

# Türk Bina Deprem Yönetmeliđi Kapsamında Performansa Dayalı Tasarım, Sismik Taban Yalıtımı ve PERFORM-3D ile Mühendislik Uygulamaları

*2017-2018 Dönemi*

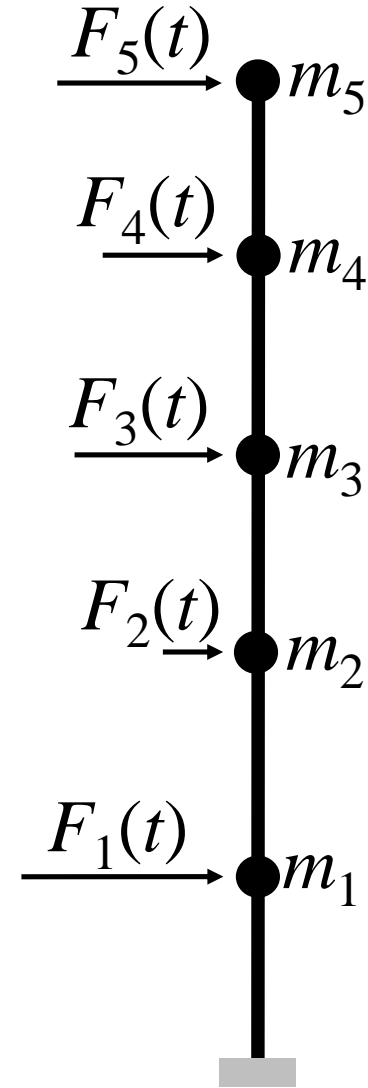
Yapı Dinamiđi ve Deprem Yönetmeliđine Giriş:

Çok Serbestlik Dereceli Sistemler – 3. Bölüm

Dr. Barış Erkuş (İTÜ)

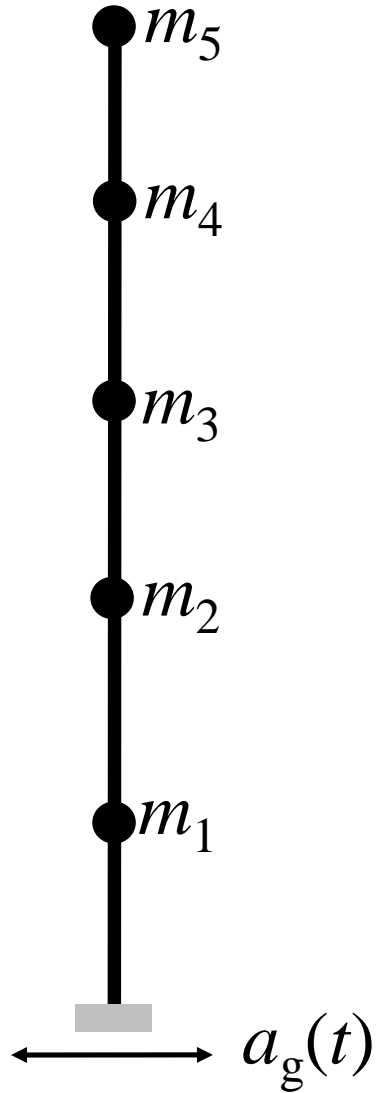
# Genel Yükleme

$$\mathbf{M}\ddot{\mathbf{x}}(t) + \mathbf{C}\dot{\mathbf{x}}(t) + \mathbf{K}\mathbf{x}(t) = \mathbf{F}(t)$$

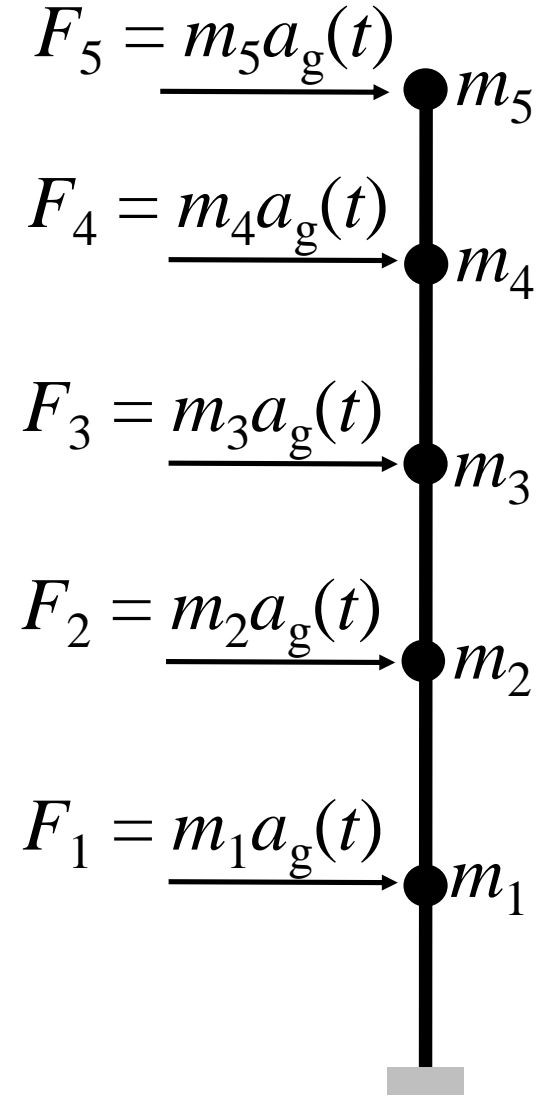


$$\mathbf{F}(t) = \begin{Bmatrix} F_1(t) \\ F_2(t) \\ F_3(t) \\ F_4(t) \\ F_5(t) \end{Bmatrix}$$

# Yer İvmesi – Konsol Kolon Tipi Yapı



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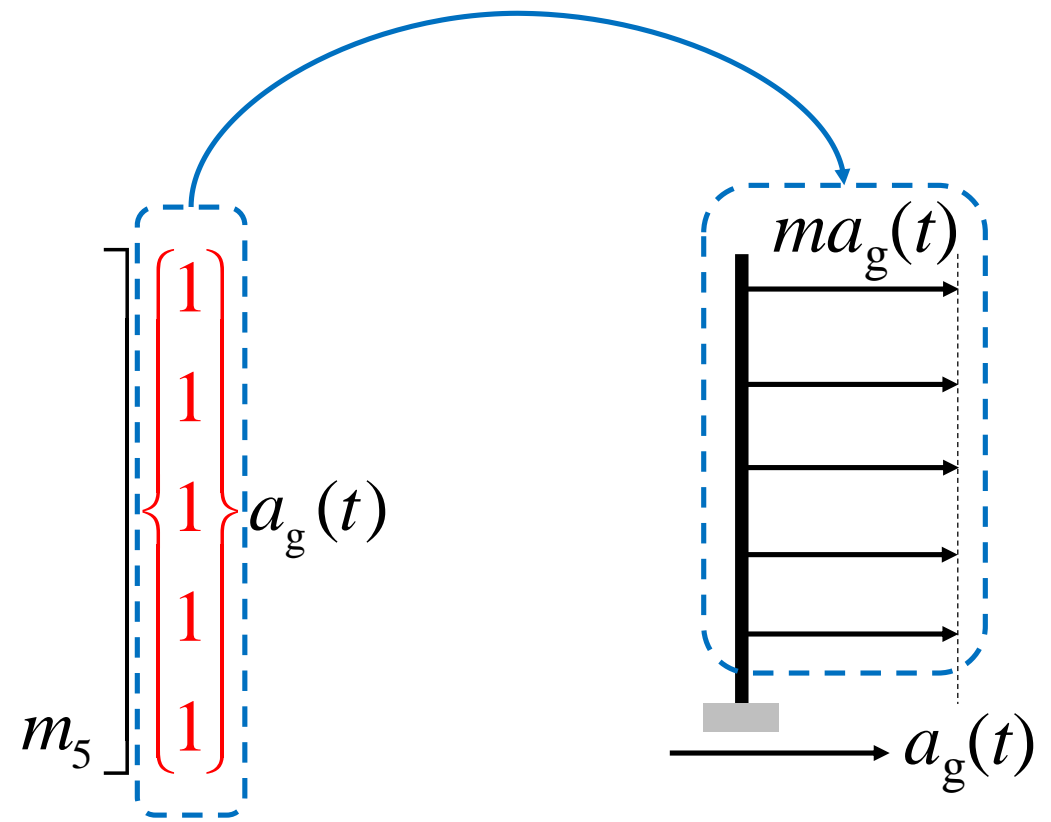


# Yer ivmesi – Konsol Kolon Tipi Yapı

$$\mathbf{F}(t) = \begin{Bmatrix} F_1(t) \\ F_2(t) \\ F_3(t) \\ F_4(t) \\ F_5(t) \end{Bmatrix} = \begin{Bmatrix} m_1 a_g(t) \\ m_2 a_g(t) \\ m_3 a_g(t) \\ m_4 a_g(t) \\ m_5 a_g(t) \end{Bmatrix}$$

$$= \begin{bmatrix} m_1 & & & & \\ & m_2 & & & \\ & & m_3 & & \\ & & & m_4 & \\ & & & & m_5 \end{bmatrix} \begin{Bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{Bmatrix} a_g(t)$$

$$= -\mathbf{M} \mathbf{r} a_g(t)$$



# Çok Serbestlik Dereceli Sistemlerin Deprem Analizleri

- Zaman-Tanım Alanında Analizler: Verilen bir deprem kaydı için dinamik simülasyon
  - Doğrudan Çözüm
    - Matris diferansiyel denklemleri doğrudan çözülür.
    - Yapısal cevaplar doğrudan zaman-tanım alanında elde edilmiş olur.
  - Modal Toplama
    - Her mod için genelleştirilmiş tek serbestlik dereceli sistemi zaman-tanım alanında çözülür.
    - Zaman-tanım alanında elde edilen genelleştirilmiş cevaplar ile mod şekilleri le çarpılarak modal cevaplar bulunur.
    - Modal cevaplar doğrudan toplanarak zaman-tanım alanında yapı cevapları elde edilir.
- Spektral Analizler: Tasarım spektrumu kullanılarak yapısal cevapların maksimum değerleri
  - Modal Birleştirme
    - Her mod için genelleştirilmiş tek serbestlik dereceli sistemin maksimum cevabı bulunur.
    - Genelleştirilmiştir cevaplar mod şekilleri ile çarpılarak modal cevapların maksimum değeri bulunur.
    - Maksimum modal cevaplar modal birleştirme yöntemi denilen yöntemlerden birisi ile birleştirilerek maksimum yapısal cevaplar bulunur.
    - Eğer iki yönde analiz yapılıyor ise, yukarıdaki işlem ayrı ayrı iki yönde yapılır. Her yön için maksimum değerler ayrı ayrı bulunur.
    - İki yöndeki maksimum değerler yönsel birleştirme yöntemi denilen yöntemlerden birisi ile birleştirilerek maksimum yapısal cevaplar bulunur.

# Zaman-Tanım Alanında Doğrudan Analiz

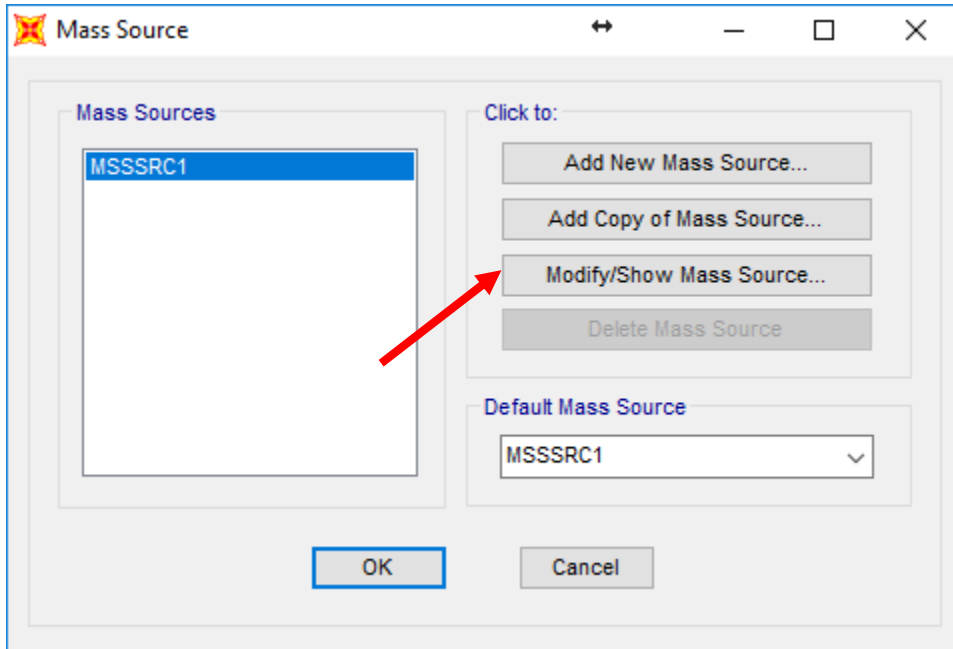
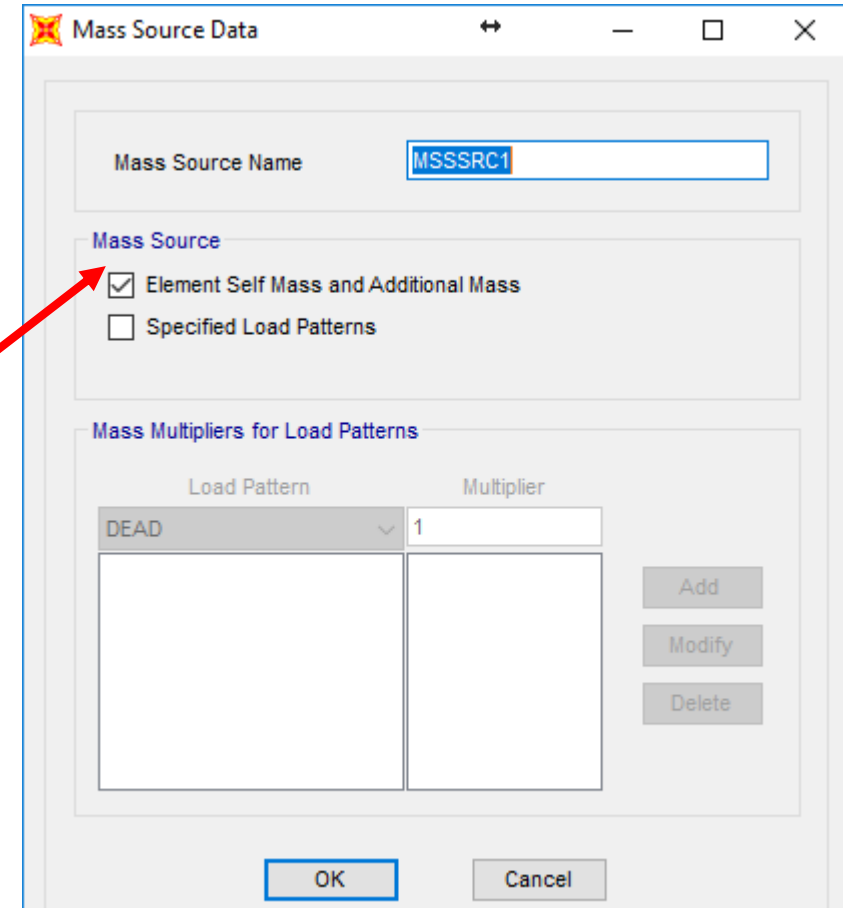
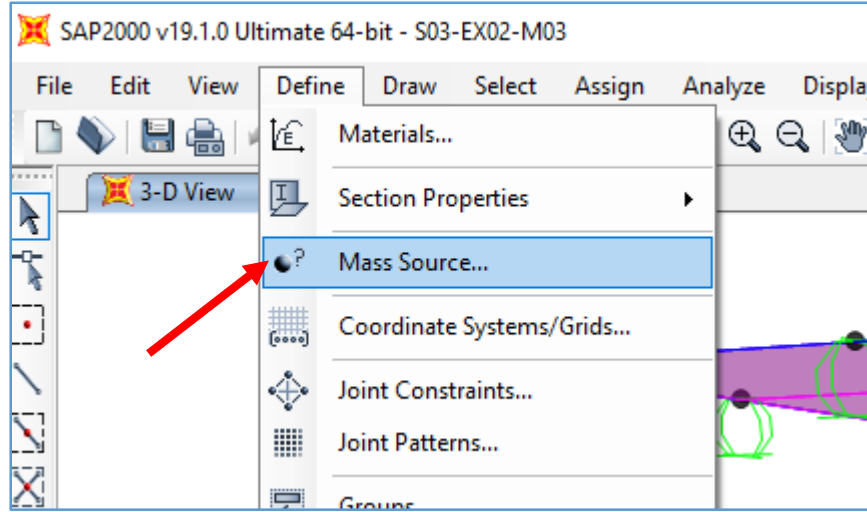
# Zaman-Tanım Alanında Doğrudan Analiz

$$\mathbf{M}\ddot{\mathbf{x}}(t) + \mathbf{C}\dot{\mathbf{x}}(t) + \mathbf{K}\mathbf{x}(t) = \mathbf{F}(t)$$

Doğrudan Matris Denklemine Çözümü

$\ddot{\mathbf{x}}(t)$ ,  $\dot{\mathbf{x}}(t)$  ve  $\mathbf{x}(t)$

# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Kütle



o **Element Self Mass and Additional Mass** option. This is the default. With this option, mass is calculated from the following specifications:

- Mass density specified for [materials](#).
- Mass specified for [link properties](#).
- Additional mass assigned directly to the [joints](#).
- Additional line mass assigned to [frame](#) or [cable](#) objects.
- Additional area mass assigned to [area](#) objects.



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Kütle

Mass Source Name: MSSSRC1

Mass Source

Element Self Mass and Additional Mass

Specified Load Patterns

Mass Multipliers for Load Patterns

Load Pattern	Multiplier
LIVE	1.
DEAD	1.
LIVE	1.

Buttons: Add, Modify, Delete, OK, Cancel

Load Patterns

Load Pattern Name	Type	Self Weight Multiplier	Auto Lateral Load Pattern
DEAD	Dead	1	
DEAD	Dead	1	
LIVE	Live	0	

Buttons: Add New Load Pattern, Modify Load Pattern, Modify Lateral Load Pattern..., Delete Load Pattern, Show Load Pattern Notes..., OK, Cancel

- **Specified Load Patterns** option. With this option, mass is calculated from a scaled combination of load patterns (see Define Mass Multiplier for Loads, below). The net load acting downward (in the negative global Z direction) on each element is divided by the acceleration due to gravity, in the current units, and is used for the mass in the three translational directions. See "Detailed Calculations" below. Load patterns should generally represent weight, and should not contain self-equilibrating loads, such as temperature and prestress.

# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Deprem

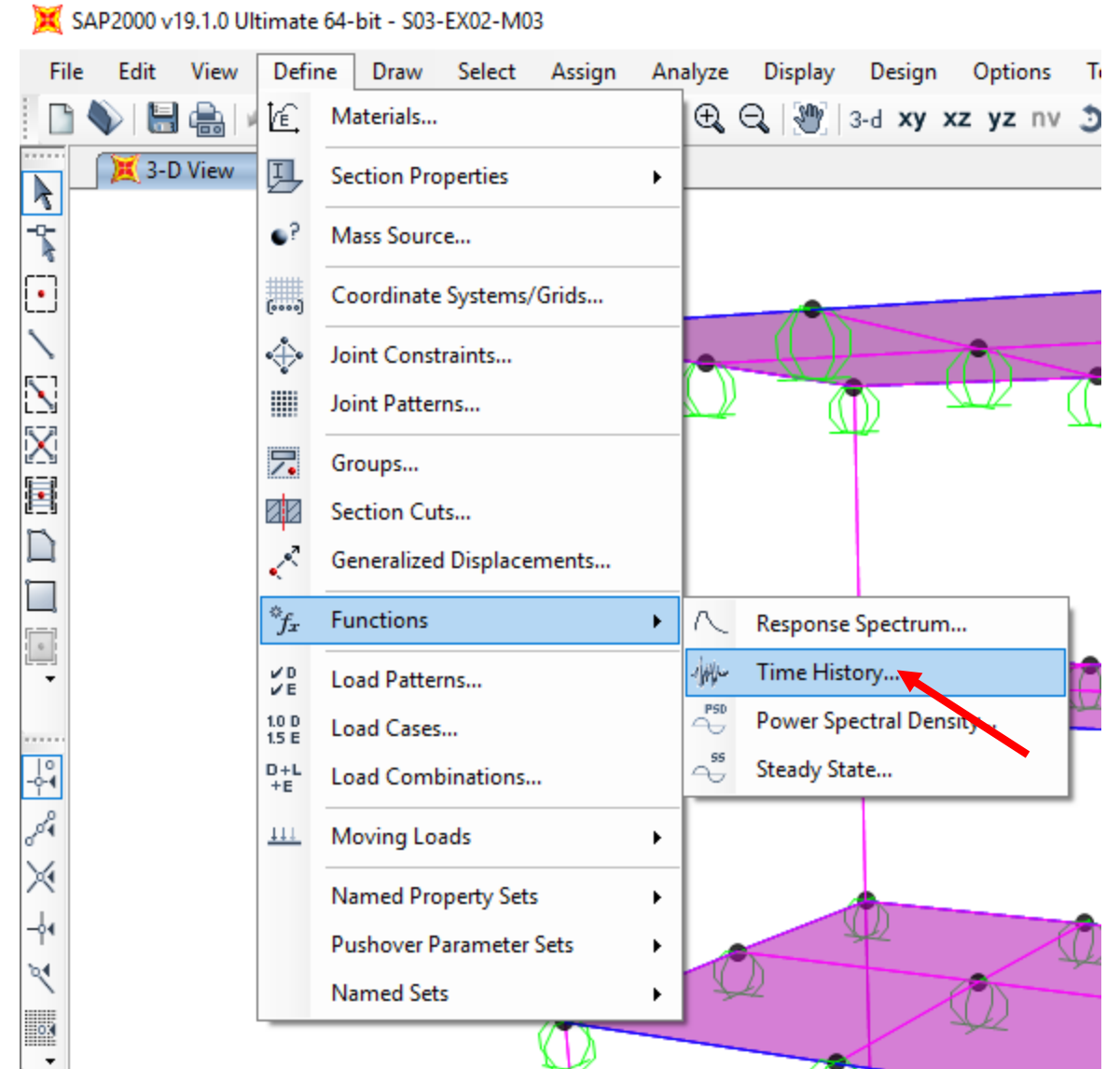
C:\Users\baris\Desktop\Dinamik\S03\Example02\Deprem\kocaeli.txt - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ? X

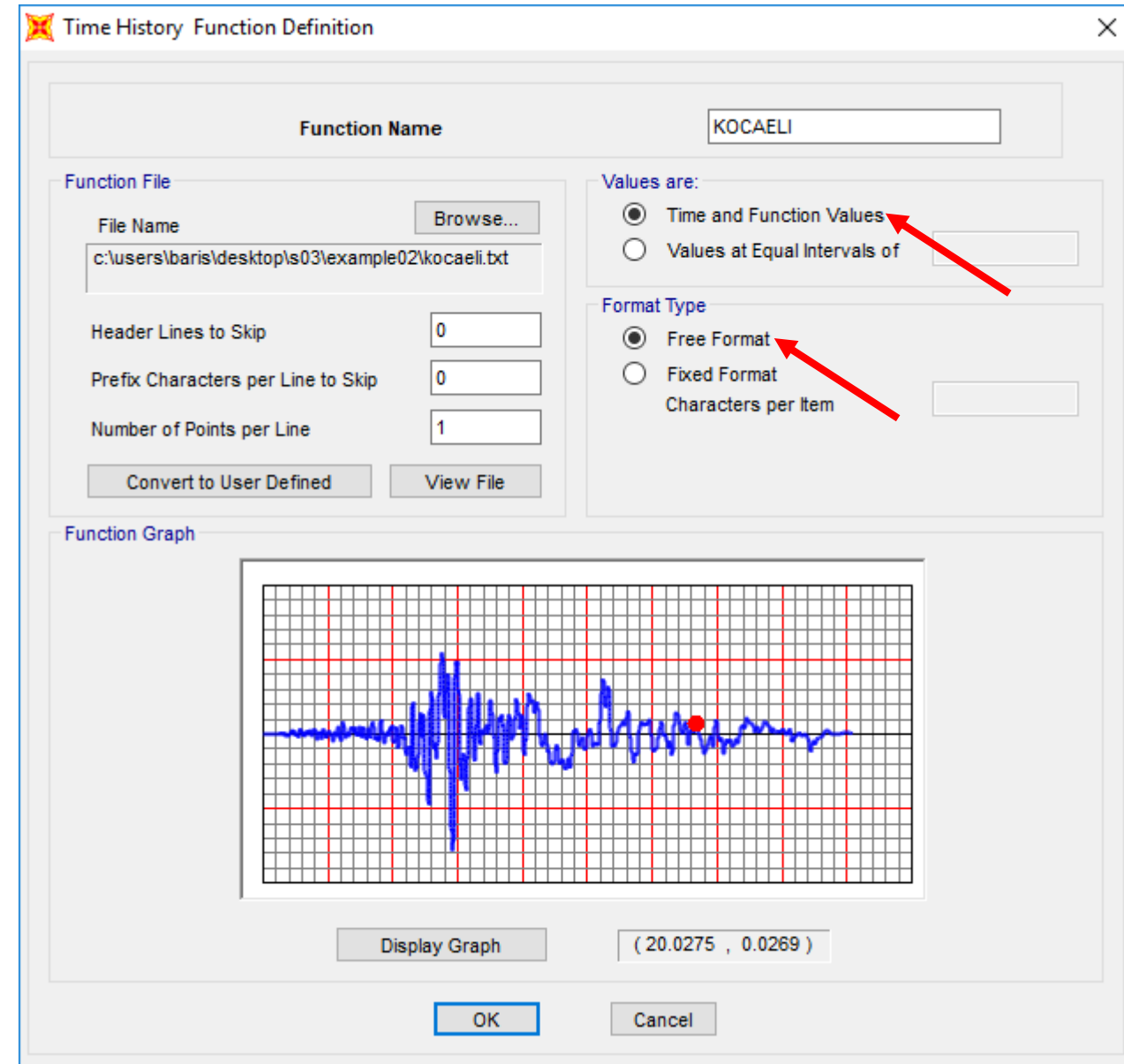
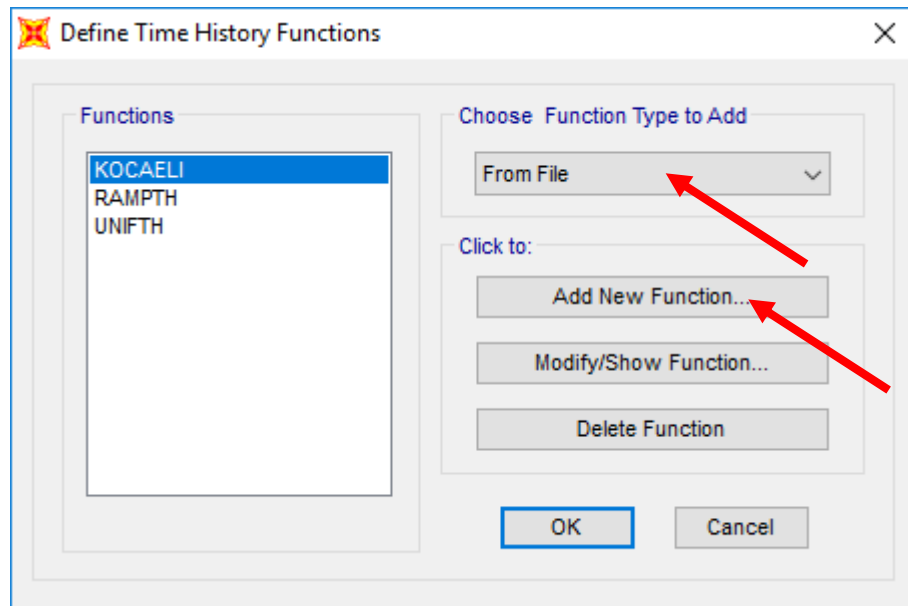
kocaeli.txt

1	0.0000	-0.00076062800
2	0.0050	-0.00075375100
3	0.0100	-0.00074687000
4	0.0150	-0.00074000800
5	0.0200	-0.00073311500
6	0.0250	-0.00072614600
7	0.0300	-0.00071891100
8	0.0350	-0.00071147700
9	0.0400	-0.00070403800
10	0.0450	-0.00069674900
11	0.0500	-0.00068947300
12	0.0550	-0.00068191400
13	0.0600	-0.00067396100
14	0.0650	-0.00066600000
15	0.0700	-0.00065826200
16	0.0750	-0.00065079700
17	0.0800	-0.00064378300
18	0.0850	-0.00063719000

length : 174,699 lines : Ln : 1 Col : 1 Sel : 0 | 0 Windows (CR LF) UTF-8 INS



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Deprem



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000

Load Case Data - Linear Direct Integration History

Load Case Name: DIRECTTHA [Set Def Name] [Modify/Show...]

Notes: [Modify/Show...]

Load Case Type: Time History [Design...]

Stiffness to Use:  Zero Initial Conditions - Unstressed State  
 Stiffness at End of Nonlinear Case

Important Note: Loads from the Nonlinear Case are NOT included in the current case

Modal Load Case: Use Modes from Case: MODAL

Loads Applied

Load Type	Load Name	Function	Scale Factor
Accel	U1	KOCAELI	21.9785
Accel	U1	KOCAELI	21.9785

[Add] [Modify] [Delete]

Show Advanced Load Parameters

Mass Source: MSSSRC1

Analysis Type:  Linear  Nonlinear

Solution Type:  Modal  Direct Integration

History Type:  Transient  Periodic

Time Step Data: Number of Output Time Steps: 2700  
Output Time Step Size: 0.01

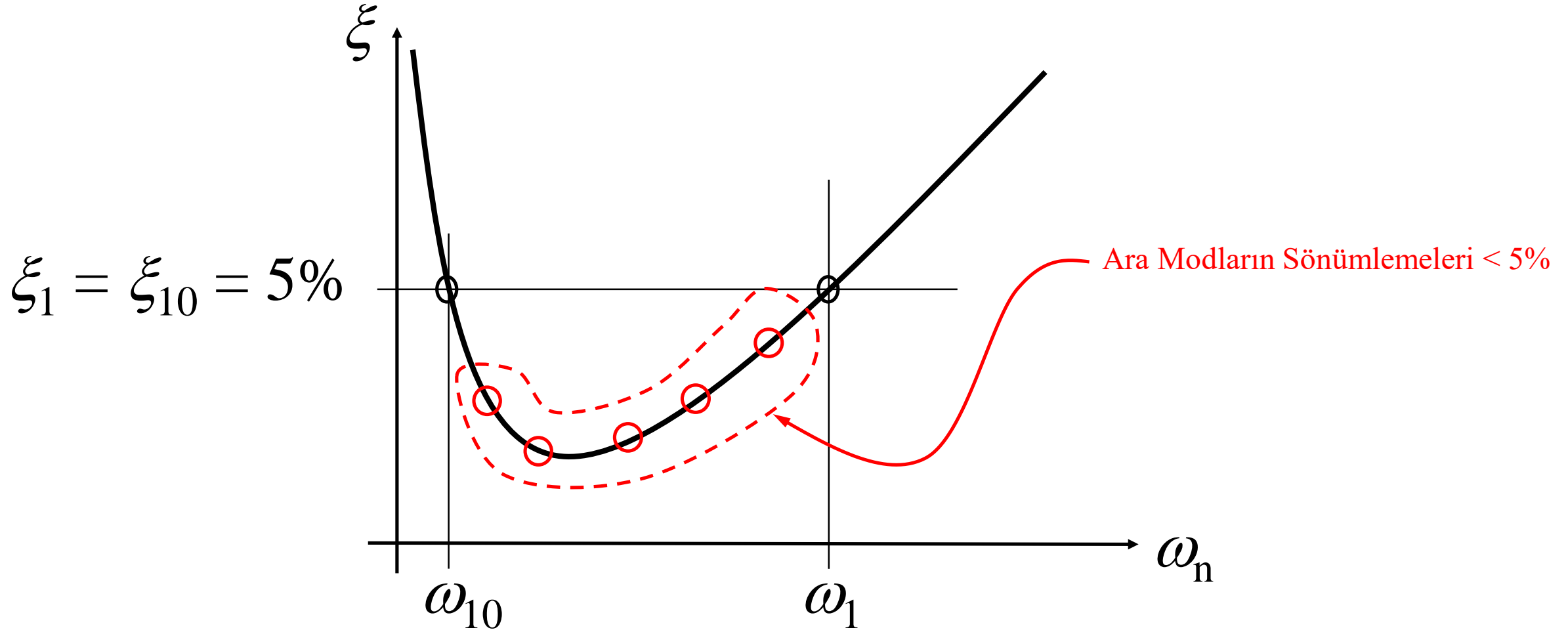
Other Parameters: Damping: Proportional Damping [Modify/Show...]  
Time Integration: Hilber-Hughes-Taylor [Modify/Show...]

[OK] [Cancel]

- **Number of Output Time Steps** edit box and **Output Time Step Size** edit box. Accept the default or enter a value for the number of output time steps and the size of the output time step. The total time of the analysis is the number of output time steps multiplied by the output time-step size. Results will be saved only at time zero and the subsequent output time steps, although the analysis will compute intermediate results at every time step of every applied-load time-history function.

# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sönümlleme

- Doğrudan çözümde  $C$  matrisinin kendisi kullanılır. Bundan dolayı  $C$  matrisinin hesabı gerekir.
- Rayleigh yöntemi modal içsel sönümlleme üzerinden klasik  $C$  matrisi oluşturmak için kullanılır.
- Bundan dolayı modal özelliklerin bilinmesinde fayda vardır. → Modal Analiz



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sönümlleme

## •Modal Analiz

**Load Case Data - Modal**

Load Case Name: MODAL [Set Def Name]

Notes: [Modify/Show...]

Load Case Type: Modal [Design...]

Stiffness to Use:

- Zero Initial Conditions - Unstressed State
- Stiffness at End of Nonlinear Case

Important Note: Loads from the Nonlinear Case are NOT included in the current case

Type of Modes:

- Eigen Vectors
- Ritz Vectors

Mass Source: MSSSRC1

Number of Modes:

- Maximum Number of Modes: 12
- Minimum Number of Modes: 1

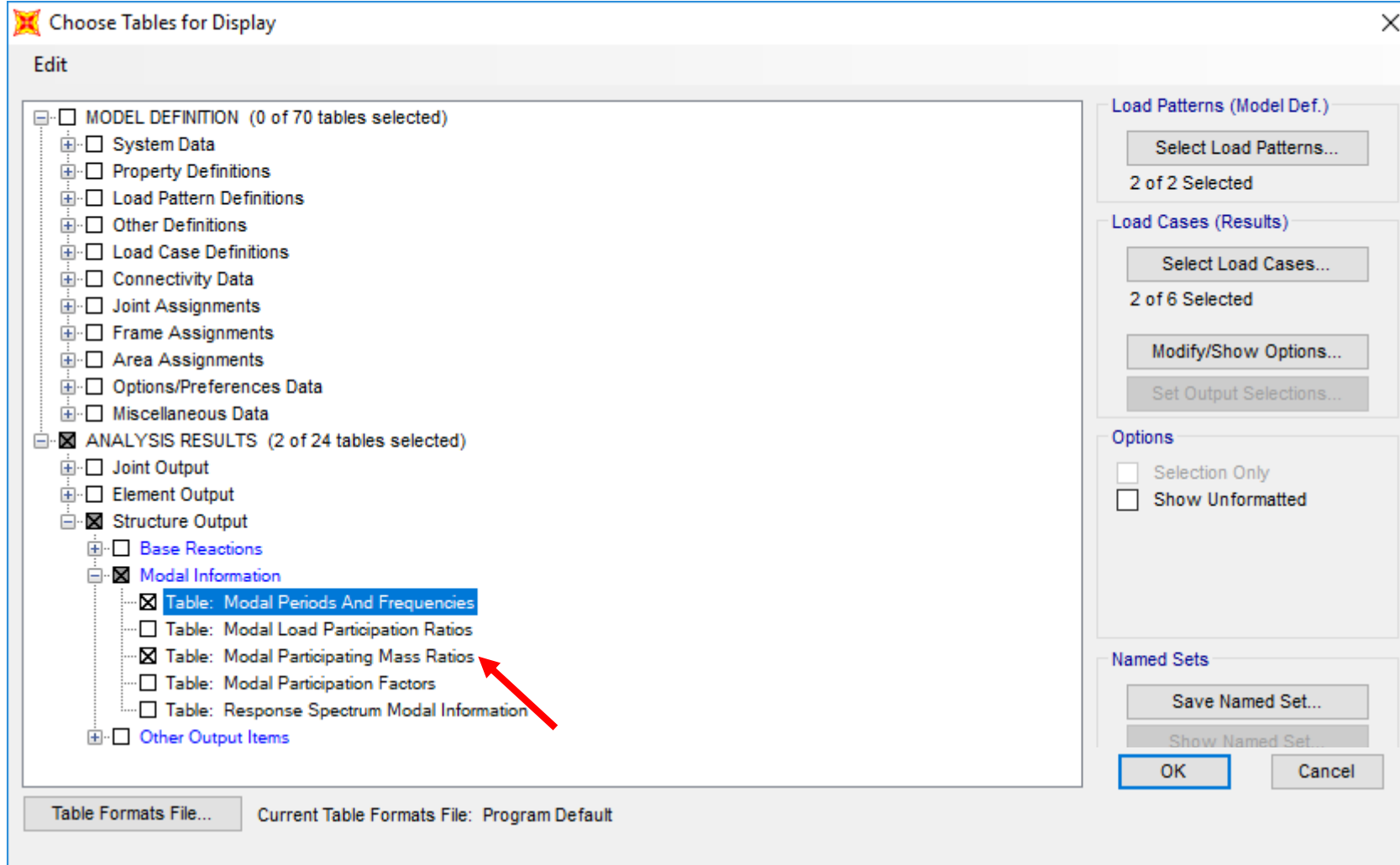
Other Parameters:

- Frequency Shift (Center): 0.
- Cutoff Frequency (Radius): 0.
- Convergence Tolerance: 1.000E-09
- Allow Automatic Frequency Shifting

[OK] [Cancel]

# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sönümlleme

## •Modal Analiz Sonuçları



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sönümlleme

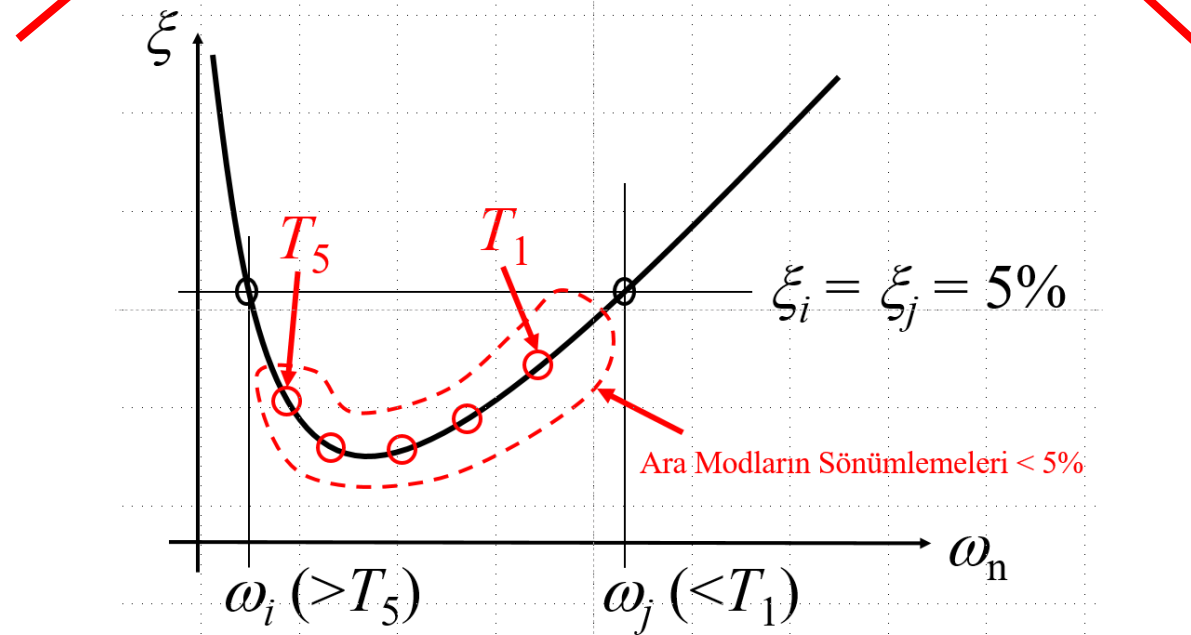
## •Modal Analiz Sonuçları

Units: As Noted

Modal Participating Mass Ratios

Filter:

	OutputCase	StepType Text	StepNum Unitless	Period Sec	UX Unitless	UY Unitless	UZ Unitless	SumUX Unitless	SumUY Unitless	SumUZ Unitless	RX Unitless	UY Unitless
▶	MODAL	Mode	1	0.704238	0.87968	0	0	0.87968	0	0	0	0
	MODAL	Mode	2	0.241363	0.08712	0	0	0.9668	0	0	0	0
	MODAL	Mode	3	0.153221	0.02416	0	0	0.99096	0	0	0	0
	MODAL	Mode	4	0.119367	0.00748	0	0	0.99844	0	0	0	0
	MODAL	Mode	5	0.104721	0.00156	0	0	1	0	0	0	0





# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sönümlleme

**Load Case Data - Linear Direct Integration History**

Load Case Name: DIRECTTHA [Set Def Name] [Modify/Show...]

Notes: [Modify/Show...]

Load Case Type: Time History [Design...]

Stiffness to Use:  Zero Initial Conditions - Unstressed State

Analysis Type:  Linear

Solution Type:  Direct Integration

History Type:  Transient

Mass Source: MSSSRC1

Loads Applied:

Load Type	Load Name	Function	Scale Factor
Accel	U1	KOCAELI	21.9785
Accel	U1	KOCAELI	21.9785

Time Step Data: Number of Output Time Steps: 2700, Output Time Step Size: 0.01

Other Parameters: Damping: Proportional Damping [Modify/Show...], Time Integration: Hilber-Hughes-Taylor [Modify/Show...]

**Mass and Stiffness Proportional Damping**

Damping Coefficients:

Direct Specification

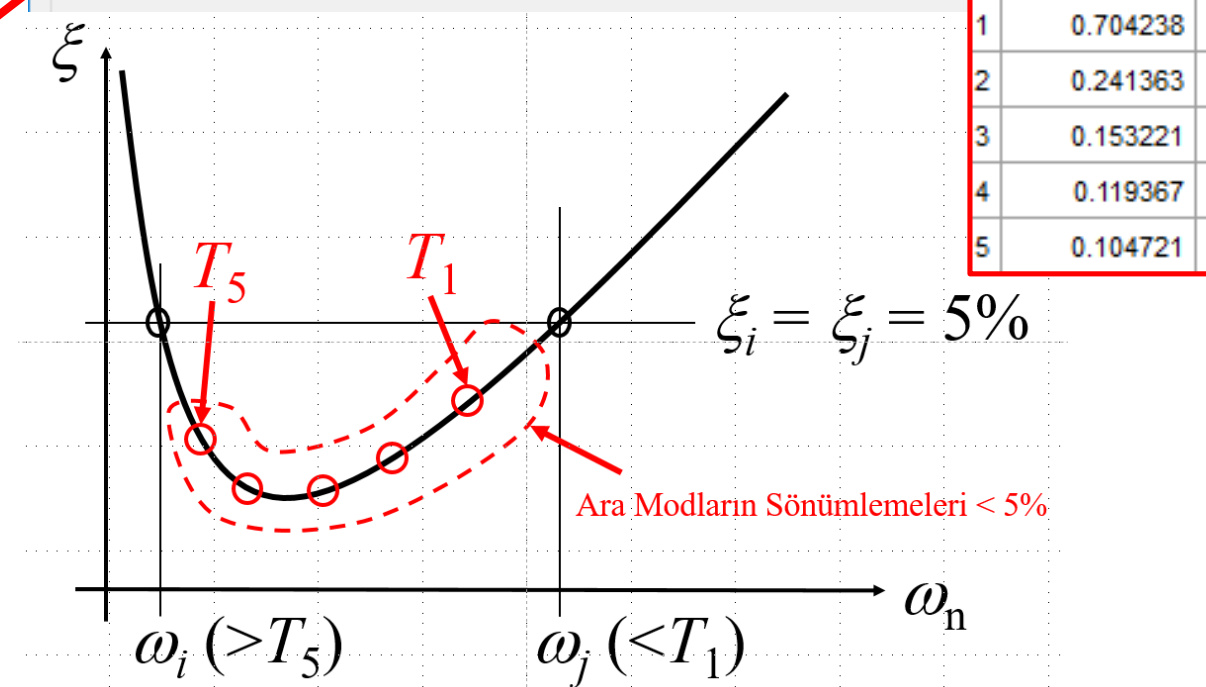
Specify Damping by Period

Specify Damping by Frequency

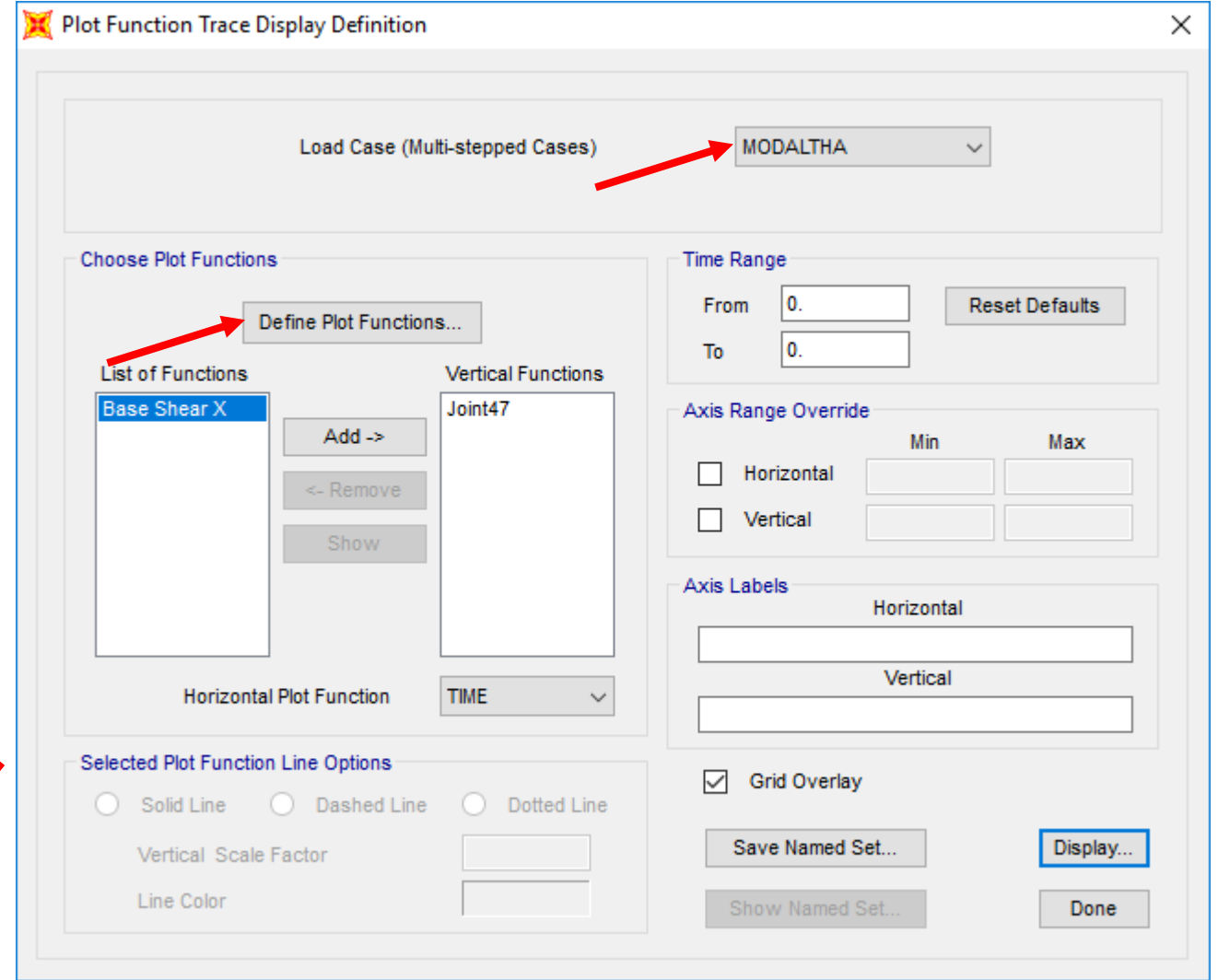
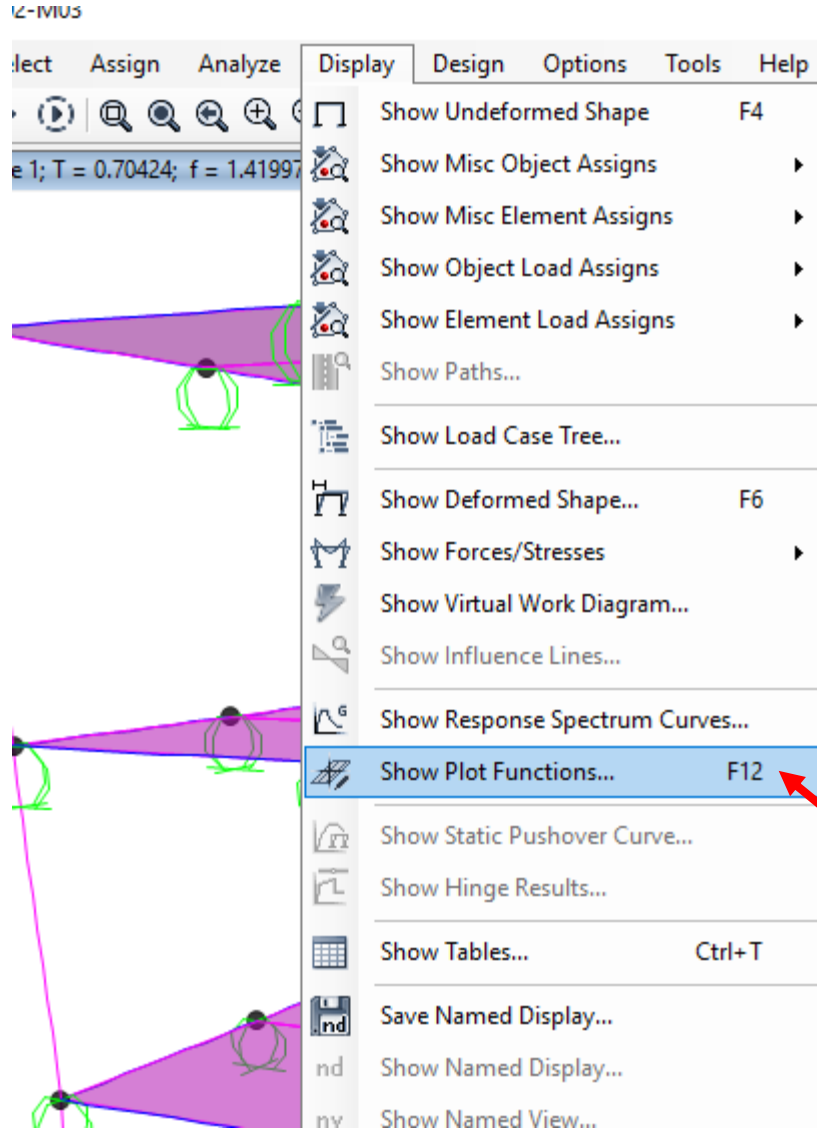
	Mass Proportional Coefficient	Stiffness Proportional Coefficient
	0.7392	7.490E-04

	Period	Frequency	Damping
First	0.80		0.05
Second	0.05		0.05

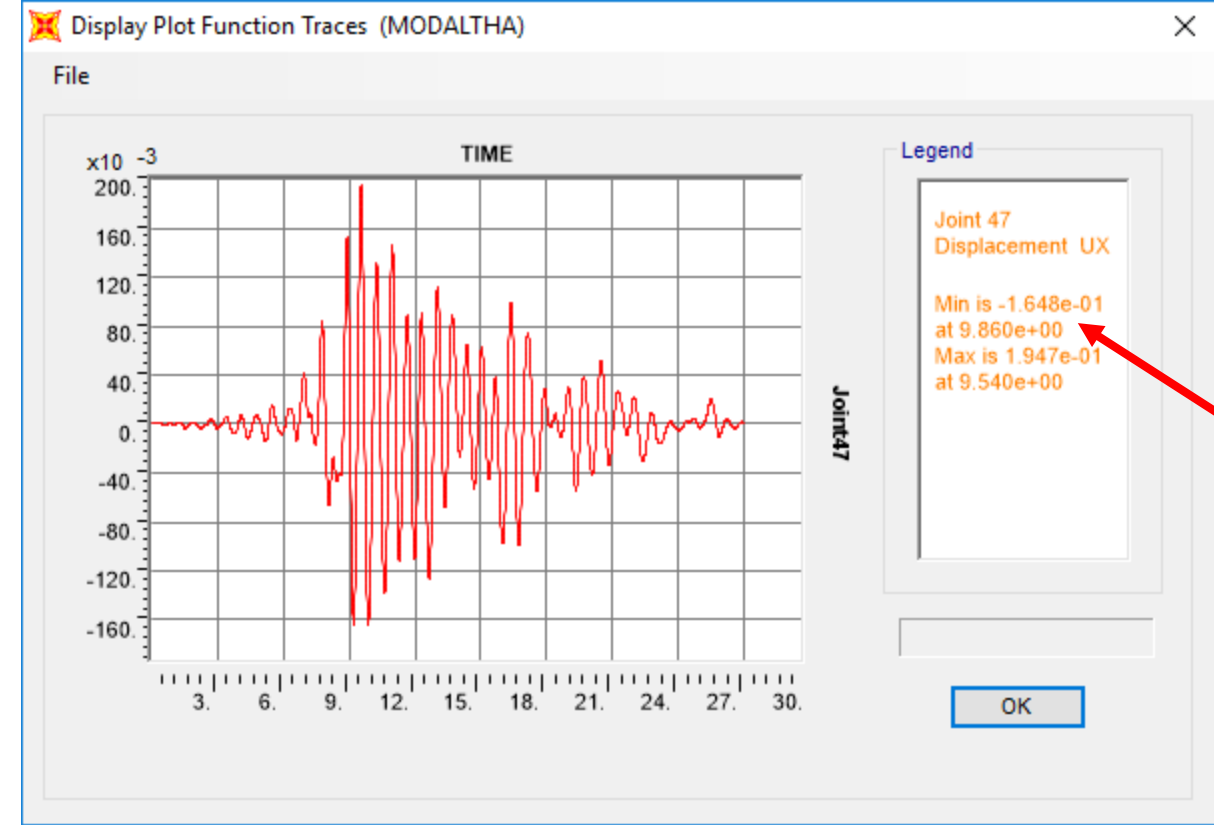
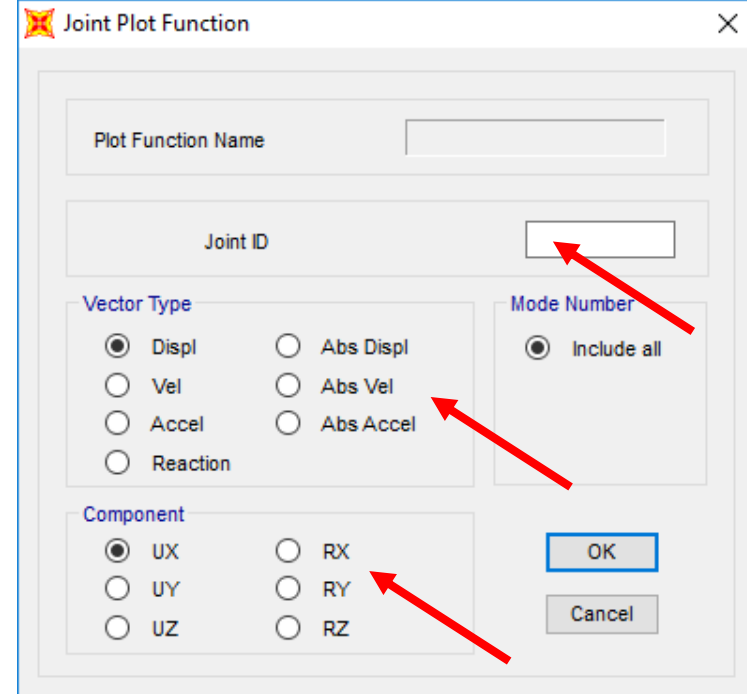
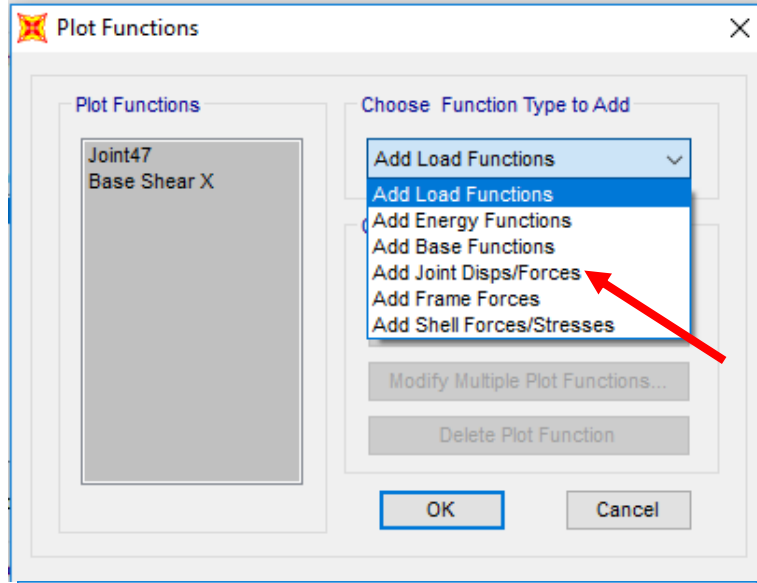
[Recalculate Coefficients]



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sonuçlar



# Zaman-Tanım Alanında Doğrudan Analiz: SAP2000 – Sonuçlar



# Zaman-Tanım Alanında Modal Toplama ile Analiz

# Zaman-Tanım Alanında Modal Toplama ile Analiz

$$\begin{bmatrix} \bar{m}_1 & 0 & \dots & 0 \\ 0 & \bar{m}_2 & & \\ \vdots & & \ddots & \\ 0 & & & \bar{m}_n \end{bmatrix}_{n \times n} \begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \vdots \\ \ddot{q}_n \end{bmatrix}_{n \times 1} + \begin{bmatrix} c_{11} & 0 & \dots & 0 \\ 0 & c_{22} & & \\ \vdots & & \ddots & \\ 0 & & & c_{nn} \end{bmatrix}_{n \times n} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \vdots \\ \dot{q}_n \end{bmatrix}_{n \times 1} + \begin{bmatrix} k_{11} & 0 & \dots & 0 \\ 0 & k_{22} & & \\ \vdots & & \ddots & \\ 0 & & & k_{nn} \end{bmatrix}_{n \times n} \begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_n \end{bmatrix}_{n \times 1} = \begin{bmatrix} \bar{f}_1(t) \\ \bar{f}_2(t) \\ \vdots \\ \bar{f}_n(t) \end{bmatrix}_{n \times 1}$$

$$\bar{m}_1 \ddot{q}_1(t) + c_{11} \dot{q}_1(t) + k_{11} q_1(t) = \bar{f}_1(t)$$

$$\bar{m}_2 \ddot{q}_2(t) + c_{22} \dot{q}_2(t) + k_{22} q_2(t) = \bar{f}_2(t)$$

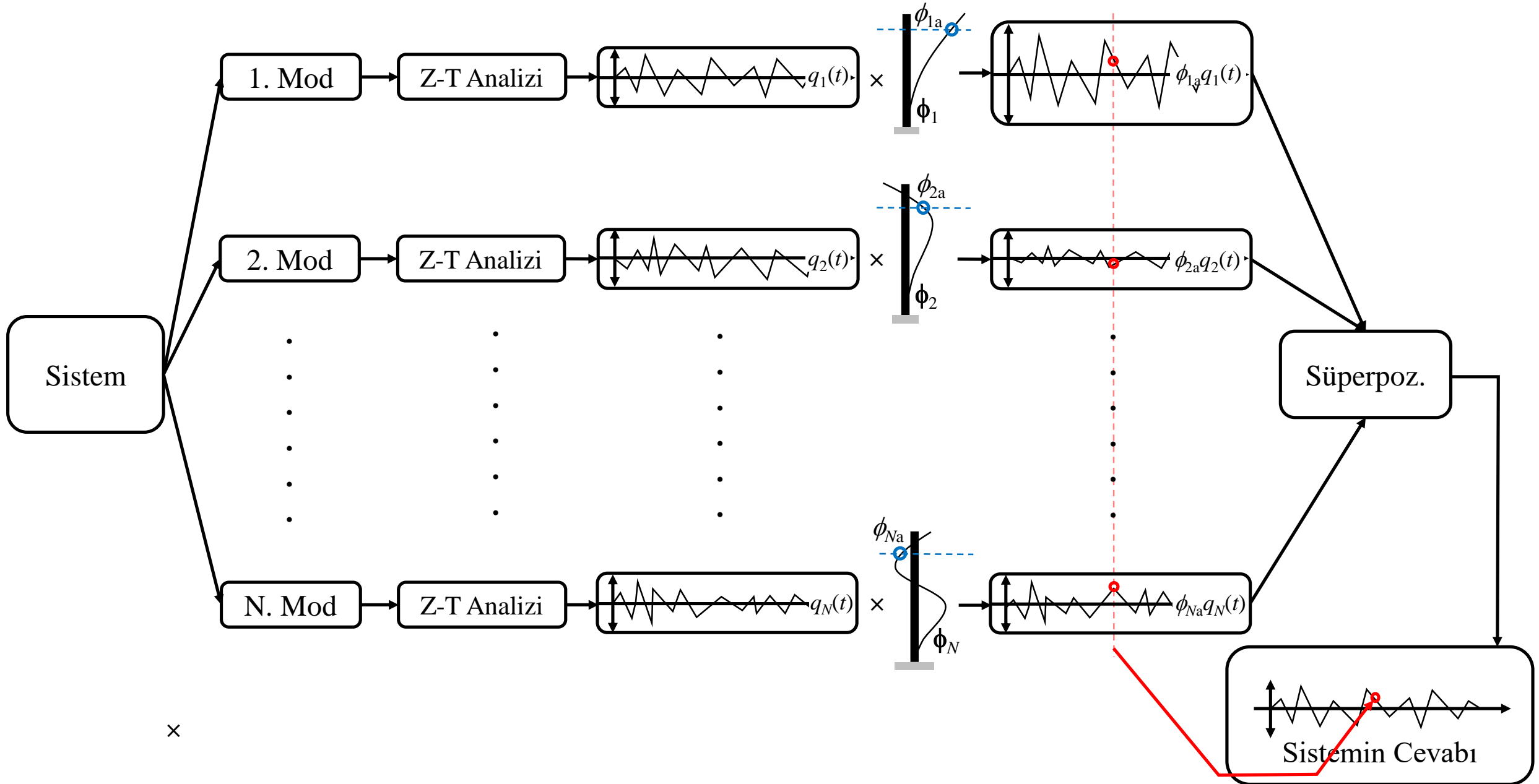
$\vdots$

$$\bar{m}_n \ddot{q}_n(t) + c_{nn} \dot{q}_n(t) + k_{nn} q_n(t) = \bar{f}_n(t)$$

$\longrightarrow q_i(t)$  için çözümler

$$\text{Unutmayalım: } \mathbf{x}(t)_{n \times 1} = \mathbf{\Phi}_{n \times n} \mathbf{q}(t)_{n \times 1}$$

# Zaman-Tanım Alanında Modal Toplama ile Analiz



# Zaman-Tanım Alanında Modal Toplama ile Analiz

$$\mathbf{M}\ddot{\mathbf{x}}(t) + \mathbf{C}\dot{\mathbf{x}}(t) + \mathbf{K}\mathbf{x}(t) = -\mathbf{M}\mathbf{r}\ddot{x}_g(t), \quad \mathbf{x}(t)_{n \times 1} = \mathbf{\Phi}_{n \times n} \mathbf{q}(t)_{n \times 1}$$

$$\mathbf{M}\mathbf{\Phi}\ddot{\mathbf{q}}(t) + \mathbf{C}\mathbf{\Phi}\dot{\mathbf{q}}(t) + \mathbf{K}\mathbf{\Phi}\mathbf{q}(t) = -\mathbf{M}\mathbf{r}\ddot{x}_g(t)$$

$$\mathbf{\Phi}^T \mathbf{M} \mathbf{\Phi} \ddot{\mathbf{q}}(t) + \mathbf{\Phi}^T \mathbf{C} \mathbf{\Phi} \dot{\mathbf{q}}(t) + \mathbf{\Phi}^T \mathbf{K} \mathbf{\Phi} \mathbf{q}(t) = -\mathbf{\Phi}^T \mathbf{M} \mathbf{r} \ddot{x}_g(t)$$

$$\bar{\mathbf{M}}\ddot{\mathbf{q}}(t) + \bar{\mathbf{C}}\dot{\mathbf{q}}(t) + \bar{\mathbf{K}}\mathbf{q}(t) = -\mathbf{L}\ddot{x}_g(t) \quad \mathbf{L} = \mathbf{\Phi}^T \mathbf{M} \mathbf{r}$$

$\mathbf{\Phi}$  doğal mod şekilleri,  $\mathbf{C}$  klasik sönümleme matrisi ise:

$$\bar{m}_1 \ddot{q}_1(t) + c_{11} \dot{q}_1(t) + k_{11} q_1(t) = L_1 \ddot{x}_g(t)$$

$$\bar{m}_2 \ddot{q}_2(t) + c_{22} \dot{q}_2(t) + k_{22} q_2(t) = L_2 \ddot{x}_g(t)$$

⋮

$$\bar{m}_n \ddot{q}_n(t) + c_{nn} \dot{q}_n(t) + k_{nn} q_n(t) = L_n \ddot{x}_g(t)$$

# Zaman-Tanım Alanında Modal Toplama ile Analiz

$n$ . Mod:

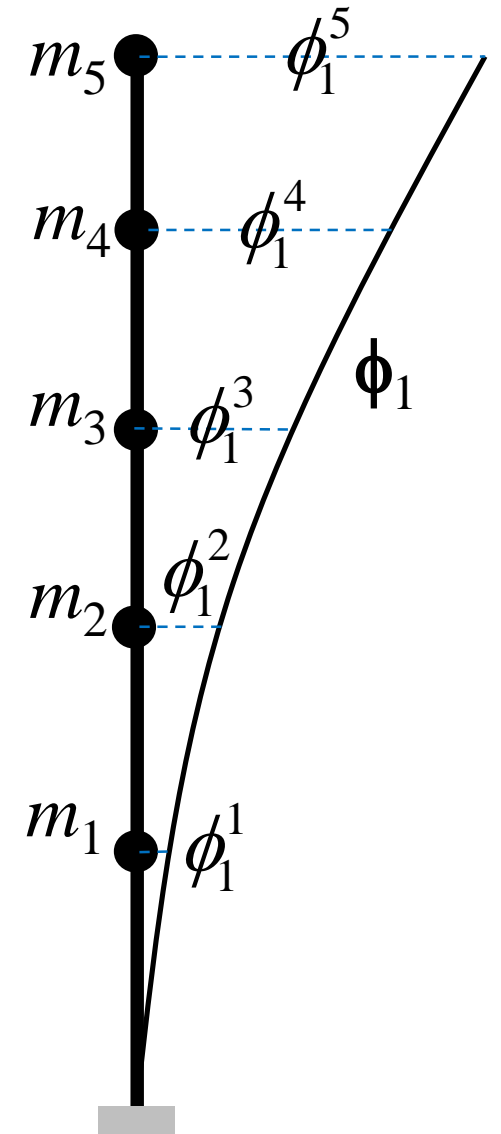
$$\bar{m}_n \ddot{q}_n(t) + c_{nn} \dot{q}_n(t) + k_{nn} q_n(t) = L_n \ddot{x}_g(t)$$

$$\ddot{q}_n(t) + 2\xi_n \omega_n \dot{q}_n(t) + \omega_n^2 q_n(t) = \Gamma_n \ddot{x}_g(t)$$

$$\bar{m}_n = \phi_n^T \mathbf{M} \phi_n = \sum_{i=1}^n (\phi_n^i)^2 m_i$$

$$L_n = \phi_n^T \mathbf{M} \mathbf{r} = \sum_{i=1}^n \phi_n^i m_i \quad L_n : \text{Kütle katılım faktörü}$$

$$\Gamma_n = \frac{L_n}{\bar{m}_n} = \frac{\phi_n^T \mathbf{M} \mathbf{r}}{\bar{m}_n} \quad \Gamma_n : \text{Normalize kütle katılım faktörü}$$

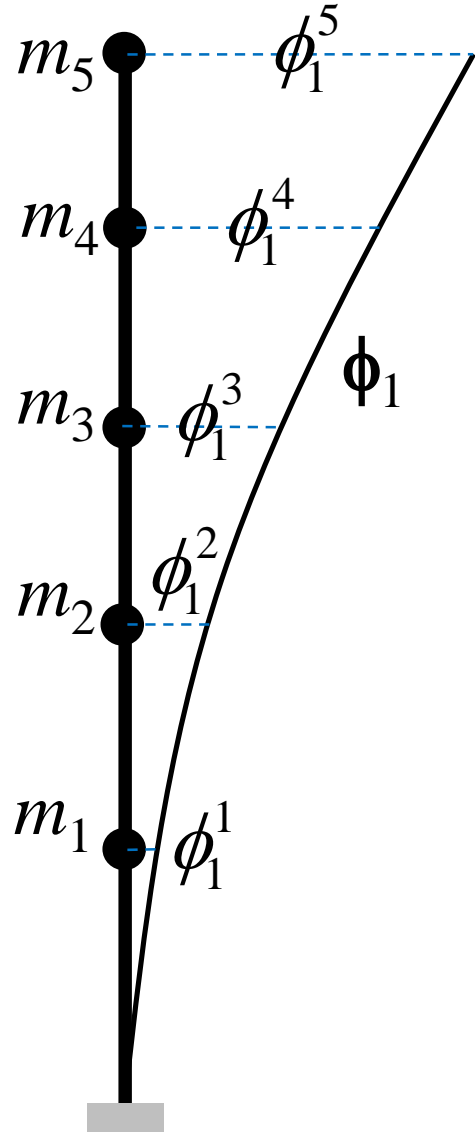


## Notlar:

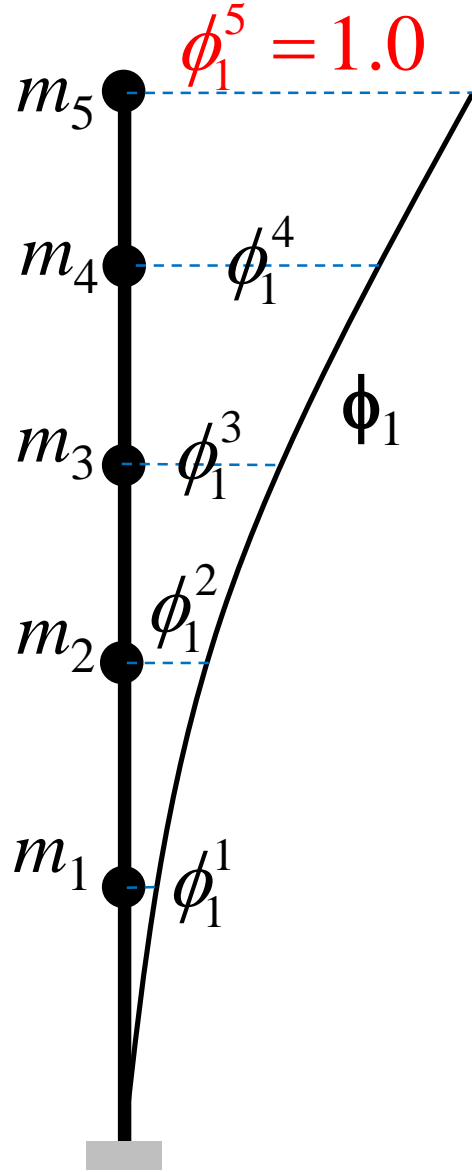
- Eğer  $\phi_1^5 = 1$  ise  $L_n$  bir tür ağırlıklı toplam kütle olacaktır.
- $\Gamma_n$  deprem ivmesinin ne kadar etkili olduğunu gösteren faktördür.



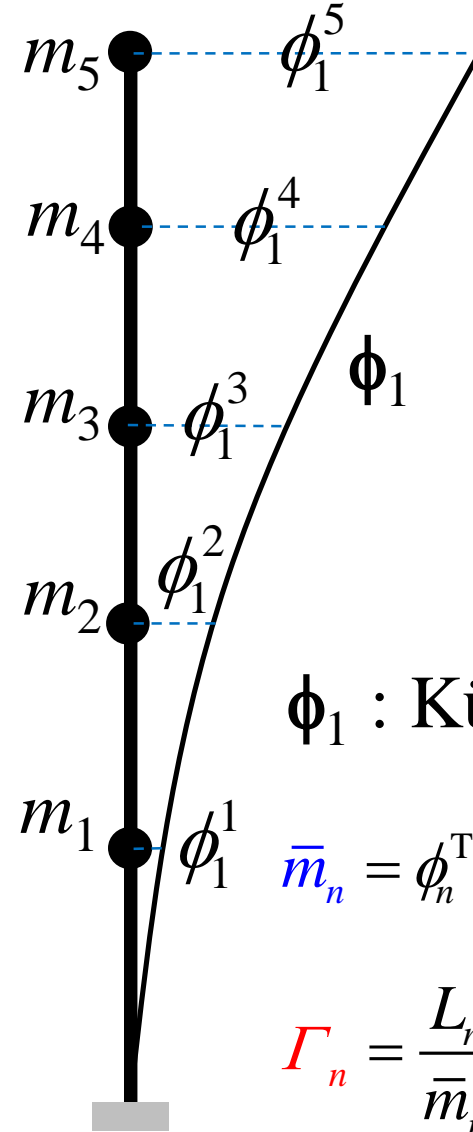
# Mod Şekillerinin Normalleştirilmesi



$\phi_1$  : Genel



$\phi_1$  : Genlik-Normalize



$\phi_1$  : Kütle-Normalize

$$\bar{m}_n = \phi_n^T \mathbf{M} \phi_n = \sum_{i=1}^n (\phi_n^i)^2 m_i = 1$$

$$\Gamma_n = \frac{L_n}{\bar{m}_n} = L_n = \phi_n^T \mathbf{M} \mathbf{r}$$

# Mod Şekillerinin Normalleştirilmesi

Parametre	Genel Şekil	Genlik-Normalize	Kütle-Normalize
$\bar{m}$	-	Etkin Kütle	-
$\bar{c}$	-	$2\bar{m}\xi\omega$	$2\xi\omega$
$\bar{k}$	-	$\bar{m}\omega^2$	$\omega^2$
$L$	-	Etkin Atalet Kütlesi	$L = I$
$\Gamma$	Etkin Yer İvmesi	Etkin Yer İvmesi	Etkin Yer İvmesi
Notlar		Fiziksel anlamı mevcuttur	Daha kolay çözülür

# Zaman-Tanım Alanında Modal Toplama ile Analiz – Değerlendirme

TSD Sistem:

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = -m\ddot{x}_g(t)$$

Modal Sistem:

$$\bar{m}_i\ddot{q}_i(t) + \bar{c}_i\dot{q}_i(t) + \bar{k}_i q_i(t) = -L_i\ddot{x}_g(t)$$

TSD Sistem:

$$\ddot{x}(t) + 2\xi_n\omega_n\dot{x}(t) + \omega_n^2x(t) = -\ddot{x}_g(t)$$

Modal Sistem:

$$\ddot{q}_i(t) + 2\xi_i\omega_i\dot{q}_i(t) + \omega_i^2q_i(t) = -\Gamma_i\ddot{x}_g(t)$$

# Zaman-Tanım Alanında Modal Toplama ile Analiz

## Tek Serbestlik Dereceli Sistemler:

Verilen bir ivme kaydı için sistem çözülürse:

$$\ddot{x}_g(t)$$

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = -m\ddot{x}_g(t)$$
$$\ddot{x}(t) + 2\xi_n\omega_n\dot{x}(t) + \omega_n^2x(t) = -\ddot{x}_g(t)$$

$$x(t)$$

## Modal Sistem:

Aynı ivme kaydı için şu sistem çözülürse:

$$\ddot{x}_g(t)$$

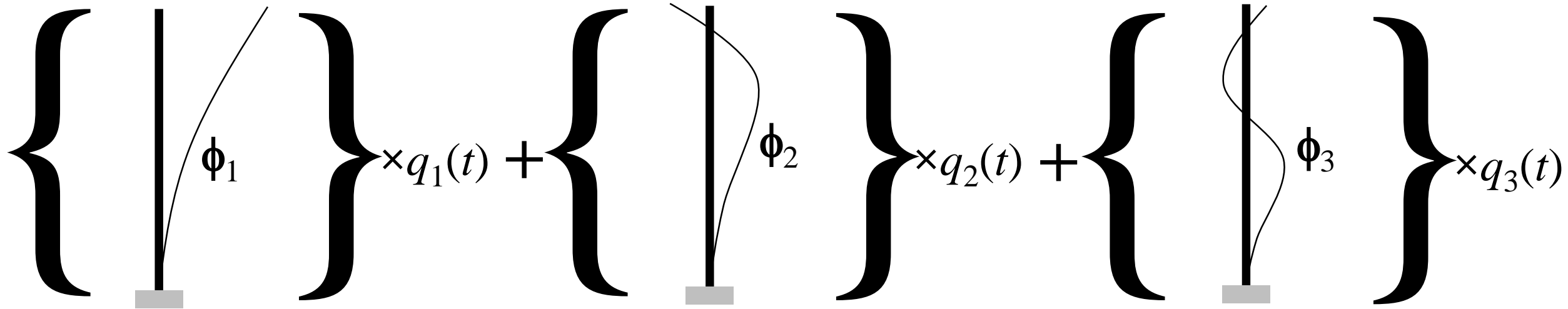
$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = -L\ddot{x}_g(t)$$
$$\ddot{x}(t) + 2\xi_n\omega_n\dot{x}(t) + \omega_n^2x(t) = -\Gamma\ddot{x}_g(t)$$

$$\Gamma x(t)$$

Doğrusal sistemler için  
yapısal cevaplar  $\Gamma$  faktörü ile değişecektir

# Zaman-Tanım Alanında Modal Toplama ile Analiz: Toplama İşlemi

$$\mathbf{x}(t) = \begin{Bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{Bmatrix} = \begin{Bmatrix} / \\ \phi_1 \\ / \end{Bmatrix} q_1(t) + \begin{Bmatrix} / \\ \phi_2 \\ / \end{Bmatrix} q_2(t) + \begin{Bmatrix} / \\ \phi_3 \\ / \end{Bmatrix} q_3(t)$$



# Zaman-Tanım Alanında Modal Toplama ile Analiz: Sönümleme

- Bu yöntemde genelleştirilmiş serbestlik dereceleri çözülür:  $a(t) + (2\xi\omega)v(t) + \omega^2x(t) = f(t)$
- Sönümleme her mod için sönümleme oranı olarak ifade edilir,  $\xi_i$
- Bundan dolayı **C** matrisinin oluşturulmasına gerek yoktur. Sadece  $\xi_i$  değerlerine ihtiyaç vardır.

$$\begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & & \\ \vdots & & \ddots & \\ 0 & & & 1 \end{bmatrix}_{n \times n} \begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \vdots \\ \ddot{q}_n \end{bmatrix}_{n \times 1} + \begin{bmatrix} 2\xi_1\omega_1 & 0 & \cdots & 0 \\ 0 & 2\xi_2\omega_2 & & \\ \vdots & & \ddots & \\ 0 & & & 2\xi_n\omega_n \end{bmatrix}_{n \times n} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \vdots \\ \dot{q}_n \end{bmatrix}_{n \times 1} + \begin{bmatrix} \omega_1^2 & 0 & \cdots & 0 \\ 0 & \omega_2^2 & & \\ \vdots & & \ddots & \\ 0 & & & \omega_n^2 \end{bmatrix}_{n \times n} \begin{bmatrix} q_1 \\ q_2 \\ \vdots \\ q_n \end{bmatrix}_{n \times 1} = \begin{bmatrix} \bar{f}_1(t) \\ \bar{f}_2(t) \\ \vdots \\ \bar{f}_n(t) \end{bmatrix}_{n \times 1}$$

# Zaman-Tanım Alanında Modal Toplama ile Analiz: İçsel Kuvvetler

İki yöntem mevcuttur:

## 1. Yöntem: Rijitlik Matrisi ile

$$\mathbf{F}^{\text{iç}}(t) = \mathbf{K}\mathbf{x}(t)$$

$$\mathbf{x}_i(t) = \boldsymbol{\phi}_i^T q_i(t), \quad i. \text{ moddan gelen yerdeğiştirme}$$

$$\mathbf{F}_i^{\text{iç}}(t) = \mathbf{K}\mathbf{x}_i(t) = \mathbf{K}\boldsymbol{\phi}_i^T q_i(t), \quad i. \text{ moddan gelen iç kuvvetler}$$

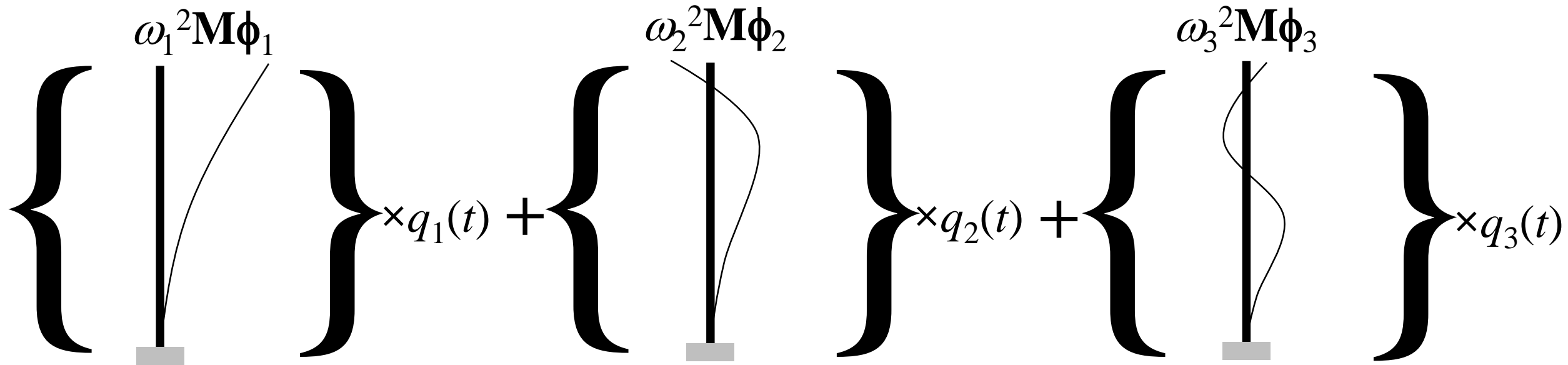
## 2. Yöntem: Kütle Matrisi ile

$$\mathbf{K}\boldsymbol{\phi}_i^T = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T, \quad \text{modal denklemden}$$

$$\mathbf{F}_i^{\text{iç}}(t) = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T q_i(t)$$

# Zaman-Tanım Alanında Modal Toplama ile Analiz: İçsel Kuvvetler

$$\mathbf{F}^{\text{iç}}(t) = \begin{Bmatrix} F_1^{\text{iç}}(t) \\ F_2^{\text{iç}}(t) \\ F_3^{\text{iç}}(t) \end{Bmatrix} \approx \begin{Bmatrix} / \\ \mathbf{F}_1^{\text{iç}}(t) \\ / \end{Bmatrix} + \begin{Bmatrix} / \\ \mathbf{F}_2^{\text{iç}}(t) \\ / \end{Bmatrix} + \begin{Bmatrix} / \\ \mathbf{F}_2^{\text{iç}}(t) \\ / \end{Bmatrix}$$





# Zaman-Tanım Alanında Modal Toplama ile Analiz: Taban Kesme Kuv.

Konsol kolon tipi yapılar için iki yöntem mevcuttur:

## 1. Yöntem: Rijitlik Matrisi ile

$$F^{\text{taban}}(t) = -\left(F_1^{\text{iç}}(t) + F_2^{\text{iç}}(t) + \dots + F_n^{\text{iç}}(t)\right), \quad \text{kat kuvvetlerinin toplamı}$$

$$F^{\text{taban}}(t) = -\mathbf{r}^T \mathbf{F}^{\text{iç}}(t), \quad \mathbf{F}^{\text{iç}}(t) = \mathbf{K} \mathbf{x}(t), \quad \mathbf{F}_i^{\text{iç}}(t) = \mathbf{K} \mathbf{x}_i(t), \quad \mathbf{x}_i(t) = \boldsymbol{\phi}_i^T q_i(t)$$

$$F_i^{\text{taban}}(t) = -\mathbf{r}^T \mathbf{F}_i^{\text{iç}}(t) = -\mathbf{r}^T \mathbf{K} \boldsymbol{\phi}_i^T q_i(t), \quad i. \text{ moddan gelen taban kesme kuvveti}$$

## 2. Yöntem: Kütle Matrisi ile

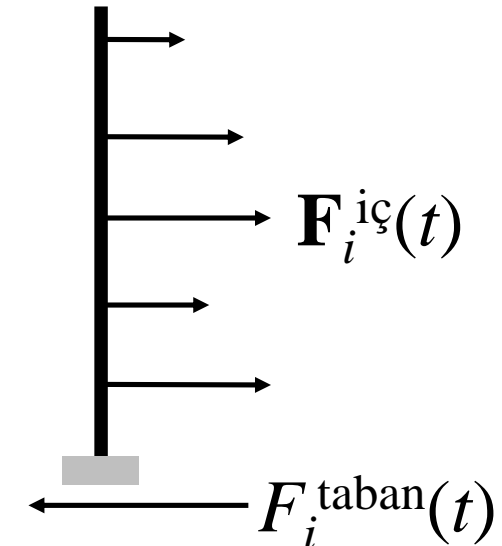
$$\mathbf{K} \boldsymbol{\phi}_i^T = \omega_i^2 \mathbf{M} \boldsymbol{\phi}_i^T, \quad \text{modal denklemden}$$

$$F_i^{\text{taban}}(t) = -\mathbf{r}^T \mathbf{F}_i^{\text{iç}}(t) = -\mathbf{r}^T \mathbf{K} \boldsymbol{\phi}_i^T q_i(t)$$

$$F_i^{\text{taban}}(t) = -\omega_i^2 \mathbf{r}^T \mathbf{M} \boldsymbol{\phi}_i^T q_i(t)$$

$$L_i = \boldsymbol{\phi}_i^T \mathbf{M} \mathbf{r}, \quad L_i = L_i^T = \mathbf{r}^T \mathbf{M} \boldsymbol{\phi}_i^T$$

$$F_i^{\text{taban}}(t) = -\omega_i^2 L_i q_i(t)$$



# Zaman-Tanım Alanında Modal Toplama ile Analiz: Taban Kesme Kuv.

$$F^{\text{taban}}(t) = F_1^{\text{taban}}(t) + F_2^{\text{taban}}(t) + F_3^{\text{taban}}(t)$$

$$F^{\text{taban}}(t) = -\omega_1^2 L_1 q_1(t) - \omega_2^2 L_2 q_2(t) - \omega_2^2 L_2 q_2(t)$$

# Modal Analiz: SAP2000

**Load Case Data - Modal**

**Load Case Name**  
MODAL

**Notes**

**Load Case Type**  
Modal

**Stiffness to Use**  
 Zero Initial Conditions - Unstressed State  
 Stiffness at End of Nonlinear Case   
Important Note: Loads from the Nonlinear Case are NOT included in the current case

**Number of Modes**  
Maximum Number of Modes: 12  
Minimum Number of Modes: 1

**Loads Applied**  
 Show Advanced Load Parameters

**Other Parameters**  
Frequency Shift (Center): 0.  
Cutoff Frequency (Radius): 0.  
Convergence Tolerance: 1.000E-09  
 Allow Automatic Frequency Shifting

**Type of Modes**  
 Eigen Vectors  
 Ritz Vectors

**Mass Source**  
MSSSRC1

# Modal Analiz: SAP2000 – Kütle Katılım Oranı

Modal Participating Mass Ratios

File View Edit Format-Filter-Sort Select Options

Units: As Noted Modal Participating Mass Ratios

Filter:

	OutputCase	StepType Text	StepNum Unitless	Period Sec	UX Unitless	UY Unitless	UZ Unitless	SumUX Unitless	SumUY Unitless	SumUZ Unitless	RX Unitless	Unif
▶	MODAL	Mode	1	0.704238	0.87968	0	0	0.87968	0	0	0	
	MODAL	Mode	2	0.241363	0.08712	0	0	0.9668	0	0	0	
	MODAL	Mode	3	0.153221	0.02416	0	0	0.99096	0	0	0	
	MODAL	Mode	4	0.119367	0.00748	0	0	0.99844	0	0	0	
	MODAL	Mode	5	0.104721	0.00156	0	0	1	0	0	0	

Record: << < 1 > >> of 5

Add Tables... Done

# Modal Analiz: SAP2000 – Normalize Kütle Katılım Faktörü

Modal Participation Factors

File View Edit Format-Filter-Sort Select Options

Units: As Noted Modal Participation Factors

Filter:

	OutputCase	StepType Text	StepNum Unitless	Period Sec	UX KN-m	UY KN-m	UZ KN-m	RX KN-m	RY KN-m	RZ KN-m	ModalMass KN-m-s2	Mo
▶	MODAL	Mode	1	0.704238	32.136398	0	0	0	50.263398	-2.38E-16	1	
	MODAL	Mode	2	0.241363	-10.113152	0	0	0	127.171923	7.359E-17	1	6
	MODAL	Mode	3	0.153221	5.326102	0	0	0	-35.342029	-4.008E-17	1	16
	MODAL	Mode	4	0.119367	2.963475	0	0	0	-31.931023	-2.126E-17	1	27
	MODAL	Mode	5	0.104721	1.353105	0	0	0	-9.937387	-1.028E-17	1	35

Record: << < 1 > >> of 5

Add Tables... Done

# Zaman-Tanım Alanında Modal Toplama ile Analiz: SAP2000

**Load Case Data - Linear Modal History**

Load Case Name: MODALTHA [Set Def Name] Notes: [Modify/Show...]

Load Case Type: Time History [Design...]

Initial Conditions:  
 Zero Initial Conditions - Start from Unstressed State  
 Continue from State at End of Modal History [ ]  
Important Note: Loads from this previous case are included in the current case

Modal Load Case: Use Modes from Case [MODAL]

Loads Applied

Load Type	Load Name	Function	Scale Factor
Accel	U1	KOCAELI	21.9785
Accel	U1	KOCAELI	21.9785

[Add] [Modify] [Delete]

Show Advanced Load Parameters

Mass Source: Previous (MSSSRC1)

Analysis Type:  
 Linear  
 Nonlinear

History Type:  
 Transient  
 Periodic

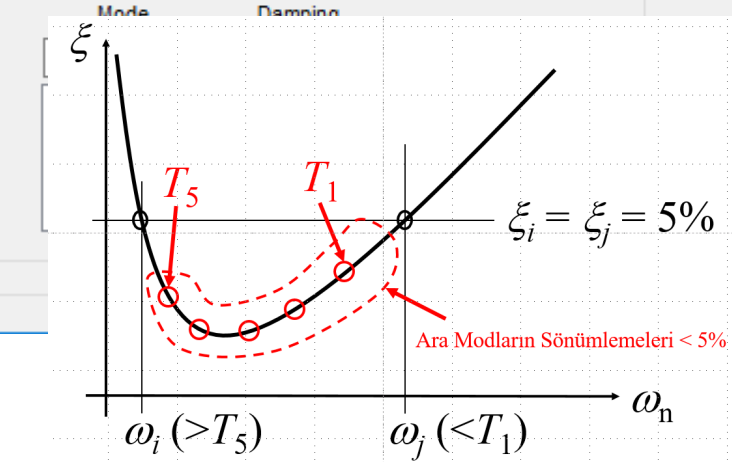
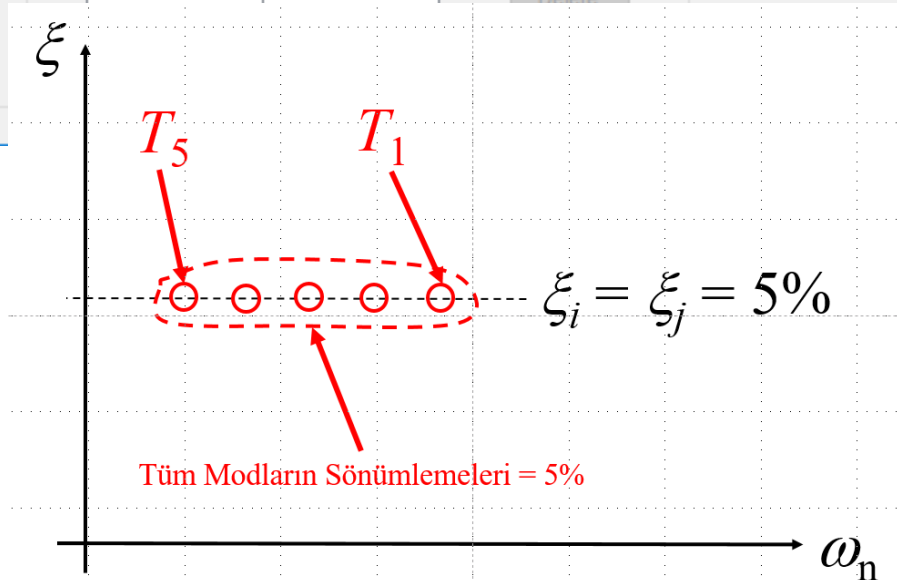
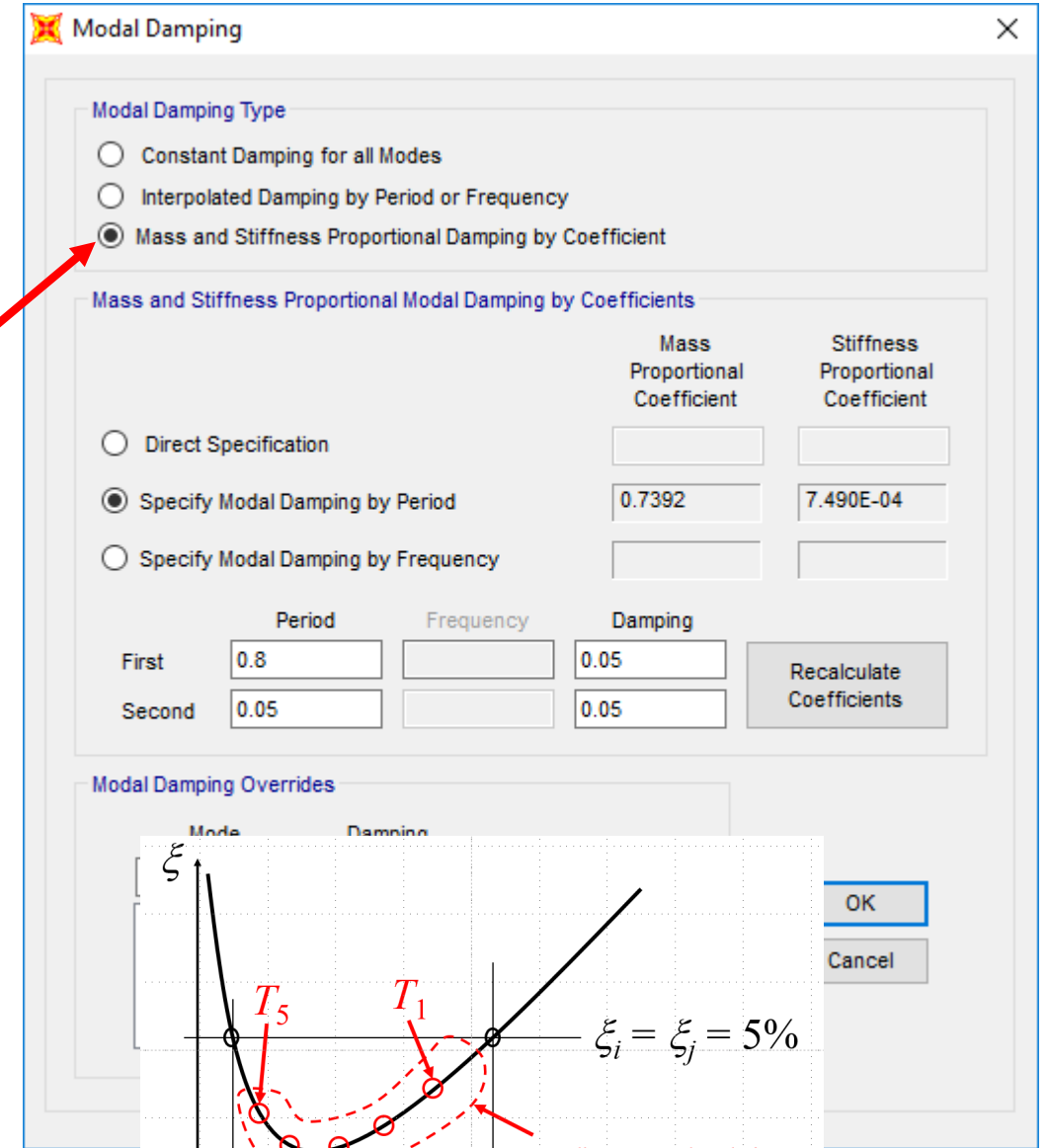
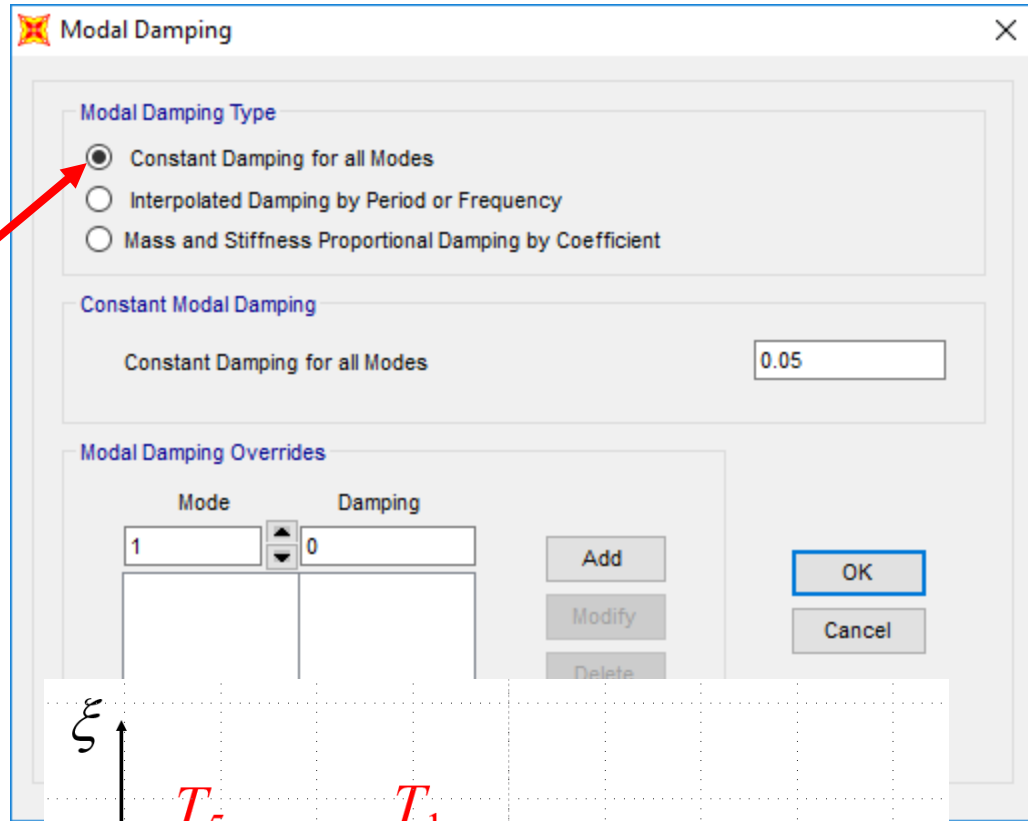
Solution Type:  
 Modal  
 Direct Integration

Time Step Data:  
Number of Output Time Steps: 2700  
Output Time Step Size: 0.01

Other Parameters:  
Modal Damping: Constant at 0.05 [Modify/Show...]

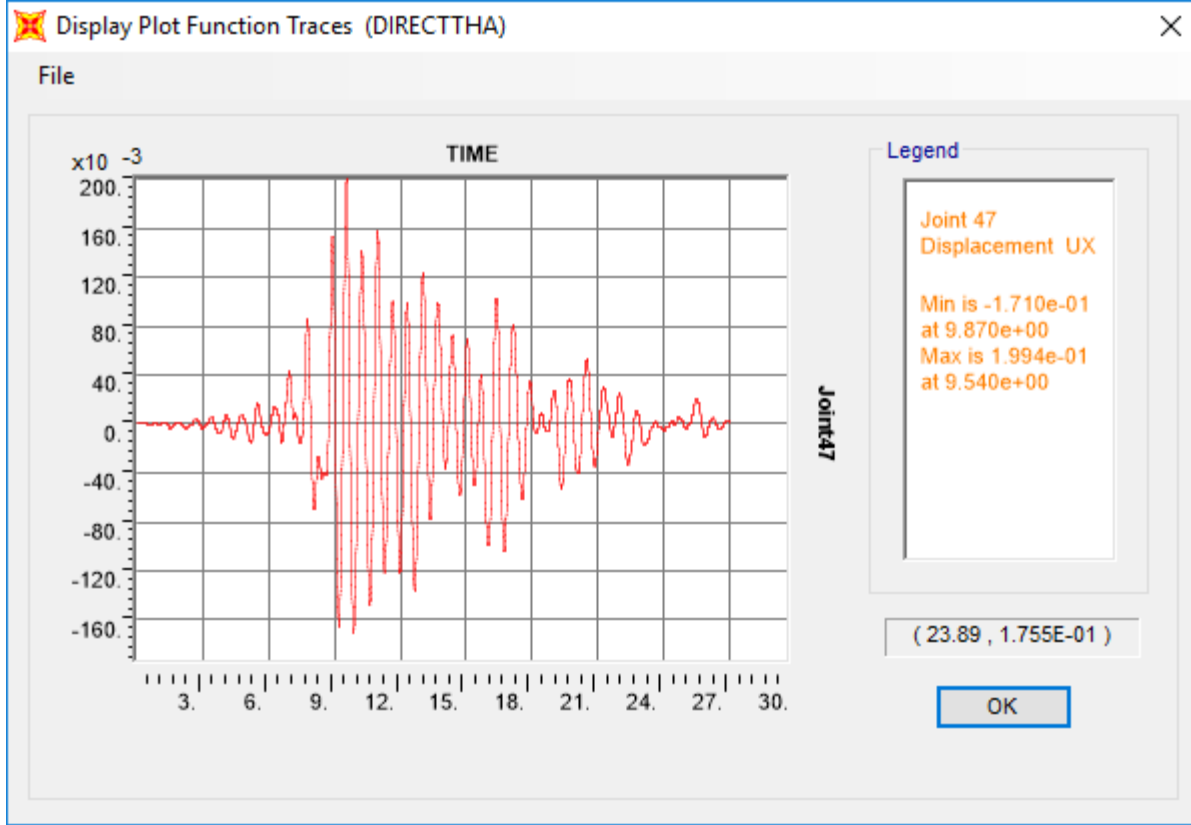
[OK] [Cancel]

# Zaman-Tanım Alanında Modal Toplama ile Analiz: SAP2000 – Sönüm.

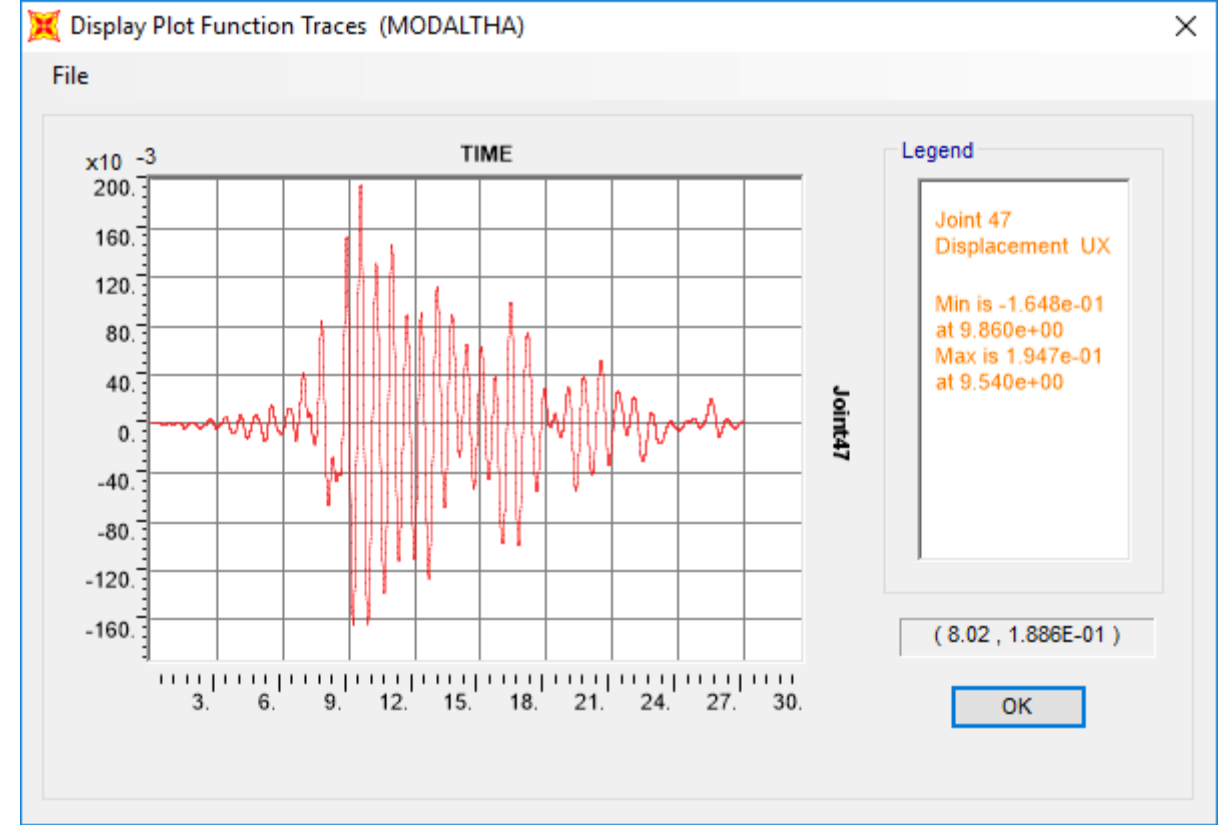


# Sonuçların Karşılaştırılması

## Doğrudan Çözüm



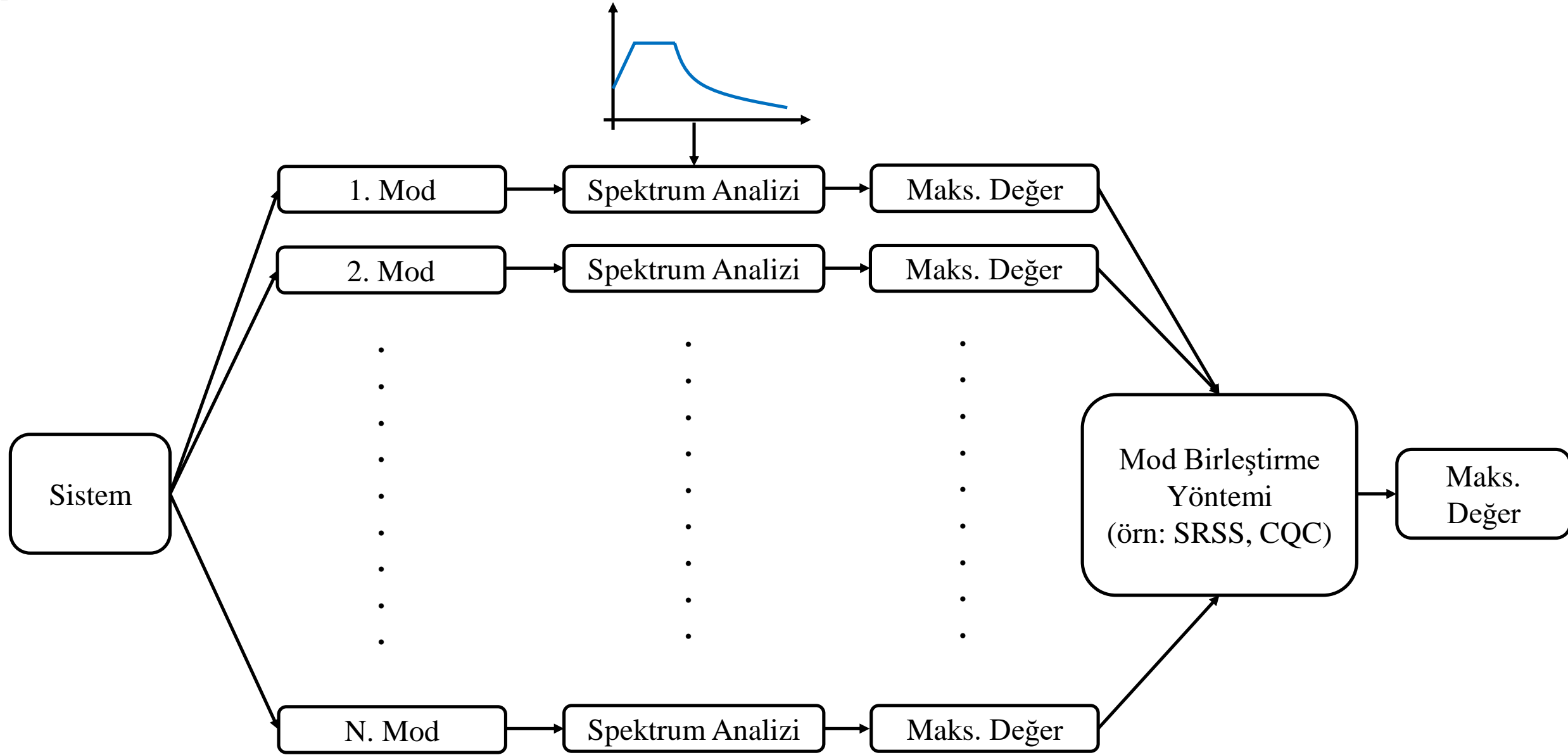
## Modal Toplama ile Çözüm



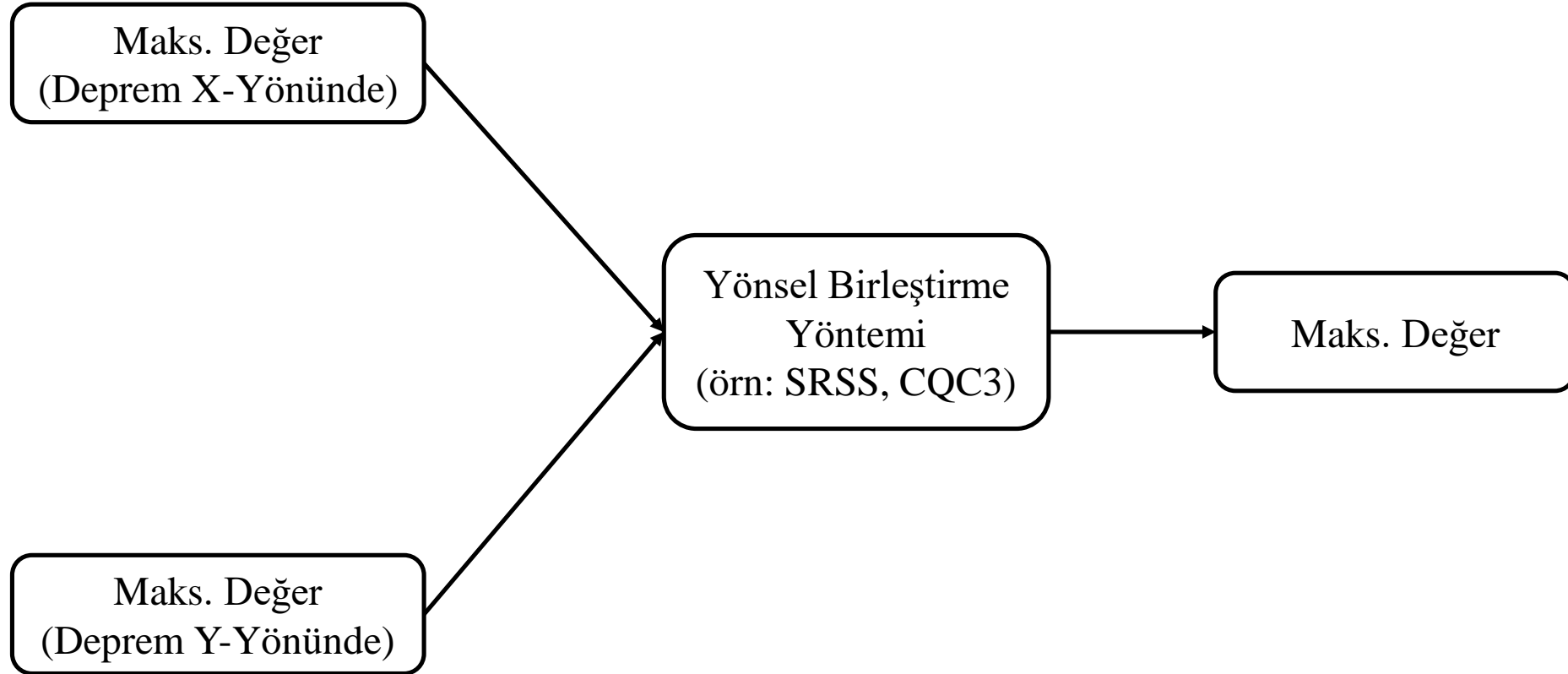


# Spektral Analiz ile Modal Birleřtirme Yöntemi

# Spektral Analiz – Bir Yönde Mod Birleştirme



# Spektral Analiz – İki Yönde Mod Birleştirme



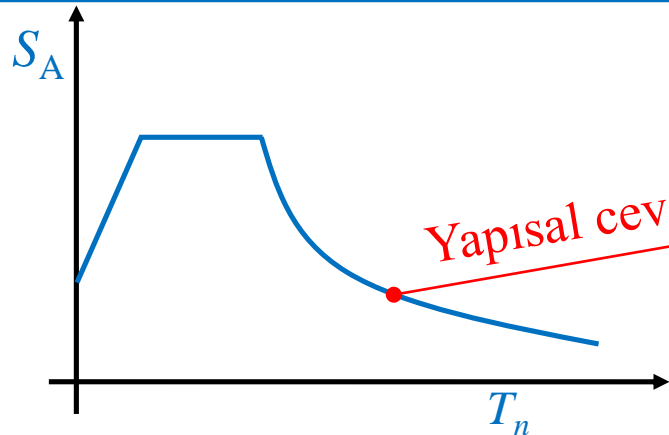
# Spektrum Analizi

## Tek Serbestlik Dereceli Sistemler:

$$\ddot{x}_g(t)$$

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = -m\ddot{x}_g(t)$$
$$\ddot{x}(t) + 2\xi_n\omega_n\dot{x}(t) + \omega_n^2x(t) = -\ddot{x}_g(t)$$

$$x^{\max} = \frac{S_A}{\omega_n^2}, \quad f_s^{\max} = kx^{\max} = mS_A$$



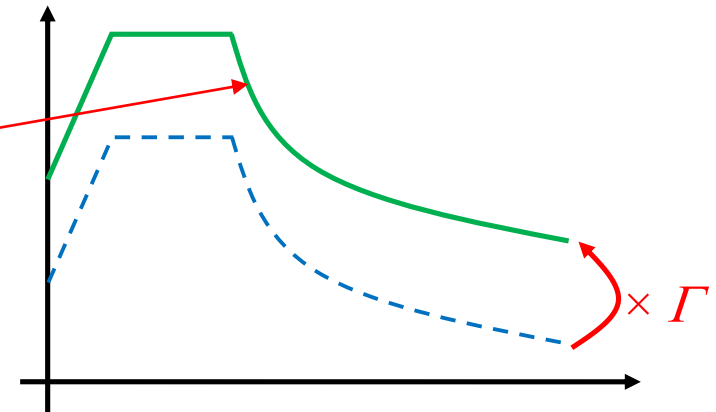
Yapısal cevaplar  $\Gamma$  faktörü ile değişecektir

## Modal Sistem:

$$\ddot{x}_g(t)$$

$$m\ddot{x}(t) + c\dot{x}(t) + kx(t) = -L\ddot{x}_g(t)$$
$$\ddot{x}(t) + 2\xi_n\omega_n\dot{x}(t) + \omega_n^2x(t) = -\Gamma\ddot{x}_g(t)$$

?



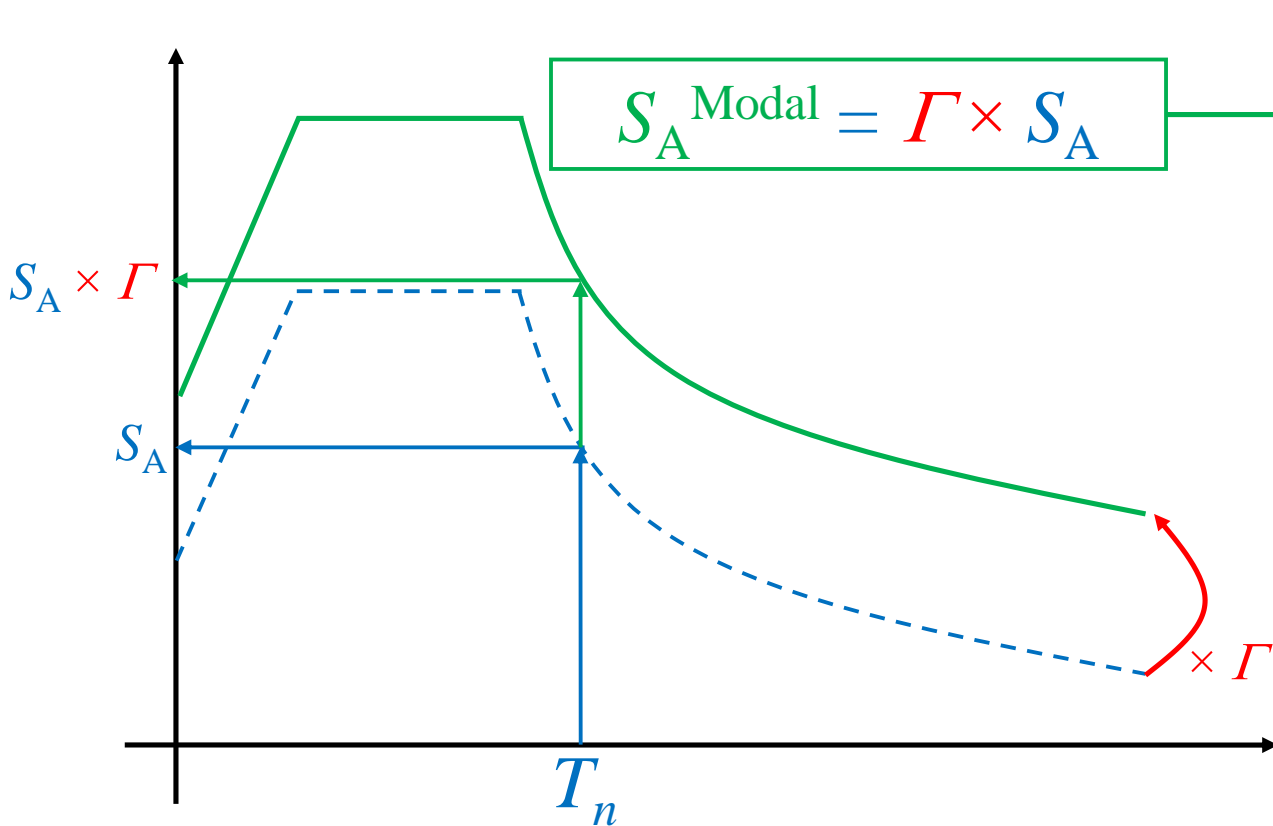
# Spektrum Analizi

Modal Denklemler:

$$\bar{m}_i \ddot{x}(t) + \bar{c}_i \dot{x}(t) + \bar{k}_i x(t) = -L_i \ddot{x}_g(t)$$

$$\ddot{q}_i(t) + 2\xi_i \omega_i \dot{q}_i(t) + \omega_i^2 q_i(t) = -\Gamma_i \ddot{x}_g(t)$$

$$L_i = \phi_i^T \mathbf{M} \mathbf{r} \quad \Gamma_i = \frac{L_i}{\bar{m}_i} = \frac{\phi_i^T \mathbf{M} \mathbf{r}}{\bar{m}_i}$$

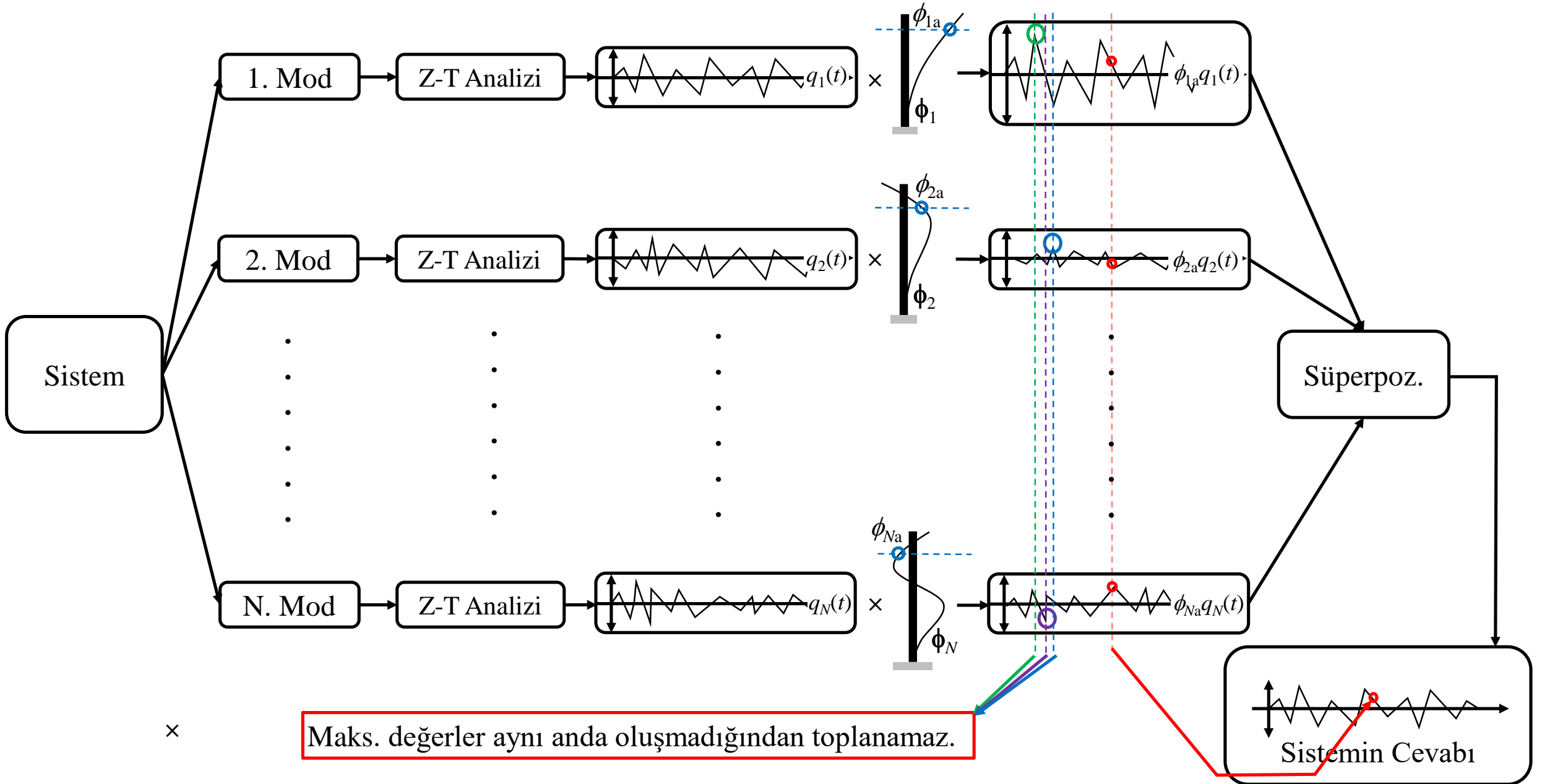


$$\max(q_i(t)) = q_i^{\max} = \frac{S_A^{\text{Modal},i}}{\omega_i^2} = \frac{\Gamma_i S_A^i}{\omega_i^2}$$

$$q_i^{\max} = \frac{1}{\omega_i^2} \Gamma_i S_A^i$$

$$q_i^{\max} = \frac{1}{\omega_i^2} \frac{L_i}{\bar{m}_i} S_A^i$$

# Modal Birleştirme



# Modal Birleřtirme

- Sistemin maksimum cevaplarını bulmak için modal maksimum cevaplar modal birleřtirme yöntemleri olarak adlandırılan yöntemler ile birleřtirilir (dođrudan toplanmaz)
- Bu yöntemlerin en bilineni SRSS'dir. Modların birbirinden ayrık olduđu durumda uygun sonuçlar verdiđi kabul edilir.
- Diđer CQC'dir. Modlar birbirine yakınsa bu yöntem tercih edilir.
- Genellikle uygulanan
  - Modal Birleřtirme → CQC
  - Yönsel Birleřtirme → SRSS

# SRSS ile Mod Birleştirme: Yerdeğiştirmeler

$$\mathbf{X}^{\max} = \begin{Bmatrix} x_1^{\max} \\ x_2^{\max} \\ x_3^{\max} \end{Bmatrix} \approx \sqrt{\left( \begin{Bmatrix} / \\ \phi_1 \\ / \end{Bmatrix} q_1^{\max} \right)^2 + \left( \begin{Bmatrix} / \\ \phi_2 \\ / \end{Bmatrix} q_2^{\max} \right)^2 + \left( \begin{Bmatrix} / \\ \phi_3 \\ / \end{Bmatrix} q_3^{\max} \right)^2}$$

~~$$\mathbf{X}^{\max} = \begin{Bmatrix} x_1^{\max} \\ x_2^{\max} \\ x_3^{\max} \end{Bmatrix} = \begin{Bmatrix} / \\ \phi_1 \\ / \end{Bmatrix} q_1^{\max} + \begin{Bmatrix} / \\ \phi_2 \\ / \end{Bmatrix} q_2^{\max} + \begin{Bmatrix} / \\ \phi_3 \\ / \end{Bmatrix} q_3^{\max}$$~~



# SRSS ile Mod Birleştirme: Göreceli Kat Ötelemeleri

$$\delta^{\max} = \begin{Bmatrix} \delta_1^{\max} \\ \delta_2^{\max} \end{Bmatrix} \approx \sqrt{\left( \begin{Bmatrix} \phi_1^2 - \phi_1^1 \\ \phi_1^3 - \phi_1^2 \end{Bmatrix} q_1^{\max} \right)^2 + \left( \begin{Bmatrix} \phi_2^2 - \phi_2^1 \\ \phi_2^3 - \phi_2^2 \end{Bmatrix} q_2^{\max} \right)^2 + \left( \begin{Bmatrix} \phi_3^2 - \phi_3^1 \\ \phi_3^3 - \phi_3^2 \end{Bmatrix} q_3^{\max} \right)^2}$$

$$\delta_{2-1}^{\max} \approx x_2^{\max} - x_1^{\max}$$

$$\delta_{3-2}^{\max} \approx x_3^{\max} - x_2^{\max}$$

$$\delta^{\max} = \begin{Bmatrix} \delta_1^{\max} \\ \delta_2^{\max} \end{Bmatrix} \approx \begin{Bmatrix} \phi_1^2 - \phi_1^1 \\ \phi_1^3 - \phi_1^2 \end{Bmatrix} q_1^{\max} + \begin{Bmatrix} \phi_2^2 - \phi_2^1 \\ \phi_2^3 - \phi_2^2 \end{Bmatrix} q_2^{\max} + \begin{Bmatrix} \phi_3^2 - \phi_3^1 \\ \phi_3^3 - \phi_3^2 \end{Bmatrix} q_3^{\max}$$

# Spektrum Analizi: İçsel Kuvvetler

İki yöntem mevcuttur:

## 1. Yöntem: Rijitlik Matrisi ile

$$\mathbf{F}^{\text{iç}}(t) = \mathbf{K}\mathbf{x}(t)$$

$$\mathbf{x}_i(t) = \boldsymbol{\phi}_i^T q_i(t), \quad i. \text{ moddan gelen yerdeğiştirme}$$

$$\mathbf{F}_i^{\text{iç}}(t) = \mathbf{K}\mathbf{x}_i(t) = \mathbf{K}\boldsymbol{\phi}_i^T q_i(t), \quad i. \text{ moddan gelen iç kuvvetler}$$

$$\text{Spektral: } \mathbf{F}_i^{\text{iç, max}} = \mathbf{K}\boldsymbol{\phi}_i^T q_i^{\text{max}} = \mathbf{K}\boldsymbol{\phi}_i^T \frac{1}{\omega_i^2} \frac{L_i}{\bar{m}_i} S_A^i$$

## 2. Yöntem: Kütle Matrisi ile

$$\mathbf{K}\boldsymbol{\phi}_i^T = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T, \quad \text{modal denklemden}$$

$$\mathbf{F}_i^{\text{iç}}(t) = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T q_i(t)$$

$$\text{Spektral: } \mathbf{F}_i^{\text{iç, max}} = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T q_i^{\text{max}} = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T \frac{1}{\omega_i^2} \frac{L_i}{\bar{m}_i} S_A^i = \mathbf{M}\boldsymbol{\phi}_i^T \frac{L_i}{\bar{m}_i} S_A^i$$

# SRSS ile Mod Birleştirme: İçsel Kuvvetler

$$\mathbf{F}^{\max} = \begin{Bmatrix} F_1^{\max} \\ F_2^{\max} \\ F_3^{\max} \end{Bmatrix} \approx \sqrt{\begin{Bmatrix} / \\ \mathbf{F}_1^{\max} \\ / \end{Bmatrix}^2 + \begin{Bmatrix} / \\ \mathbf{F}_2^{\max} \\ / \end{Bmatrix}^2 + \begin{Bmatrix} / \\ \mathbf{F}_3^{\max} \\ / \end{Bmatrix}^2}$$

~~$$\mathbf{F}^{\max} = \begin{Bmatrix} F_1^{\max} \\ F_2^{\max} \\ F_3^{\max} \end{Bmatrix} = \begin{Bmatrix} / \\ \mathbf{F}_1^{\max} \\ / \end{Bmatrix} + \begin{Bmatrix} / \\ \mathbf{F}_2^{\max} \\ / \end{Bmatrix} + \begin{Bmatrix} / \\ \mathbf{F}_3^{\max} \\ / \end{Bmatrix}$$~~

# Spektrum Analizi: Taban Kesme Kuvveti

İki yöntem mevcuttur

## 1. Yöntem: Rijitlik Matrisi ile

$$F^{\text{taban}}(t) = -\left(F_1^{\text{iç}}(t) + F_2^{\text{iç}}(t) + \dots + F_n^{\text{iç}}(t)\right), \quad \text{kat kuvvetlerinin toplamı}$$

$$F^{\text{taban}}(t) = -\mathbf{r}^T \mathbf{F}^{\text{iç}}(t), \quad \mathbf{F}^{\text{iç}}(t) = \mathbf{K} \mathbf{x}(t), \quad \mathbf{F}_i^{\text{iç}}(t) = \mathbf{K} \mathbf{x}_i(t), \quad \mathbf{x}_i(t) = \boldsymbol{\phi}_i^T q_i(t)$$

$$F_i^{\text{taban}}(t) = -\mathbf{r}^T \mathbf{F}_i^{\text{iç}}(t) = -\mathbf{r}^T \mathbf{K} \boldsymbol{\phi}_i^T q_i(t), \quad i. \text{ moddan gelen taban kesme kuvveti}$$

$$\text{Spektral: } F_i^{\text{taban, max}} = -\mathbf{r}^T \mathbf{F}_i^{\text{iç, max}} = -\mathbf{r}^T \mathbf{K} \boldsymbol{\phi}_i^T q_i^{\text{max}} = -\mathbf{r}^T \mathbf{K} \boldsymbol{\phi}_i^T \frac{1}{\omega_i^2} \frac{L_i}{\bar{m}_i} S_A^i$$

# Spektrum Analizi: Taban Kesme Kuvveti

İki yöntem mevcuttur

## 2. Yöntem: Kütle Matrisi ile

$$\mathbf{K}\boldsymbol{\phi}_i^T = \omega_i^2 \mathbf{M}\boldsymbol{\phi}_i^T, \quad \text{modal denklemden}$$

$$F_i^{\text{taban}}(t) = -\mathbf{r}^T \mathbf{F}_i^{\text{iç}}(t) = -\mathbf{r}^T \mathbf{K}\boldsymbol{\phi}_i^T q_i(t)$$

$$F_i^{\text{taban}}(t) = -\omega_i^2 \mathbf{r}^T \mathbf{M}\boldsymbol{\phi}_i^T q_i(t)$$

$$L_i = \boldsymbol{\phi}_i^T \mathbf{M}\mathbf{r}, \quad L_i = L_i^T = \mathbf{r}^T \mathbf{M}\boldsymbol{\phi}_i^T$$

$$F_i^{\text{taban}}(t) = -\omega_i^2 L_i q_i(t)$$

$$\text{Spektral: } F_i^{\text{taban, max}} = -\omega_i^2 L_i q_i^{\text{max}} = -\omega_i^2 L_i \frac{1}{\omega_i^2} \frac{L_i}{\bar{m}_i} S_A^i = -\frac{L_i^2}{\bar{m}_i} S_A^i$$

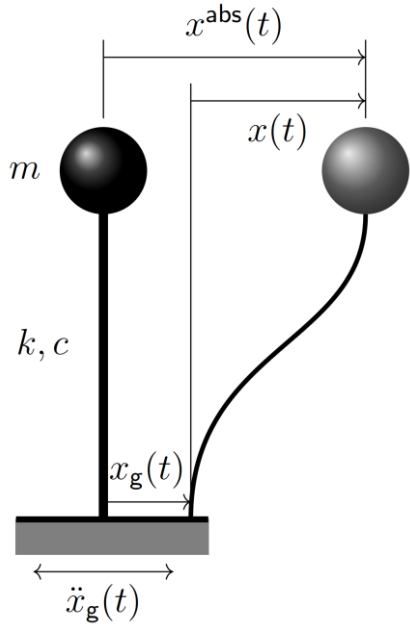
# Spektrum Analizi: Taban Kesme Kuvveti

$$F^{\text{taban, max}} = \sqrt{\left(F_1^{\text{taban, max}}\right)^2 + \left(F_2^{\text{taban, max}}\right)^2 + \left(F_3^{\text{taban, max}}\right)^2}$$

~~$$F^{\text{taban, max}} = F_1^{\text{max}} + F_2^{\text{max}} + F_3^{\text{max}}$$~~

# Spektrum Analizi: Efektif Modal Kütle

## Tek Serbestlik Dereceli Sistemler:

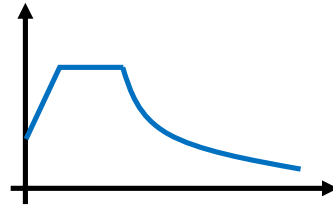


$f_s$  : yay kuvveti, **taban kesme kuvveti**

$$f_s = kx = \omega_n^2 mx$$

$\frac{f_s}{m}$  : kütlede bağımsız (normalize) yay kuvveti

$$\frac{f_s}{m} = S_A$$



$f_s = m S_A$  : taban kesme kuvvetinin kütle üzerinden ifadesi

Benzer ifadeler

## Modal Sistem:

$$F_i^{\text{taban, max}} = - \frac{L_i^2}{\bar{m}_i} S_A^i$$

$$m_{\text{eff}, i} = \frac{L_i^2}{\bar{m}_i} : \text{Efektif Modal Kütle}$$

# Spektrum Analizi : Efektif Modal Kütle

$$m_{\text{eff}, i} = \frac{L_i^2}{\bar{m}_i} : \text{Efektif Modal Kütle}$$

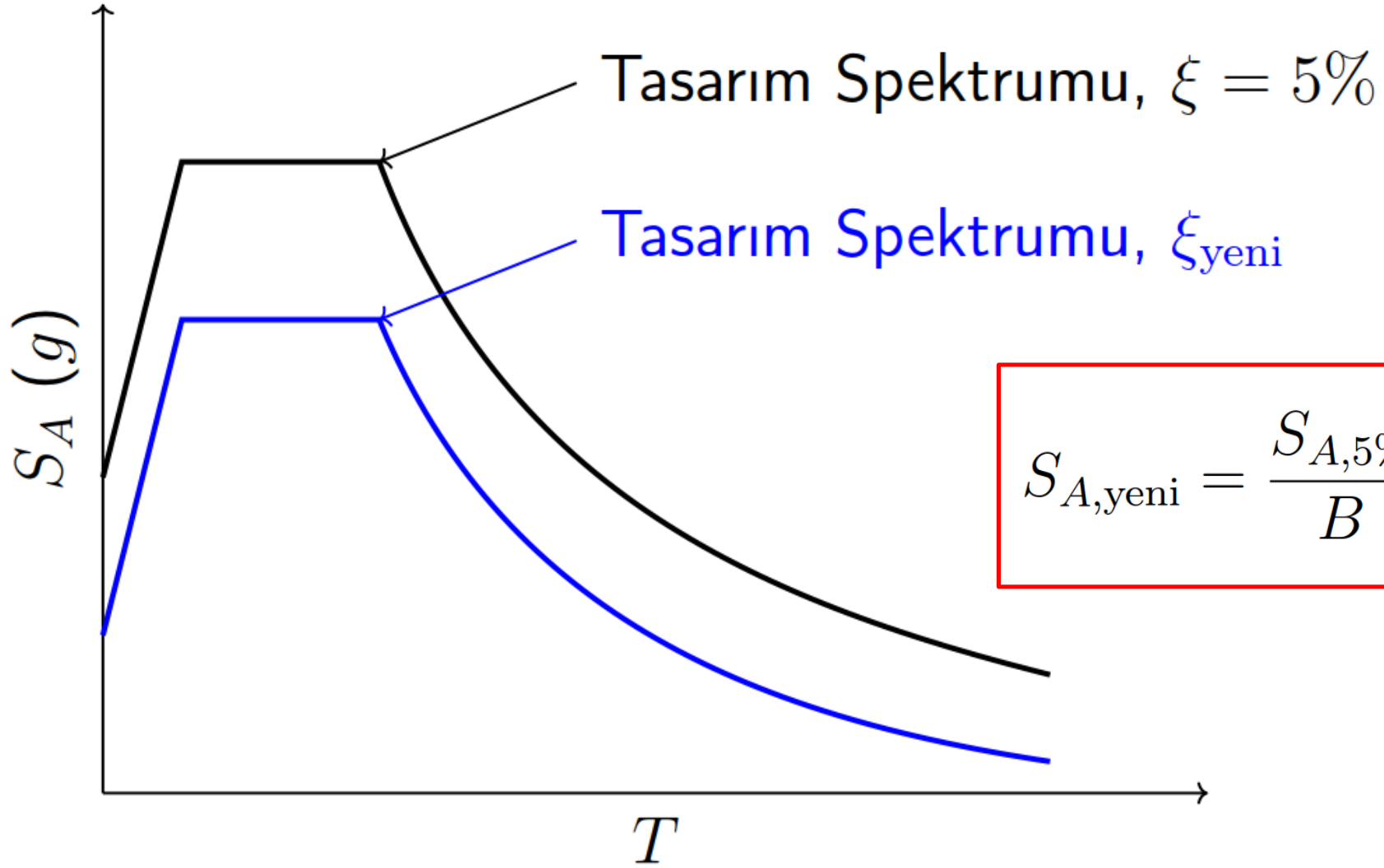
$$\sum_{i=1}^n m_{\text{eff}, i} = \sum \mathbf{M} : \text{Yapının Toplam Kütlesi (ispatı mevcuttur)}$$

$$\frac{m_{\text{eff}, i}}{\sum \mathbf{M}} : i \text{ modunun kütle katılım oranı}$$

$$\frac{\sum_{i=1}^{gm} m_{\text{eff}, i}}{\sum \mathbf{M}} > 90\% : \text{Yönetmelik şartı (en az } gm \text{ (gerekli mod) adet mod kullanılmalı)}$$



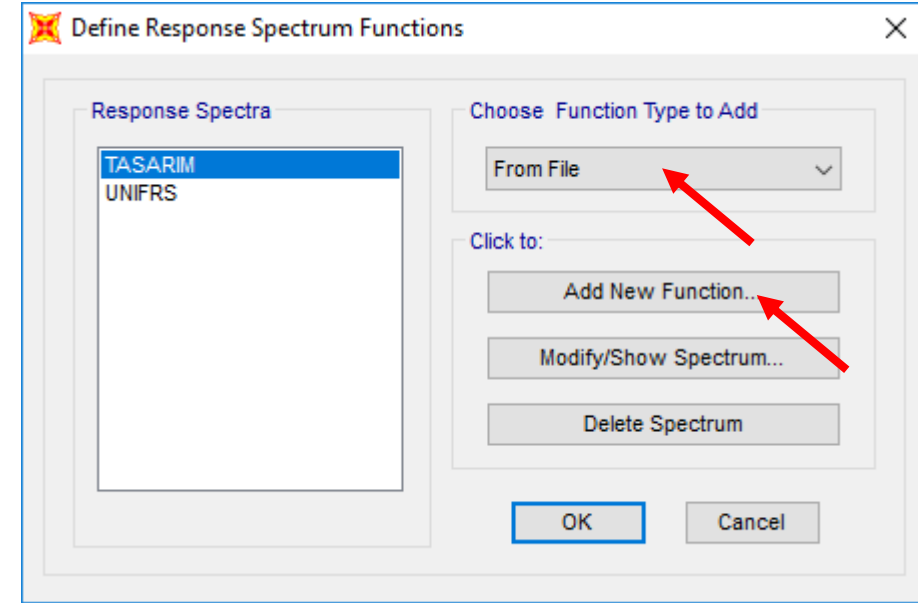
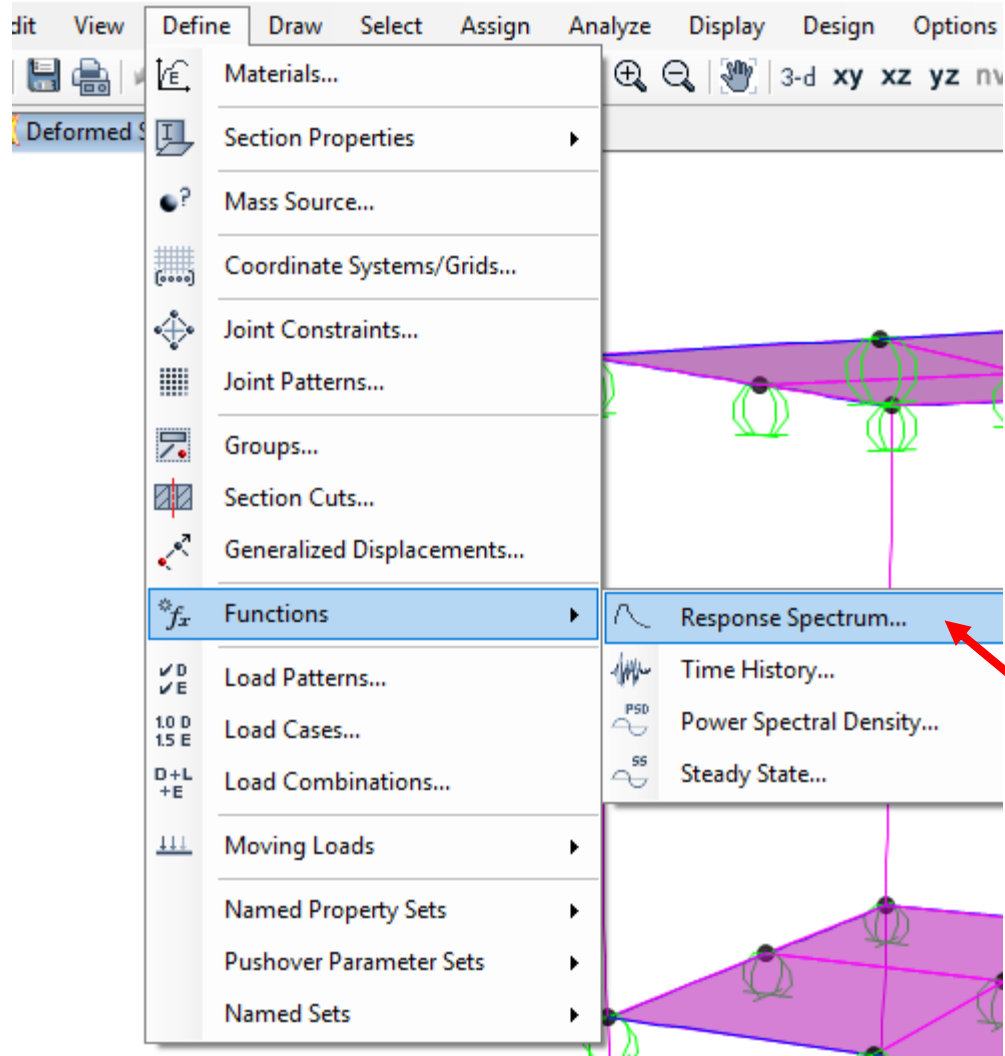
# Tasarım Spektrumunu Sönümlleme ile Deęiřtirme



$$S_{A,\text{yeni}} = \frac{S_{A,5\%}}{B}, \quad B = \left( \frac{\xi_{\text{yeni}}}{0.05} \right)^{0.3}$$

# Spektrum Analizi: SAP2000 – Tasarım Spektrumunun Tanımlanması

00 v19.1.0 Ultimate 64-bit - S03-EX02-M03



# Spektrum Analizi: SAP2000 – Tasarım Spektrumunun Tanımlanması

Response Spectrum Function Definition

Function Name:  Function Damping Ratio:

Function File

File Name:  Browse...

Header Lines to Skip:

Values are:

Frequency vs Value

Period vs Value

Convert to User Defined View File

Function Graph

Display Graph (3.9783 , 0.1648)

OK Cancel

C:\Users\baris\Desktop\Dinamik\S03\Example02\Deprem\RS2475.txt - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ? X

RS2475.txt

1	0	0.571412531
2	0.05	1.038236161
3	0.1	1.428531327
4	0.15	1.428531327
5	0.2	1.428531327
6	0.25	1.428531327
7	0.3	1.428531327
8	0.35	1.428531327
9	0.4	1.428531327
10	0.45	1.428531327
11	0.5	1.311438595
12	0.55	1.192216905
13	0.6	1.092865496
14	0.65	1.008798919
15	0.7	0.936741854
16	0.75	0.874292397
17	0.8	0.819649122
18	0.85	0.771434468

length : 2,853 lines : 1( Ln : 1 Col : 1 Sel : 0 | 0 Windows (CR LF) UTF-8 INS

# Spektrum Analizi: SAP2000 – Tek Yön

Load Case Data - Response Spectrum

Load Case Name: MODALRSA  Notes:

Load Case Type: Response Spectrum

Modal Combination

CQC  SRSS  Absolute  GMC  NRC 10 Percent  Double Sum

GMC f1: 1. GMC f2: 0. Periodic + Rigid Type: SRSS

Directional Combination

SRSS  CQC3  Absolute Scale Factor:

Mass Source: Previous (MSSSRC1)

Diaphragm Eccentricity

Eccentricity Ratio: 0.

Modal Load Case

Use Modes from this Modal Load Case: MODAL

Standard - Acceleration Loading  Advanced - Displacement Inertia Loading

Loads Applied

Load Type	Load Name	Function	Scale Factor
Accel	U1	TASARIM	9.807
Accel	U1	TASARIM	9.807

Show Advanced Load Parameters

Other Parameters

Modal Damping: Constant at 0.05

# Spektrum Analizi: SAP2000 – İki Yön

**Load Case Data - Response Spectrum**

Load Case Name: MODALRSA  Notes:

Load Case Type: Response Spectrum

Modal Combination:

- CQC
- SRSS
- Absolute
- GMC
- NRC 10 Percent
- Double Sum

GMC f1: 1.0  
GMC f2: 0.0  
Periodic + Rigid Type: SRSS

Directional Combination:

- SRSS
- CQC3
- Absolute

Scale Factor:

Mass Source: Previous (MSSSRC1)

Diaphragm Eccentricity:

Eccentricity Ratio: 0.0

Modal Load Case:

Use Modes from this Modal Load Case: MODAL

- Standard - Acceleration Loading
- Advanced - Displacement Inertia Loading

Loads Applied:

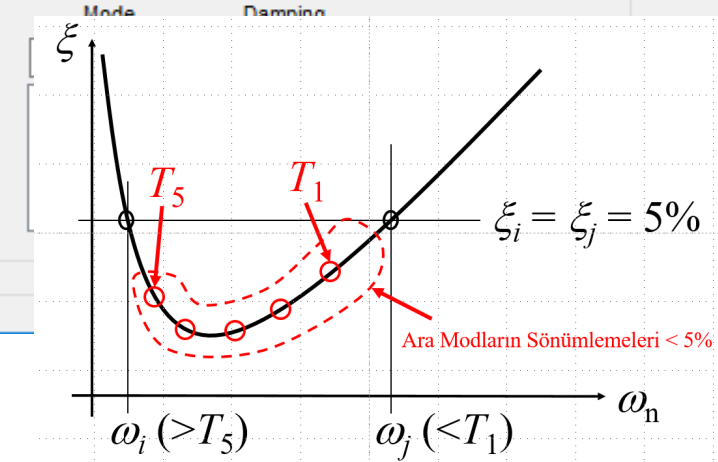
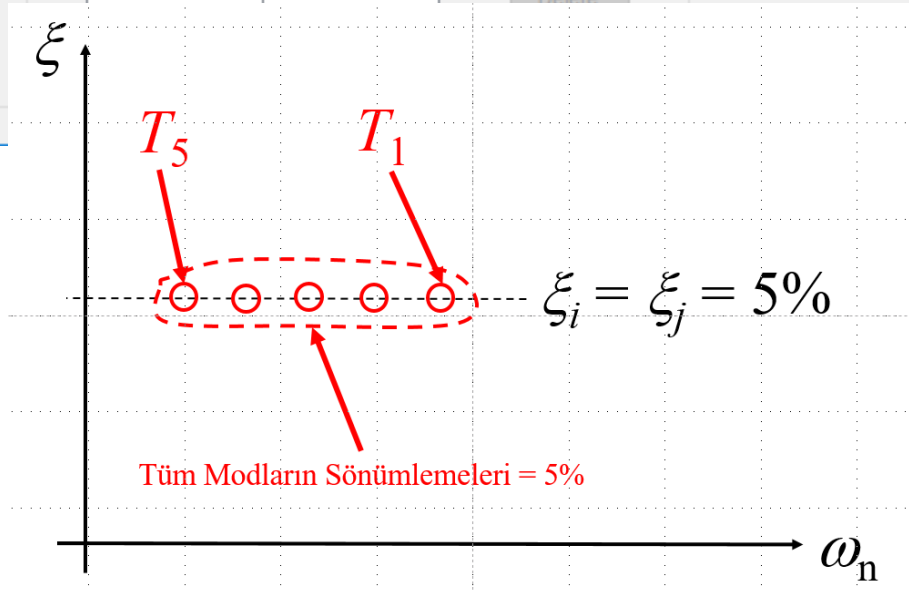
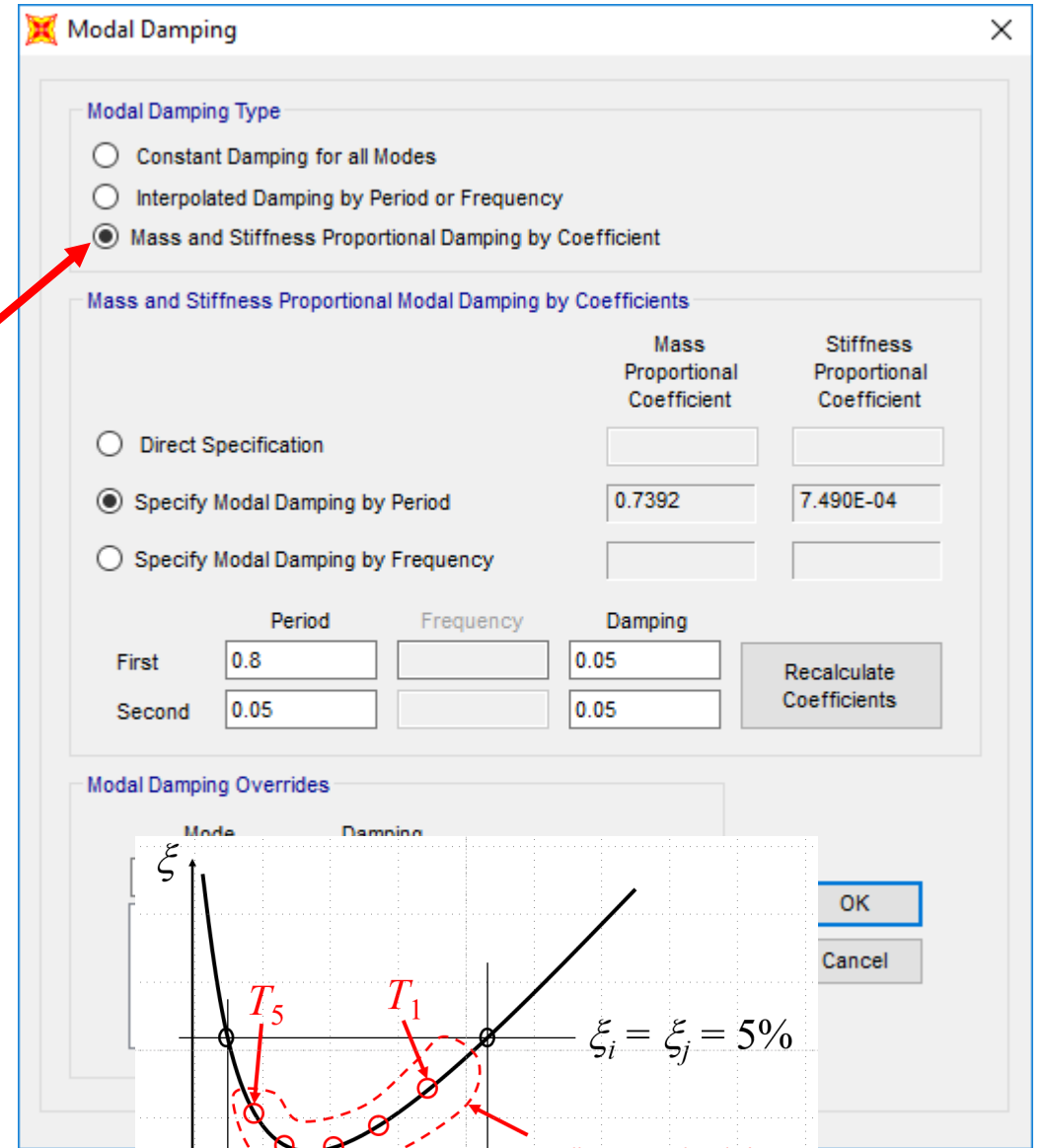
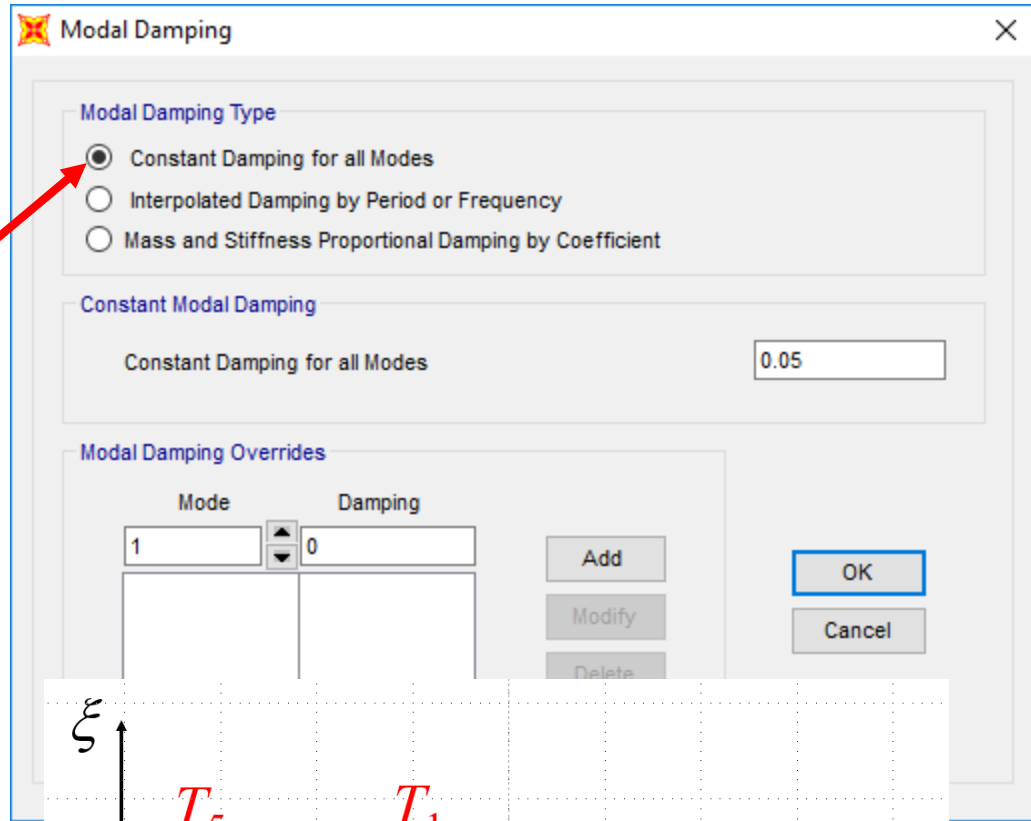
Load Type	Load Name	Function	Scale Factor
Accel	U2	TASARIM	9.807
Accel	U1	TASARIM	9.807
Accel	U2	TASARIM	9.807

Show Advanced Load Parameters

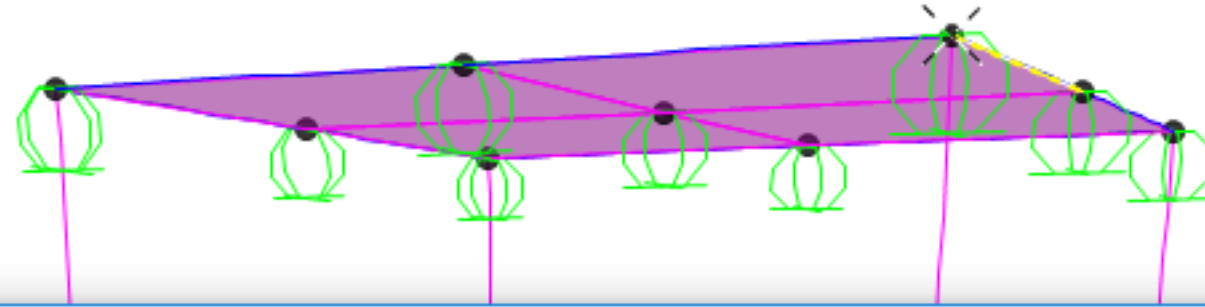
Other Parameters:

Modal Damping: Constant at 0.05

# Spektrum Analizi: SAP2000 – Sönümlleme



# Karşılaştırma



## Joint Displacements

File View Edit Format-Filter-Sort Select Options

Units: As Noted

Filter:

Joint Displacements

	Joint Text	OutputCase	CaseType Text	StepType Text	U1 m	U2 m	U3 m	R1 Radians	R2 Radians	R3 Radians
▶	6	MODALTHA	LinModHist	Max	0.199545	0	0	0	0	0
	6	MODALTHA	LinModHist	Min	-0.171099	0	0	0	0	0
	6	MODALRSA	LinRespSpec	Max	0.143857	0	0	0	0	0
	6	DIRECTTHA	LinDirHist	Max	0.199418	0	0	0	0	0
	6	DIRECTTHA	LinDirHist	Min	-0.170998	0	0	0	0	0

# Karşılaştırma

180 - PEER No: 1158, PEER GM Scale Factor = 2.2411

