4.1.1.H-1

6.2.1A.DOC
043002

EFFECT OF REINFORCEMENT

OBJECTIVE

This example illustrates the effect of reinforcement ratio on displacement and stresses in concrete elements.

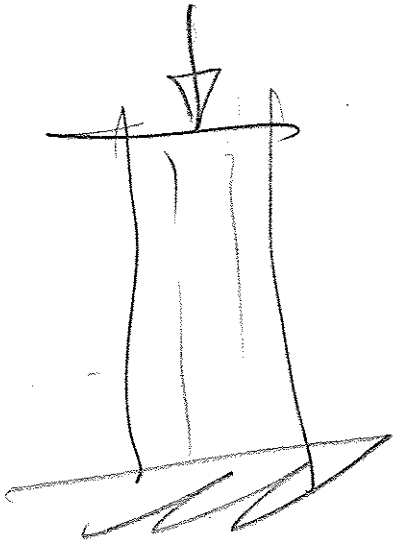
STRUCTURE

The example consists of two concrete specimens having the dimensions:
Cross-section - rectangle 100 mm x 100 mm,
Length - 1000 mm

The samples are supported at the bottom and axially loaded at the top.

INPUT DATA

```
;=============================================================================
;                              ADAPT-ABI
;      1733 Woodside Rd # 220, Redwood City, Ca 94061   www.adaptsoft.com
;=============================================================================
; Name of this file is:  6-2-1a    Date of last update: April 30, 2002

START
TITLE N=1
                        Example of effect of reinforcement ratio

UNITS U=SI

CONCRETE PARAMETERS N=1
  1  M=ACI a=0 b=1 W=0.0000024

MESH INPUT
  NODES N=4
    1 Y=   0.00 X=0.0
    2 Y=1000.00 X=0.0
    3 Y=   0.00 X=2000.0
    4 Y=1000.00 X=2000.0

  SECTION PROPERTIES N=1
    1 B=100 D=100

  CONCRETE PROPERTIES  N=1
    1 Fpc=30 Cr=0.0 Sh=0.0 W=0.0 Ac=0.0

  MILD STEEL PROPERTIES N=2
     1 Es=200000 P=0.01
     2 Es=200000 P=0.05

  ELEMENTS N=2
    FRAME N=2
      1,1,2 C=1 X=1 Day=0 St=1
```



```
      2,3,4 C=1 X=1 Day=0 St=2

MESH COMPLETE

SET  G=0,0

CHANGE STRUCTURE
  BUILD N=1,2,1

  RESTRAINTS
    1 R=1,1,1
    3 R=1,1,1

CHANGE COMPLETE

SOLVE Day=28       ! OUTPUT

LOADING
   N=2 F=0,-50000,0
   N=4 F=0,-50000,0

SOLVE Day=28       ! OUTPUT

STOP
```

RESULTS

The verification is performed at Day=28.

Hand calculated results are as follows:

Loading force F=50 kN
Cross-section area A= 100mm x 100 mm = 10000 mm^2

Concrete Modulus of Elasticity:
F'c = 30 MPa
$Ec = 1.3518*10^{12} * (W)^{1.5} * (F'c)^{0.5} = 1.3518*10^{12} * (2.4*10^{-6})^{1.5} * (30)^{0.5}$
Ec = 27529 MPa

Steel/Concrete Modulus Ratio
N = Es/Ec = 200000/27529 = 7.265

Calculations for Specimen 1. (P=0.01)

Stress in concrete
$\sigma = (F/A)/(1+n*P) = (50000/10000)/(1+7.265*0.01) = 4.661\ N/mm^2$
Program calculated value $\sigma = 4.661\ N/mm^2$

Displacement
$\delta = (F*L)/(Ec*A)/(1+n*P) = (50000*1000)/(27529*10000)/(1+7.265*0.01)$
$\delta = 0.169325$ mm
Program calculated value $\delta = 0.16933$ mm

Calculations for Specimen 2. (P=0.05)

Stress in concrete

$\sigma = (F/A)/(1+n*P) = (50000/10000)/(1+7.265*0.05) = 3.6677$ N/mm^2

Program calculated value $\sigma = 3.6677$ N/mm^2

Displacement

$\delta = (F*L)/(Ec*A)/(1+n*P)=(50000*1000)/(27529*10000)/(1+7.265*0.05)$

$\delta = 0.13323$ mm

Program calculated value $\delta = 0.13323$ mm

Hand calculated values compare well with program output.

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ADAPT-ABI BASIC Large Size Release 4.06
ADAPT-ABI for Bridges and Frames

DATE: Jun 21, 2002
TIME: 10:43:53

1 - PROBLEM TITLE:

EXAMPLE OF EFFECT OF REINFORCEMENT RATIO

2 - UNITS

MKS

3 - MATERIALS

3.1 CONCRETE PROPERTIES

CONCRETE PROPERTIES: N = 1

CONCRETE NO.	1
MODEL NO.	1
ULTIMATE STRENGTH	3.000E+02
CREEP COEFF /SCALE	0.000E+00
SHRINK STRAIN/SCALE	0.000E+00
UNIT WEIGHT	0.000E+00
THERM EXPN COEFF	0.000E+00

3.2 MILD STEEL PROPERTIES

N = 2

MILD STEEL NO.	ELASTIC MODULUS	PERCENTAGE IN CROSS SECTION	THERMAL EXPANSION COEFFICIENT
1	2.00000E+06	1.00000E+00	0.00000E+00
2	2.00000E+06	5.00000E+00	0.00000E+00

4 - SECTION GEOMETRIES

4.1 INPUT OR COMPUTED SECTION PROPERTIES

N = 1

SECTION NO.	1
CROSS SECTION AREA	1.000E+02
MOMENT OF INERTIA	8.333E+02
DISTANCE CG TO TOP	5.000E+00
DISTANCE CG TO BOT	5.000E+00
SHRIN FACTOR, TOP	1.000E+00
SHRIN FACTOR, BOT	1.000E+00

5 - FRAME GEOMETRY

5.1 NODES

N = 4

NODE	X-COORD	Y-COORD	NODE	X-COORD	Y-COORD
1	.000	.000	3	200.000	.000
2	.000	100.000	4	200.000	100.000

5.2 FRAME ELEMENTS

5.2.1 PRIMARY FRAME ELEMENTS.....
N = 2

ELEMENT NO.	I NODE	J NODE	CONCR TYPE	STEEL TYPE	SECT TYPE	CASTING DAY
1	1	2	1	1	1	0
2	3	4	1	2	1	0

CONSTRUCTION AND SOLUTION AT DAY 28 STAGE 1

100 - SOLUTION CONTROL DATA

CURRENT TEMPERATURE.....	=	20.00
X-DIRECTION GRAVITY MULTIPLIER	=	.00
Y-DIRECTION GRAVITY MULTIPLIER	=	.00
STRESS CONVERGENCE FACTOR.....	=	.70

102 - STRUCTURE

102.1 ACTIVE NODES

1 2 3 4

102.2 ACTIVE FRAME ELEMENTS

1 2

105 - NODAL BOUNDARY CONDITIONS AND TOTAL DISPLACEMENTS

Legend: 0 = Free ; 1 = Fixed

NODE	U(X)	U(Y)	R(Z)	X-DISP	Y-DISP	Z-ROTN
1	1	1	1	0.0000E+00	0.0000E+00	0.0000E+00
2	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00
3	1	1	1	0.0000E+00	0.0000E+00	0.0000E+00
4	0	0	0	0.0000E+00	0.0000E+00	0.0000E+00

106 - TOTAL REACTIONS AT FIXED NODES

NODE	X-FORCE	Y-FORCE	Z-MOMENT
1	0.0000E+00	0.0000E+00	0.0000E+00
3	0.0000E+00	0.0000E+00	0.0000E+00
TOTAL	0.0000E+00	0.0000E+00	0.0000E+00

107 - FRAME ELEMENT ACTIONS

107.1 PRIMARY ELEMENTS

ELEMENT NO	BENDING (END I)	BENDING (END J)	SHEAR FORCE	AXIAL FORCE
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

108 - STRESSES

ELEMENT	I-TOP	I-BOT	J-TOP	J-BOT	AXIAL-I	AXIAL-J
1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

CONSTRUCTION AND SOLUTION AT DAY 28 STAGE 2

100 - SOLUTION CONTROL DATA

CURRENT TEMPERATURE.....	=	20.00
X-DIRECTION GRAVITY MULTIPLIER	=	.00
Y-DIRECTION GRAVITY MULTIPLIER	=	.00
STRESS CONVERGENCE FACTOR.....	=	.70

102 - STRUCTURE

102.1 ACTIVE NODES

1 2 3 4

102.2 ACTIVE FRAME ELEMENTS

1 2

104 - LOADING

104.1 EXTERNALLY APPLIED LOAD OF THIS I N C R E M E N T

NODE	X-FORC	Y-FORC	Z-MOMT	X-DISP	Y-DISP	Z-ROTN
2	0.0000E+00	-5.0000E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.0000E+00	-5.0000E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

104.2 ELEMENT TEMPERATURES APPLIED AT THIS I N C R E M E N T

ELEMENT TEMPERATURES

FRAME ELEMENT	TOP FIBER TEMPERATURE	BOTTOM FIBER TEMPERATURE
1	20.0	20.0
2	20.0	20.0

104.3 T O T A L OF EXTERNALLY APPLIED LOADING AT THIS S T A G E

NODE	X-FORC	Y-FORC	Z-MOMT	X-DISP	Y-DISP	Z-ROTN
2	0.0000E+00	-5.0000E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4	0.0000E+00	-5.0000E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

104.4 T O T A L OF ELEMENT TEMPERATURES AT THIS S T A G E

ELEMENT TEMPERATURES

FRAME ELEMENT	TOP FIBER TEMPERATURE	BOTTOM FIBER TEMPERATURE
1	20.0	20.0
2	20.0	20.0

105 - NODAL BOUNDARY CONDITIONS AND TOTAL DISPLACEMENTS

Legend: 0 = Free ; 1 = Fixed

NODE	U(X)	U(Y)	R(Z)	X-DISP	Y-DISP	Z-ROTN
1	1	1	1	0.0000E+00	0.0000E+00	0.0000E+00
2	0	0	0	0.0000E+00	-1.6782E-02	0.0000E+00
3	1	1	1	0.0000E+00	0.0000E+00	0.0000E+00
4	0	0	0	0.0000E+00	-1.3230E-02	0.0000E+00

106 - TOTAL REACTIONS AT FIXED NODES

NODE	X-FORCE	Y-FORCE	Z-MOMENT
1	0.0000E+00	-5.0000E+03	0.0000E+00
3	0.0000E+00	-5.0000E+03	0.0000E+00
TOTAL	0.0000E+00	-1.0000E+04	0.0000E+00

107 - FRAME ELEMENT ACTIONS

107.1 PRIMARY ELEMENTS

ELEMENT NO	BENDING (END I)	BENDING (END J)	SHEAR FORCE	AXIAL FORCE
1	0.0000E+00	0.0000E+00	0.0000E+00	-5.0000E+03
2	0.0000E+00	0.0000E+00	0.0000E+00	-5.0000E+03

108 - STRESSES

ELEMENT	I-TOP	I-BOT	J-TOP	J-BOT	AXIAL-I	AXIAL-J
1	-4.6644E+01	-4.6644E+01	-4.6644E+01	-4.6644E+01	-4.6644E+01	-4.6644E+01
2	-3.6770E+01	-3.6770E+01	-3.6770E+01	-3.6770E+01	-3.6770E+01	-3.6770E+01