Pamukkale Üniversitesi Mühendislik Fakültesi İnşaat Mühendisliği Bölümü

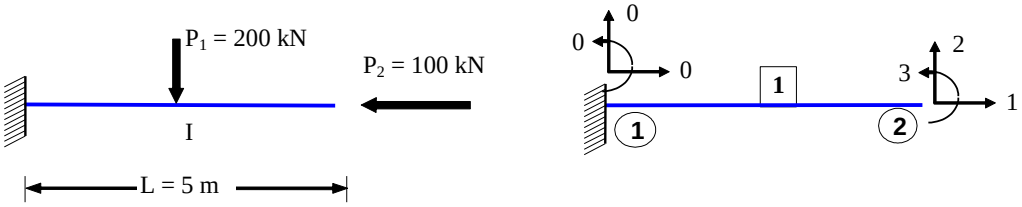
YAPI STATİĞİ II
UYGULAMA PAKETİ 3

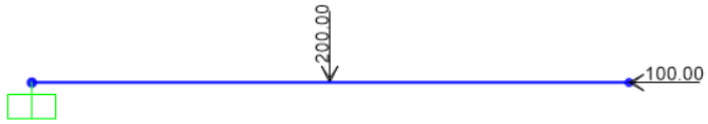
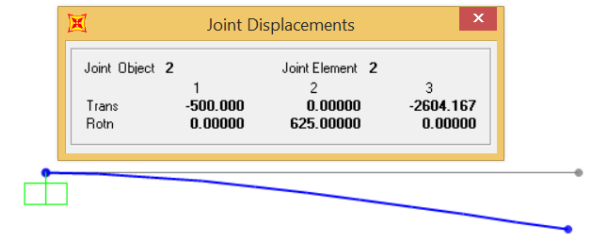
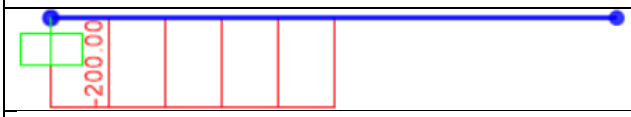
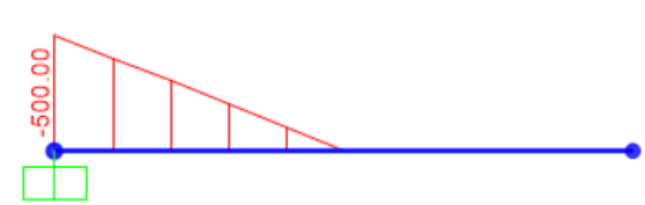
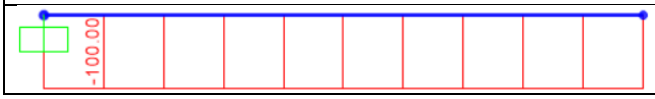
Prof. Dr. Hasan KAPLAN

Bu uygulama paketinde, ders notlarında yer alan ve bir kısmı derslerde çözülen örneklerin SAP2000 ile yapılan çözümleri verilmiştir. Öğrencilerimizin davranışa yönelik bilgi düzeylerinin geliştirilmesi için yararlı olacaktır. Ayrıca SAP2000 ile çözüm yaparak taşıyıcı sistemlerin, modellenmesi, yük ve deformasyon ilişkilerinin bilgisayar destekli öğrenilmesi hedeflenmiştir.

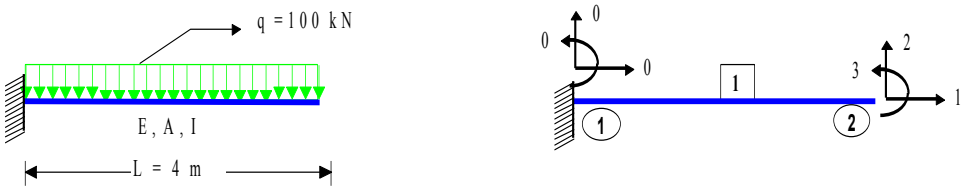
25.03.2015

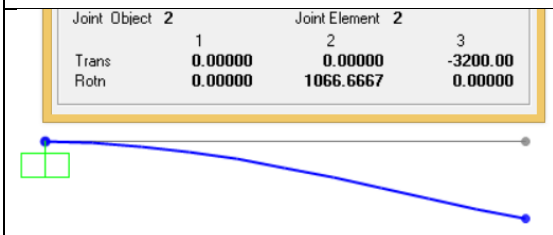
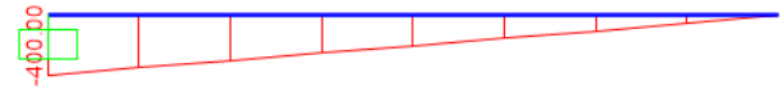
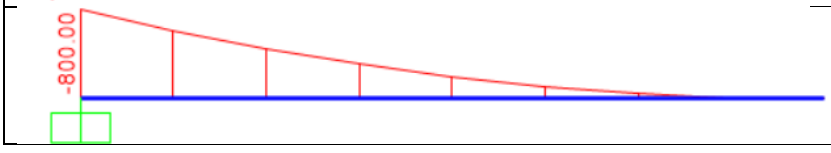
ÖRNEK 1:



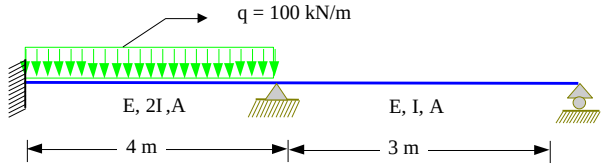
	Yükleme
	Deformasyon Yapmış Sistem ve Deplasmanlar $\{D\} = \begin{Bmatrix} -500 \\ -2604 \\ -625 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \end{matrix}$ Kayma Deformasyonları ihmal, AE=1, EI=1
	Kesme Kuvveti
	Eğilme Momenti
	Normal Kuvvet

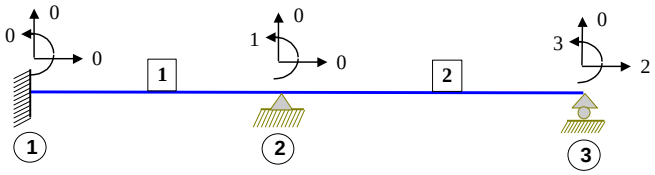
ÖRNEK 2:



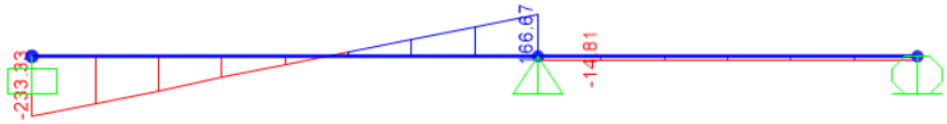
	Yükleme
	Deformasyon Yapmış Sistem ve Deplasmanlar $\{D\} = \begin{Bmatrix} 0 \\ -3166 \\ -1054 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \end{matrix}$ Kayma Deformasyonları ihmal, AE=1, EI=1
	Kesme Kuvveti
	Eğilme Momenti

ÖRNEK 3

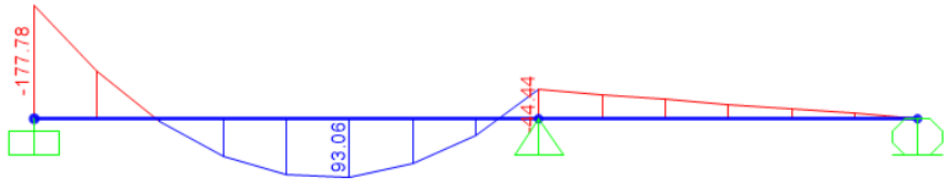




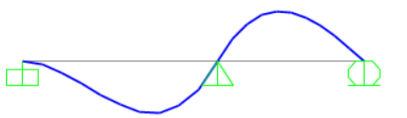
$$\{D\} = \begin{Bmatrix} 44.454 \\ 0 \\ -22.22 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \end{matrix}$$

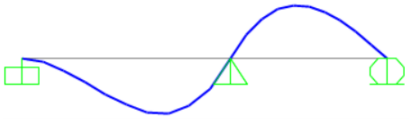


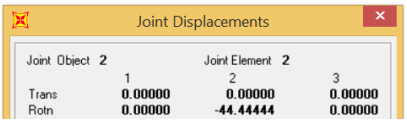
V

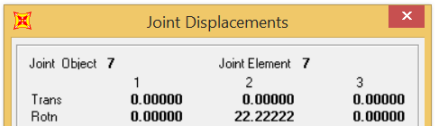


M

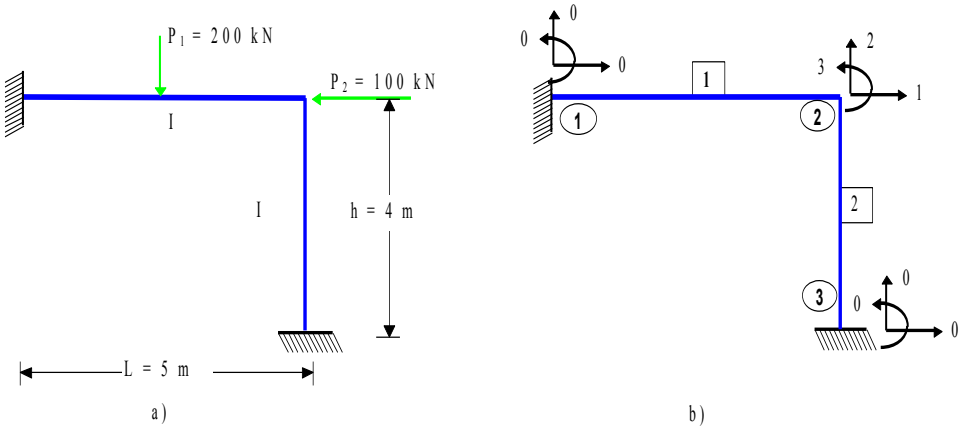






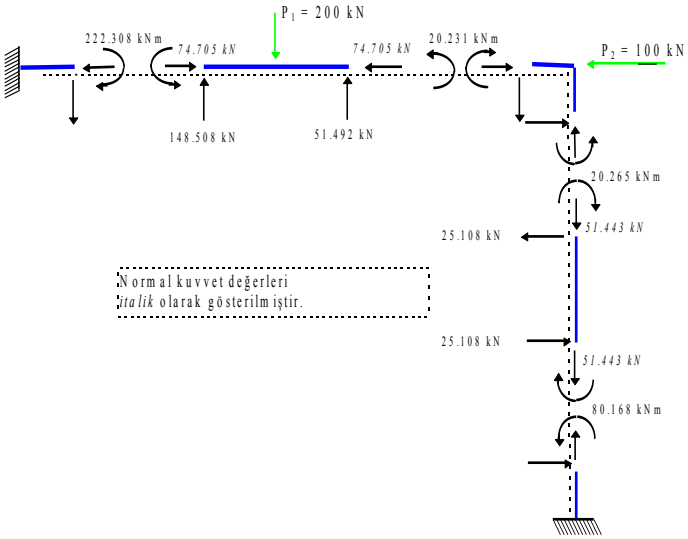


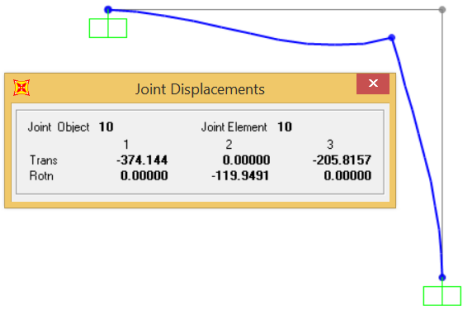
ÖRNEK 4

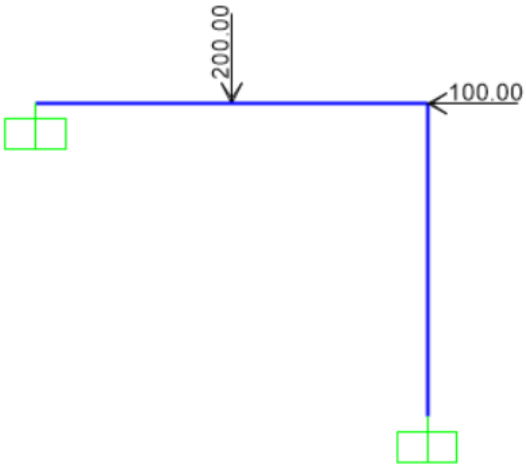


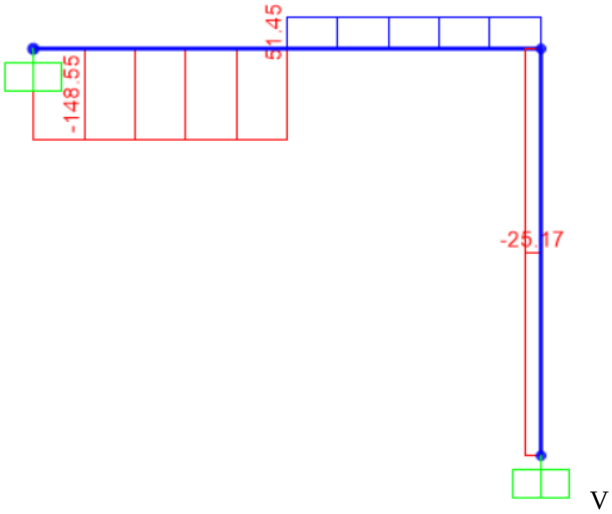
E=1 A=1 I=1 L ise elemanın boyu alınacaktır.

$$\{Q\}=\begin{Bmatrix}0\\-100\\125\end{Bmatrix}+\begin{Bmatrix}-100\\0\\0\end{Bmatrix}=\begin{Bmatrix}-100\\100\\-125\end{Bmatrix}\quad,\quad \{D\}=\begin{Bmatrix}750\\-3164.2135\\1500\\1457.106\\-2164.21\end{Bmatrix}\begin{matrix}1\\2\\3\\4\\5\end{matrix}$$

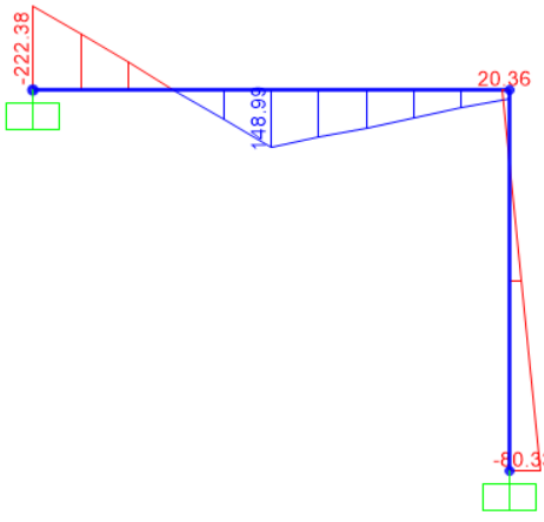




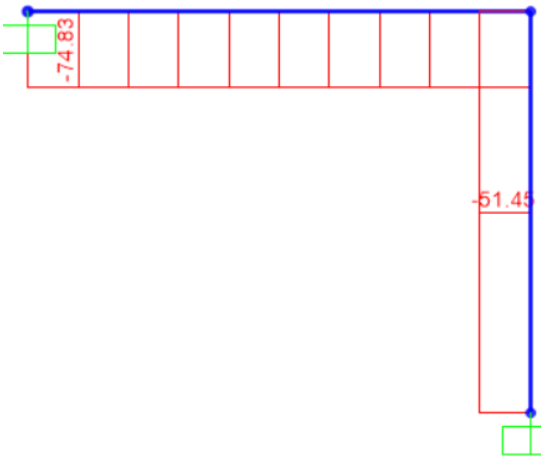




V



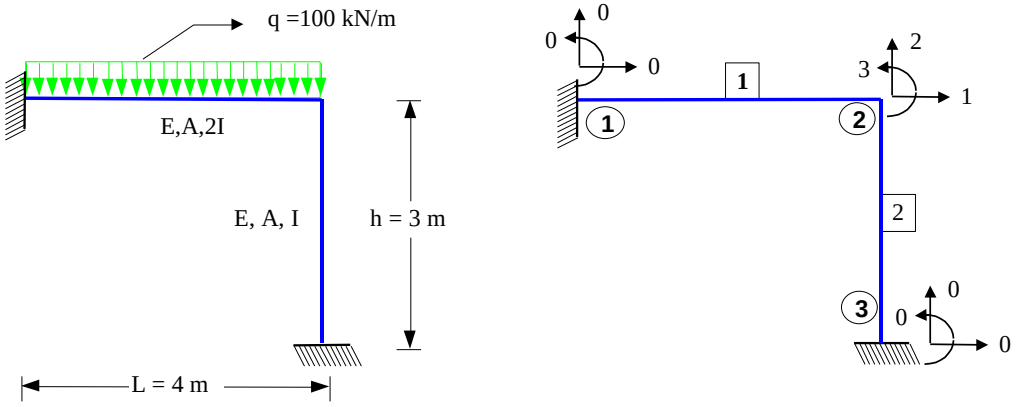
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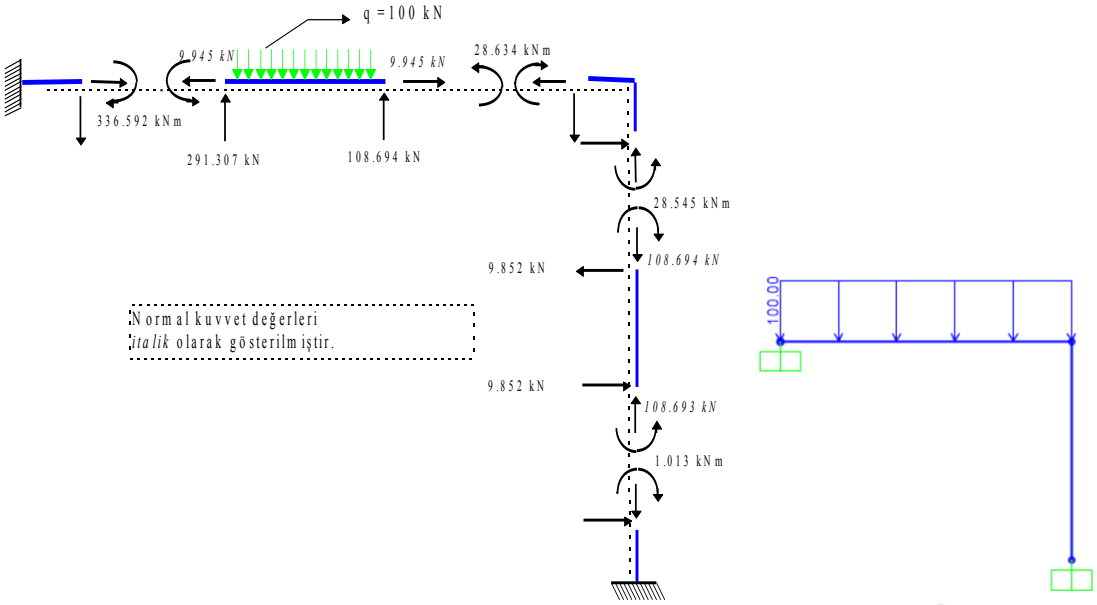
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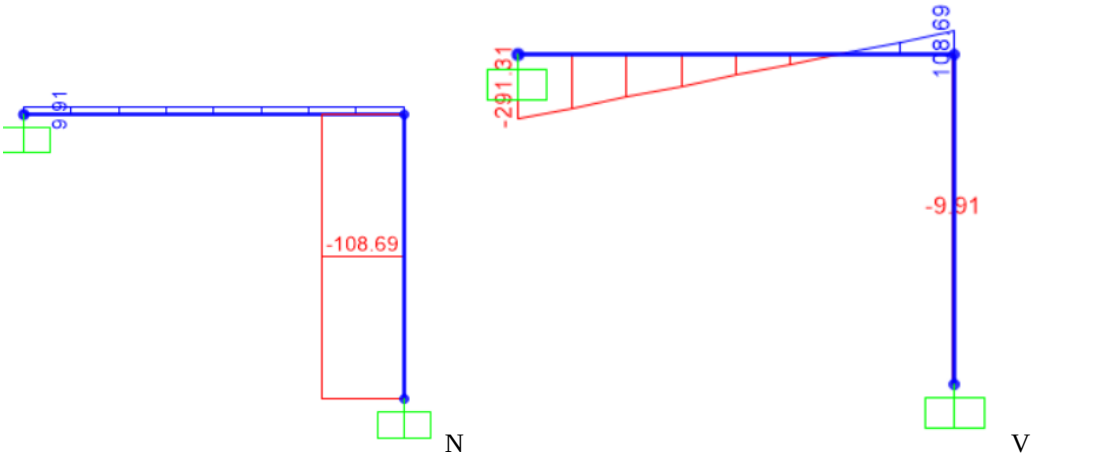
ÖRNEK 5

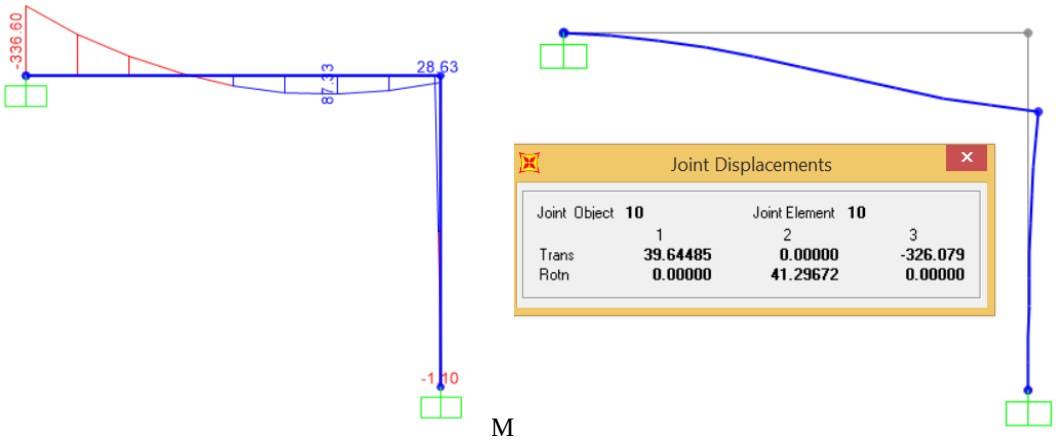
Örnek 4'de verilen çerçeveyi, kirişin üniform yayılı yükle yüklenmesi durumu için çözelim.



$$\{Q\} = \begin{Bmatrix} 0 \\ -200 \\ 133.33 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \end{matrix} \qquad \{D\} = \begin{Bmatrix} 39.779 \\ -326.08 \\ -41.298 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \end{matrix}$$



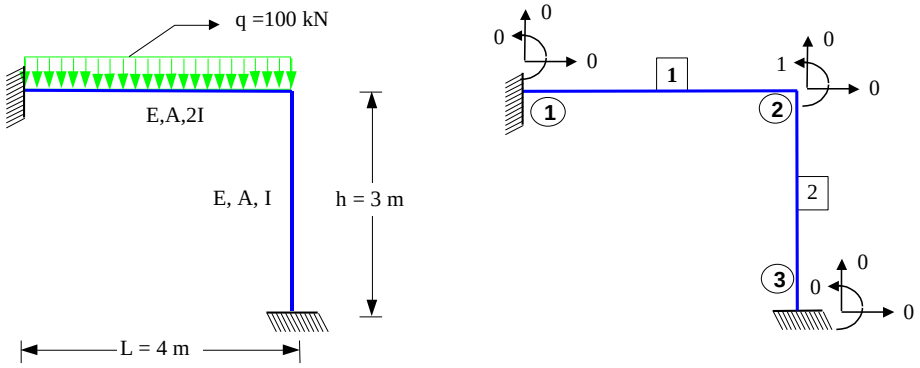




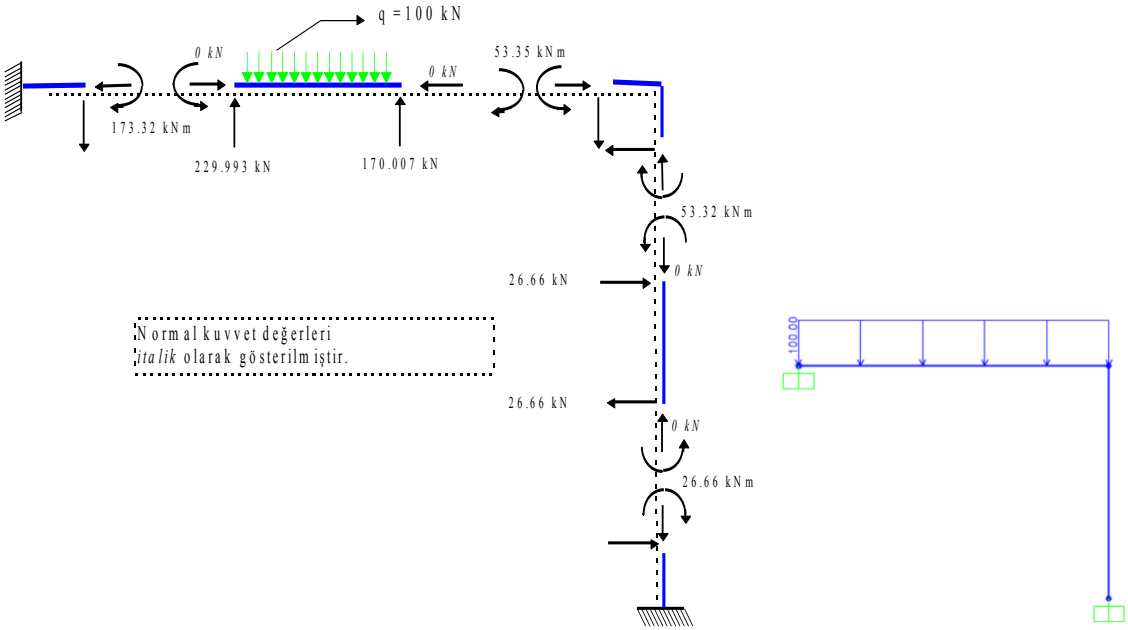
M

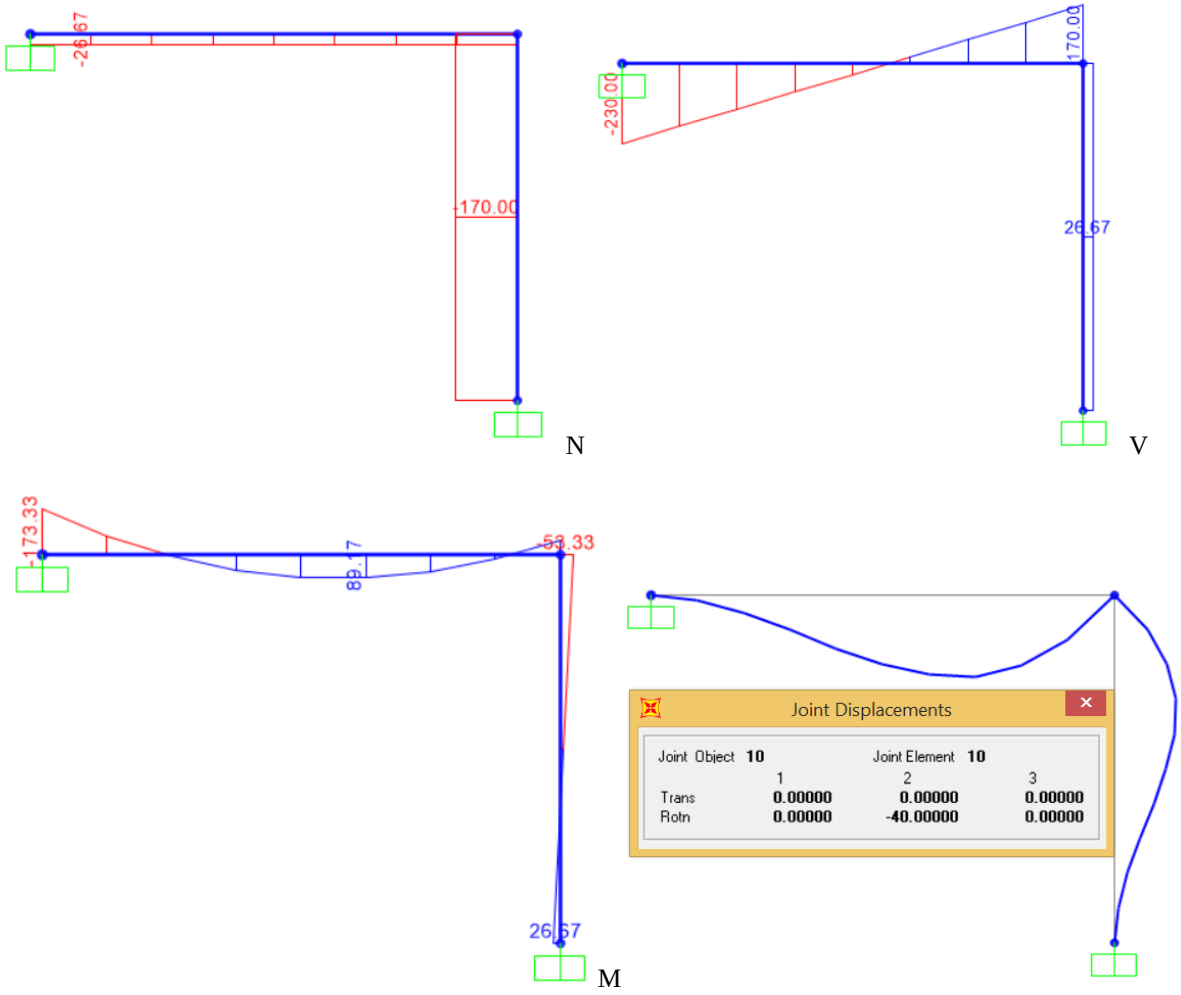
ÖRNEK 6:

Bir karşılaştırma yapılması maksadı ile Örnek 5'de verilen çerçeve sistemi eksenel deformasyonlar ihmal edilerek yeniden çözülmüştür. Örnek 5 de verilen çerçevede eksenel deformasyonlar ihmal edecek olursak, 2 nolu düğümde tek serbestlik derecesi kalır. Bu durumdaki çözüm, yaklaşık yöntemler (Crosss ve Açı) ile aynı sonucu verecektir.



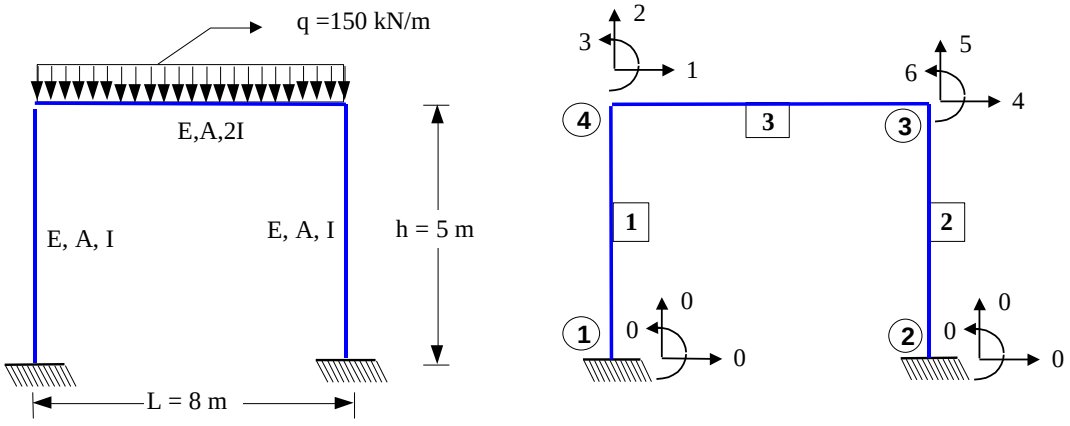
$$[K]=[2+1.33]=[3.33],\ \{Q\}=\{133.33\}\quad,\{D\}=\{39.99\}$$



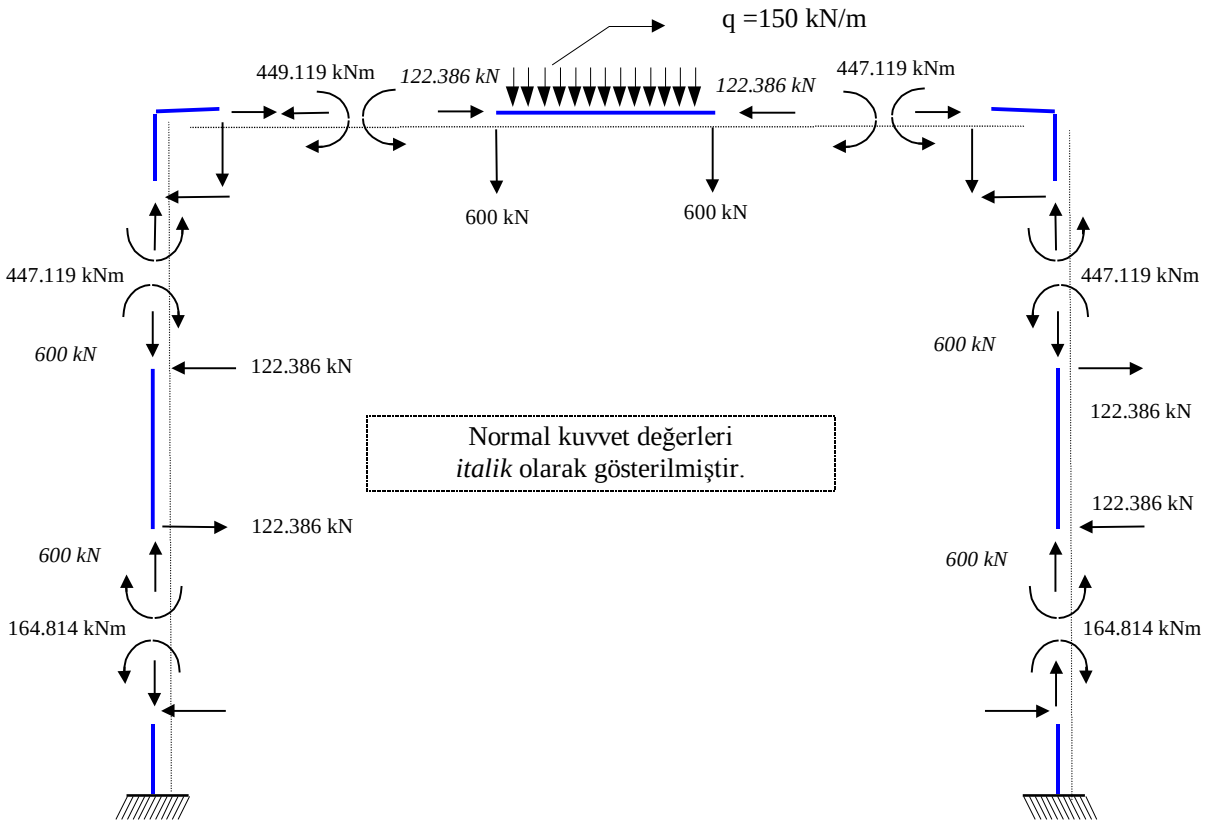


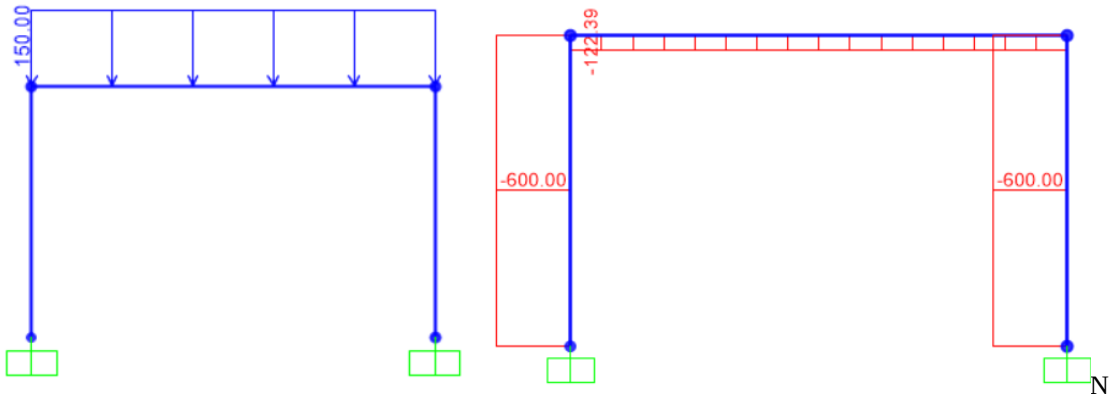
ÖRNEK 7

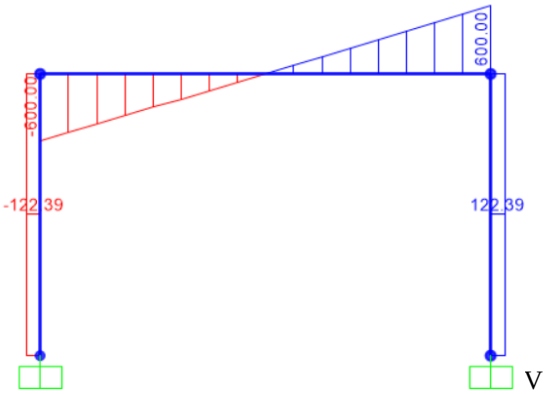
Şekilde verilen tek katlı düzlem çerçevenin kesit tesirleri diyagramları belirlenecektir. 2 düğümü serbest olan çerçeve taşıyıcı sistemin sistem serbestlik derecesi 6'dır.



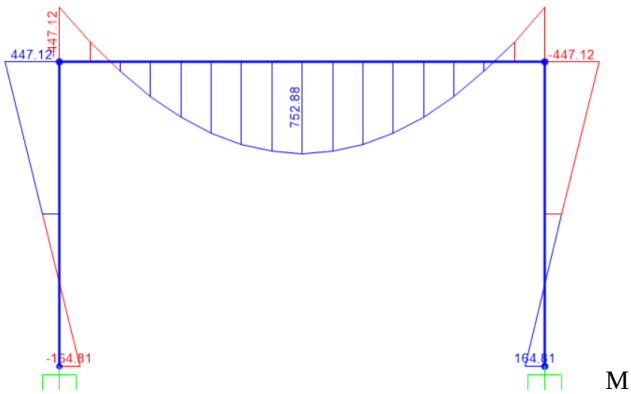
$$[K]=\begin{array}{c}\begin{matrix}1 & 2 & 3 & 4 & 5 & 6\end{matrix}\\ \begin{bmatrix} 0.221 & 0 & 0.24 & -0.125 & 0 & 0 \\ 0 & 0.247 & 0.188 & 0 & -0.047 & 0.188 \\ 0.24 & 0.188 & 1.8 & 0 & -0.188 & 0.5 \\ -0.125 & 0 & 0 & 0.221 & 0 & 0.24 \\ 0 & -0.047 & -0.188 & 0 & 0.247 & -0.188 \\ 0 & 0.188 & 0.5 & 0.24 & -0.188 & 1.8 \end{bmatrix}\begin{matrix}1\\2\\3\\4\\5\\6\end{matrix}\end{array},\quad \{Q\}=\begin{Bmatrix}0\\-200\\0\\100\\0\end{Bmatrix}\begin{matrix}1\\2\\3\\4\\5\end{matrix},\quad \{D\}=\begin{Bmatrix}750\\-3164.2135\\1500\\1457.106\\-2164.21\end{Bmatrix}\begin{matrix}1\\2\\3\\4\\5\end{matrix}$$



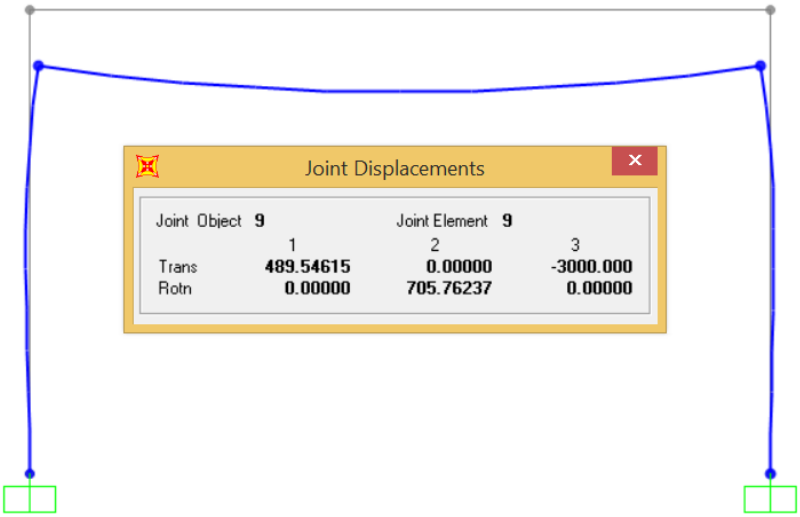




V

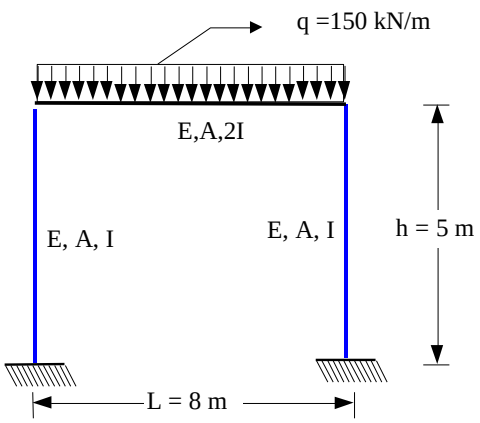


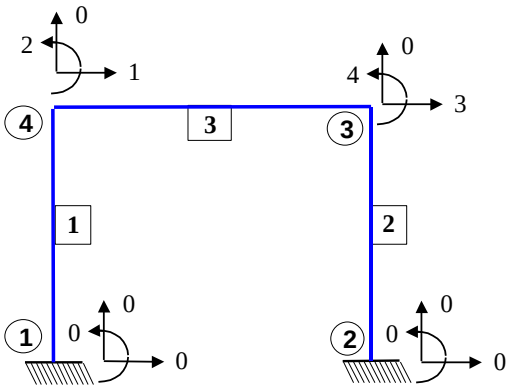
M



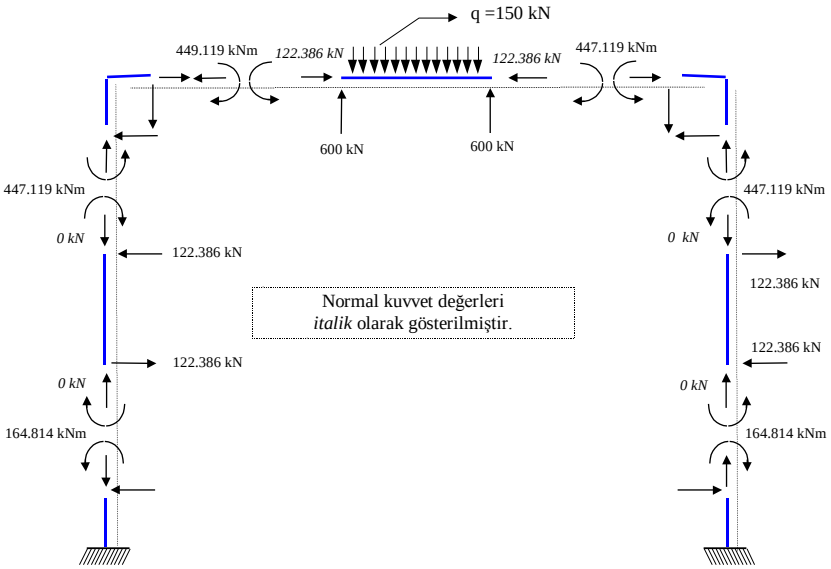
ÖRNEK 8

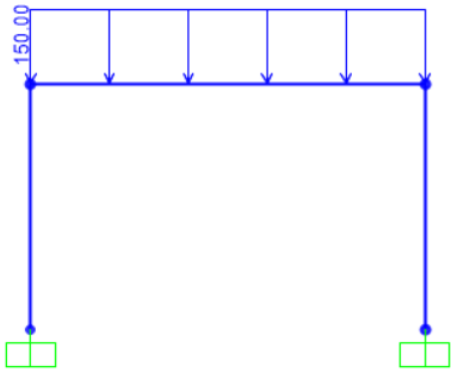
Örnek 7'de ele alınan çerçevede eksenel deformasyonlar ihmal edilerek çözüm yapılmıştır. Bu durumda kolonlardaki boy değişimi ihmal edildiği için düşeydeki serbestlik dereceleri sıfır olacaktır.

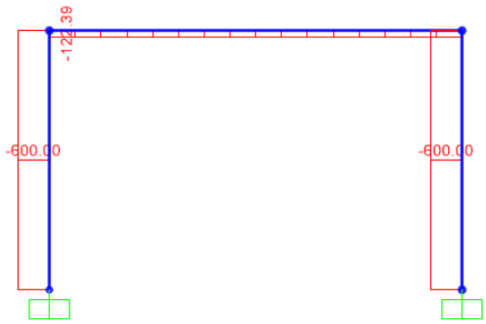




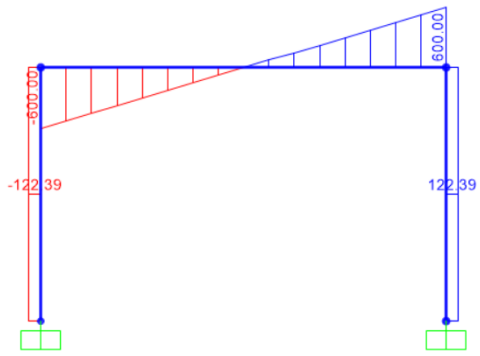
E=1 A=1 I=1 L ise elemanın boyu alınacaktır.



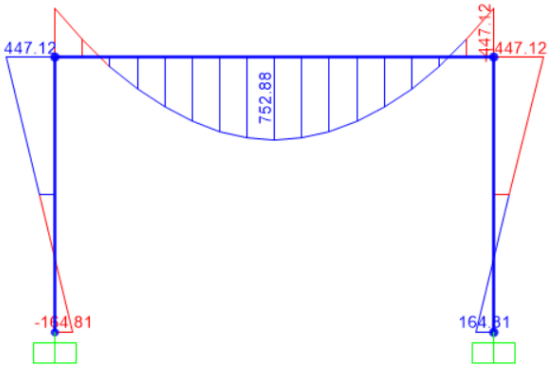




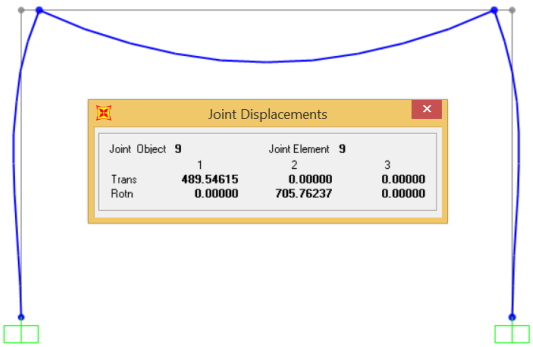
N



V



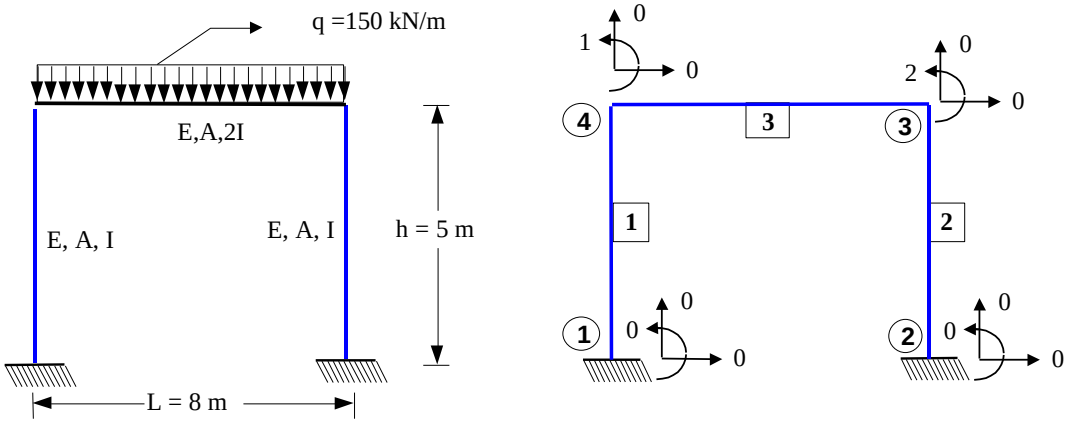
M



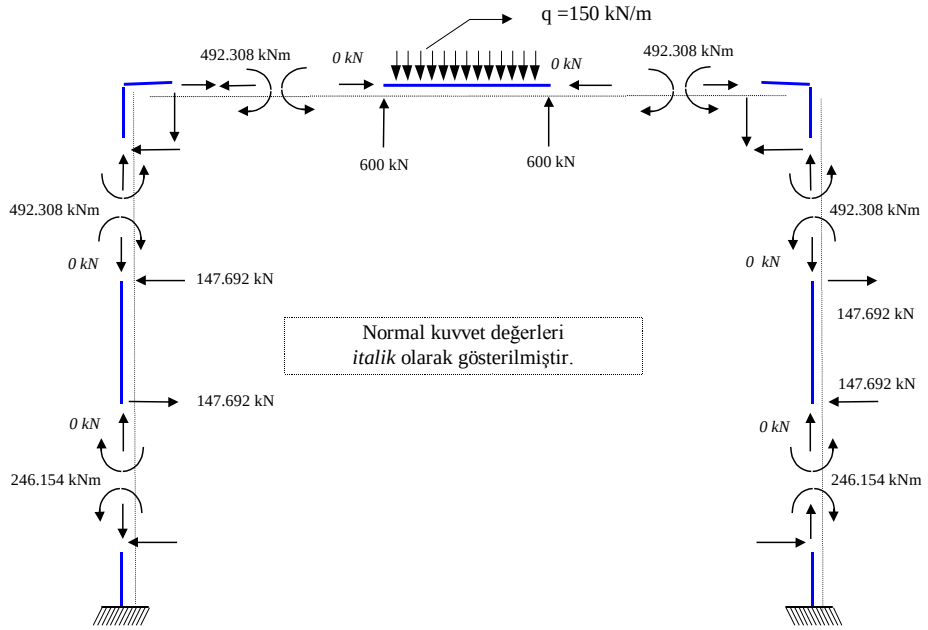
$$\{D\} = \begin{Bmatrix} 489.546 \\ -705.762 \\ -489.546 \\ 705.762 \end{Bmatrix}$$

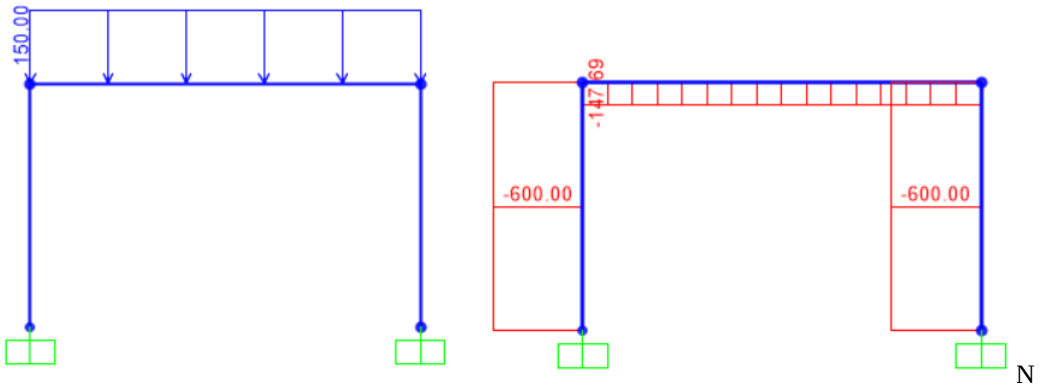
ÖRNEK 9

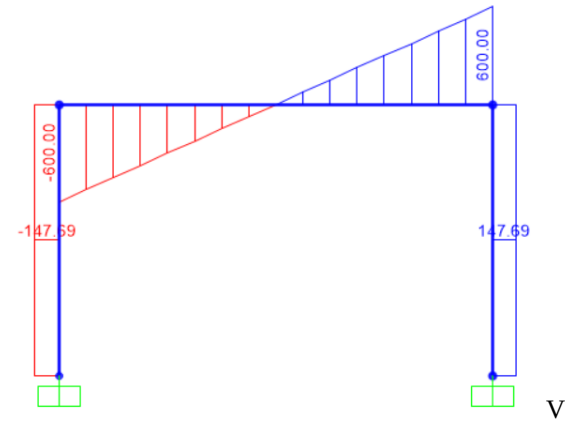
Düğümlerde sadece dönme serbestlik derecelerini dikkate alarak aynı çerçevenin kesit tesirleri diyagramlarını çizelim. Bu durumda sistemimiz düğüm noktaları sabit sistem olacaktır.



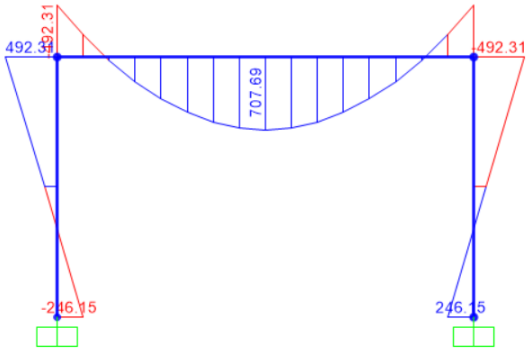
$$[K]=\begin{bmatrix}1.8 & 0.5\\ 0.5 & 1.8\end{bmatrix}\begin{matrix}1\\2\end{matrix},\ \{Q\}=\begin{Bmatrix}-800\\ 800\end{Bmatrix}\begin{matrix}1\\2\end{matrix},\quad \{D\}=\begin{Bmatrix}-615.385\\ 615.385\end{Bmatrix}$$



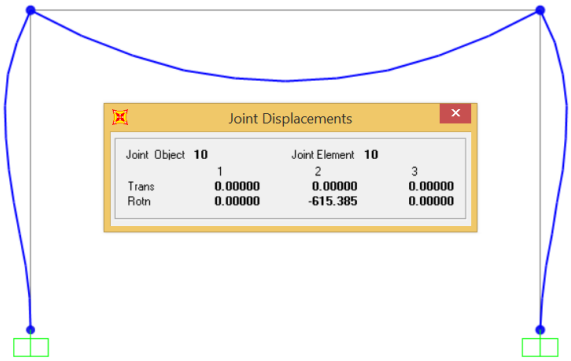




V

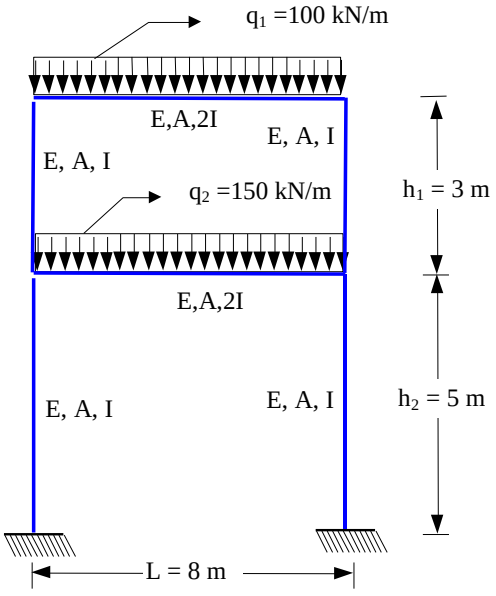


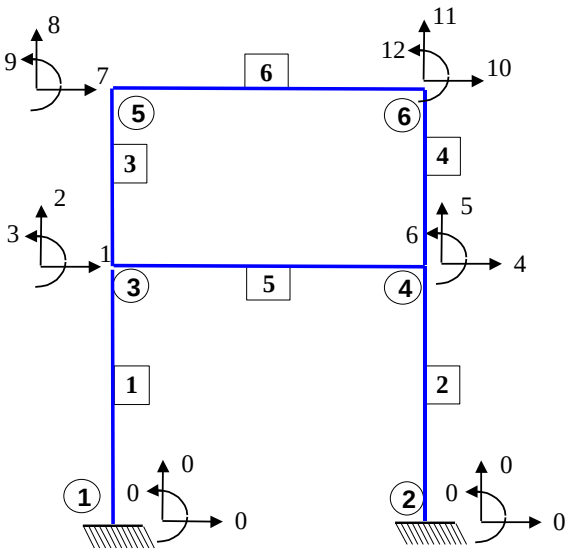
M

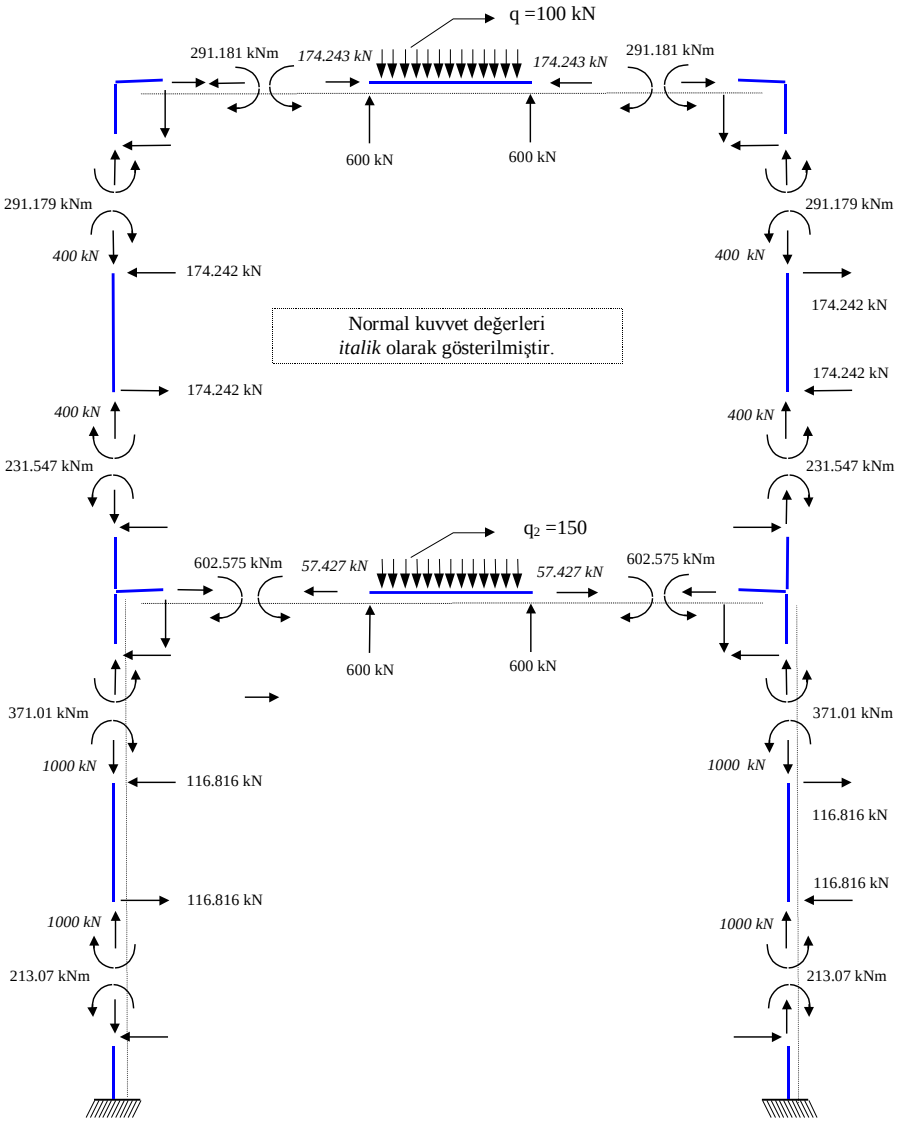


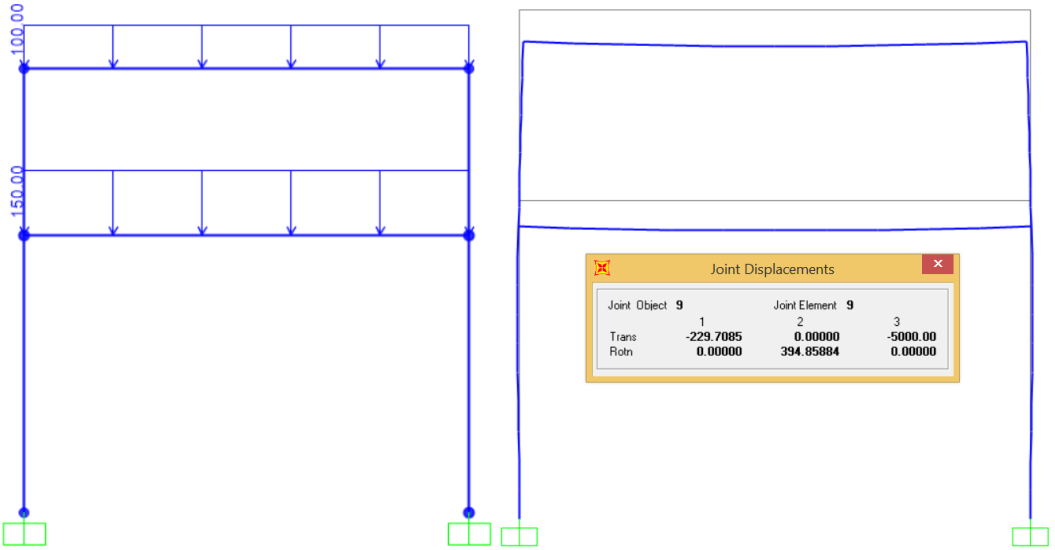
ÖRNEK 10

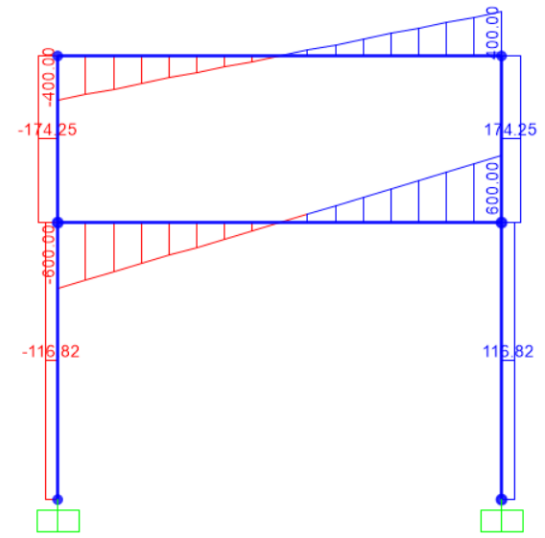
Şekilde verilen iki katlı çerçeveyi rijitlik matrisi yöntemi ile çözelim



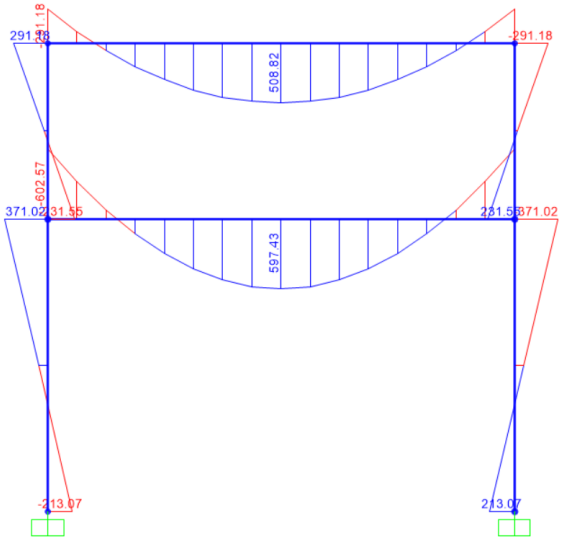



q =100 kN
291.181 kNm
174.243 kN
174.243 kN
291.181 kNm
600 kN
600 kN
291.179 kNm
291.179 kNm
400 kN
174.242 kN
400 kN
174.242 kN
Normal kuvvet değerleri
italik olarak gösterilmiştir.
174.242 kN
174.242 kN
400 kN
400 kN
231.547 kNm
231.547 kNm
q2 =150
602.575 kNm
57.427 kN
57.427 kN
602.575 kNm
600 kN
600 kN
371.01 kNm
371.01 kNm
1000 kN
116.816 kN
1000 kN
116.816 kN
116.816 kN
116.816 kN
1000 kN
1000 kN
213.07 kNm
213.07 kNm

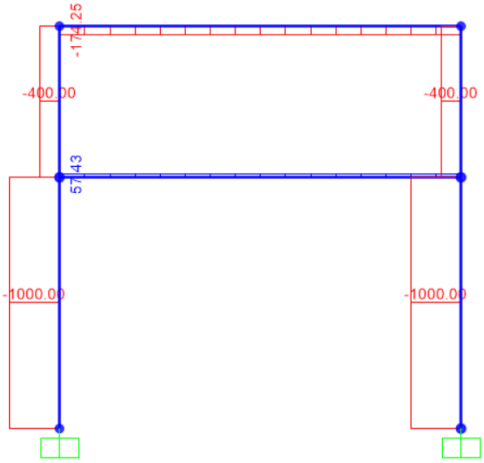

100.00
150.00
Joint Displacements
Joint Object 9
Joint Element 9
1
2
3
Trans
-229.7085
0.00000
-5000.00
Rotn
0.00000
394.85884
0.00000



V



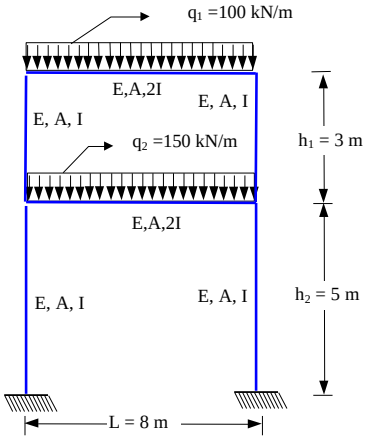
M

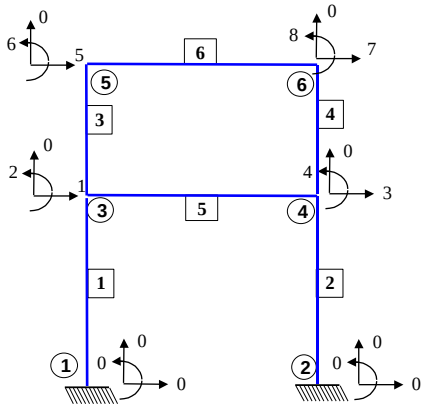


N

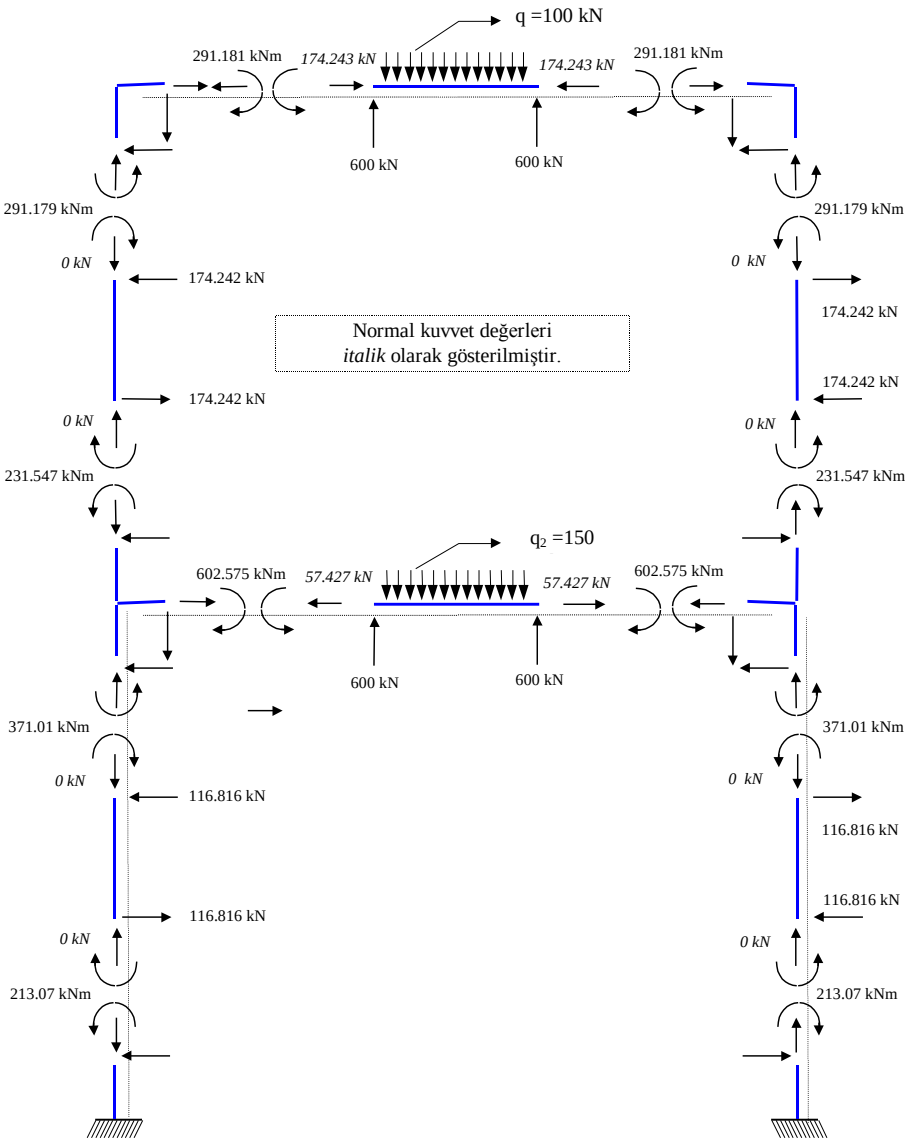
ÖRNEK 11

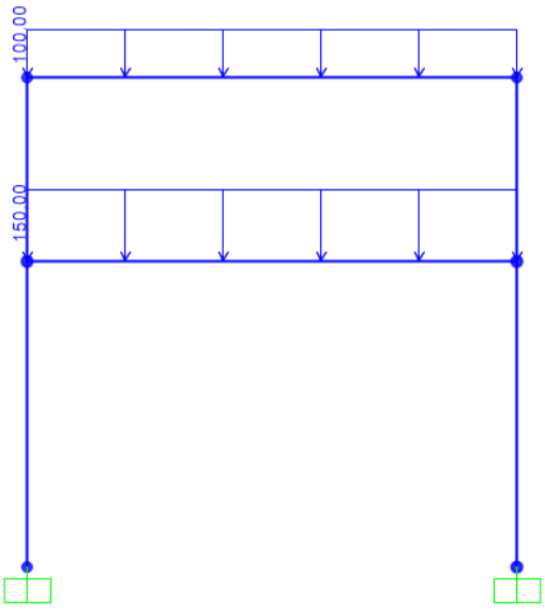
Örnek 10 da verilen problemi kolonlardaki eksenel deformasyonları ihmal ederek rijitlik matrisi yöntemi ile çözelim. Bu durumda her düğümde bir dönme birde yatay doğrultuda olmak üzere iki serbestlik derecesi olacaktır. Sistemin toplam serbestlik derecesi 8 dir.

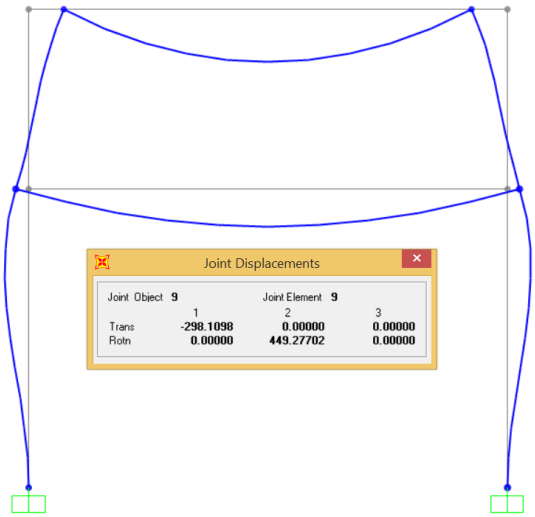


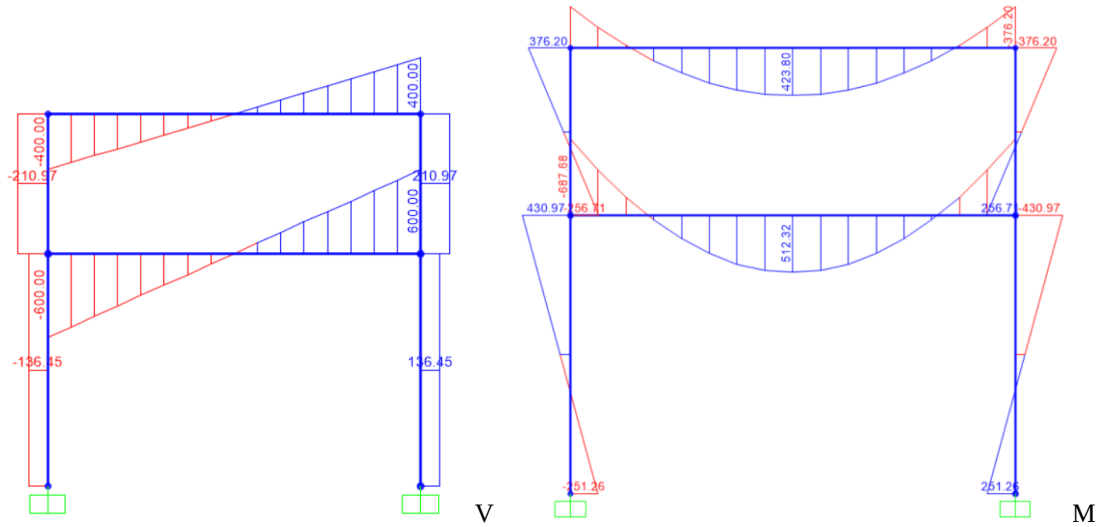


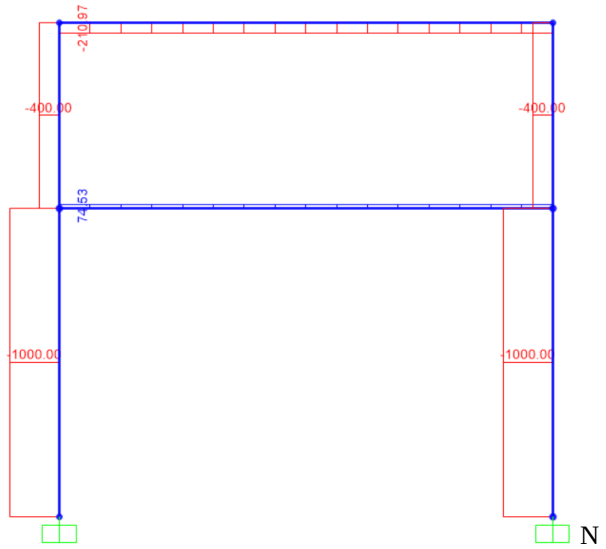
$$\{D\} = \begin{Bmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \\ D_6 \\ D_7 \\ D_8 \end{Bmatrix} \begin{Bmatrix} -229.707 \\ -394.858 \\ 229.707 \\ 394.858 \\ 696.97 \\ -484.298 \\ -696.97 \\ 484.298 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \end{matrix}$$


q =100 kN
291.181 kNm
174.243 kN
174.243 kN
291.181 kNm
600 kN
600 kN
291.179 kNm
291.179 kNm
0 kN
0 kN
174.242 kN
174.242 kN
Normal kuvvet değerleri
italik olarak gösterilmiştir.
174.242 kN
174.242 kN
0 kN
0 kN
231.547 kNm
231.547 kNm
q2 =150
602.575 kNm
57.427 kN
57.427 kN
602.575 kNm
600 kN
600 kN
371.01 kNm
371.01 kNm
0 kN
0 kN
116.816 kN
116.816 kN
116.816 kN
116.816 kN
0 kN
0 kN
213.07 kNm
213.07 kNm


100.00
150.00

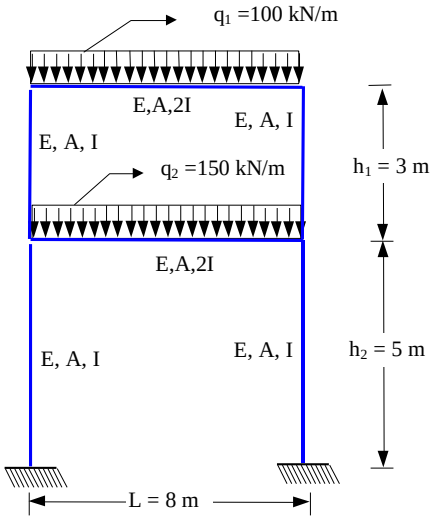

Joint Displacements
Joint Object 9
Joint Element 9
1
2
3
Trans
-298.1098
0.00000
0.00000
Rotn
0.00000
449.27702
0.00000

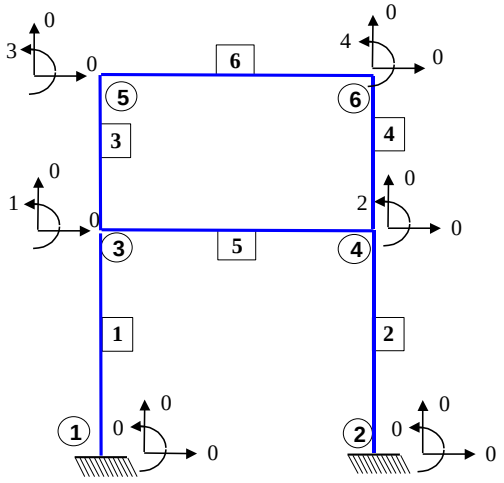


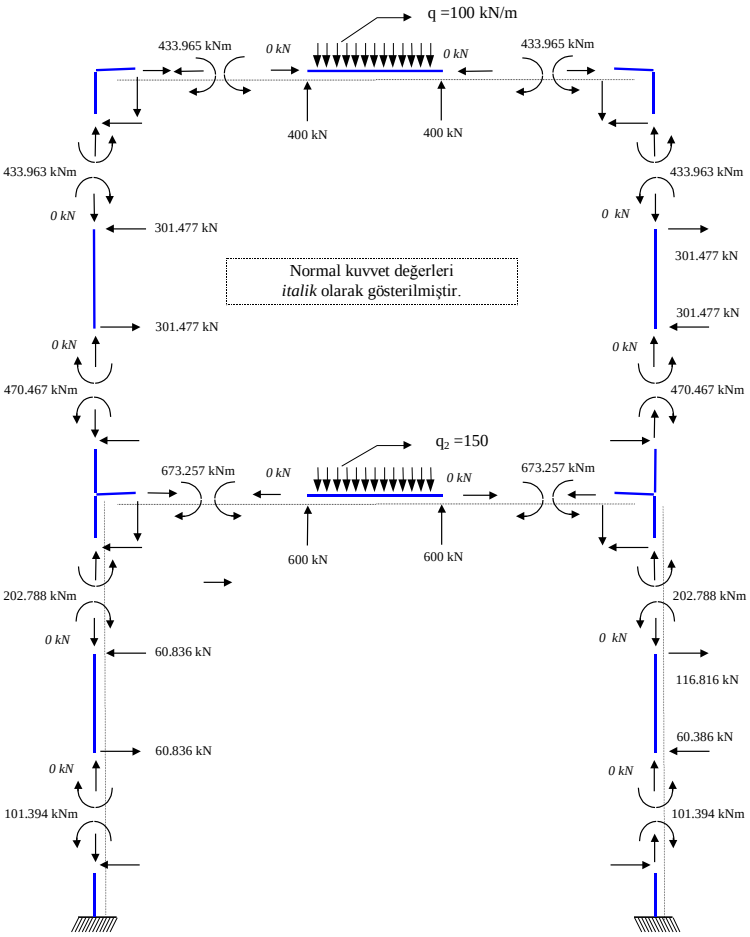


ÖRNEK 12

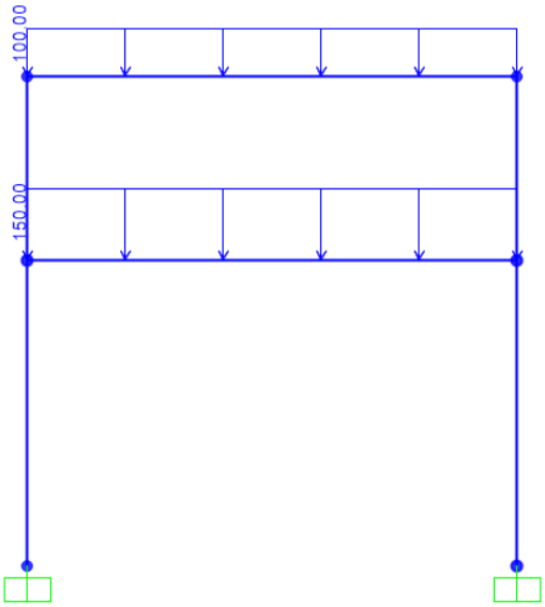
Örnek 10-11'de verilen iki katlı çerçeven düğüm noktaları sabit sistem olarak çözümü. Bu durumda her düğümde sadece dönmeler meydana gelecektir. Düğümlerdeki yatay yer değiştirmeler ve kolonlardaki eksenel deformasyonlar terk edilmiştir. Bu durumdaki çözüm Cross ve Açı yöntemi ile aynı çözümü verecektir.

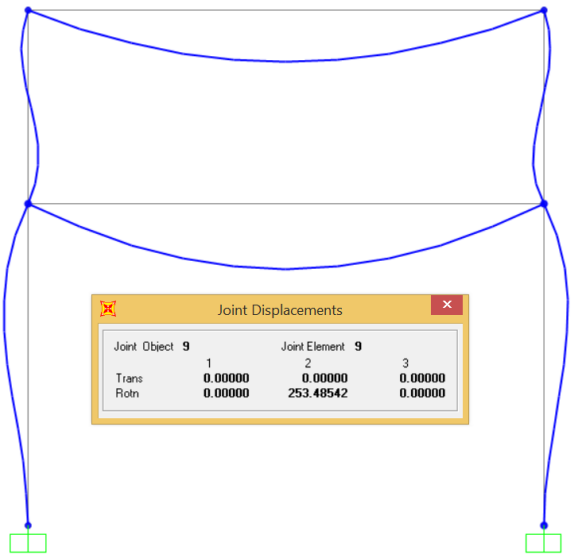


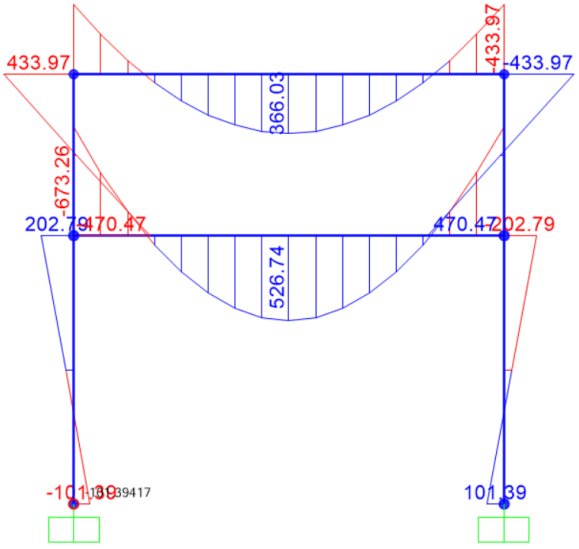




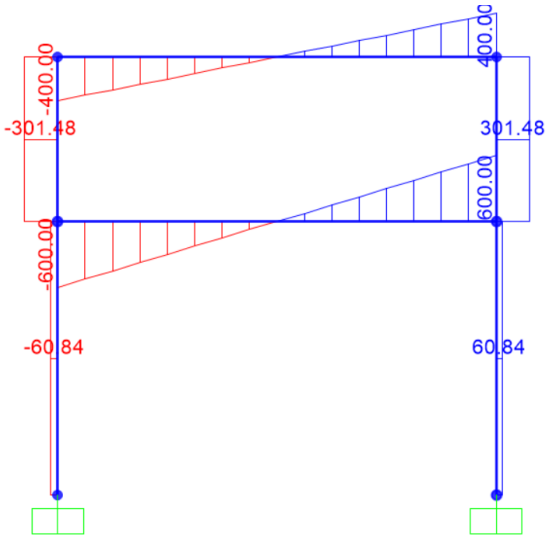
$$\{D\} = \begin{Bmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \end{Bmatrix} = \begin{Bmatrix} -253.485 \\ 253.485 \\ -198.730 \\ 198.730 \end{Bmatrix}$$



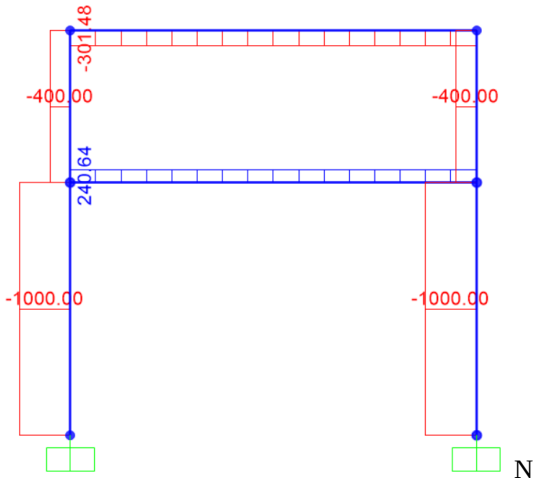




V



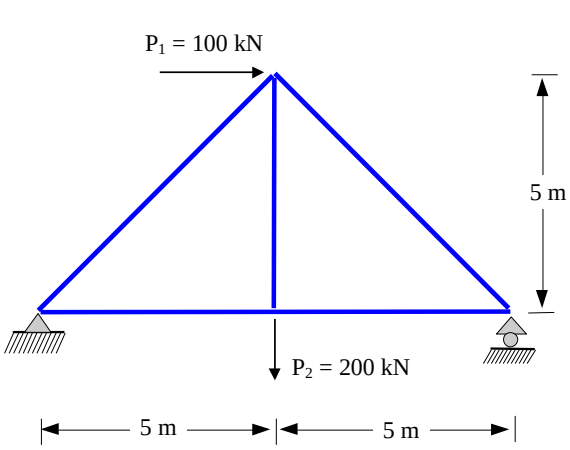
M

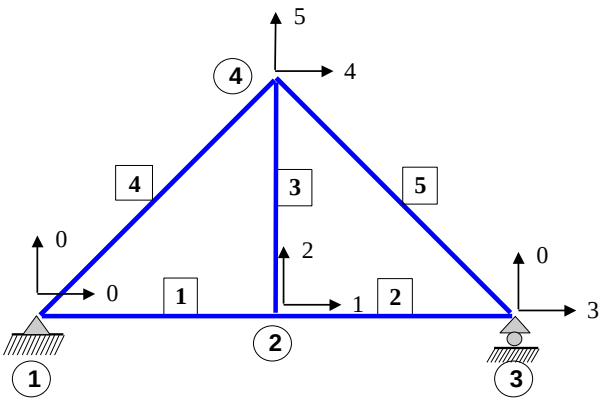


N

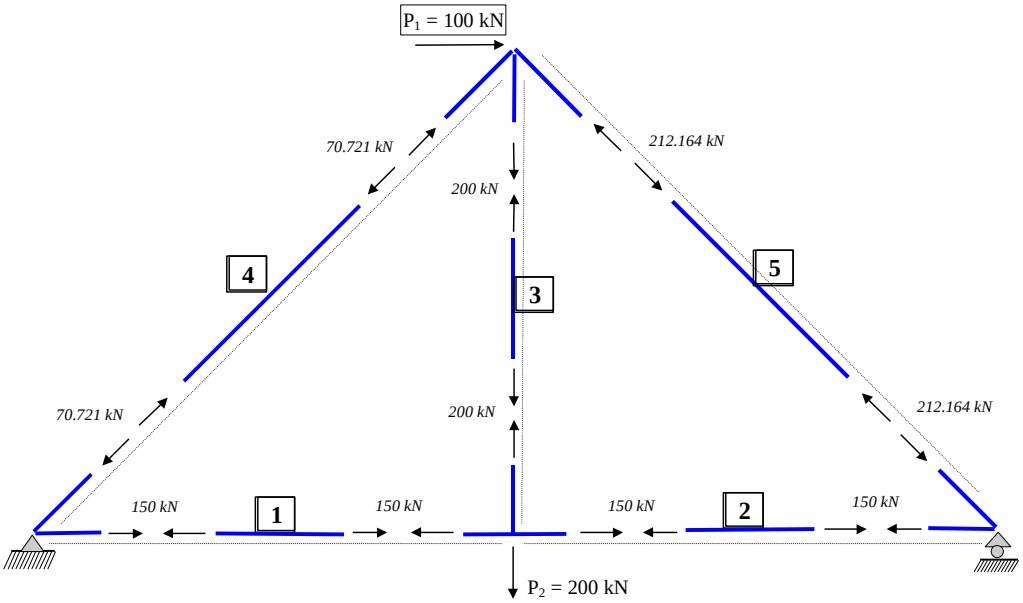
ÖRNEK 13

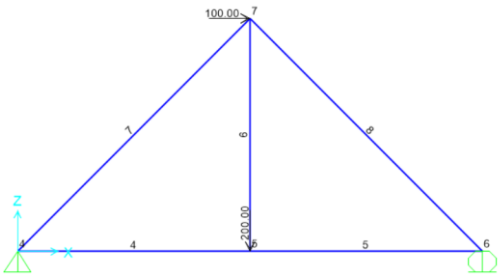
Kafes sistemlerin rijitlik matrisi ile çözümüne ait bir örnek ele alınmıştır. Bilindiği gibi düzlem kafes sitemin her düğümünde x ve y yönünde ötelenme olmak üzere iki serbestlik derecesi vardır. Bu serbestlik derecelerinden bazıları mesnet olan düğümlerde tutulmuş olabilir.

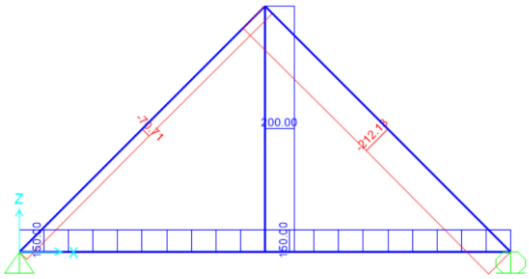


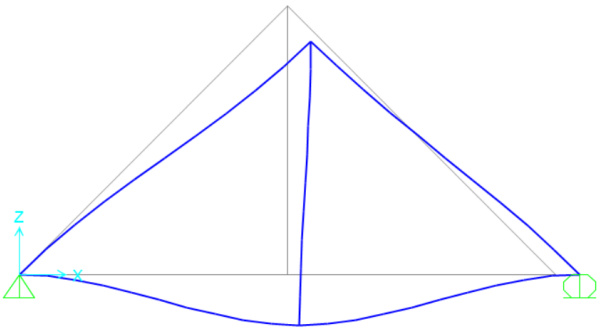


$$\{Q\} = \begin{Bmatrix} 0 \\ -200 \\ 0 \\ 100 \\ 0 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix} \qquad \{D\} = \begin{Bmatrix} 750 \\ -3164.2135 \\ 1500 \\ 1457.106 \\ -2164.21 \end{Bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix}$$



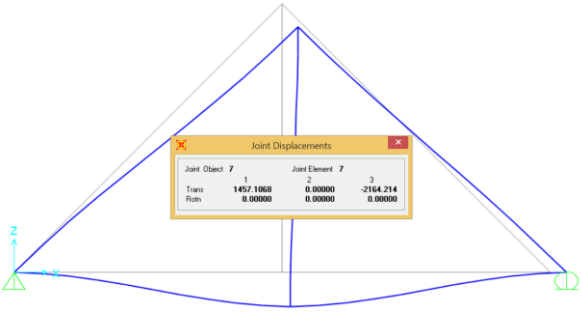






Joint Displacements

Joint Object 5	Joint Element 5		
	1	2	3
Trans	750.00000	0.00000	-3164.21
Rotn	0.00000	0.00000	0.00000

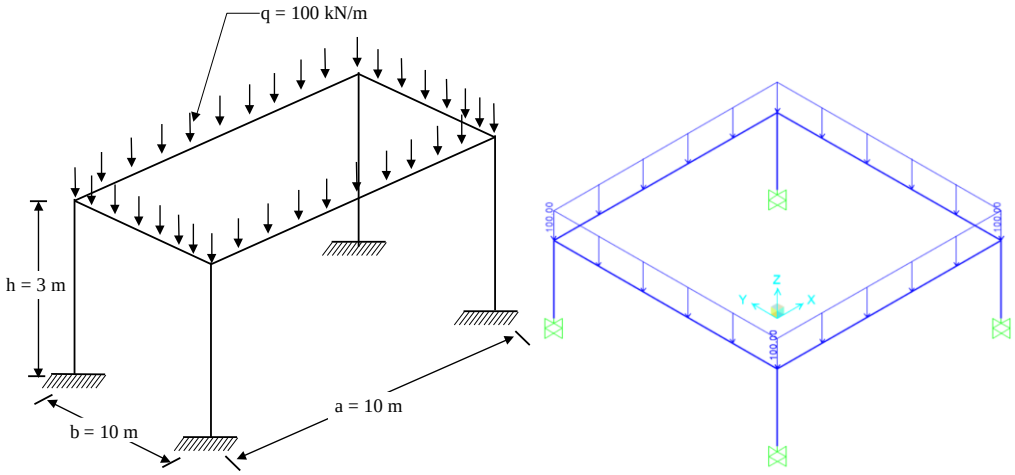


Joint Displacements

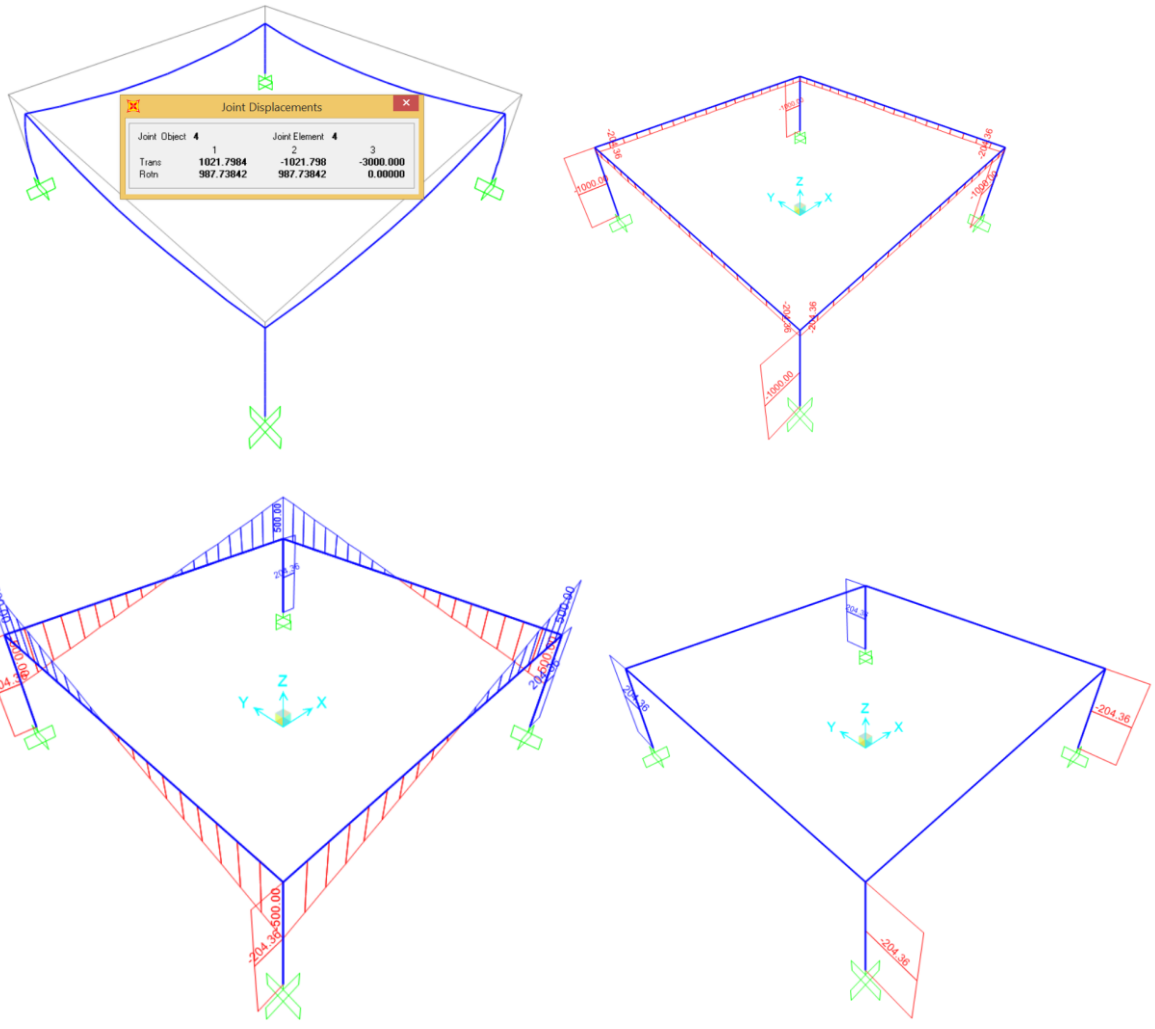
Joint Object 7	Joint Element 7		
	1	2	3
Trans	1457.1068	0.00000	-2164.214
Rotn	0.00000	0.00000	0.00000

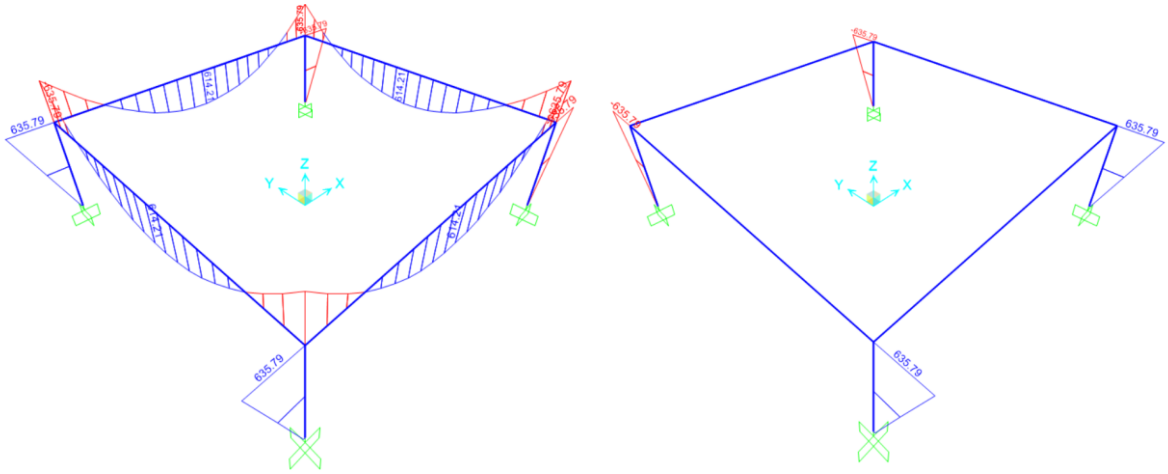
ÖRNEK 14

Gerçekte sistemler üç boyutlu uzayda yer almaktadır. uzay çerçeve için rijitlik matrisi formülasyonu kullanılarak her taşıyıcı sistemin çözümü yapılabilir. Ancak uzay çerçevede bilinmeyen sayısı daha fazla olduğundan, çözümlerin el ile yapılması zor olmaktadır. Örnek olarak tek katlı simetrik bir uzay çerçeve rijitlik matrisi yöntemi ile çözülmüştür.



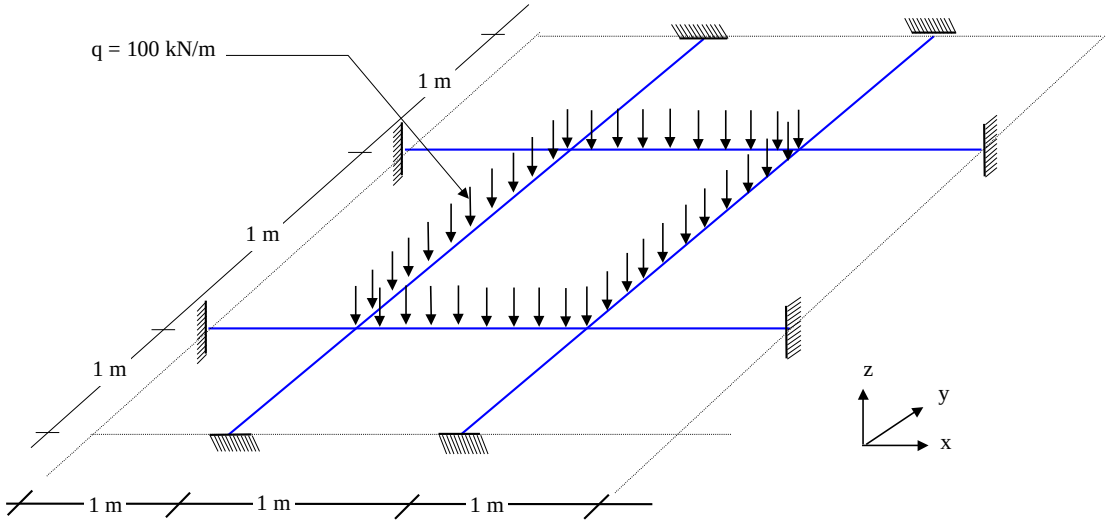
Uzay çerçeve Taşıyıcı sistem

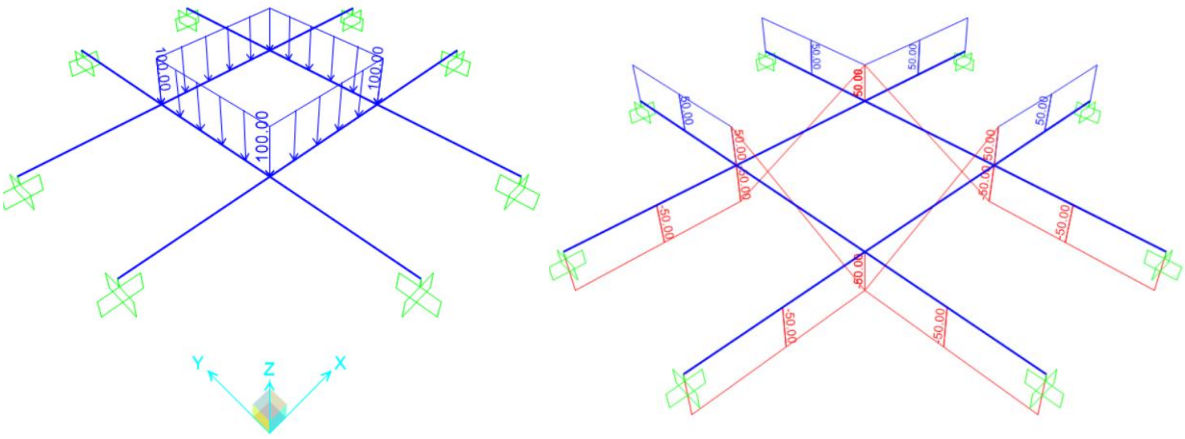


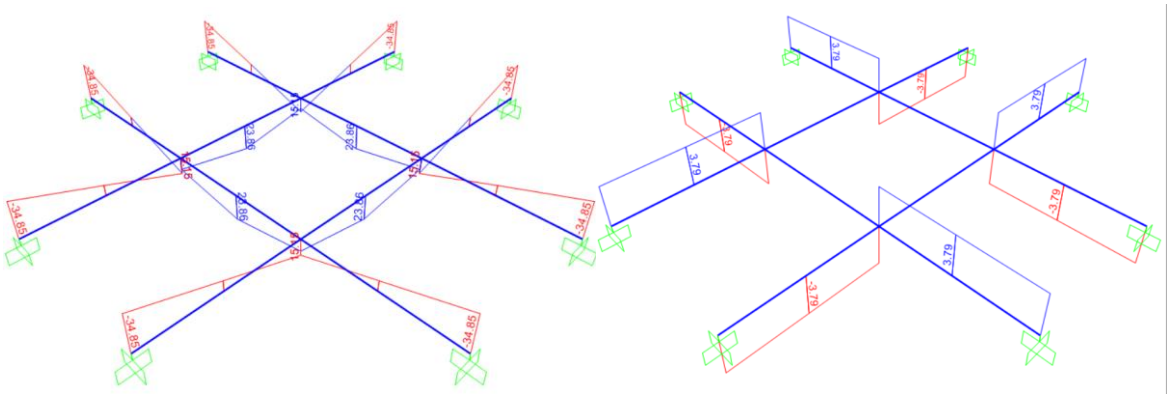


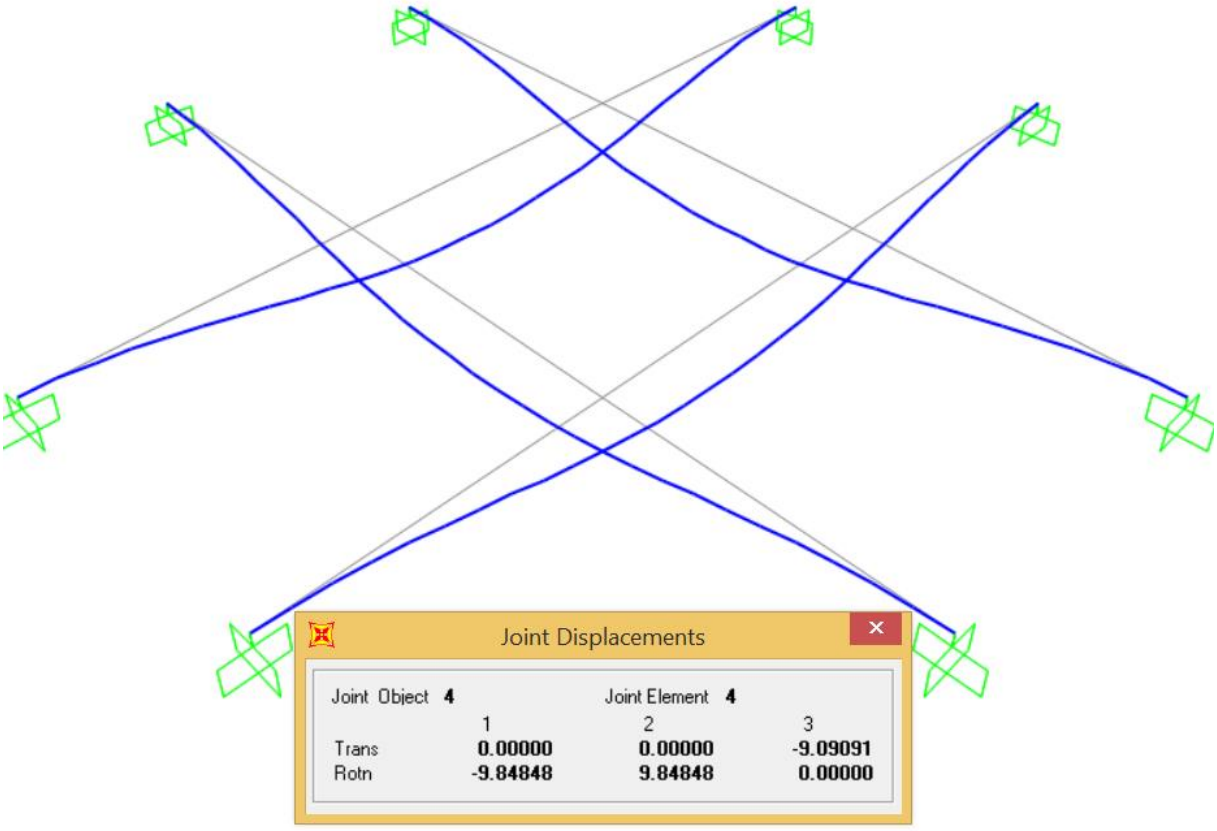
ÖRNEK 15:Düzlem ızgara

Düzlemine dik yüklü sistemler (ızgara temel, kaset döşeme) içinde bir örnek rijitlik matrisi yöntemi ile çözülmüştür. Ara işlemlerin tamamı yerine sonuçlar verilmiştir.



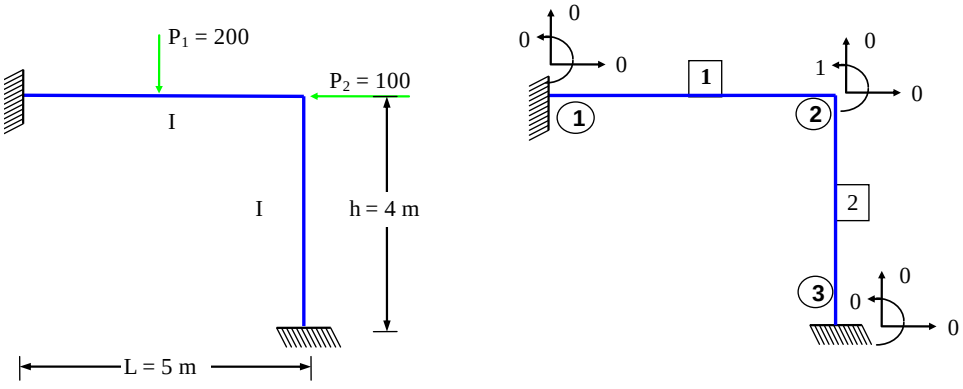


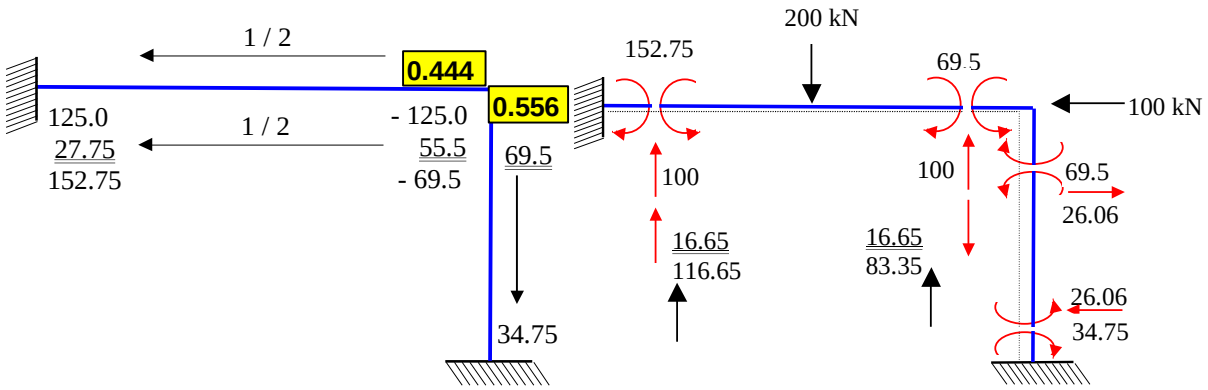


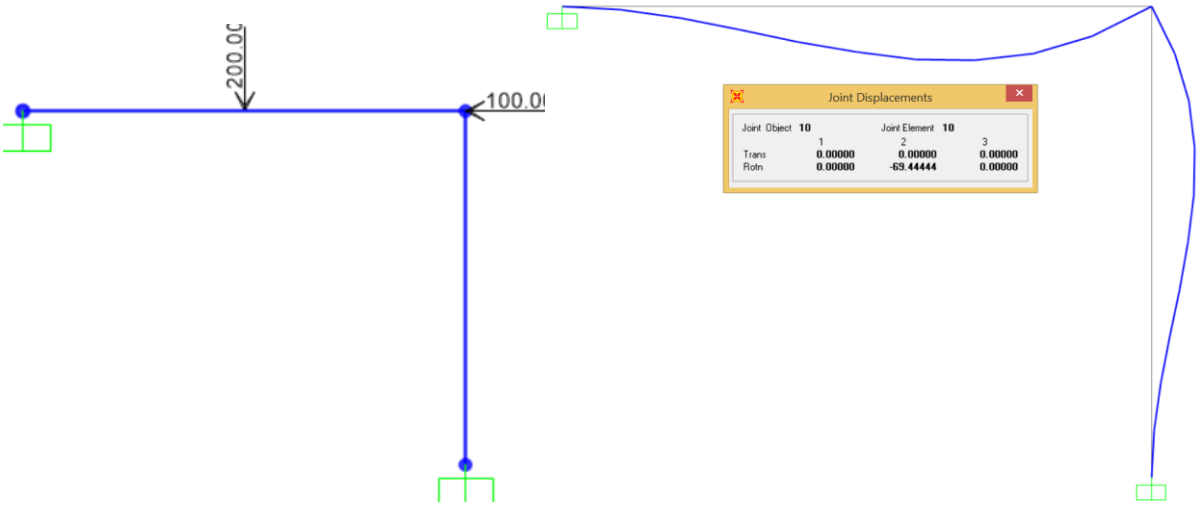


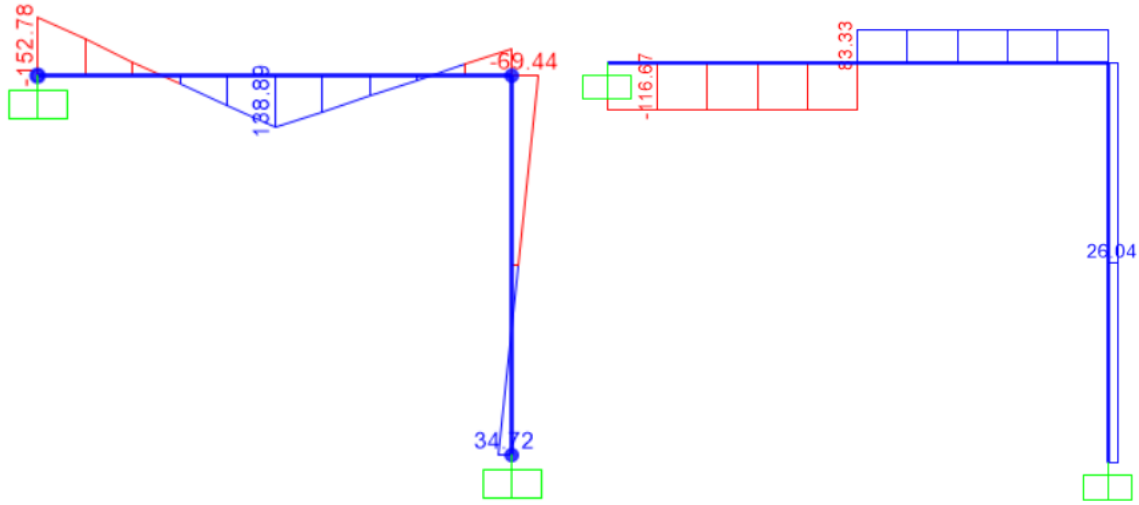
ÖRNEK 16

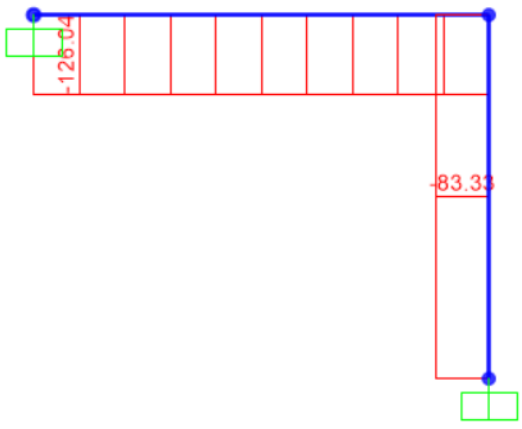
Örnek 4 te verilen çerçevenin düğüm Noktaları sabit kabul edilerek Cross ve Açı Yöntemi ile çözümü




1 / 2
0.444
125.0
27.75
152.75
1 / 2
- 125.0
55.5
- 69.5
0.556
69.5
34.75
152.75
200 kN
69.5
100 kN
100
16.65
116.65
100
16.65
83.35
69.5
26.06
26.06
34.75

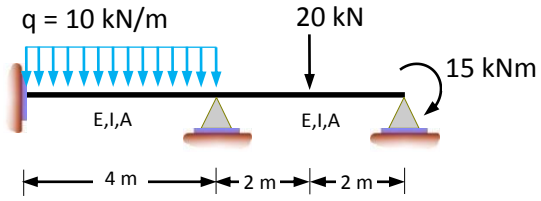

200.00
100.00
Joint Displacements
Joint Object 10
Joint Element 10
1
2
3
Trans
0.00000
0.00000
0.00000
Rotn
0.00000
-69.44444
0.00000

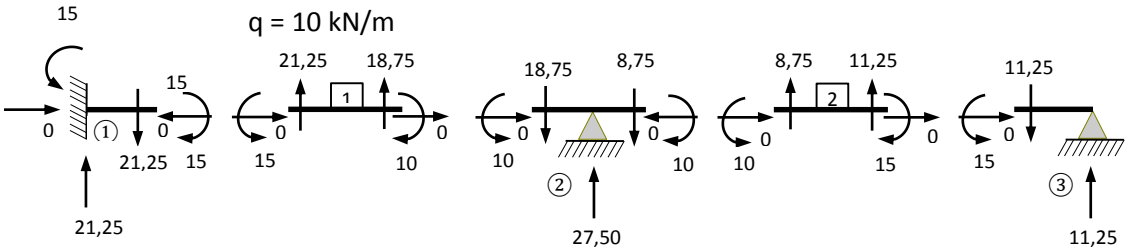

152.78
-69.44
-116.67
83.33
26.04

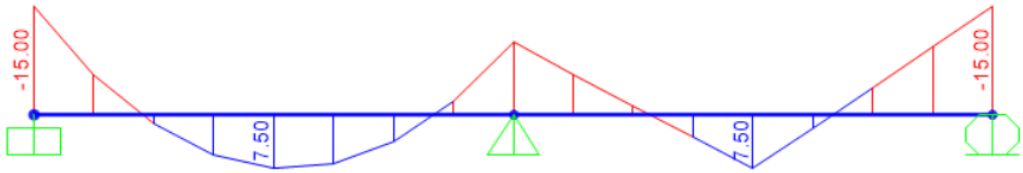

-125.04
-83.33

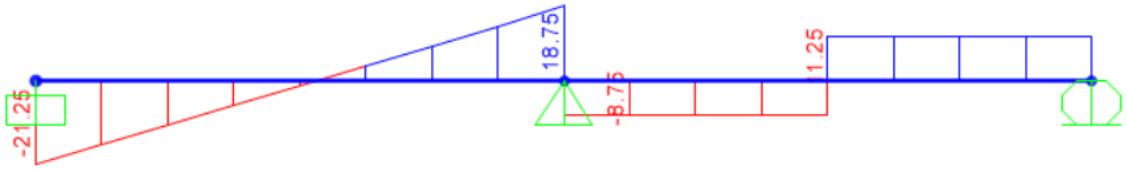
ÖRNEK 17

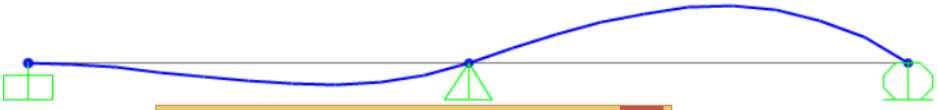
Sürekli Kiriş, Yayılı Yük, tekil yük ve <Düğüme tekil moment etkiyen sistemin, Düğüm noktaları sabit sistem olarak kabul ederek; rijitlik matrisi, açı ve Cross yöntemi ile çözülmüş ve kesit tesirleri elde edilmiştir (Uygulama paketi 2). Burada aynı örnek SAP2000 ile modellenerek sonuçlar elde edilecektir.

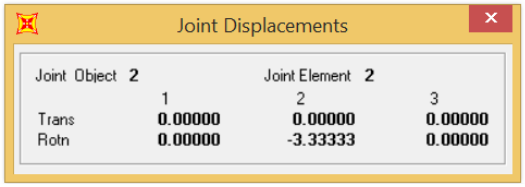






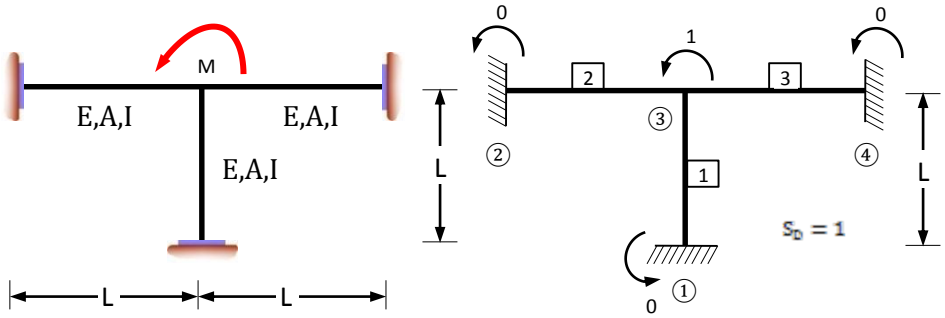




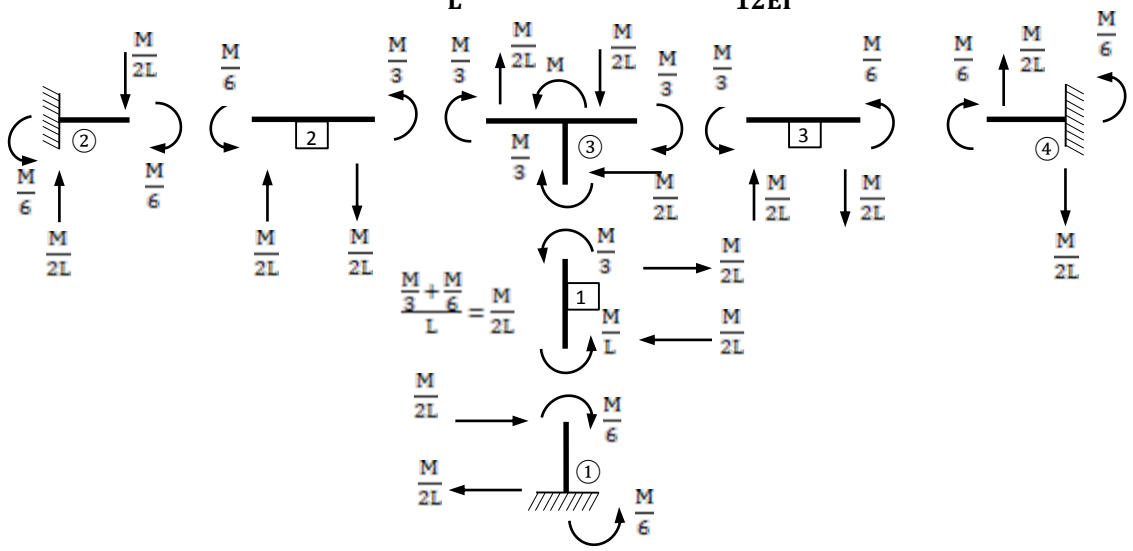


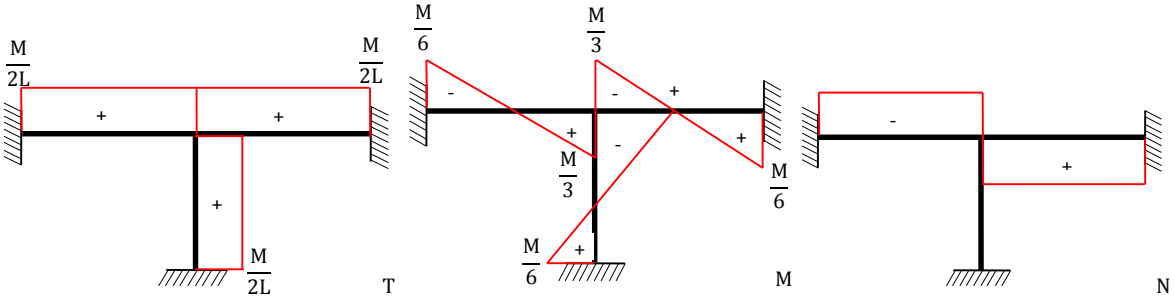
ÖRNEK 18

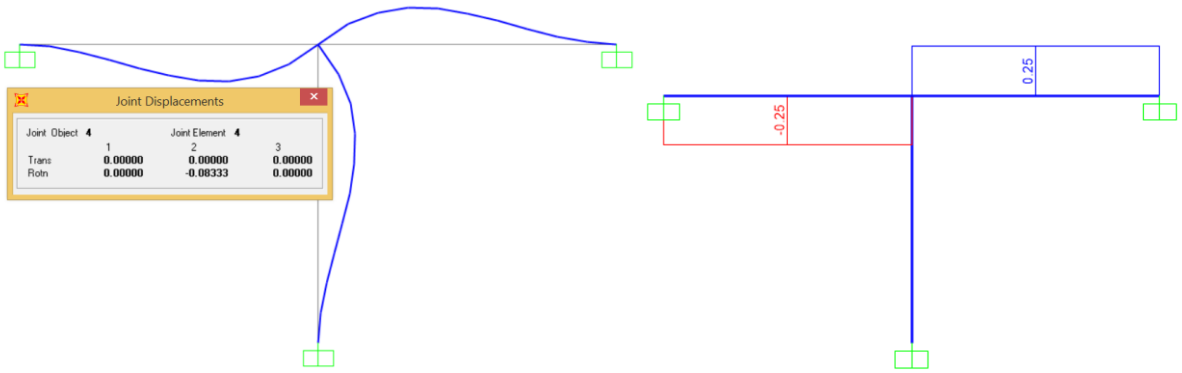
Verilen çerçeve sistem Düğüm noktaları sabit sistem olarak kabul ederek; rijitlik matrisi, açı ve Cross yöntemi ile çözülmüş ve kesit tesirleri elde edilmiştir (Uygulama paketi 2). Burada aynı örnek SAP2000 ile modellenerek sonuçlar elde edilecektir. M ve yerine 1 konulacaktır.



$$\frac{12EI}{L}.D_1 = M \Rightarrow \quad D_1 = \frac{ML}{12EI}$$

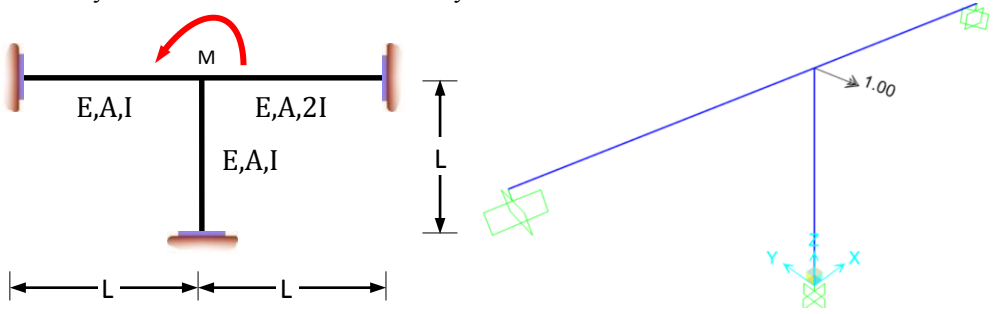


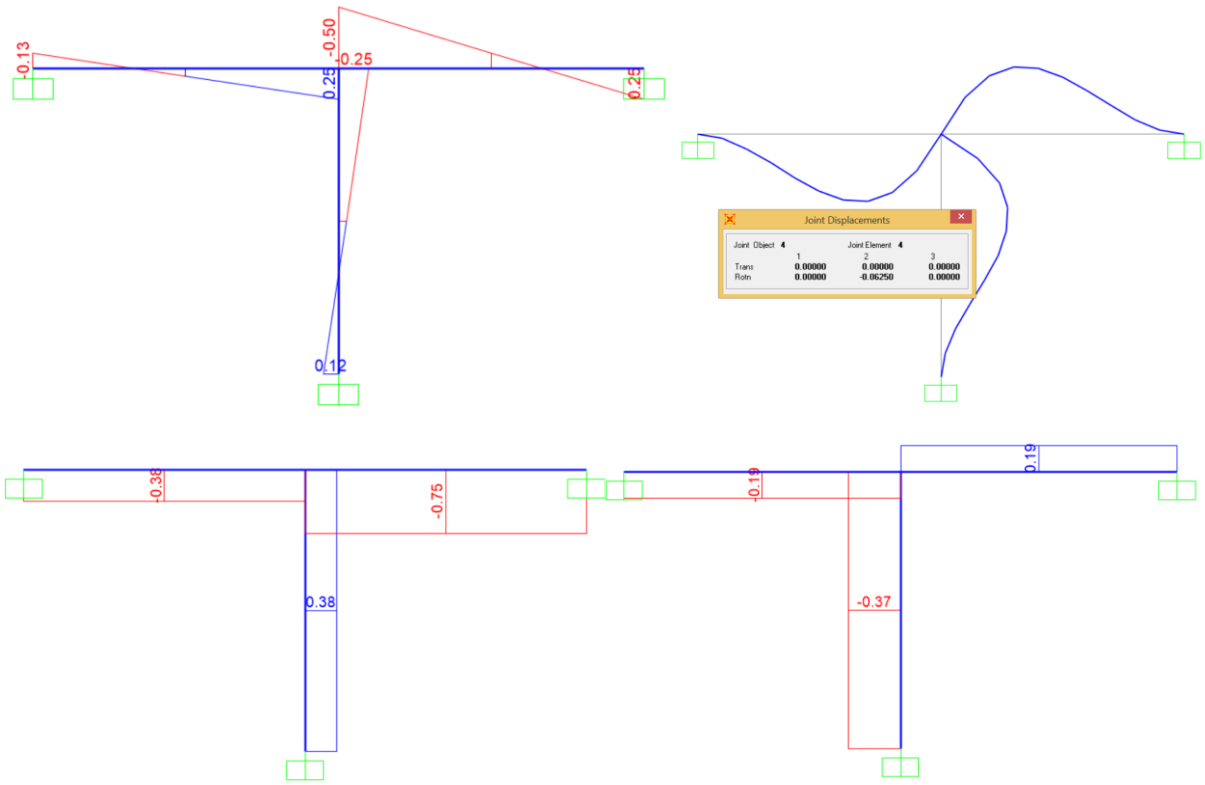




ÖRNEK 19

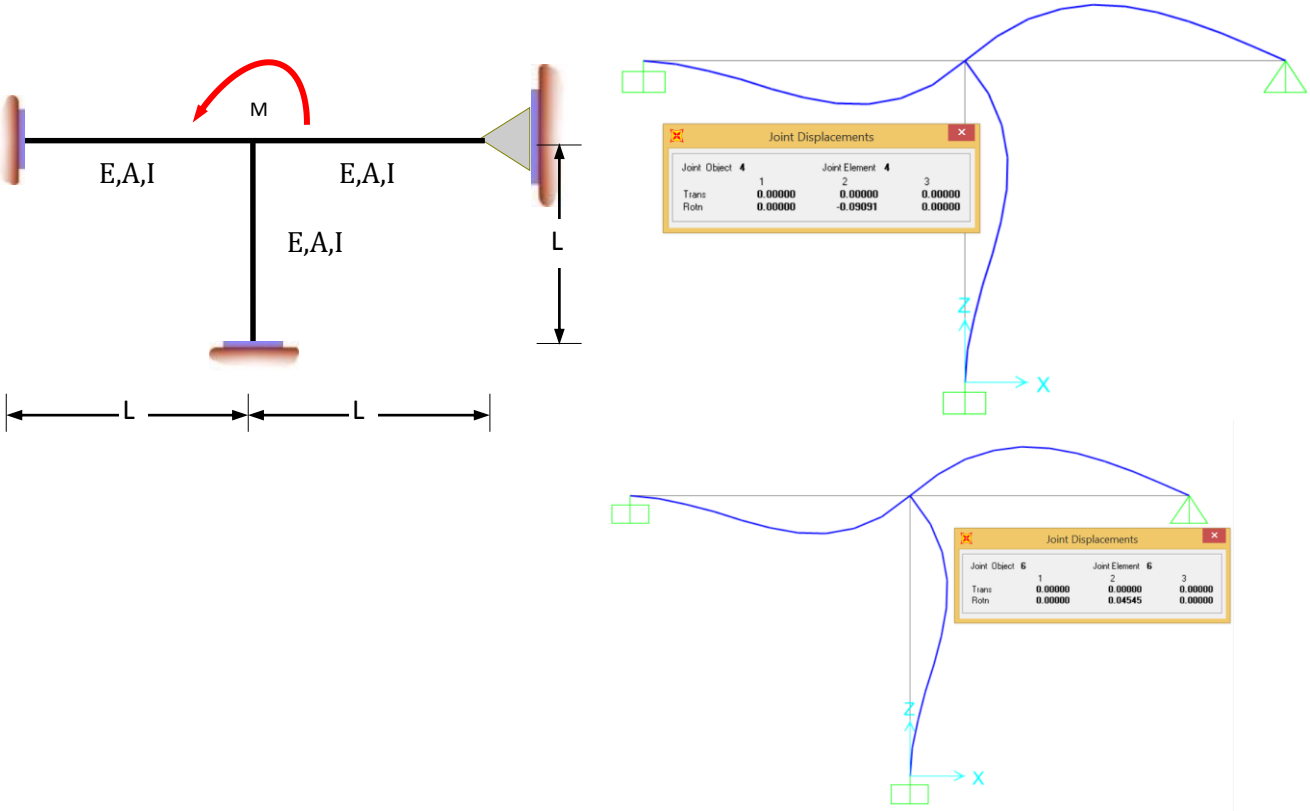
Örnek 18 de verilen sistemde ikinci kirişin rijitliğini 2 katı alarak çözüm yapalım. Çubuklarda; eksenel ve kayma deformasyonları ihmal edilecektir. L ve M yerine 1 alınacaktır.

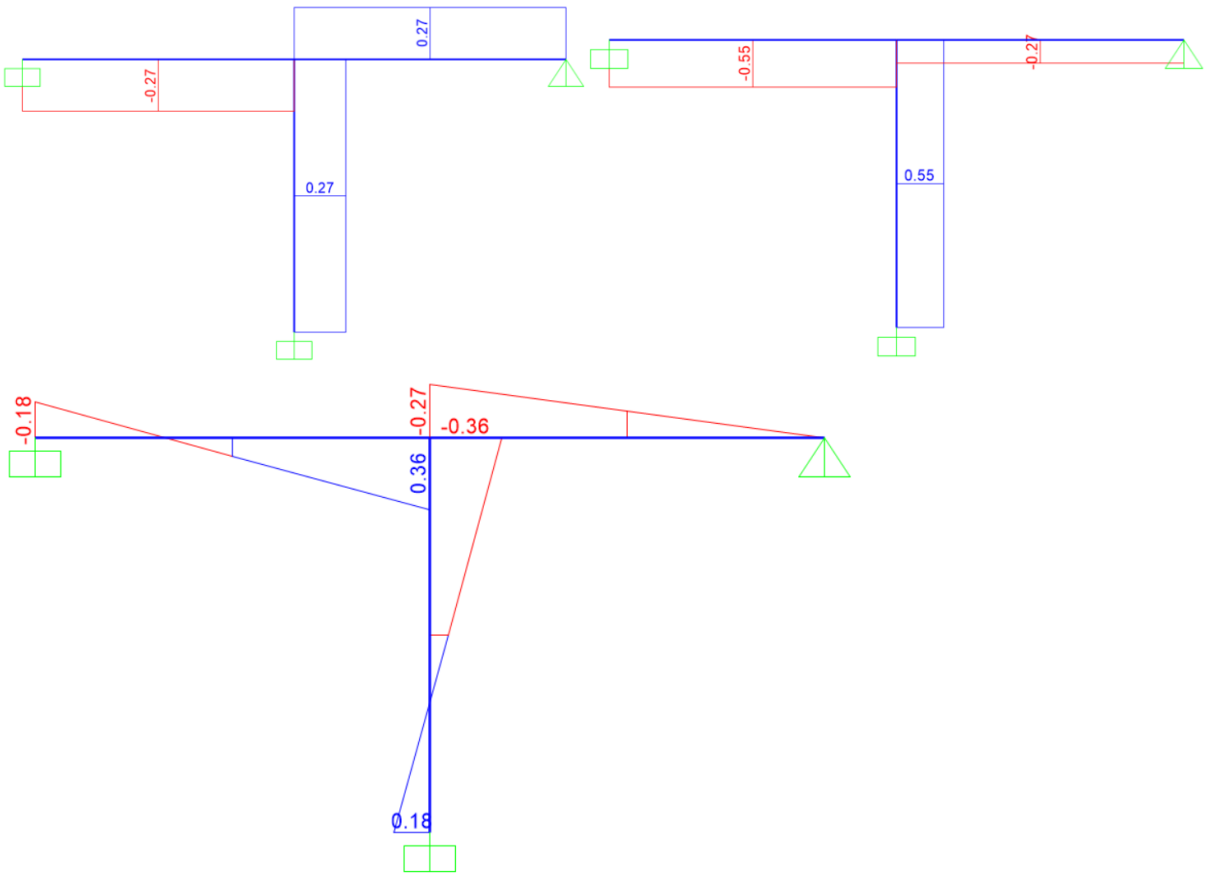




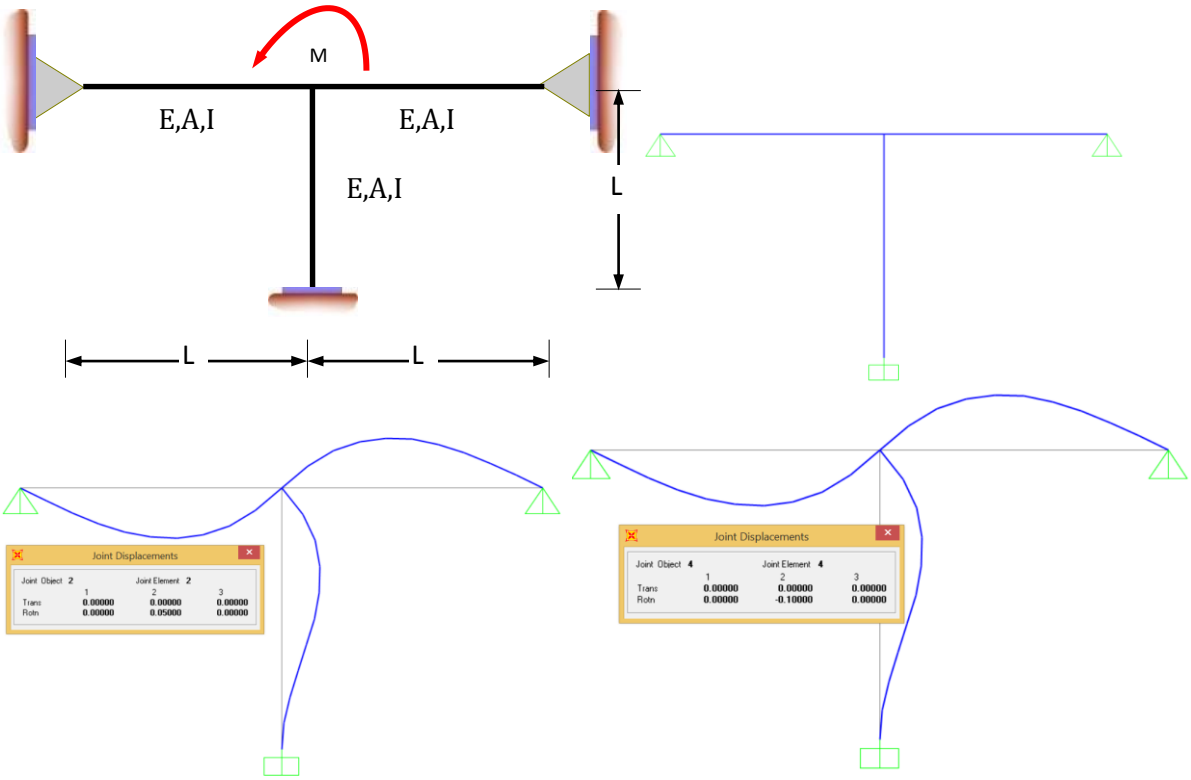
ÖRNEK 20

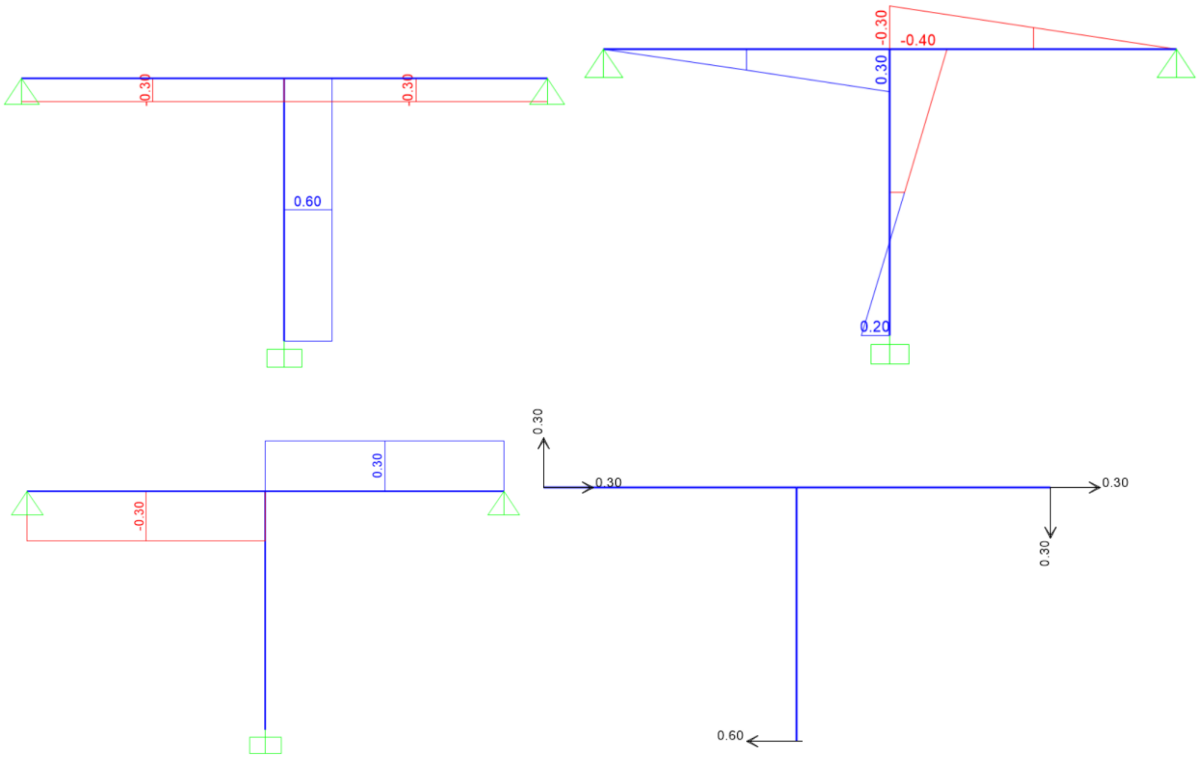
Mesnetlerden Birisi sabit mesnet diğerleri ankastre olursa moment dağılımı nasıl olur?.





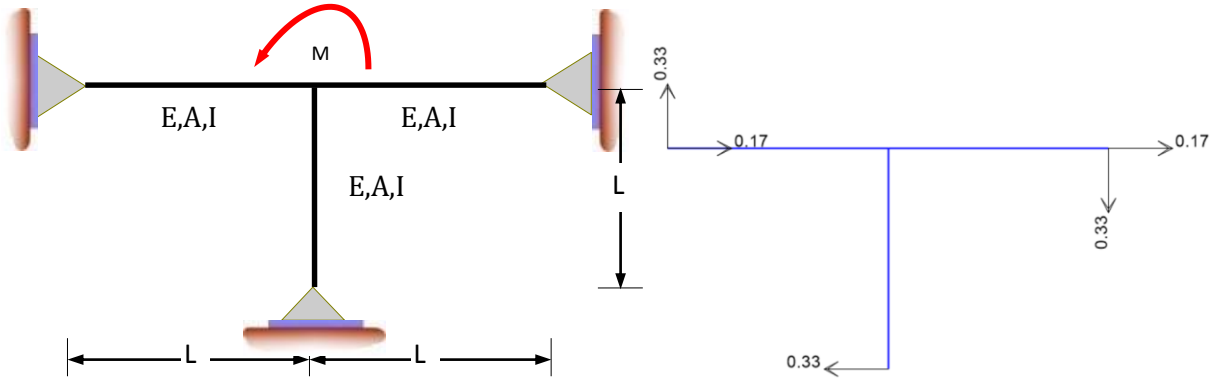
ÖRNEK 21
Kirişlerin Uçları Sabit Mesnetli Olursa

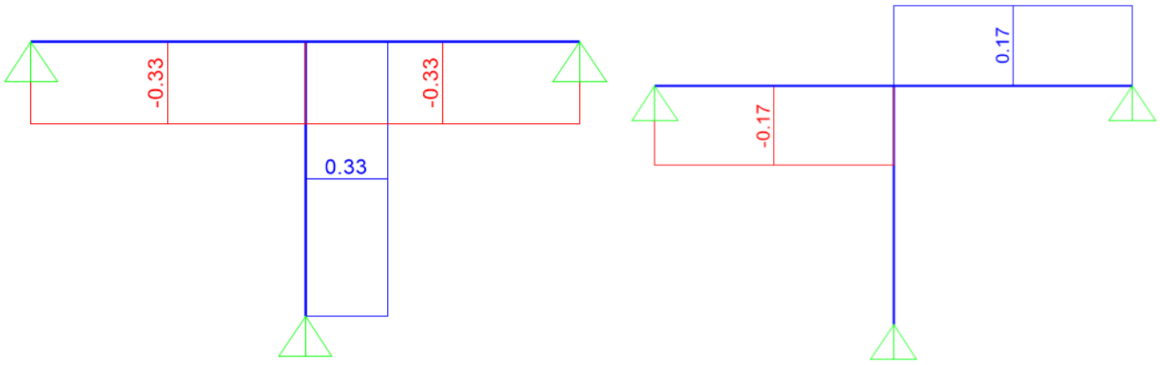


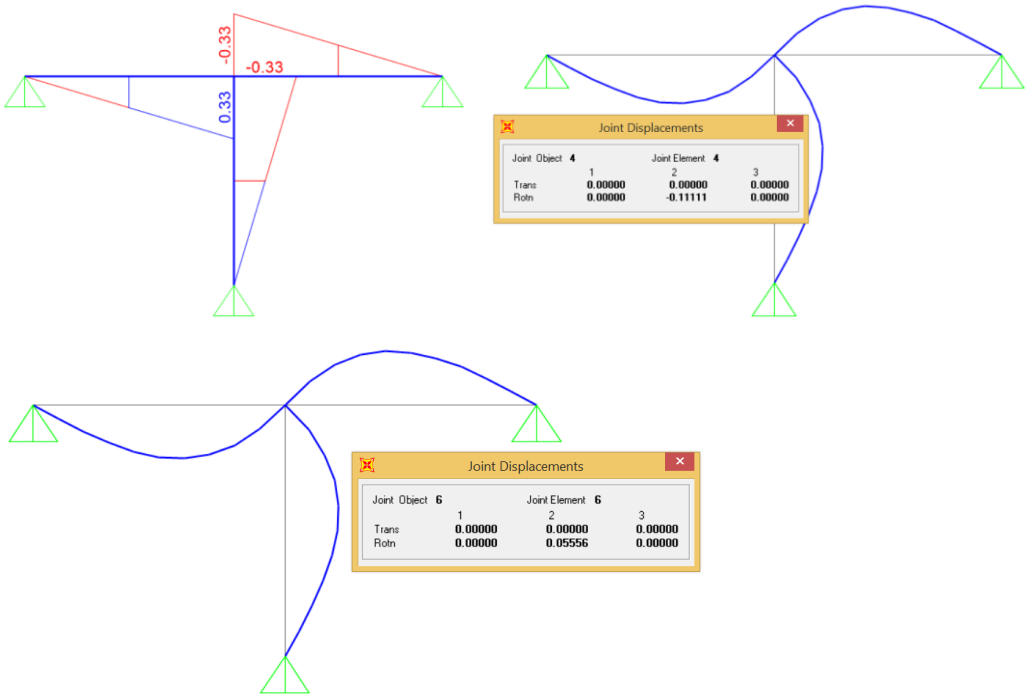


ÖRNEK 22

Örnek 22 deki sistemde; Tüm mesnetler basit mesnet olarak teşkil edilirse moment dağılımı nasıl olur?

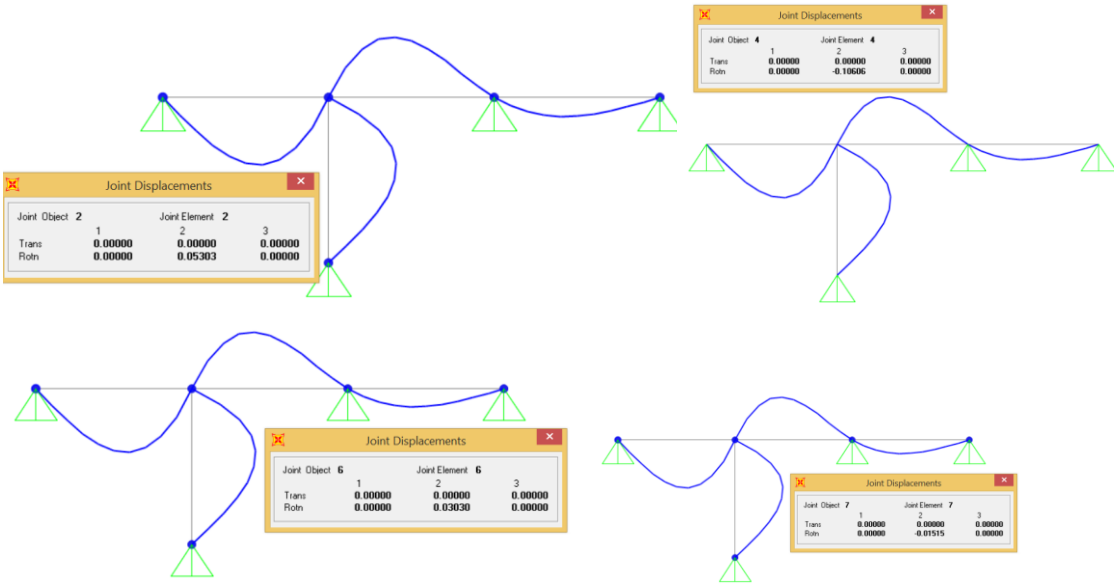






ÖRNEK 23

İki Açıklıklı Kirişte ilk ara mesnede etki eden bir moment nasıl dağılır?

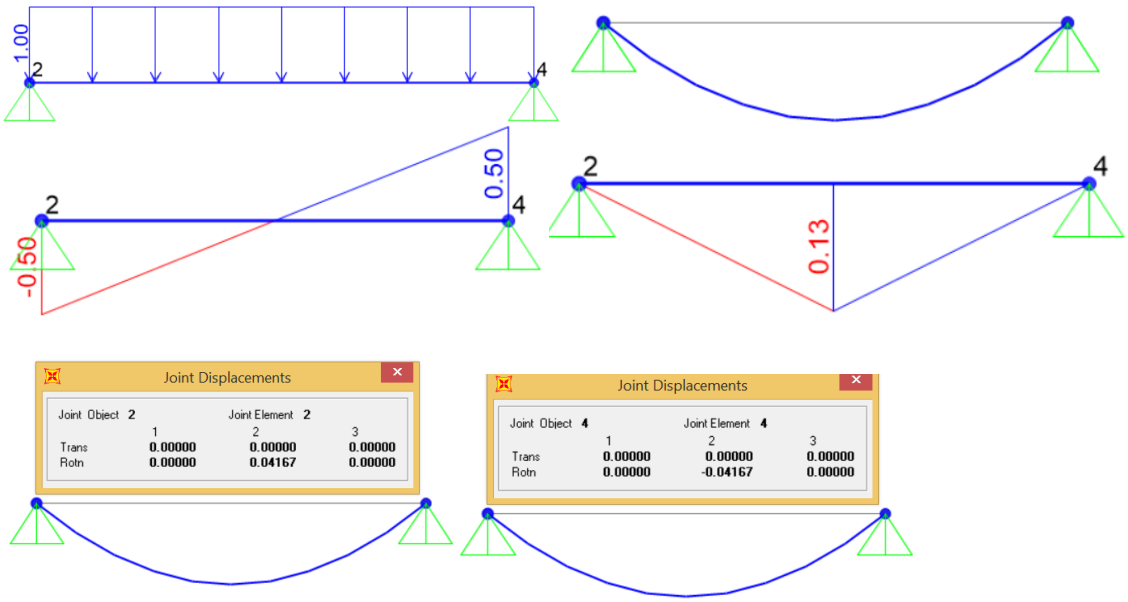


Örnek 24

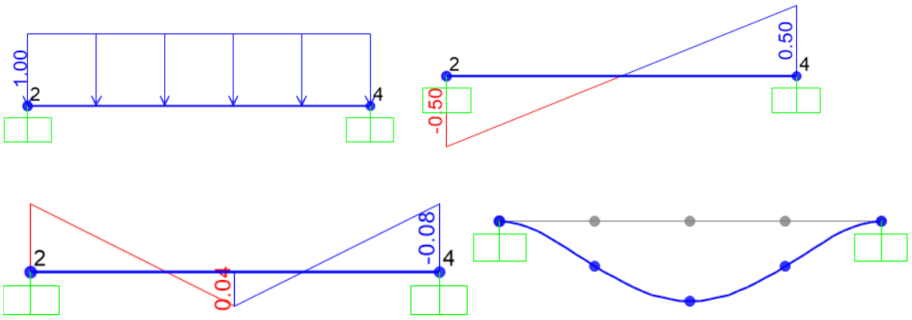
Sürekli Kirişlerde Moment ve deformasyonların dağılımı

Bu uygulamada, eşit açıklıklı ve aynı yayılı yüke maruz kirişlerin davranışı incelenmiştir. Özellikle simetrik sürekli kirişlerin, İki ucu ankastre ya da bir ucu ankastre tek açıklıklı kirişlere benzerliğine dikkat edilmeli..

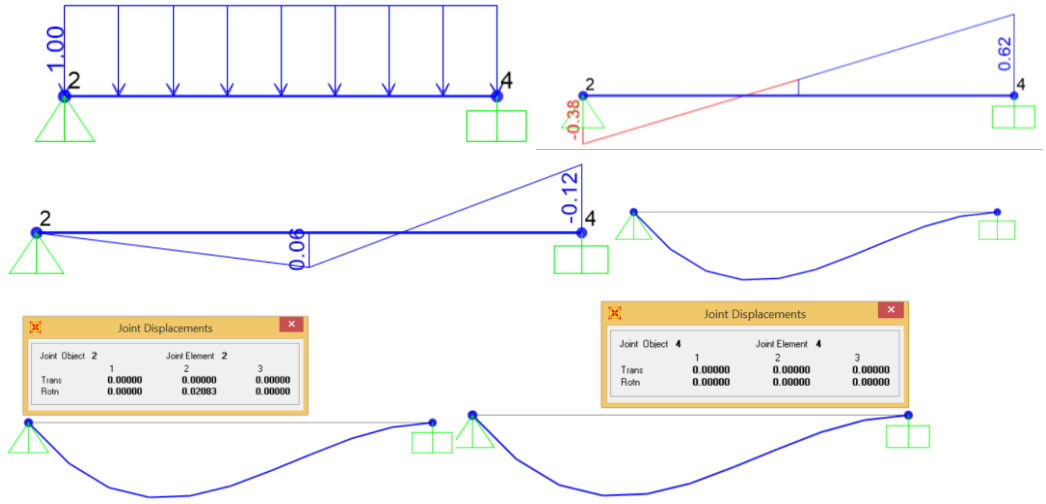
TEK AÇIKLIK İKİ UCU BASİT MESNETLİ KİRİŞ



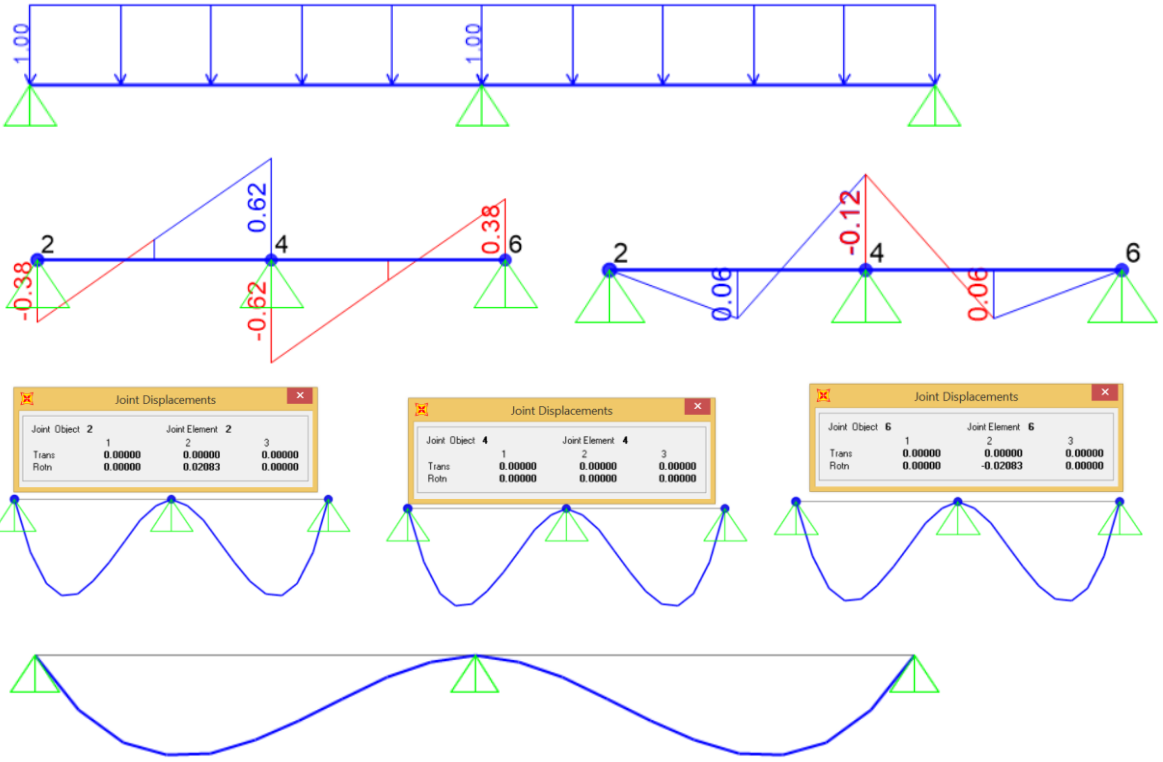
TEK AÇIKLIK İKİ UCU ANKASTRE



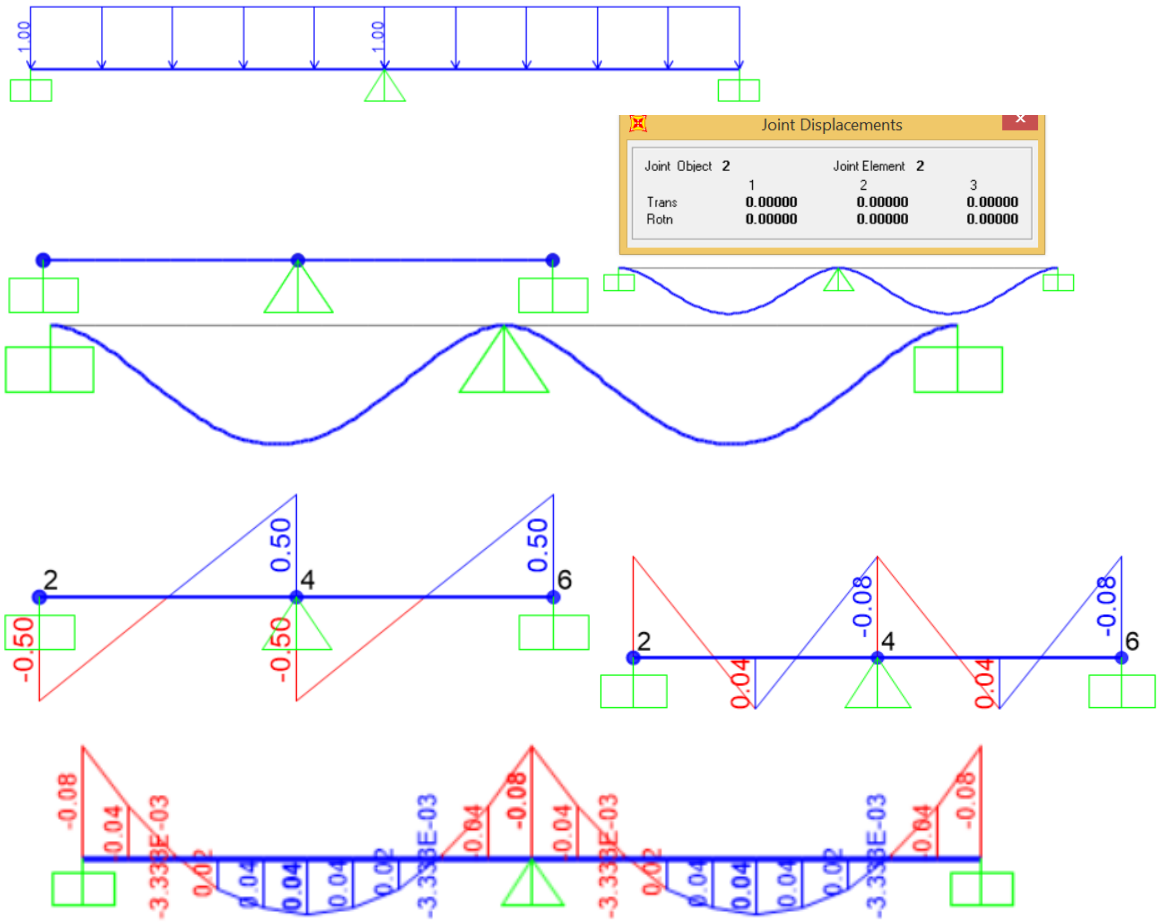
TEK AÇIKLIK BİR UCU ANKASTRE BİR UCU BASİT



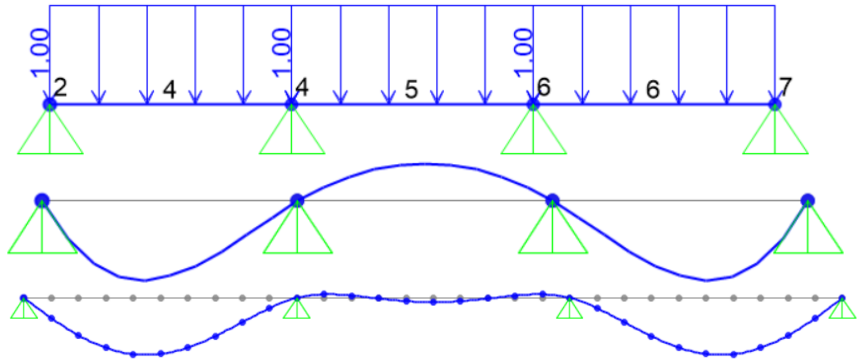
EŞİT İKİ AÇIKLIKLI SÜREKLİ KİRİŞ KENAR MESNETLER BASİT

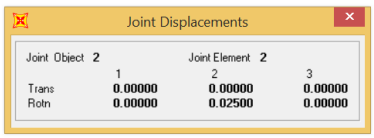


EŞİT İKİ AÇIKLIKLI SÜREKLİ KİRİŞ KENAR MESNETLER ANKASTRE

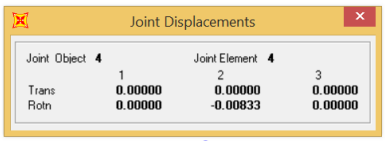


EŞİT ÜÇ AÇIKLIKLI SÜREKLİ KİRİŞ KENAR MESNETLER BASİT

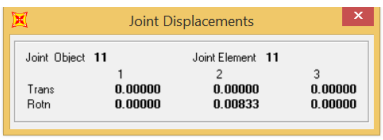


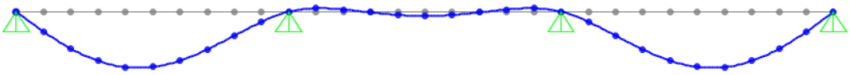


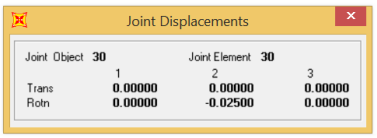




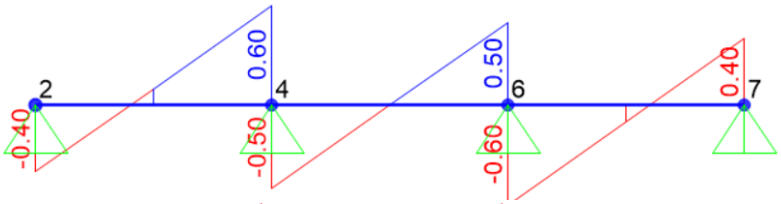


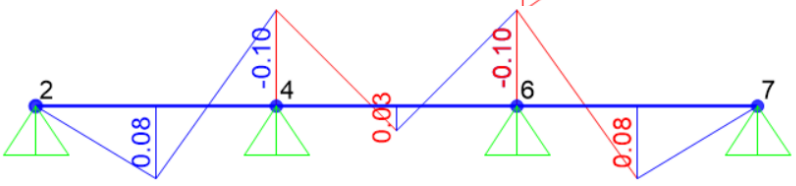


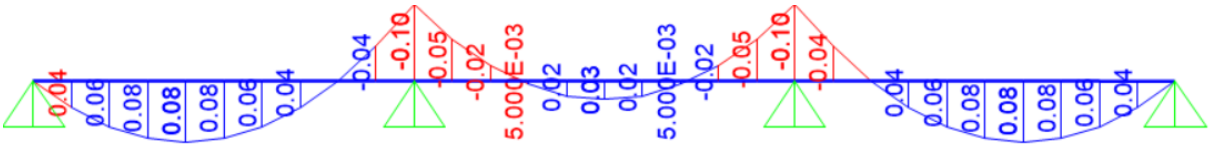




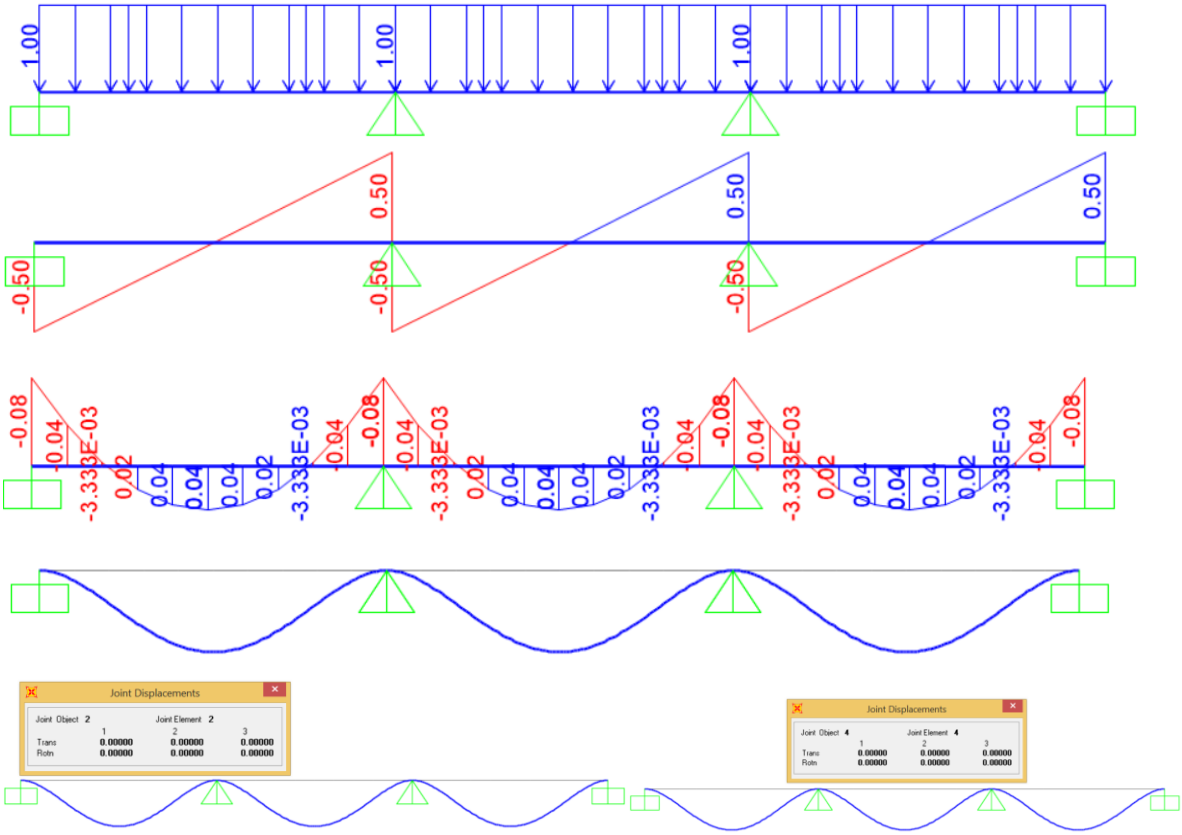






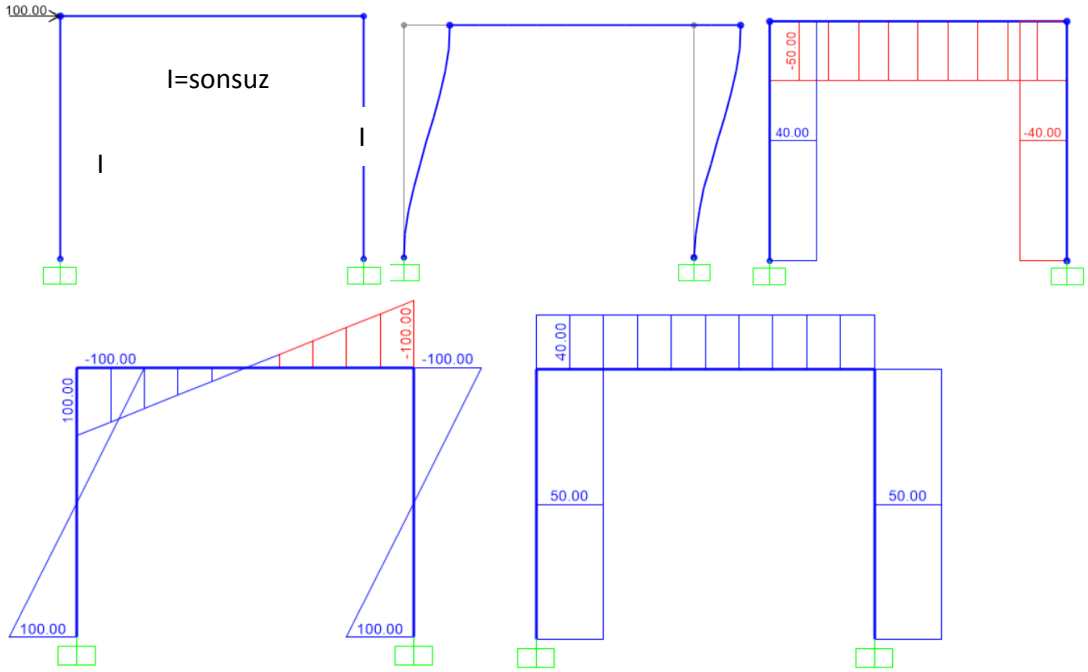


EŞİT ÜÇ AÇIKLIKLI SÜREKLİ KİRİŞ KENAR MESNETLER ANKASTRE



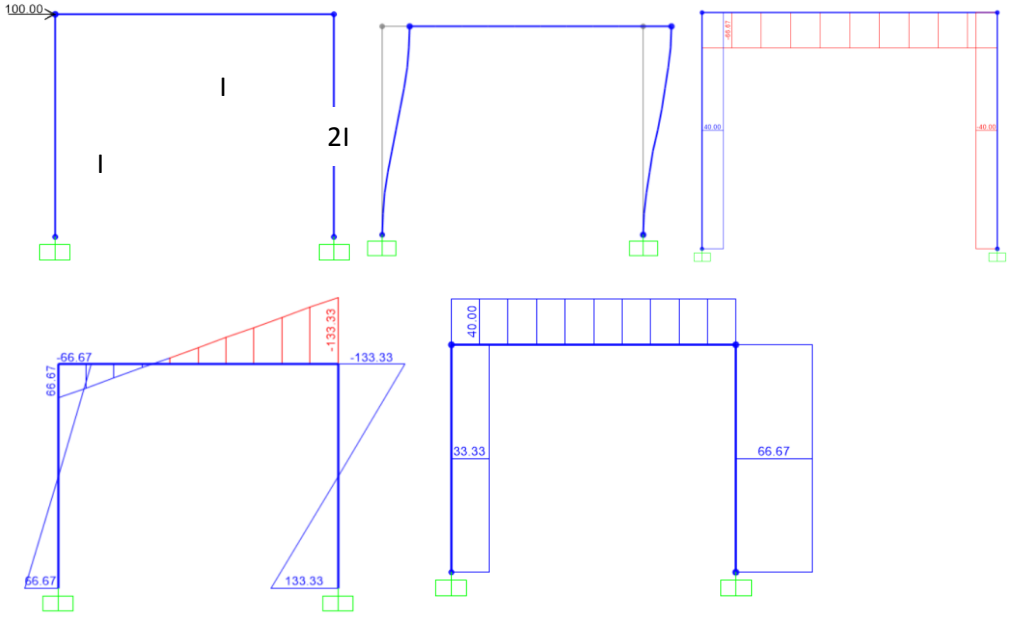
Örnek 25: Çerçevelerin yatay Yükler Altındaki Davranışı
5 m açıklık ve 4 m yüksekliğe sahip bir çerçeveye 100 kN yatay yük etkimektedir. Betonarme yapılarda, kiriş ve döşemlerden oluşan ve düzenli olan katların yatayda rijit hareket ettiği kabul edilebilir. Bu kabule dayalı yapılan çözüme rijit diyafram kabulü denilmektedir. Bu durumda, yatay yükler kolonlara rijitlikleri oranında dağılır. Kat düzlemi içerisindeki, kiriş ve döşemlerin eğilme rijitliğine bağlı olarak bu durum değişebilir. Gerçek yapılarda modeli oluştururken, düzenli sistem tercih edilmelidir. Bu kısımda, rijit kat kirişine bağlı kolonların rijitlikleri değiştirilerek yatay yük paylaşımları incelenmiştir

Kolon rijitlikleri Aynı Olması Durumu



Eğilme Momenti Kesme Kuvveti

Kolonlardan biri diğerinin iki katu atalet momentine sahip olması durumu



Eğilme Momenti Kesme Kuvveti

Betonarme yapılarda, kat döşemleri düzlemi içinde rijit diyafram davranışı göstermesi halinde; Deprem yüküne maruz kolon/perde elemanlar, reşitlikleri oranında yatay yük taşırlar. Kolon uçlarında dönme oluşmaz. İkinci durumda kolon kesme kuvvetleri eşit ikin, ikinci durumda atalet momenti iki katına çıkarılan kolon iki kat daha fazla yatay yük taşımaktadır. Aynı zamanda moment payları da değişmektedir.