.1515  106.7651  107.3787
  Columns 177 through 184
  107.9922  108.6058  109.2194  109.8330  110.4466  111.0602  111.6738  112.2874
  Columns 185 through 192
  112.9010  113.5146  114.1282  114.7418  115.3554  115.9689  116.5825  117.1961
  Columns 193 through 200
  117.8097  118.4233  119.0369  119.6505  120.2641  120.8777  121.4913  122.1049
  Columns 201 through 208
  122.7185  123.3321  123.9456  124.5592  125.1728  125.7864  126.4000  127.0136
  Columns 209 through 216
  127.6272  128.2408  128.8544  129.4680  130.0816  130.6952  131.3088  131.9223
  Columns 217 through 224
  132.5359  133.1495  133.7631  134.3767  134.9903  135.6039  136.2175  136.8311
  Columns 225 through 232
  137.4447  138.0583  138.6719  139.2855  139.8990  140.5126  141.1262  141.7398
  Columns 233 through 240
  142.3534  142.9670  143.5806  144.1942  144.8078  145.4214  146.0350  146.6486
```

```
  Columns 241 through 248
  147.2622  147.8757  148.4893  149.1029  149.7165  150.3301  150.9437  151.5573
  Columns 249 through 256
  152.1709  152.7845  153.3981  154.0117  154.6253  155.2389  155.8524  156.4660
  Columns 257 through 264
  157.0796  157.6932  158.3068  158.9204  159.5340  160.1476  160.7612  161.3748
  Columns 265 through 272
  161.9884  162.6020  163.2156  163.8291  164.4427  165.0563  165.6699  166.2835
  Columns 273 through 280
  166.8971  167.5107  168.1243  168.7379  169.3515  169.9651  170.5787  171.1923
  Columns 281 through 288
  171.8058  172.4194  173.0330  173.6466  174.2602  174.8738  175.4874  176.1010
  Columns 289 through 296
  176.7146  177.3282  177.9418  178.5554  179.1690  179.7825  180.3961  181.0097
  Columns 297 through 304
  181.6233  182.2369  182.8505  183.4641  184.0777  184.6913  185.3049  185.9185
  Columns 305 through 312
  186.5321  187.1457  187.7592  188.3728  188.9864  189.6000  190.2136  190.8272
  Columns 313 through 320
  191.4408  192.0544  192.6680  193.2816  193.8952  194.5088  195.1224  195.7359
  Columns 321 through 328
  196.3495  196.9631  197.5767  198.1903  198.8039  199.4175  200.0311  200.6447
  Columns 329 through 336
  201.2583  201.8719  202.4855  203.0991  203.7126  204.3262  204.9398  205.5534
  Columns 337 through 344
  206.1670  206.7806  207.3942  208.0078  208.6214  209.2350  209.8486  210.4622
  Columns 345 through 352
  211.0758  211.6893  212.3029  212.9165  213.5301  214.1437  214.7573  215.3709
  Columns 353 through 360
  215.9845  216.5981  217.2117  217.8253  218.4389  219.0525  219.6660  220.2796
  Columns 361 through 368
  220.8932  221.5068  222.1204  222.7340  223.3476  223.9612  224.5748  225.1884
  Columns 369 through 376
  225.8020  226.4156  227.0292  227.6427  228.2563  228.8699  229.4835  230.0971
  Columns 377 through 384
  230.7107  231.3243  231.9379  232.5515  233.1651  233.7787  234.3923  235.0059
  Columns 385 through 392
  235.6194  236.2330  236.8466  237.4602  238.0738  238.6874  239.3010  239.9146
  Columns 393 through 400
  240.5282  241.1418  241.7554  242.3690  242.9826  243.5961  244.2097  244.8233
  Columns 401 through 408
  245.4369  246.0505  246.6641  247.2777  247.8913  248.5049  249.1185  249.7321
  Columns 409 through 416
  250.3457  250.9593  251.5728  252.1864  252.8000  253.4136  254.0272  254.6408
  Columns 417 through 424
  255.2544  255.8680  256.4816  257.0952  257.7088  258.3224  258.9360  259.5495
  Columns 425 through 432
  260.1631  260.7767  261.3903  262.0039  262.6175  263.2311  263.8447  264.4583
  Columns 433 through 440
  265.0719  265.6855  266.2991  266.9127  267.5262  268.1398  268.7534  269.3670
  Columns 441 through 448
  269.9806  270.5942  271.2078  271.8214  272.4350  273.0486  273.6622  274.2758
  Columns 449 through 456
  274.8894  275.5029  276.1165  276.7301  277.3437  277.9573  278.5709  279.1845
  Columns 457 through 464
  279.7981  280.4117  281.0253  281.6389  282.2525  282.8661  283.4796  284.0932
  Columns 465 through 472
  284.7068  285.3204  285.9340  286.5476  287.1612  287.7748  288.3884  289.0020
  Columns 473 through 480
  289.6156  290.2292  290.8428  291.4563  292.0699  292.6835  293.2971  293.9107
  Columns 481 through 488
  294.5243  295.1379  295.7515  296.3651  296.9787  297.5923  298.2059  298.8195
  Columns 489 through 496
  299.4330  300.0466  300.6602  301.2738  301.8874  302.5010  303.1146  303.7282
  Columns 497 through 504
  304.3418  304.9554  305.5690  306.1826  306.7962  307.4097  308.0233  308.6369
  Columns 505 through 512
  309.2505  309.8641  310.4777  311.0913  311.7049  312.3185  312.9321  313.5457
  Column 513
  314.1593
>>
```

LAMPIRAN 4
OUTPUT – METODE FDD
PADA STRUKTUR KANTILEVER

OUTPUT PARAMETER MODAL – METODE FDD PADA STRUKTUR CANTILEVER

```
NFFT =
        2048
>> freq
freq =
  Columns 1 through 8
         0    0.3068    0.6136    0.9204    1.2272    1.5340    1.8408    2.1476
  Columns 9 through 16
    2.4544    2.7612    3.0680    3.3748    3.6816    3.9884    4.2951    4.6019
  Columns 17 through 24
    4.9087    5.2155    5.5223    5.8291    6.1359    6.4427    6.7495    7.0563
  Columns 25 through 32
    7.3631    7.6699    7.9767    8.2835    8.5903    8.8971    9.2039    9.5107
  Columns 33 through 40
    9.8175   10.1243   10.4311   10.7379   11.0447   11.3515   11.6583   11.9651
  Columns 41 through 48
   12.2718   12.5786   12.8854   13.1922   13.4990   13.8058   14.1126   14.4194
  Columns 49 through 56
   14.7262   15.0330   15.3398   15.6466   15.9534   16.2602   16.5670   16.8738
  Columns 57 through 64
   17.1806   17.4874   17.7942   18.1010   18.4078   18.7146   19.0214   19.3282
  Columns 65 through 72
   19.6350   19.9418   20.2485   20.5553   20.8621   21.1689   21.4757   21.7825
  Columns 73 through 80
   22.0893   22.3961   22.7029   23.0097   23.3165   23.6233   23.9301   24.2369
  Columns 81 through 88
   24.5437   24.8505   25.1573   25.4641   25.7709   26.0777   26.3845   26.6913
  Columns 89 through 96
   26.9981   27.3049   27.6117   27.9185   28.2252   28.5320   28.8388   29.1456
  Columns 97 through 104
   29.4524   29.7592   30.0660   30.3728   30.6796   30.9864   31.2932   31.6000
  Columns 105 through 112
   31.9068   32.2136   32.5204   32.8272   33.1340   33.4408   33.7476   34.0544
  Columns 113 through 120
   34.3612   34.6680   34.9748   35.2816   35.5884   35.8952   36.2019   36.5087
  Columns 121 through 128
   36.8155   37.1223   37.4291   37.7359   38.0427   38.3495   38.6563   38.9631
  Columns 129 through 136
   39.2699   39.5767   39.8835   40.1903   40.4971   40.8039   41.1107   41.4175
  Columns 137 through 144
   41.7243   42.0311   42.3379   42.6447   42.9515   43.2583   43.5651   43.8719
  Columns 145 through 152
   44.1786   44.4854   44.7922   45.0990   45.4058   45.7126   46.0194   46.3262
  Columns 153 through 160
   46.6330   46.9398   47.2466   47.5534   47.8602   48.1670   48.4738   48.7806
  Columns 161 through 168
   49.0874   49.3942   49.7010   50.0078   50.3146   50.6214   50.9282   51.2350
  Columns 169 through 176
   51.5418   51.8486   52.1553   52.4621   52.7689   53.0757   53.3825   53.6893
  Columns 177 through 184
   53.9961   54.3029   54.6097   54.9165   55.2233   55.5301   55.8369   56.1437
  Columns 185 through 192
   56.4505   56.7573   57.0641   57.3709   57.6777   57.9845   58.2913   58.5981
  Columns 193 through 200
   58.9049   59.2117   59.5185   59.8253   60.1320   60.4388   60.7456   61.0524
  Columns 201 through 208
   61.3592   61.6660   61.9728   62.2796   62.5864   62.8932   63.2000   63.5068
  Columns 209 through 216
   63.8136   64.1204   64.4272   64.7340   65.0408   65.3476   65.6544   65.9612
  Columns 217 through 224
   66.2680   66.5748   66.8816   67.1884   67.4952   67.8020   68.1087   68.4155
  Columns 225 through 232
   68.7223   69.0291   69.3359   69.6427   69.9495   70.2563   70.5631   70.8699
  Columns 233 through 240
   71.1767   71.4835   71.7903   72.0971   72.4039   72.7107   73.0175   73.3243
```

```
Columns 241 through 248
 73.6311   73.9379   74.2447   74.5515   74.8583   75.1651   75.4719   75.7787
Columns 249 through 256
 76.0854   76.3922   76.6990   77.0058   77.3126   77.6194   77.9262   78.2330
Columns 257 through 264
 78.5398   78.8466   79.1534   79.4602   79.7670   80.0738   80.3806   80.6874
Columns 265 through 272
 80.9942   81.3010   81.6078   81.9146   82.2214   82.5282   82.8350   83.1418
Columns 273 through 280
 83.4486   83.7554   84.0621   84.3689   84.6757   84.9825   85.2893   85.5961
Columns 281 through 288
 85.9029   86.2097   86.5165   86.8233   87.1301   87.4369   87.7437   88.0505
Columns 289 through 296
 88.3573   88.6641   88.9709   89.2777   89.5845   89.8913   90.1981   90.5049
Columns 297 through 304
 90.8117   91.1185   91.4253   91.7321   92.0388   92.3456   92.6524   92.9592
Columns 305 through 312
 93.2660   93.5728   93.8796   94.1864   94.4932   94.8000   95.1068   95.4136
Columns 313 through 320
 95.7204   96.0272   96.3340   96.6408   96.9476   97.2544   97.5612   97.8680
Columns 321 through 328
 98.1748   98.4816   98.7884   99.0952   99.4020   99.7088  100.0155  100.3223
Columns 329 through 336
100.6291  100.9359  101.2427  101.5495  101.8563  102.1631  102.4699  102.7767
Columns 337 through 344
103.0835  103.3903  103.6971  104.0039  104.3107  104.6175  104.9243  105.2311
Columns 345 through 352
105.5379  105.8447  106.1515  106.4583  106.7651  107.0719  107.3787  107.6855
Columns 353 through 360
107.9922  108.2990  108.6058  108.9126  109.2194  109.5262  109.8330  110.1398
Columns 361 through 368
110.4466  110.7534  111.0602  111.3670  111.6738  111.9806  112.2874  112.5942
Columns 369 through 376
112.9010  113.2078  113.5146  113.8214  114.1282  114.4350  114.7418  115.0486
Columns 377 through 384
115.3554  115.6622  115.9689  116.2757  116.5825  116.8893  117.1961  117.5029
Columns 385 through 392
117.8097  118.1165  118.4233  118.7301  119.0369  119.3437  119.6505  119.9573
Columns 393 through 400
120.2641  120.5709  120.8777  121.1845  121.4913  121.7981  122.1049  122.4117
Columns 401 through 408
122.7185  123.0253  123.3321  123.6389  123.9456  124.2524  124.5592  124.8660
Columns 409 through 416
125.1728  125.4796  125.7864  126.0932  126.4000  126.7068  127.0136  127.3204
Columns 417 through 424
127.6272  127.9340  128.2408  128.5476  128.8544  129.1612  129.4680  129.7748
Columns 425 through 432
130.0816  130.3884  130.6952  131.0020  131.3088  131.6156  131.9223  132.2291
Columns 433 through 440
132.5359  132.8427  133.1495  133.4563  133.7631  134.0699  134.3767  134.6835
Columns 441 through 448
134.9903  135.2971  135.6039  135.9107  136.2175  136.5243  136.8311  137.1379
Columns 449 through 456
137.4447  137.7515  138.0583  138.3651  138.6719  138.9787  139.2855  139.5923
Columns 457 through 464
139.8990  140.2058  140.5126  140.8194  141.1262  141.4330  141.7398  142.0466
Columns 465 through 472
142.3534  142.6602  142.9670  143.2738  143.5806  143.8874  144.1942  144.5010
Columns 473 through 480
144.8078  145.1146  145.4214  145.7282  146.0350  146.3418  146.6486  146.9554
Columns 481 through 488
147.2622  147.5690  147.8757  148.1825  148.4893  148.7961  149.1029  149.4097
Columns 489 through 496
149.7165  150.0233  150.3301  150.6369  150.9437  151.2505  151.5573  151.8641
Columns 497 through 504
152.1709  152.4777  152.7845  153.0913  153.3981  153.7049  154.0117  154.3185
Columns 505 through 512
154.6253  154.9321  155.2389  155.5457  155.8524  156.1592  156.4660  156.7728
Columns 513 through 520
157.0796  157.3864  157.6932  158.0000  158.3068  158.6136  158.9204  159.2272
Columns 521 through 528
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159.5340  159.8408  160.1476  160.4544  160.7612  161.0680  161.3748  161.6816
Columns 529 through 536
161.9884  162.2952  162.6020  162.9088  163.2156  163.5224  163.8291  164.1359
Columns 537 through 544
164.4427  164.7495  165.0563  165.3631  165.6699  165.9767  166.2835  166.5903
Columns 545 through 552
166.8971  167.2039  167.5107  167.8175  168.1243  168.4311  168.7379  169.0447
Columns 553 through 560
169.3515  169.6583  169.9651  170.2719  170.5787  170.8855  171.1923  171.4991
Columns 561 through 568
171.8058  172.1126  172.4194  172.7262  173.0330  173.3398  173.6466  173.9534
Columns 569 through 576
174.2602  174.5670  174.8738  175.1806  175.4874  175.7942  176.1010  176.4078
Columns 577 through 584
176.7146  177.0214  177.3282  177.6350  177.9418  178.2486  178.5554  178.8622
Columns 585 through 592
179.1690  179.4758  179.7825  180.0893  180.3961  180.7029  181.0097  181.3165
Columns 593 through 600
181.6233  181.9301  182.2369  182.5437  182.8505  183.1573  183.4641  183.7709
Columns 601 through 608
184.0777  184.3845  184.6913  184.9981  185.3049  185.6117  185.9185  186.2253
Columns 609 through 616
186.5321  186.8389  187.1457  187.4525  187.7592  188.0660  188.3728  188.6796
Columns 617 through 624
188.9864  189.2932  189.6000  189.9068  190.2136  190.5204  190.8272  191.1340
Columns 625 through 632
191.4408  191.7476  192.0544  192.3612  192.6680  192.9748  193.2816  193.5884
Columns 633 through 640
193.8952  194.2020  194.5088  194.8156  195.1224  195.4292  195.7359  196.0427
Columns 641 through 648
196.3495  196.6563  196.9631  197.2699  197.5767  197.8835  198.1903  198.4971
Columns 649 through 656
198.8039  199.1107  199.4175  199.7243  200.0311  200.3379  200.6447  200.9515
Columns 657 through 664
201.2583  201.5651  201.8719  202.1787  202.4855  202.7923  203.0991  203.4059
Columns 665 through 672
203.7126  204.0194  204.3262  204.6330  204.9398  205.2466  205.5534  205.8602
Columns 673 through 680
206.1670  206.4738  206.7806  207.0874  207.3942  207.7010  208.0078  208.3146
Columns 681 through 688
208.6214  208.9282  209.2350  209.5418  209.8486  210.1554  210.4622  210.7690
Columns 689 through 696
211.0758  211.3826  211.6893  211.9961  212.3029  212.6097  212.9165  213.2233
Columns 697 through 704
213.5301  213.8369  214.1437  214.4505  214.7573  215.0641  215.3709  215.6777
Columns 705 through 712
215.9845  216.2913  216.5981  216.9049  217.2117  217.5185  217.8253  218.1321
Columns 713 through 720
218.4389  218.7457  219.0525  219.3593  219.6660  219.9728  220.2796  220.5864
Columns 721 through 728
220.8932  221.2000  221.5068  221.8136  222.1204  222.4272  222.7340  223.0408
Columns 729 through 736
223.3476  223.6544  223.9612  224.2680  224.5748  224.8816  225.1884  225.4952
Columns 737 through 744
225.8020  226.1088  226.4156  226.7224  227.0292  227.3360  227.6427  227.9495
Columns 745 through 752
228.2563  228.5631  228.8699  229.1767  229.4835  229.7903  230.0971  230.4039
Columns 753 through 760
230.7107  231.0175  231.3243  231.6311  231.9379  232.2447  232.5515  232.8583
Columns 761 through 768
233.1651  233.4719  233.7787  234.0855  234.3923  234.6991  235.0059  235.3127
Columns 769 through 776
235.6194  235.9262  236.2330  236.5398  236.8466  237.1534  237.4602  237.7670
Columns 777 through 784
238.0738  238.3806  238.6874  238.9942  239.3010  239.6078  239.9146  240.2214
Columns 785 through 792
240.5282  240.8350  241.1418  241.4486  241.7554  242.0622  242.3690  242.6758
Columns 793 through 800
242.9826  243.2894  243.5961  243.9029  244.2097  244.5165  244.8233  245.1301
Columns 801 through 808
245.4369  245.7437  246.0505  246.3573  246.6641  246.9709  247.2777  247.5845
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  Columns 809 through 816
  247.8913  248.1981  248.5049  248.8117  249.1185  249.4253  249.7321  250.0389
  Columns 817 through 824
  250.3457  250.6525  250.9593  251.2661  251.5728  251.8796  252.1864  252.4932
  Columns 825 through 832
  252.8000  253.1068  253.4136  253.7204  254.0272  254.3340  254.6408  254.9476
  Columns 833 through 840
  255.2544  255.5612  255.8680  256.1748  256.4816  256.7884  257.0952  257.4020
  Columns 841 through 848
  257.7088  258.0156  258.3224  258.6292  258.9360  259.2428  259.5495  259.8563
  Columns 849 through 856
  260.1631  260.4699  260.7767  261.0835  261.3903  261.6971  262.0039  262.3107
  Columns 857 through 864
  262.6175  262.9243  263.2311  263.5379  263.8447  264.1515  264.4583  264.7651
  Columns 865 through 872
  265.0719  265.3787  265.6855  265.9923  266.2991  266.6059  266.9127  267.2195
  Columns 873 through 880
  267.5262  267.8330  268.1398  268.4466  268.7534  269.0602  269.3670  269.6738
  Columns 881 through 888
  269.9806  270.2874  270.5942  270.9010  271.2078  271.5146  271.8214  272.1282
  Columns 889 through 896
  272.4350  272.7418  273.0486  273.3554  273.6622  273.9690  274.2758  274.5826
  Columns 897 through 904
  274.8894  275.1962  275.5029  275.8097  276.1165  276.4233  276.7301  277.0369
  Columns 905 through 912
  277.3437  277.6505  277.9573  278.2641  278.5709  278.8777  279.1845  279.4913
  Columns 913 through 920
  279.7981  280.1049  280.4117  280.7185  281.0253  281.3321  281.6389  281.9457
  Columns 921 through 928
  282.2525  282.5593  282.8661  283.1729  283.4796  283.7864  284.0932  284.4000
  Columns 929 through 936
  284.7068  285.0136  285.3204  285.6272  285.9340  286.2408  286.5476  286.8544
  Columns 937 through 944
  287.1612  287.4680  287.7748  288.0816  288.3884  288.6952  289.0020  289.3088
  Columns 945 through 952
  289.6156  289.9224  290.2292  290.5360  290.8428  291.1496  291.4563  291.7631
  Columns 953 through 960
  292.0699  292.3767  292.6835  292.9903  293.2971  293.6039  293.9107  294.2175
  Columns 961 through 968
  294.5243  294.8311  295.1379  295.4447  295.7515  296.0583  296.3651  296.6719
  Columns 969 through 976
  296.9787  297.2855  297.5923  297.8991  298.2059  298.5127  298.8195  299.1263
  Columns 977 through 984
  299.4330  299.7398  300.0466  300.3534  300.6602  300.9670  301.2738  301.5806
  Columns 985 through 992
  301.8874  302.1942  302.5010  302.8078  303.1146  303.4214  303.7282  304.0350
  Columns 993 through 1000
  304.3418  304.6486  304.9554  305.2622  305.5690  305.8758  306.1826  306.4894
  Columns 1001 through 1008
  306.7962  307.1030  307.4097  307.7165  308.0233  308.3301  308.6369  308.9437
  Columns 1009 through 1016
  309.2505  309.5573  309.8641  310.1709  310.4777  310.7845  311.0913  311.3981
  Columns 1017 through 1024
  311.7049  312.0117  312.3185  312.6253  312.9321  313.2389  313.5457  313.8525
  Column 1025
  314.1593
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