

Program

DYNAM

For use with Windows 95/98/ME/NT 4.0/2000

**Natural Frequencies, Eigenvibrations, Forced
Vibrations, Equivalent Lateral Forces,
Earthquake Analysis**

User Manual

Version: Mai 2001

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1. Introduction

1.1 About DYNAM for Windows

Whether you are a first time DYNAM user or someone using a previous version, the practical oriented development has made it possible for anyone to start the program and find their way around. Much of DYNAM's user-friendliness comes from the cooperative work with customers and business partners. Their valuable tips contributed to improvements in DYNAM 4.xx and ultimately in this version of DYNAM for Windows.

DYNAM for Windows is fully integrated into RSTAB 5 for Windows. Eigenfrequency results can be integrated into the RSTAB printout report. Therefore, the results of all calculations are presented in one concise, complete report.

While working with DYNAM, the [F1] key can be used to open the online help system.

We wish you much success with RSTAB and DYNAM.

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1.2 The DYNAM-Team

The following people contributed to the development of DYNAM for Windows:

- **Program Coordinators:**
Dipl.-Ing. Georg Dlubal
Dipl.-Ing. Peter Achter
Ing. Pavel Bartoš
- **Programmers:**
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- **Program Testing:**
Dipl.-Ing. Georg Dlubal
Dipl.-Ing. Peter Achter
Dipl.-Ing. (FH) Walter Rustler
- **Manual and Help System:**
Dipl.-Ing. Peter Achter
- **English Translation:**
Jana Rustler
Dipl.-Ing. (FH) Walter Rustler



2. Installing DYNAM

2.1 System Requirements

To use DYNAM, we recommend the following minimum system requirements:

- Windows 95 / 98 / NT 4.0 / 2000 Operating System
- 200 MHz Processor
- 64 MB Memory
- CD ROM and 3.5" disk drive for installation
- 2 GB total hard disk capacity with 150 MB reserved for installation
- 4 MB Graphic's card and monitor with a resolution of 1024 x 768 pixels

With the exception of the operating system, no product recommendations are made. DYNAM and RSTAB basically run on all systems that fulfill the system requirements. Your computer does not need to have "Intel Inside", and it is also unnecessary to have an expensive 3D graphic's card. Because DYNAM and RSTAB are generally used for extensive calculations, the phrase "more is better" holds true.

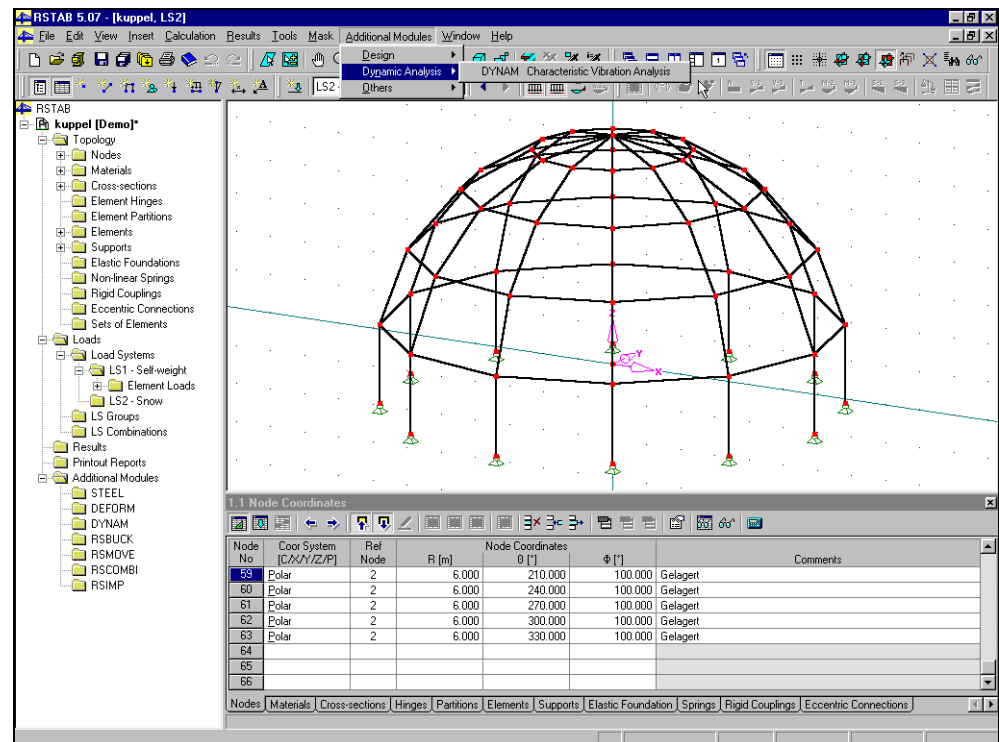
2.2 Installation Process

Licensed DYNAM users should follow the installation instructions in the RSTAB manual. DYNAM will be automatically installed. If there is an authorization fail message when starting the DYNAM module from RSTAB, the program will run as a limited but functional demo version.

3. Working with DYNAM

3.1 Starting DYNAM

DYNAM can either be started from the *Additional Modules*→*DYNAM* menu or by selecting it from *Additional Modules* in the *Position* or *Project Navigator* on the left side of the screen.



Starting DYNAM with the Menu or the Navigator

3.2 Masks

Input to define Eigenvalues and the output for numerical results can be done with masks. DYNAM has its own Navigator with all available masks shown to the left. The masks can be opened through the DYNAM Navigator or the *Masks* menu. Skim backward or forward through the list with the [F2] and [F3] keys or with the [<<] and [>>] buttons at the bottom of each mask. Click on the [Graphic] button to view results of the Eigenfrequency analysis. (You'll find other information about viewing results in Chapter 3.4.) [OK] saves the input and results before leaving DYNAM. [Cancel] ends DYNAM without saving any work done. The [Help] button or the [F1] key will activate the online help system.

The title bar at the top has *File* and *Help* menus. Refer to Chapter 3.5 for the explanation of their functions.

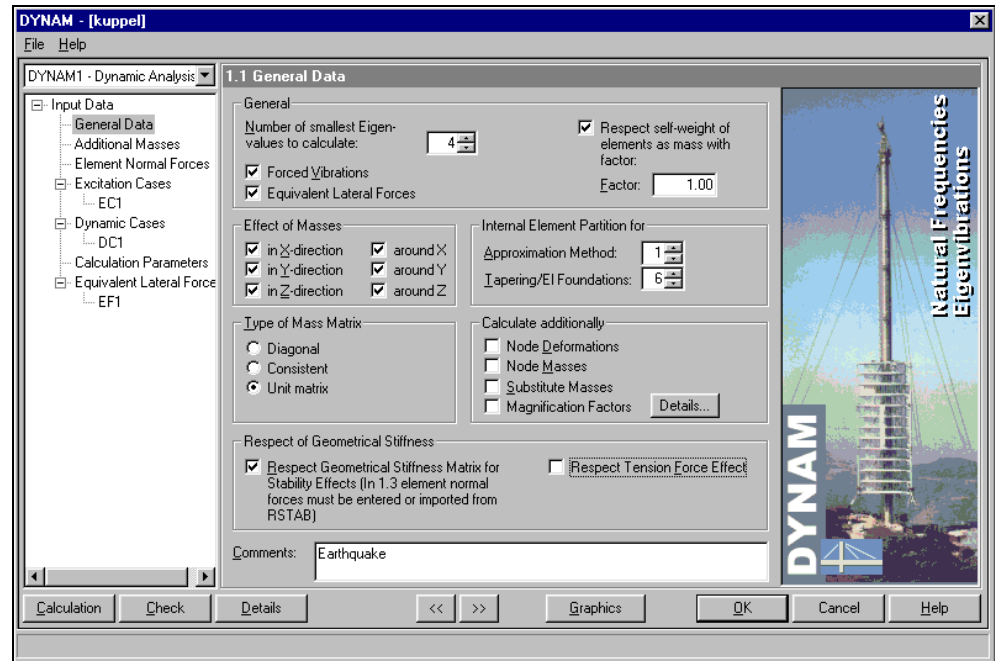
3.3 Input Masks

The full version of DYNAM consists of DYNAM BASIC, DYNAM ADDITION 1 and DYNAM ADDITION 2 modules. Different input masks are available depending on which modules are authorized. Input masks are used to enter parameters for determining Eigenfrequencies (DYNAM BASIC), forced vibrations (DYNAM ADDITION 1) or equivalent lateral forces (DYNAM ADDITION 2).



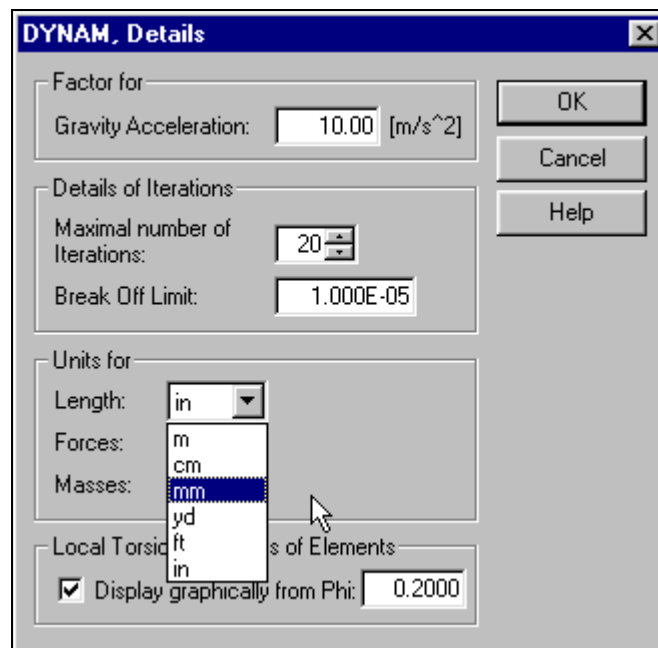
3.3.1 Mask 1.1 General Data

After starting DYNAM, the *1.1 General Data* mask opens.



Mask 1.1 General Data

DYNAM can handle several DYNAM cases which are actually different dynamic analysis for the same structure. This way a comparison between several calculations is possible. Select an existing DYNAM case with the help of the list box. You can write *Comments* in a field for each DYNAM case. The [Details] button opens a mask where specific parameters can be selected before you [Calculate]. The [Check] button is available to run a plausibility check.



DYNAM, Details

Number of smallest Eigenvalues to calculate: DYNAM BASIC determines the lowest Eigenfrequency of a structure. In theory, it is not possible to rule out lower Eigenfrequencies



from the analysis and determine the higher Eigenfrequencies at the same time. The analysis must always start with the lowest Eigenfrequencies when calculating higher Eigenfrequencies. With DYNAM BASIC, the 200 lowest Eigenfrequencies of a system can be determined.

Respect self-weight of elements as mass with factor: From the topology defined in RSTAB, DYNAM can determine the resulting mass of the system from the elements. The mass will be multiplied by the factor in the input field. Entering *Zero* in the field means that the element mass will not be applied in the dynamic analysis.

Forced Vibrations: This checkbox is available only to DYNAM ADDITION 1 license holders. When checked, excitation loads can be defined in Masks 1.4 and 1.6.

Equivalent Lateral Forces: This option is only available to licensees of DYNAM ADDITION 2. By defining Norm values within Mask 1.7 (DIN 4149 and related, later EC 8, IBC 2000 and others) the static equivalent lateral forces will be analyzed.

Effect of Masses in/about X-, Y- and Z-directions: To determine in which global direction masses should be considered, the appropriate boxes must be checked. DYNAM considers element (topology) masses and also additional masses from nodes and elements defined in the 1.2.1 Additional Node Masses and 1.2.2 Additional Element Masses masks.

Type of Mass Matrix: The type of Mass Matrix determines the accuracy of Eigenfrequencies and the necessary computing time. In the *consistent* mass matrix, the same mathematical formula is used to arrange both the mass and stiffness matrix. Because precision is high, it takes longer to compute.

A *diagonal* matrix is more simple so that the mass will be concentrated on the structure nodes. The Unit Matrix is structured the same as the diagonal mass matrix, but contains only the unit mass of the system, not the real mass. It also considers only the displacement components of the mass. The unit matrix can calculate the spectral values of the stiffness matrix. If the unit matrix is selected, no standardization follows. Therefore, the analysis results depend on units. The unit corresponds to the stiffness matrix. After selecting the unit matrix, calculating the node and substitute mass are longer possible. Analysis with DYNAM ADDITION 1 and DYNAM ADDITION 2 will not be started when the Eigenvalues of the stiffness matrix are unavailable and would therefore produce false dynamic analysis results.

Internal Element Partition for: Under certain circumstances it may be necessary to define more element divisions to reach a more approximate solution. The exactness of the design will be increased, particularly for tapered or elastic bedded elements. By entering a number greater than 1 in the input field, the program divides an element internally. You must use whole numbers.

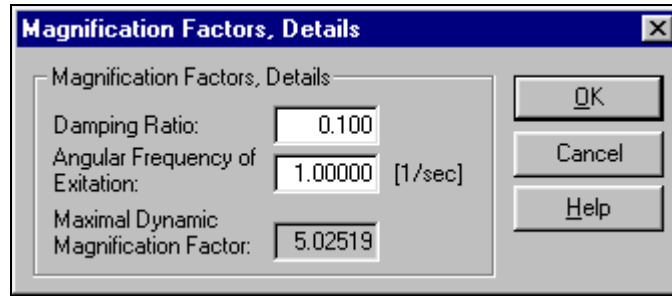
Example: For a simple single-span beam a maximum of 6 lowest Eigenfrequencies can be calculated with a partition of 1. After entering 2 in *Approximation Method*, the 12 lowest Eigenfrequencies can be calculated. To reach the same result in RSTAB, the single-span beam would need to be divided by a node put in-between.

Calculate Additional Node Deformations: If this option is selected, mask 2.3 opens and shows the deformations of the nodes standardized on the greatest deformation.

Calculate Additional Node Masses: After selecting the diagonal mass matrix, DYNAM distributes the entire mass to the nodes of the structure. However, active masses are considered in the calculation (controlling masses for the dynamic behavior of the structure).

Calculate Additional Substitute Masses: Details about the theory behind this are found in Chapter 4.

Calculate Additional Magnification Factors: This option provides the resonance spectrum of the excitation frequencies. Click on [Details] to define the damping ratio and angular frequency of the load excitation.



Magnification Factors, Details

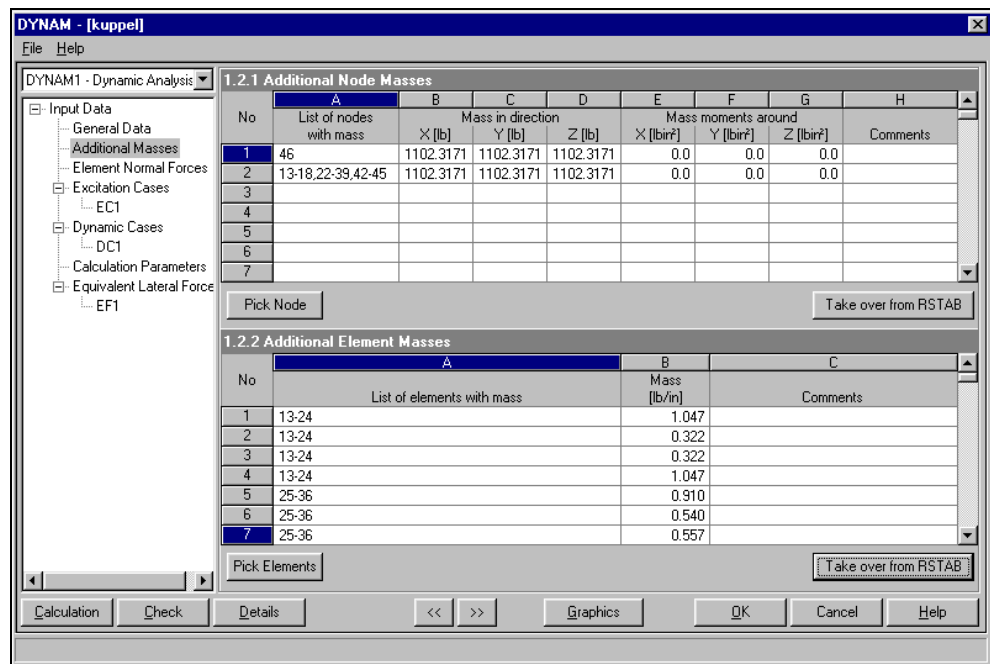
Respect of Geometrical Stiffness: If the geometric stiffness matrix is used for the calculation, Theory II order will be applied. Through the slant of the system, normal forces create additional bending moments that contribute to an increased or decreased stiffness of the system. Check this box to open mask 1.3 and enter normal forces.

Respect Tension Force Effect: Tensile forces lead to an increase of the element's Eigenfrequency. Check this box to analyze the effect.

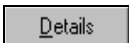
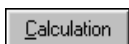
Comments: Particular notes can be entered here.

3.3.2 Mask 1.2 Additional Masses

DYNAM imports a defined structure from RSTAB. If a factor greater than 0 is entered in the *Respect self-weight of elements as mass with factor* field in the 1.1 General Data mask, DYNAM uses the element mass of the structure for the analysis. Additionally or alternatively, you can define this information in the 1.2.1 Additional Node Masses/1.2.2 Additional Element Masses masks.



Mask 1.2 Additional Node/Element Masses



Import RSTAB loads as masses easily with the [Import from RSTAB] button. Only the loads which would be defined as G or in the Z-axis direction will be imported from RSTAB. If you want to import only individual node loads respective to element loads in DYNAM, use the [Pick Elements] button or enter the loads by hand.

RSTAB imported element loads defined as *Single Load* or *Trapezoidal Load* will be distributed as mass over the entire length of the element. If, for example, there is a single load



of 10 kN defined on an element 5 meters long, it will be converted into an element mass of 200 kg/m.

List of nodes with mass:

...numbers the nodes where additional masses should be considered.

Mass in direction:

...is the amount of the mass that should be considered at the respective nodes.

Mass moments about:

The mass moments applied to the nodes. When importing data from RSTAB, rotational moments on nodes will be automatically converted to mass moments.

List of elements with mass

...numbers the elements on which additional masses should be applied.

Mass

...is the amount of the mass that should be applied on the respective elements.

3.3.3 Mask 1.3 Element Normal Forces

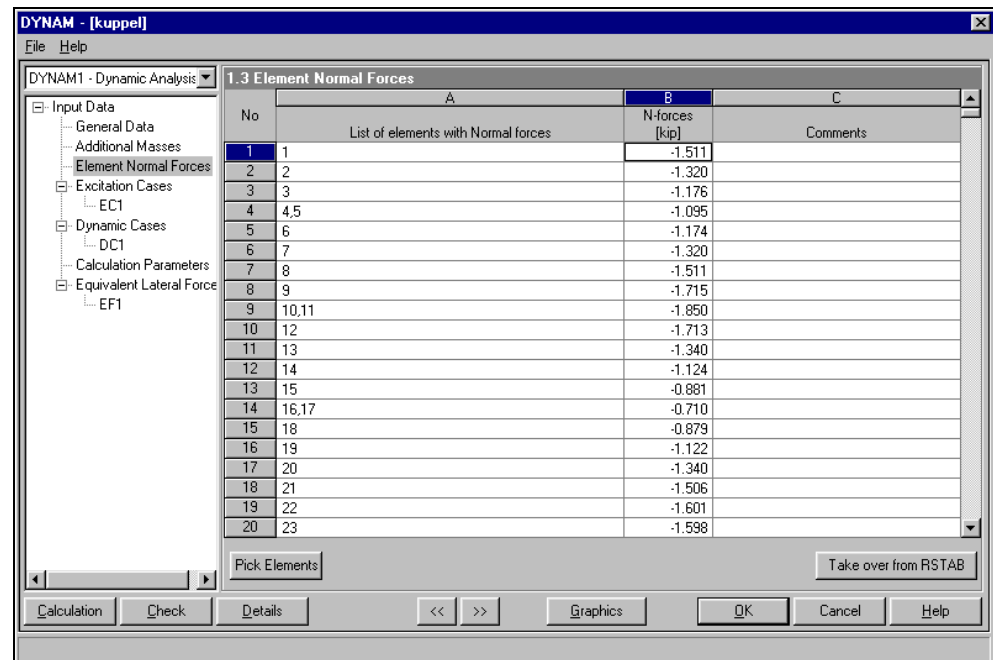
To consider element normal forces when analyzing the Eigenfrequencies check the *Respect Geometrical Stiffness Matrix for Stability Effects* box in the *1.1 General Data* mask. Then you can access the *1.3 Element Normal Forces* mask. Normal forces are assigned to one or more elements in the same way as additional masses in the *1.2.2 Additional Element Masses* mask.

List of elements with Normal Forces

Enter the element numbers in column A that should be given defined normal forces.

N-forces

Define the values of the normal forces for each element listed in column B. Negative values are compression forces and positive values are tension forces.



Mask 1.3 Element Normal Forces



3.3.4 Mask 1.4 Excitation Cases

Masks 1.4 to 1.6 can only be opened by DYNAM ADDITION 1 licenses.

EC Number: Define and save various types of excitation cases for a structure with a specifically assigned number.

Excitation Type: Three excitation types are available in DYNAM ADDITION 1. After defining the excitation type, all other input tables will be adjusted automatically. It is not possible to mix several excitation types in one DYNAM case.

Accelerogram: One or more support nodes are stimulated when time and corresponding acceleration are entered in the table. This excitation type is used to describe earthquake excitations.

Time is entered in seconds. Always enter the time beginning with $t=0$. The time points must be entered in increasing sequence, although the time steps can be any size. For numerical reasons, set the last time point (T_n) higher than the top time limit (TI) of the integration:

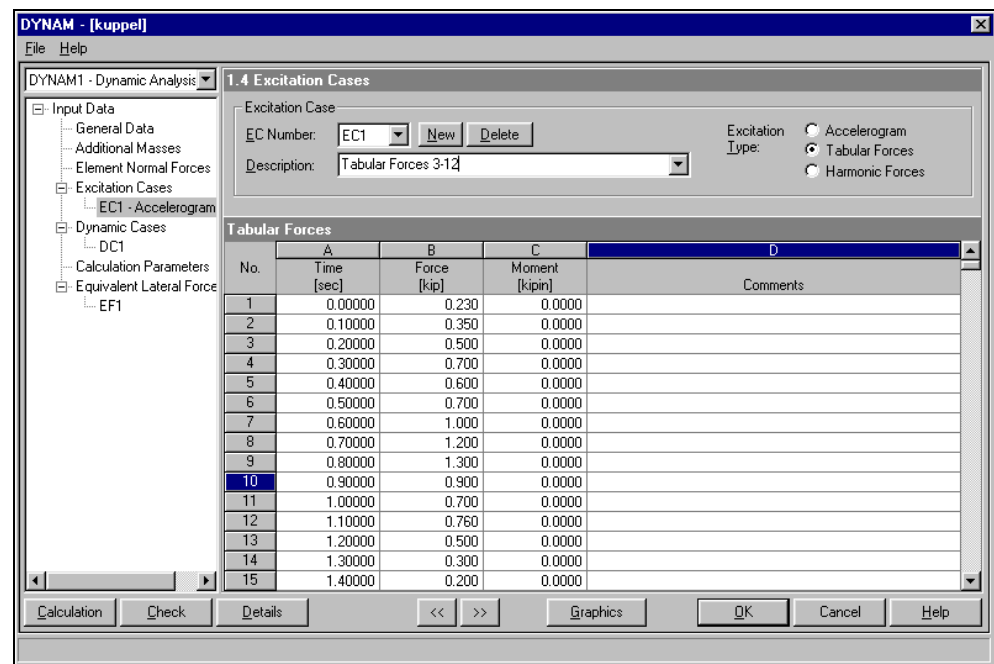
$$T_1 = 0 < T_2 < \dots < T_{n-1} < TI < T_n$$

No.	Time [sec]	Acceleration [in/sec ²] in			Comments
		X-direction	Y-direction	Z-direction	
1	0.00000	0.00	0.00	0.00	
2	0.10000	40.00	24.00	0.00	
3	0.20000	69.00	54.00	0.00	
4	0.30000	23.00	34.00	0.00	
5	0.40000	58.00	34.00	0.00	
6	0.50000	69.00	44.00	0.00	
7	0.60000	56.00	55.00	0.00	
8	0.70000	69.00	65.00	0.00	
9	0.80000	34.00	67.00	0.00	
10	0.90000	67.00	3.00	0.00	
11	1.00000	45.00	34.00	0.00	
12	1.10000	78.00	33.00	0.00	
13	1.20000	35.00	33.00	0.00	
14	1.30000	78.00	54.00	0.00	
15	1.40000	126.00	67.00	0.00	

Mask 1.4 Excitation Cases (Accelerogram)



Tabular Forces: Enter time-dependent forces (single forces and moments) in a table.

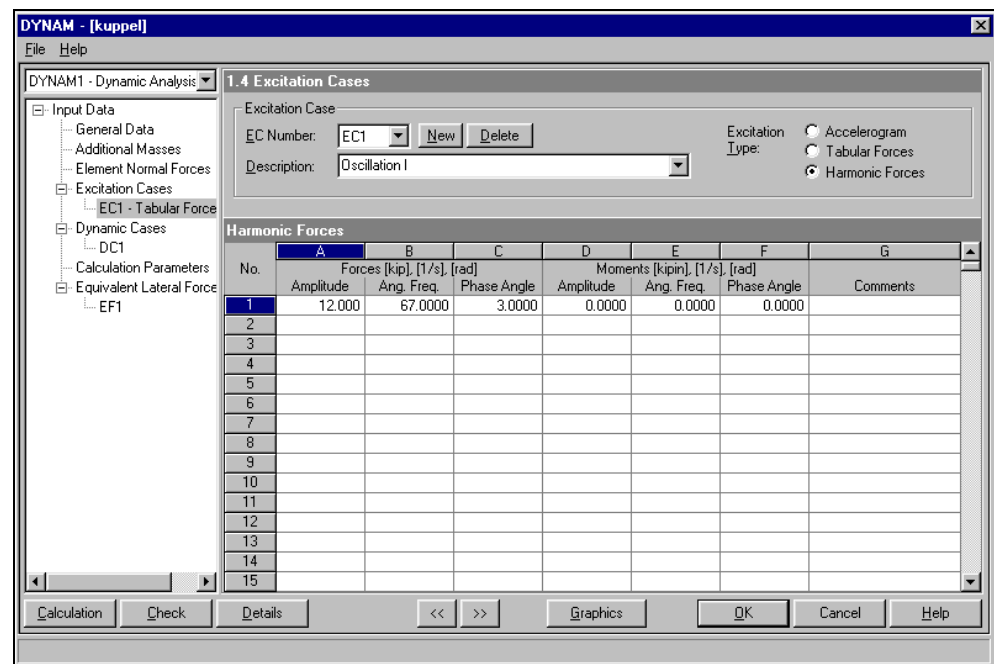


Mask 1.4 Excitation Cases (Tabular Forces)

Harmonic Forces: Define dynamic loads (like vibrations caused by machines) affecting a structure by entering amplitude, angular velocity and phase angle.

In this case, the force function $f(t)$ and moment function $m(t)$ have the following shape:

$$f(t) = A_f \sin(\omega_f t + \phi_f), \text{ and}$$
$$m(t) = A_m \sin(\omega_m t + \phi_m),$$



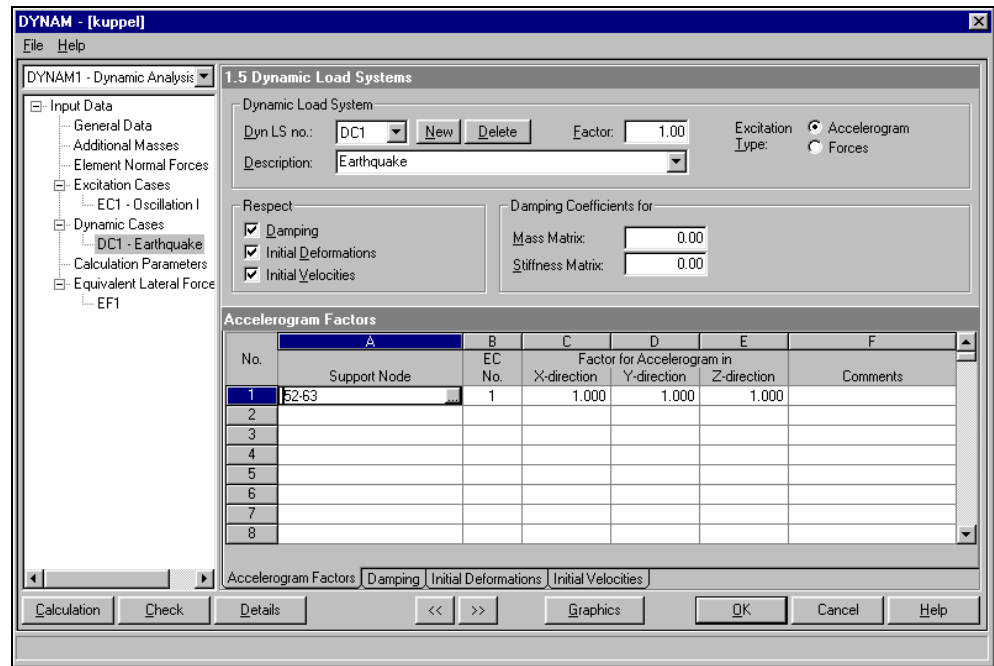
Mask 1.4 Excitation Cases (Harmonic Forces)



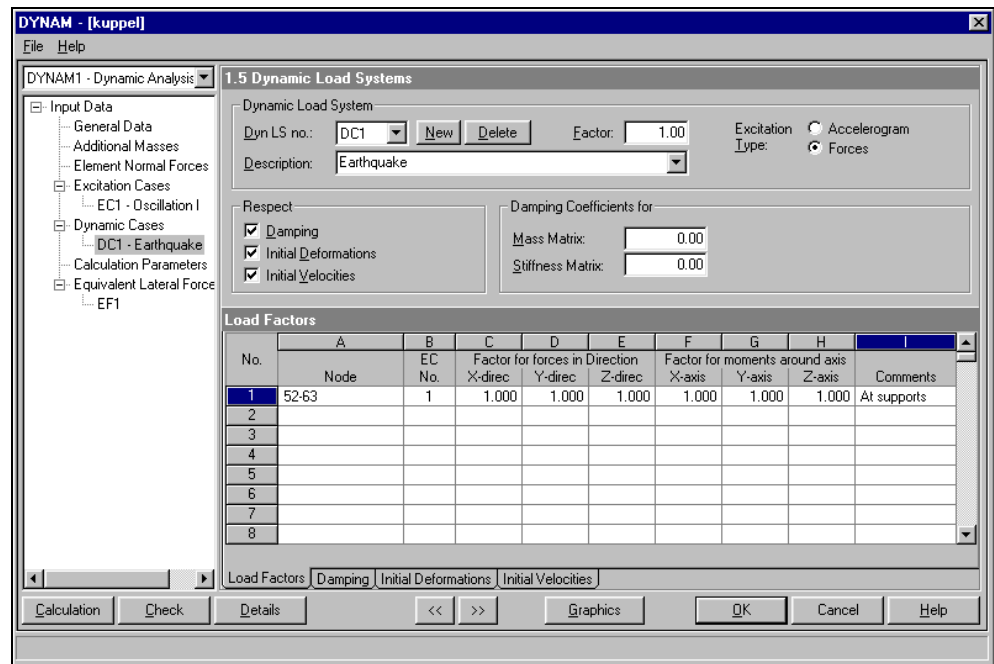
3.3.5 Mask 1.5 Dynamic Load Systems

After defining an excitation case as an accelerogram or as harmonic or tabular forces in mask 1.4, open the *1.5 Dynamic Load Systems* mask.

Dynamik LS Number: One or several different excitation cases can be combined in a *Dynamic Load System* and be identified by this number and a *Description*. The entire dynamic load system may also be multiplied by a *Factor*. Choose either *Accelerogram* or *Forces* for the type of *Excitation*. It is not possible to mix an excitation of an accelerogram with a force excitation in a dynamic load system. Below are two examples with different excitation types.



Mask 1.5 Dynamic Load Systems (Accelerogram Factors)

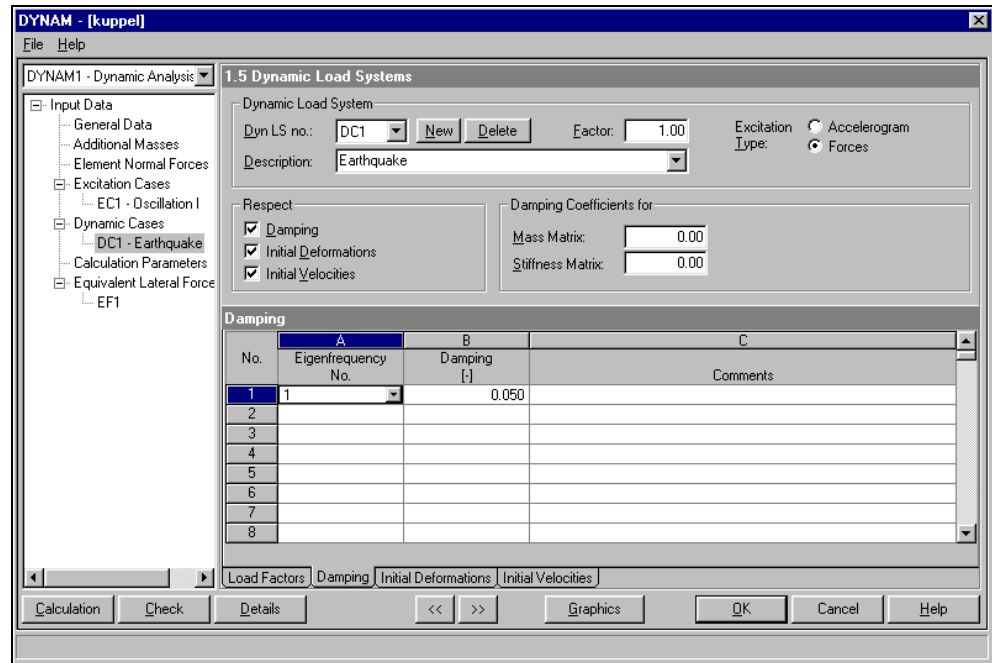


Mask 1.5 Dynamic Load Systems (Load Factors)



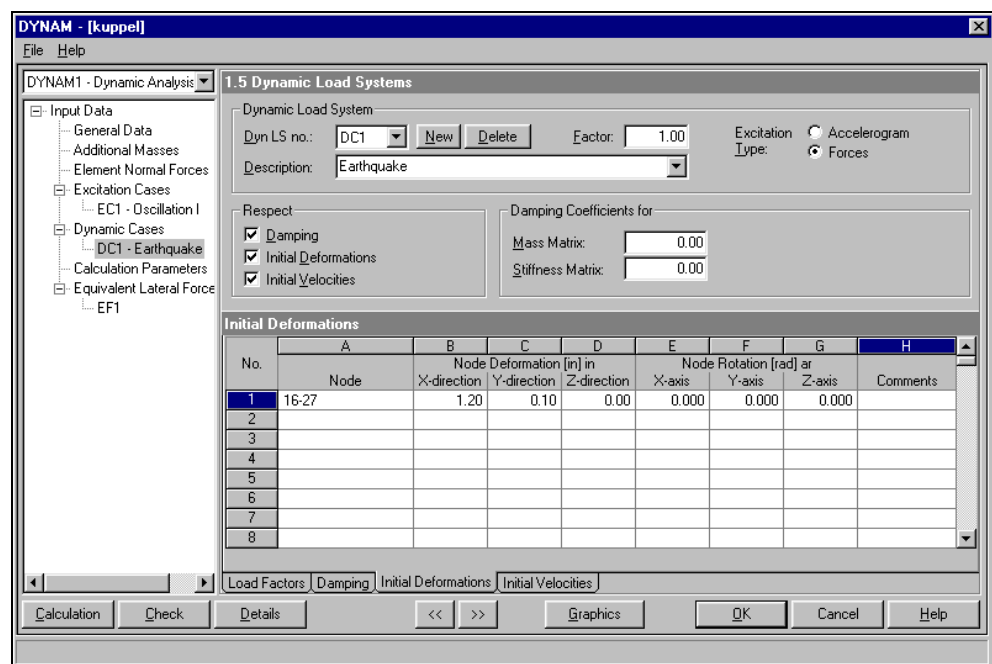
Several more options can be selected, each with their own corresponding tables as follows.

Damping: The damping of an Eigenfrequency is a dimensionless coefficient proportional to the corresponding Eigenshape of the structure. It describes the ratio of existing damping to critical damping. When calculating, it is assumed that the Eigenshape of the system is the same with or without damping. This condition is only acceptable for low damping values.



Mask 1.5 Dynamic Load Systems (Damping)

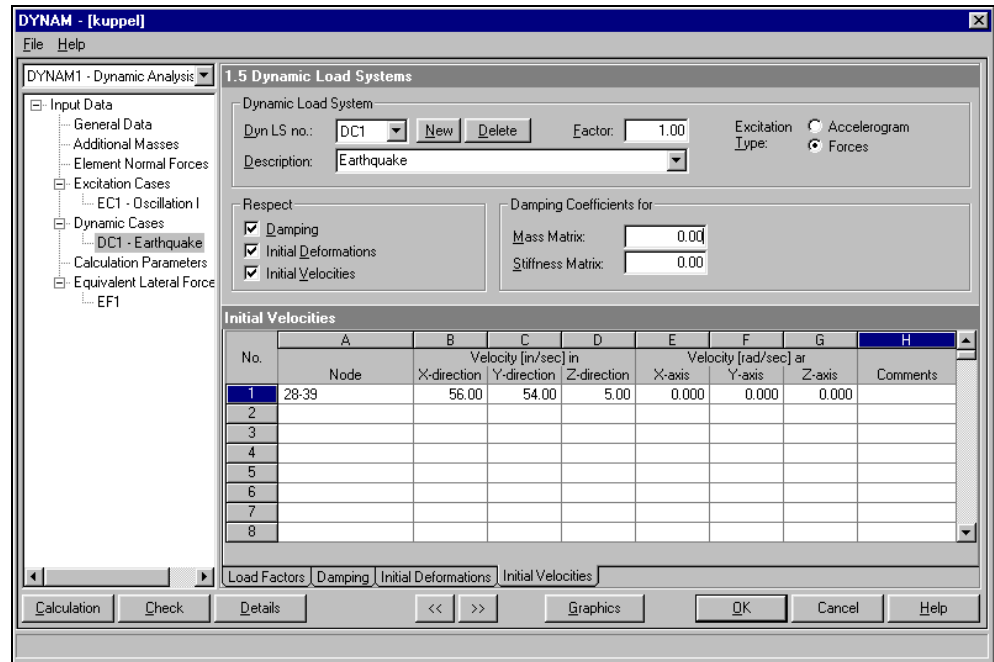
Initial Deformations: Define the initial deformations and/or initial rotations, which decisively influence the initial vibration process. Initial Deformations can only be applied to those nodes which are not supported in the direction of the initial deformation. Any input neglecting this rule will be ignored. Because DYNAM uses the method of Eigenvector subspace projection, the initial conditions cannot be freely selected. The *Initial deformation* vector must be a linear combination of the Eigenvector. (See part 5 of the theory section.)



Mask 1.5 Dynamic Load Systems (Initial Deformations)



Initial Velocities: Enter the initial velocities in and/or about the global axes. As with the initial deformations the nodes must be freely moveable (not supported) in or about the respective axis because the velocity is the first derivative of the deformation.



Mask 1.5 Dynamic Load Systems (Initial Velocities)

Damping Coefficient (α) for Mass Matrix: Coefficient α of the mass proportional damping. The unit for α is [1/s].

Damping Coefficient (β) for Stiffness Matrix : Coefficient β of the stiffness proportional damping. The unit for β is [s].

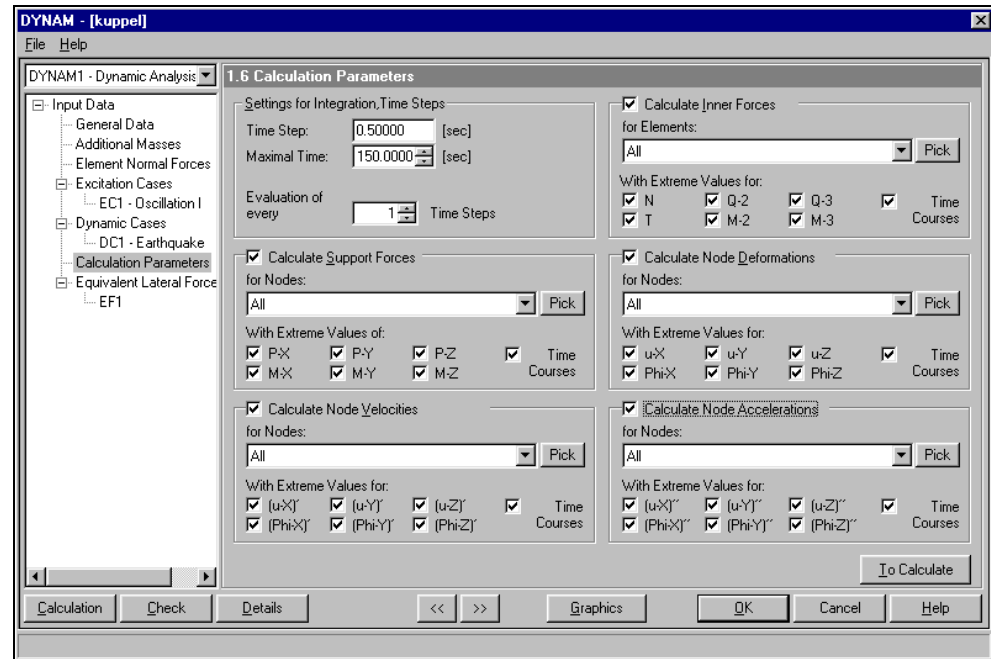
The damping matrix shape is: $\alpha M + \beta K$

The entire damping, including the damping D_i for the Eigenfrequency ω_i is: $d_i = D_i + \frac{1}{2} [\alpha / \omega_i + \beta \omega_i]$



3.3.6 Mask 1.6 Calculation Parameters

Various parameters for the calculation can be selected in mask 1.6.



Mask 1.6 Calculation Parameters

Integration, Time Steps Settings: *Time Step* and *Maximal Time* can influence the exactness and length of the integration. It is important that the maximum time does not exceed what was defined in mask 1.4. Use *Evaluation every ... Time Steps* to define whether results should be provided for each time step or, for only every fifth time step, for example.

Calculate Support Forces, Inner Forces, Node Velocities, Node Deformations, Node Accelerations: Mask 1.6 can also define some output parameters. Checking *Time Courses* lets you define whether only the minimal and maximal values and the corresponding time points will be in the output or only results for each time point. This option can reduce the amount of data to a minimum. Use the [Pick] button to graphically select which nodes and elements should be listed in the results.





3.3.7 Mask 1.7 Equivalent Lateral Forces

Mask 1.7 is only available to DYNAM ADDITION 2 licensees.

A common method in earthquake design is to reduce the dynamic acting earthquake to a static problem by determining equivalent lateral loads. DYNAM ADDITION 2 is able to do this for several international codes.

The screenshot shows the '1.7 Equivalent Lateral Forces' dialog box. The 'Equivalent Lateral Force' section includes:

- EF Number: EF1 (with New and Delete buttons)
- Description: Chile Earthquake 1985
- LS Number: 3
- Action of Earthquake: In Direction of Eigenvibration, User-defined Direction
- Norm: DIN 4149
- Earthq. zone: 4
- Building Class: Other
- Parameter a_0 : 3.54000 [m/s²]
- Reduction Factor Alpha: 0.80000
- Factor for influence of ground Kappa: 1.00000
- Calculation Value a_c : 2.83200 [m/s²]

 The 'Selection of Eigenvibration' table is as follows:

No.	A		B		C	D	E
	Eigenvibration No.	Auto	Coeff. Beta of Stand. Response Spectrum	Direction Beta of Earthquake [°]			
1	1	<input checked="" type="checkbox"/>					
2							
3							
4							

Mask 1.7 Equivalent Lateral Forces

EF Number: Several load systems with sets of equivalent lateral forces can be created in RSTAB, defined with an EF number and given a *Description*.

LS Number defines the load system number to be created in RSTAB.

Action of Earthquake: The *In Direction of Eigenvibration* option automatically sets the direction of the earthquake to the direction of the standardized deformation of the node with the largest standardized Eigenvector. *User-defined Direction* lets you enter any Beta earthquake direction as an angle in reference to the global x-axis.

Norm: Select whether equivalent loads should be determined according to DIN 4149 (or later to EC 8 or IBC 2000). For DIN 4149 the following parameters need to be defined.

Earthquake Zone: The differences in the structure of the continental earthquake shells are described through earthquake zones. The characteristic size for an earthquake zone is the parameter a_0 , which corresponds to an anticipated acceleration. For central Europe, consideration of *Building Class* 1-4 is sufficient. For other regions, select *Other* in the building class field and enter appropriate acceleration values.

Parameter a_0 : The program automatically sets an acceleration value if one of the earthquake zones 1 to 4 is selected. If *Other* earthquake zones are entered the parameter is user-defined.

Factor for influence of ground - κ : The factor is 1.0 for hard rock and 1.4 for loose rock.

Building Class: This addresses the protective worthiness of the building. There are 3 categories, which the norms describe in more detail.

Reduction Factor α : Parameter a_0 can be multiplied by a reduction factor α independent of the building class and earthquake zone. (See more about this subject in Chapter 7.2.3, DIN 4149)



Calculation Value cal a: This value is made up of the parameter a_0 , the reduction factor α and the factor for influence of ground κ . After entering the parameters, *cal a* will be calculated automatically by the program. It can also be edited.

More input selection is needed in the following *Selection of Eigenvibrations* table.

Eigenvibration No: defines which Eigenvibration should be used.

Auto: Coefficient Beta of the Standardized Response Spectrum will be automatically determined according the selected norm (code). If *Auto* is not selected, a value can be entered to enable a calculation beside the limits of the selected code. The *Coefficient Beta of the Standardized Response Spectrum* is usually a function of the Eigenperiod T .

Earthquake Direction Beta: The user defines the beta angle under which the earthquake wave will affect the supports of the structure. 0° corresponds to the positive global x-axis while 90° corresponds to the positive global y-axis.



3.4 Result Masks

3.4.1 Mask 2.1 Eigenvalues and Eigenfrequencies

After the successful calculation, DYNAM shows the first results in the 2.1 *Eigenvalues and Eigenfrequencies* mask.

Eigen No	A Eigenvalue [1/sec ²]	B Angular Frequency [1/sec]	C Frequency [Hz]	D Eigenperiod [sec]	E
1	5.75286	2.39851	0.38173	2.619619	
2	11.30880	3.36296	0.53522	1.868408	
3	21.63798	4.65166	0.74034	1.350739	
4	283.32447	16.83225	2.67893	0.373283	
5	315.55995	17.76401	2.82723	0.353703	
6	381.85642	19.54115	3.11007	0.321536	
7	595.50792	24.40303	3.88386	0.257476	
8	619.15989	24.88292	3.96024	0.25251	
9	800.98166	28.30162	4.50434	0.222008	
10	987.42793	31.42337	5.00118	0.199953	
11	991.46872	31.48760	5.01141	0.199545	
12	1114.21178	33.37981	5.31256	0.188233	
13	1175.58361	34.28678	5.45691	0.183254	
14	1445.85494	38.02440	6.05177	0.1652409	
15	1543.82954	39.29160	6.25345	0.159912	
16	1586.50404	39.83094	6.33929	0.157746	
17	1597.60386	39.97004	6.36143	0.157197	
18	2293.02496	47.88554	7.62122	0.131213	
19	2298.62524	47.94398	7.63052	0.131053	
20	2825.48725	53.15531	8.45993	0.118204	

Mask 2.1 *Eigenvalues and Eigenfrequencies*

The results will be sorted by Eigenfrequency in a spreadsheet.

- *Eigenvalue*
The Eigenvalue λ_i [1/sec²] is calculated from the motion equation without damping. (For the theory behind this, refer to chapter 4.)
- *Angular Velocity*
The correlation between the Eigen angular velocity ω [1/sec] and the Eigenvalue is:
$$\lambda_i = \omega^2$$
- *Eigenfrequency*
The Eigenfrequency f_i [Hertz] is a measure for the incidence of the Eigenvibrations per second. The Eigenfrequency and the Eigenperiod have a direct reciprocal relation to each other: $\omega = 2\pi f_i$.
- *Eigenperiod*
The Eigenperiod T_0 [s] describes the time difference the structure needs to carry out one complete vibration.



3.4.2 Mask 2.2 Eigenvibrations

An Eigenfunction $u(x)$ belongs to each Eigenfrequency. This function describes the Eigenvibration shape of the structure. Structure nodes deformations and rotations will be sorted by element number, node number and Eigenshape number, and displayed by lines. The results are standardized on 1. That means the value of the largest deformation or rotation is 1.

Element No	Node No	Eigen No	Standardized Deformation	Standardized Rotation
			u-X	Phi-X
			u-Y	Phi-Y
			u-Z	Phi-Z
1	4	1	-0.00158	-0.03890
		2	-0.90764	-0.05333
		3	0.09325	0.00198
		4	-0.06759	0.01668
		5	-0.05582	0.02314
		6	0.43614	0.19105
		7	0.12191	0.15413
		8	0.12864	0.25546
		9	-0.44011	-0.16026
		10	0.13860	0.35848
		11	-0.02738	-0.06835
		12	-0.10812	0.00653
		13	0.06205	-0.07633
		14	0.03391	-0.08794
		15	0.01049	-0.10428
		16	0.05208	0.29408
		17	0.07512	0.35060
		18	-0.02323	-0.27337
		19	-0.01563	-0.20682
		20	0.03371	0.01908
	5	1	0.00151	-0.03708
		2	-0.88788	-0.05601

Mask 2.2 Eigenvibrations

The standardized Eigenvibrations can be used in the additional RSIMP module to create a new structure in RSTAB that has the shape of this Eigenvibration. To determine the absolute value of the Eigenvibration the standardized deformation is set to an absolute value in RSIMP. More information on the topic is found in RSIMP



3.4.3 Mask 2.3 Global Node Deformations

This result mask appears only when the *Calculate Additionally Node Deformations* field in the *1.1 General Data* mask is checked. The global node deformations will be sorted and listed by node number and Eigenfrequency. At the end of the list are the extreme deformations relating to each Eigenfrequency.

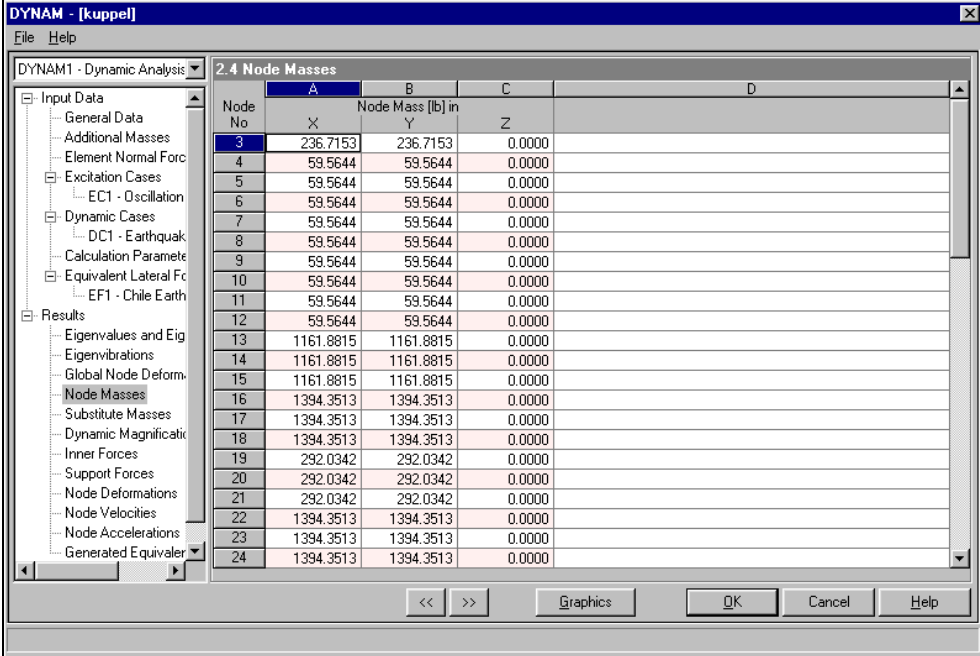
Node No	Eigen No	u-X	u-Y	u-Z
3	1	-0.00127	0.95959	0.00003
	2	-0.88412	-0.00442	-0.00004
	3	0.09305	-0.01270	0.00001
	4	-0.08346	0.13428	0.00050
	5	-0.04721	0.26031	0.00147
	6	0.32243	0.09744	0.00193
	7	0.06571	0.04068	0.00050
	8	0.04811	-0.13472	-0.00052
	9	-0.33354	0.20392	0.00005
	10	0.05130	0.02096	-0.00001
	11	0.00026	-0.09736	-0.00019
	12	-0.08495	-0.17566	-0.00036
	13	0.06725	0.01529	0.00000
	14	0.03920	0.06417	0.00053
	15	-0.02050	0.01018	-0.00020
	16	0.02016	0.00723	-0.00029
	17	0.01790	0.03317	-0.00016
	18	-0.00154	-0.01422	-0.00034
	19	-0.00485	0.00648	-0.00005
	20	0.03077	0.08965	0.00375
4	1	-0.00158	0.97976	0.00174
	2	-0.90764	0.03456	0.13330

Mask 2.3 Global Node Deformations



3.4.4 Mask 2.4 Node Masses

This result mask appears only when the *Calculate Additionally Node Masses* field in the *1.1 General Data* mask is checked. The masses will be sorted by node number and displayed relating to the global coordinate system. The node masses are those relevant for dynamic calculation. Note that a node supported in the Y- and Z-directions, for example, will only be respected with its mass dynamically in the X-direction.



Node No	Node Mass [lb] in			D
	X	Y	Z	
3	236.7153	236.7153	0.0000	
4	59.5644	59.5644	0.0000	
5	59.5644	59.5644	0.0000	
6	59.5644	59.5644	0.0000	
7	59.5644	59.5644	0.0000	
8	59.5644	59.5644	0.0000	
9	59.5644	59.5644	0.0000	
10	59.5644	59.5644	0.0000	
11	59.5644	59.5644	0.0000	
12	59.5644	59.5644	0.0000	
13	1161.8815	1161.8815	0.0000	
14	1161.8815	1161.8815	0.0000	
15	1161.8815	1161.8815	0.0000	
16	1394.3513	1394.3513	0.0000	
17	1394.3513	1394.3513	0.0000	
18	1394.3513	1394.3513	0.0000	
19	292.0342	292.0342	0.0000	
20	292.0342	292.0342	0.0000	
21	292.0342	292.0342	0.0000	
22	1394.3513	1394.3513	0.0000	
23	1394.3513	1394.3513	0.0000	
24	1394.3513	1394.3513	0.0000	

Mask 2.4 Node Masses



3.4.5 Mask 2.5 Substitute Masses

This result mask only appears when the *Calculate Additionally Substitute Masses* field in the *1.1 General Data* mask is checked. The size of the kinetic equivalent mass, modal mass, participation factors and substitute masses will be sorted and listed by Eigenfrequency.

DYNAM - [kuppel]					
File Help					
DYNAM1 - Dynamic Analysis					
2.5 Substitute Masses					
Eigen No	A Kinetic equiv. Mass [lb]	B Modal Mass Matrix [lb]	C Participation Factor	D Substitute Mass [lb]	E
1	37725.6199	907.2178	6211.9660	42535.0141	
2	31382.2300	924.9896	6229.4959	41953.5720	
3	27142.2421	1071.2220	530.7603	262.9768	
4	15375.9677	719.0765	66.2310	6.1002	
5	9362.6726	553.1741	222.9534	89.3770	
6	11084.7741	536.4460	701.7319	917.9444	
7	5659.6680	623.8760	88.0395	12.4239	
8	8136.0425	610.9746	52.0157	4.4284	
9	18102.0850	587.0945	76.3650	9.9330	
10	17833.3408	878.6265	88.2086	8.8556	
11	7396.0813	835.1119	51.7302	3.2044	
12	5024.1614	651.4295	329.2006	166.3618	
13	4032.5453	746.4676	206.4178	57.0799	
14	6608.4079	834.7145	118.1281	16.7174	
15	6357.5049	418.3179	17.8827	0.7645	
16	14324.6334	891.5675	8.3151	0.0775	
17	11643.0362	964.0866	46.9988	2.2912	
18	8039.9256	945.6497	1.3028	0.0018	
19	11090.3595	946.9760	4.7768	0.0241	
20	12188.2027	660.8366	31.2192	1.4749	

Mask 2.5 Substitute Masses



3.4.6 Mask 2.6 Dynamic Magnification Factors

The result mask appears only when the *Calculate Additionally Dynamic Magnification Factors* field in the *1.1 General Data* mask is checked. Dynamic magnification factor and the phase angle are given in the results. The dynamic magnification factor describes the dynamic load increase in comparison with the static load. Because of mass inertia, the vibration of the structure generally has a certain delay to the Eigen angular velocity of the excitation. This is described as the delay angle or *phase angle*.

Eigen No	A Angular Frequency [1/sec]	B Dynamic Magnification Factors	C Phase Angle [rad]	D Excitation Frequency for maximal Dynamic Magnification [1/sec]
1	2.39851	1.20428	0.10059	2.374405
2	3.36296	1.09468	0.06515	3.329057
3	4.65166	1.04739	0.04505	4.604913
4	16.83225	1.00347	0.01192	16.663072
5	17.76401	1.00312	0.01129	17.585470
6	19.54115	1.00257	0.01026	19.344748
7	24.40303	1.00165	0.00821	24.157768
8	24.88292	1.00159	0.00805	24.632838
9	28.30162	1.00122	0.00708	28.017174
10	31.42337	1.00099	0.00637	31.107545
11	31.48760	1.00099	0.00636	31.17113
12	33.37981	1.00088	0.00600	33.044327
13	34.28678	1.00083	0.00584	33.942185
14	38.02440	1.00068	0.00526	37.642235
15	39.29160	1.00064	0.00509	38.896696
16	39.83094	1.00062	0.00502	39.430622
17	39.97004	1.00061	0.00501	39.568318
18	47.88554	1.00043	0.00418	47.404266

Mask 2.6 Dynamic Magnification Factors



3.4.7 Mask 2.7 Inner Forces

According to the mask 1.6 definitions, the selected inner forces, with or without their time course, will be displayed. If *Time Courses* was not checked in mask 1.6, only the maximum and minimum inner forces and their time points will be displayed.

DYNAM - [kuppel]										
2.7 Inner Forces										
Elem No.	A	B	C	D	E	F	G	H	I	
DC	Time [sec]	Node	N	Forces [kip]			Moments [kipin]			
				V-2	V-3	T	M-2	M-3		
4	Min-N	1.00000	7	-0.445	-0.568	-2.449	-9.3756	-2.0105	-16.5417	
	Max-V-2	0.00000	7	0.321	0.485	0.409	-0.5192	-7.1810	10.3743	
	Min-V-2	1.30000	7	-0.393	-0.595	-2.256	-6.6750	-9.4719	-17.3437	
	Max-V-3	0.50000	7	0.212	0.111	0.986	5.1724	1.4655	4.2682	
	Min-V-3	1.00000	7	-0.445	-0.568	-2.449	-9.3756	-2.0105	-16.5417	
	Max-T	0.50000	7	0.212	0.111	0.986	5.1724	1.4655	4.2682	
	Min-T	1.00000	7	-0.445	-0.568	-2.449	-9.3756	-2.0105	-16.5417	
	Max-M-2	0.50000	8	0.212	0.111	0.986	5.1724	43.2187	-0.4054	
	Min-M-2	1.00000	8	-0.445	-0.568	-2.449	-9.3756	-106.0211	7.4872	
	Max-M-3	0.00000	7	0.321	0.485	0.409	-0.5192	-7.1810	10.3743	
	Min-M-3	1.30000	7	-0.393	-0.595	-2.256	-6.6750	-9.4719	-17.3437	
5	1	0.00000	8	-0.302	0.443	0.309	0.0130	-2.7369	9.6506	
		0.00000	9	-0.302	0.443	0.309	0.0130	10.4354	-9.2126	
		0.50000	8	0.033	0.075	-0.733	-3.6319	40.4307	3.8466	
		0.50000	9	0.033	0.075	-0.733	-3.6319	9.3367	0.5551	
		1.00000	8	0.280	-0.399	1.427	7.0534	-90.9215	-13.7486	
		1.00000	9	0.280	-0.399	1.427	7.0534	-30.7017	3.4596	
		1.30000	8	0.305	-0.400	1.573	8.7449	-89.2519	-13.2106	
		1.30000	9	0.305	-0.400	1.573	8.7449	-23.1676	3.9655	
	Max-N	1.30000	8	0.305	-0.400	1.573	8.7449	-89.2519	-13.2106	

Mask 2.7 Inner Forces



3.4.8 Mask 2.8 Support Forces

According to the mask 1.6 definitions, the selected support forces, with or without their time courses will be displayed. If *Time Courses* was not checked in mask 1.6, only the maximum and minimum support forces and their time points will be displayed.

2.8 Support Forces									
Node No.	A	B	C	D	E	F	G	H	
	DC	Time [sec]	P-X	Forces [kip] P-Y	P-Z	M-X	Moments [kipin] M-Y	M-Z	
52	1	0.00000	0.126	0.250	0.502	0.0000	0.0000	0.3317	
		0.50000	1.738	1.651	1.530	0.0000	0.0000	1.2480	
		1.00000	0.220	0.912	0.409	0.0000	0.0000	-2.9604	
		1.30000	-0.212	0.210	-0.699	0.0000	0.0000	0.2178	
	Max-P-X	0.50000	1.738	1.651	1.530	0.0000	0.0000	1.2480	
	Min-P-X	1.30000	-0.212	0.210	-0.699	0.0000	0.0000	0.2178	
	Max-P-Y	0.50000	1.738	1.651	1.530	0.0000	0.0000	1.2480	
	Min-P-Y	1.30000	-0.212	0.210	-0.699	0.0000	0.0000	0.2178	
	Max-P-Z	0.50000	1.738	1.651	1.530	0.0000	0.0000	1.2480	
	Min-P-Z	1.30000	-0.212	0.210	-0.699	0.0000	0.0000	0.2178	
	Max-M-X	0.00000	0.126	0.250	0.502	0.0000	0.0000	0.3317	
	Min-M-X	1.30000	-0.212	0.210	-0.699	0.0000	0.0000	0.2178	
	Max-M-Y	1.00000	0.220	0.912	0.409	0.0000	0.0000	-2.9604	
	Min-M-Y	0.00000	0.126	0.250	0.502	0.0000	0.0000	0.3317	
	Max-M-Z	0.50000	1.738	1.651	1.530	0.0000	0.0000	1.2480	
	Min-M-Z	1.00000	0.220	0.912	0.409	0.0000	0.0000	-2.9604	
53	1	0.00000	0.200	0.232	0.820	0.0000	0.0000	0.4602	
		0.50000	2.323	1.761	0.326	0.0000	0.0000	-1.9216	
		1.00000	0.401	0.892	-0.294	0.0000	0.0000	0.7526	
		1.30000	-0.209	0.062	-1.397	0.0000	0.0000	4.7765	

Mask 2.8 Support Forces



3.4.9 Mask 2.9 Node Deformations

According to the mask 1.6 definitions, the selected node deformations, with or without their time courses will be displayed. If *Time Courses* was not checked in mask 1.6, only the maximum and minimum node deformations and their time points will be displayed.

Node		A	B	C	D	E	F	G	H
Node No.	DC	Time [sec]	u _X	Deformations [in]	u _Y	u _Z	Phi _X	Rotations [mrad]	Phi _Z
3	1	0.00000	0.76	0.07	0.00	-2.59	9.00	8.32	
		0.50000	7.12	8.85	0.00	-4.32	0.68	2.29	
		1.00000	-2.29	5.56	0.00	8.33	-11.78	-10.27	
		1.30000	-7.72	-0.14	0.00	11.47	-26.11	-8.31	
	Max u _X	0.50000	7.12	8.85	0.00	-4.32	0.68	2.29	
	Min u _X	1.30000	-7.72	-0.14	0.00	11.47	-26.11	-8.31	
	Max u _Y	0.50000	7.12	8.85	0.00	-4.32	0.68	2.29	
	Min u _Y	1.30000	-7.72	-0.14	0.00	11.47	-26.11	-8.31	
	Max u _Z	0.00000	0.76	0.07	0.00	-2.59	9.00	8.32	
	Min u _Z	0.50000	7.12	8.85	0.00	-4.32	0.68	2.29	
	Max Phi _X	1.30000	-7.72	-0.14	0.00	11.47	-26.11	-8.31	
	Min Phi _X	0.50000	7.12	8.85	0.00	-4.32	0.68	2.29	
	Max Phi _Y	0.00000	0.76	0.07	0.00	-2.59	9.00	8.32	
	Min Phi _Y	1.30000	-7.72	-0.14	0.00	11.47	-26.11	-8.31	
	Max Phi _Z	0.00000	0.76	0.07	0.00	-2.59	9.00	8.32	
	Min Phi _Z	1.00000	-2.29	5.56	0.00	8.33	-11.78	-10.27	
4	1	0.00000	0.88	0.68	-0.70	-0.60	8.96	5.20	
		0.50000	7.13	9.02	-0.11	4.75	0.98	2.24	
		1.00000	-2.45	4.82	0.95	-16.93	-8.13	-9.48	
		1.30000	-8.07	-0.78	1.99	-11.87	-18.19	-7.63	

Mask 2.9 Node Deformations



3.4.10 Mask 2.10 Node Velocities

According to the mask 1.6 definitions, the selected node velocities, with or without their time courses will be displayed. If *Time Courses* was not checked in mask 1.6, only the maximum and minimum node velocities and their time points will be displayed.

DYNAM - [kuppel]									
2.10 Node Velocities									
Node No.	A	B	C	D	E	F	G	H	
	DC	Time [sec]	Velocities [in/sec]			Velocities [mm/sec]			
			(u-X)	(u-Y)	(u-Z)	(Phi-X)	(Phi-Y)	(Phi-Z)	
3	1	0.00000	2.58	-0.86	-0.15	680.95	-666.02	6.39	
		0.50000	2.50	15.34	0.00	-274.47	70.13	399.09	
		1.00000	-17.76	-11.02	0.05	-143.46	128.94	45.69	
		1.30000	-13.10	-23.40	-0.05	73.62	-212.62	129.41	
	Max (u-X)	0.00000	2.58	-0.86	-0.15	680.95	-666.02	6.39	
	Min (u-X)	1.00000	-17.76	-11.02	0.05	-143.46	128.94	45.69	
	Max (u-Y)	0.50000	2.50	15.34	0.00	-274.47	70.13	399.09	
	Min (u-Y)	1.30000	-13.10	-23.40	-0.05	73.62	-212.62	129.41	
	Max (u-Z)	1.00000	-17.76	-11.02	0.05	-143.46	128.94	45.69	
	Min (u-Z)	0.00000	2.58	-0.86	-0.15	680.95	-666.02	6.39	
	Max (Phi-X)	0.00000	2.58	-0.86	-0.15	680.95	-666.02	6.39	
	Min (Phi-X)	0.50000	2.50	15.34	0.00	-274.47	70.13	399.09	
	Max (Phi-Y)	1.00000	-17.76	-11.02	0.05	-143.46	128.94	45.69	
	Min (Phi-Y)	0.00000	2.58	-0.86	-0.15	680.95	-666.02	6.39	
	Max (Phi-Z)	0.50000	2.50	15.34	0.00	-274.47	70.13	399.09	
	Min (Phi-Z)	0.00000	2.58	-0.86	-0.15	680.95	-666.02	6.39	
4	1	0.00000	-4.96	-8.39	43.18	628.59	-270.92	66.50	
		0.50000	3.37	47.03	-5.27	-303.19	89.36	213.52	
		1.00000	-16.25	-6.72	-8.61	100.53	83.50	60.92	
		1.30000	-16.01	-14.79	16.63	-114.12	-78.62	43.94	

Mask 2.10 Node Velocities



3.4.11 Mask 2.11 Node Accelerations

According to the mask 1.6 definitions, the selected node accelerations, with or without their time courses will be displayed. If *Time Courses* was not checked in mask 1.6, only the maximum and minimum node accelerations and their time points will be displayed.

DYNAM - [kuppel]									
2.11 Node Accelerations									
Node No.	DC	Time [sec]	Accelerations [in/sec ²]			Accelerations [mrad]			
			(u-X)''	(u-Y)''	(u-Z)''	(Phi-X)''	(Phi-Y)''	(Phi-Z)''	
3	1	0.0000	-199.80	-17.89	-0.40	2516.76	-2103.20	-1.422E4	
		0.5000	-54.19	-284.09	1.03	3677.10	3088.81	-2531.80	
		1.0000	331.74	463.24	1.24	-1.301E4	4078.46	14290.57	
		1.3000	426.96	471.83	1.73	-1.246E4	5473.31	13308.13	
	Max (u-X)''	1.3000	426.96	471.83	1.73	-1.246E4	5473.31	13308.13	
	Min (u-X)''	0.0000	-199.80	-17.89	-0.40	2516.76	-2103.20	-1.422E4	
	Max (u-Y)''	1.3000	426.96	471.83	1.73	-1.246E4	5473.31	13308.13	
	Min (u-Y)''	0.5000	-54.19	-284.09	1.03	3677.10	3088.81	-2531.80	
	Max (u-Z)''	1.3000	426.96	471.83	1.73	-1.246E4	5473.31	13308.13	
	Min (u-Z)''	0.0000	-199.80	-17.89	-0.40	2516.76	-2103.20	-1.422E4	
	Max (Phi-X)''	0.5000	-54.19	-284.09	1.03	3677.10	3088.81	-2531.80	
	Min (Phi-X)''	1.0000	331.74	463.24	1.24	-1.301E4	4078.46	14290.57	
	Max (Phi-Y)''	1.3000	426.96	471.83	1.73	-1.246E4	5473.31	13308.13	
	Min (Phi-Y)''	0.0000	-199.80	-17.89	-0.40	2516.76	-2103.20	-1.422E4	
	Max (Phi-Z)''	1.0000	331.74	463.24	1.24	-1.301E4	4078.46	14290.57	
	Min (Phi-Z)''	0.0000	-199.80	-17.89	-0.40	2516.76	-2103.20	-1.422E4	
4	1	0.0000	-245.81	-1042.26	261.57	-630.45	-7037.26	-9012.09	
		0.5000	-11.79	-461.33	-226.90	-5737.45	3384.17	-2193.76	
		1.0000	394.76	1547.87	-367.54	7819.52	3925.94	10464.40	
		1.3000	506.42	1489.33	-455.37	7274.94	4247.15	9943.11	

Mask 2.11 Node Accelerations

3.4.12 Mask 2.12 Generated Equivalent Lateral Forces

The results of the equivalent lateral force input data in mask 1.7 can be viewed in this result mask. The list contains the *Nodal Forces in X-, Y- and Z-direction* sorted by the *EF* numbers.

EF	2.12 Generated Equivalent Lateral Forces			Nodal Forces [kip]		
	A LS- No.	B Node Number	C in X	D in Y	E in Z	F
1	3	25	0.000	0.040	0.000	
		26	0.000	0.040	0.000	
		27	0.000	0.040	0.000	
		28	0.000	0.943	0.000	
		29	0.001	0.943	0.000	
		30	-0.001	0.945	0.000	
		31	-0.002	0.949	0.000	
		32	-0.003	0.947	0.000	
		33	-0.003	0.946	0.000	
		34	0.000	0.947	0.000	
		35	0.003	0.946	0.000	
		36	0.003	0.947	0.000	
		37	0.002	0.949	0.000	
		38	0.001	0.945	0.000	
		39	-0.001	0.942	0.000	
		40	0.000	0.002	0.000	
		41	0.000	0.002	0.000	
		42	0.000	0.026	0.000	
		43	0.000	0.026	0.000	
		44	0.000	0.026	0.000	

Mask 2.12 Generated Equivalent Lateral Forces

[Generate RSTAB Load System...]

This button opens the following dialogue to *Generate* a new RSTAB Load System with equivalent lateral forces.

Not Calculated Equivalent Lateral Forces:		Selected to Calculate:	
No	Description	No	Description
		LS3	Chile Earthquake 1985

To generate

Select the equivalent lateral forces on the left to import to RSTAB with the [Add] or [Add All] buttons. On the right, any forces *Selected to Generate* can be removed with the [←Remove] or [Remove All] buttons. The [Generate] button finishes the process and actually creates the RSTAB load system.

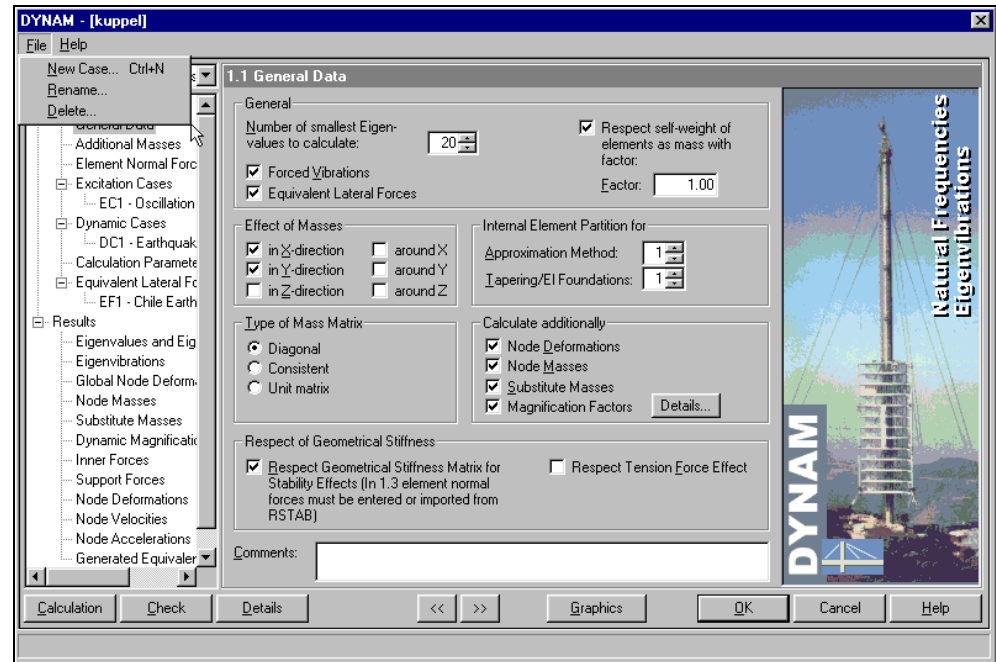


3.5 Menus

The menus contain the necessary functions to work with DYNAM Cases and results. Activate a menu by clicking on a menu title or simultaneously pressing the [Alt] key and the underlined letter in the menu title. Activate functions within the menus the same way.

3.5.1 File

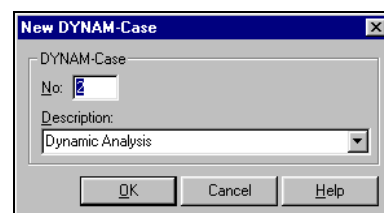
...lets you work with DYNAM Cases.



Menu - File

New [Ctrl+N]

...lets you create a new DYNAM case.

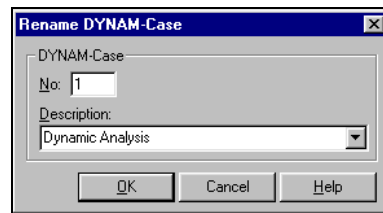


New DYNAM Case

Give each *New DYNAM Case* a *No.* and *Description*. Click on the [Downward Arrow] for a list of all existing descriptions. You may use one of these descriptions. [OK] creates the new case.

Rename

...lets you rename the *Description* and select a different *No.* for an existing DYNAM case.

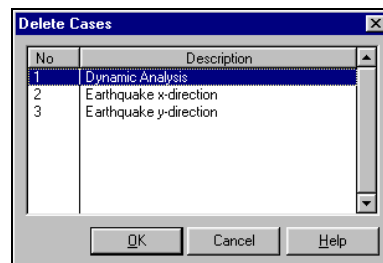


Rename DYNAM Case

It is important to assign a number not already in use.

Delete

...shows all existing DYNAM cases in a list.

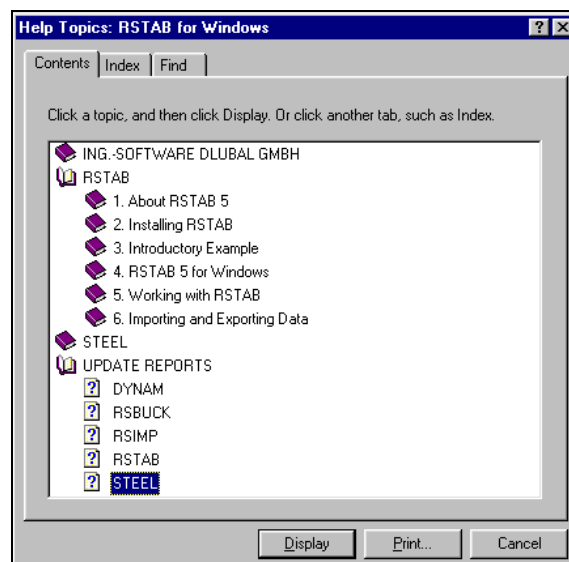


Delete Cases

Delete a case(s) by clicking on the description and then on [OK].

3.5.2 Help

...opens the online help system.



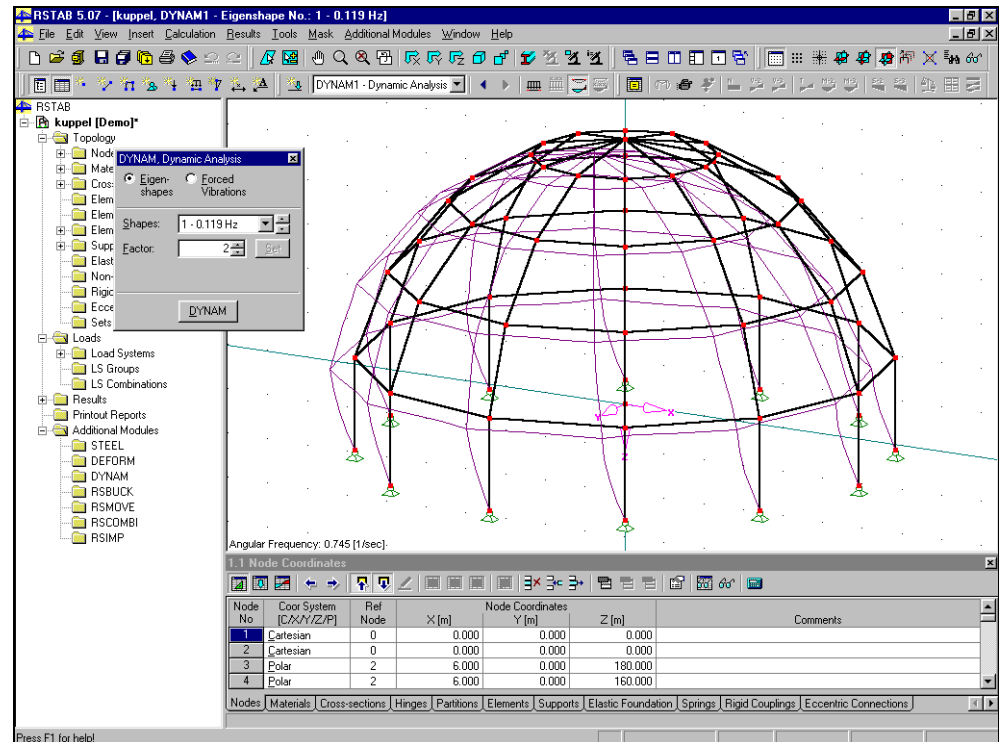
RSTAB Help System



4. Results

4.1 Screen Views

Following a successful calculation, you can graphically view the results with the [Graphic] button. The current DYNAM case is automatically put in graphic form.

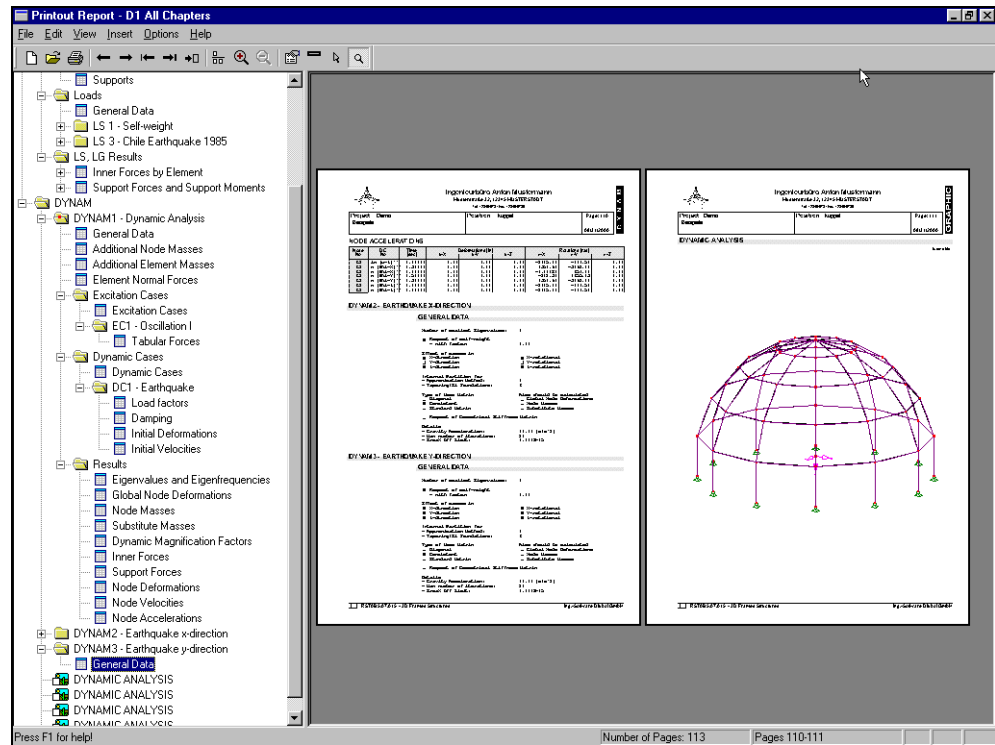


Viewing Results Graphically

Activate the DYNAM case in the *View Results* drop down list box in RSTAB for the option of viewing DYNAM results in the RSTAB working window. The DYNAM results are viewed just like any other RSTAB load system results. A smaller floating window will open to select which *Eigenshape* should be displayed. The distance of the Eigen shape lines from the elements can be set with the *Factor* option. Use the [Set] button to apply the altered factors for the line distance in the larger window. [DYNAM] takes you back to the DYNAM module. Like all other graphics of RSTAB, the [Print] button in the RSTAB main working window prints graphic results immediately or integrates the results in the printout report.

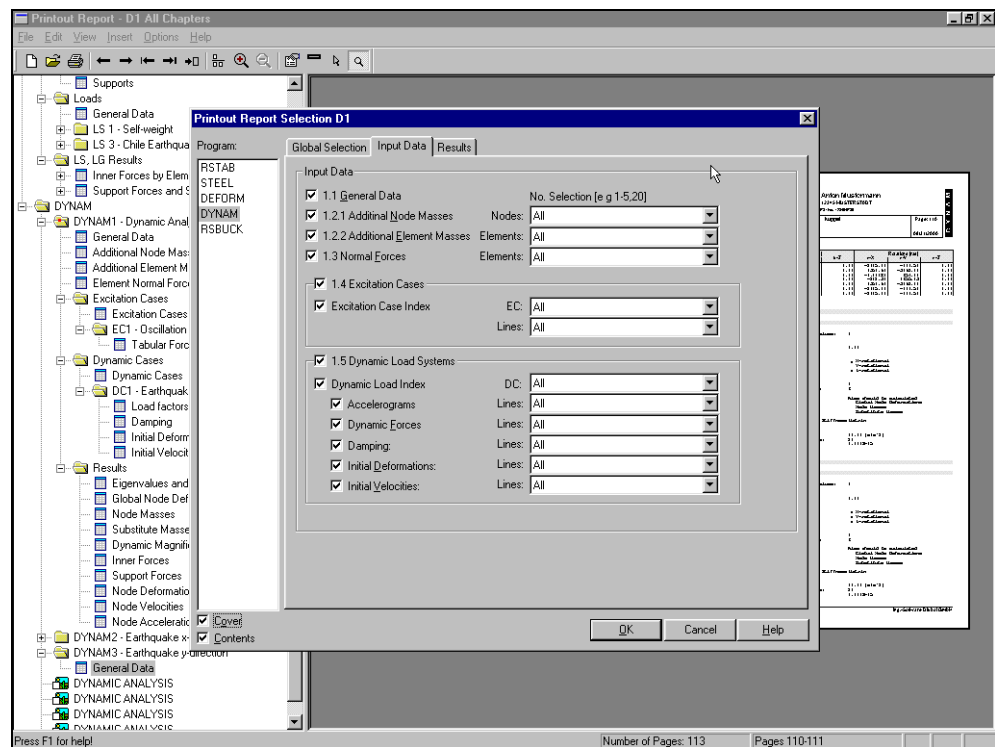
4.2 Printing

To print the numerical results, return to RSTAB and open an existing [Printout Report] or create a new one as described in the RSTAB manual. The DYNAM data follows the RSTAB data in the printout report. Note that the printout report is an entire unit of all data from RSTAB, DYNAM and other modules.



DYNAM Data and Results in the Printout Report

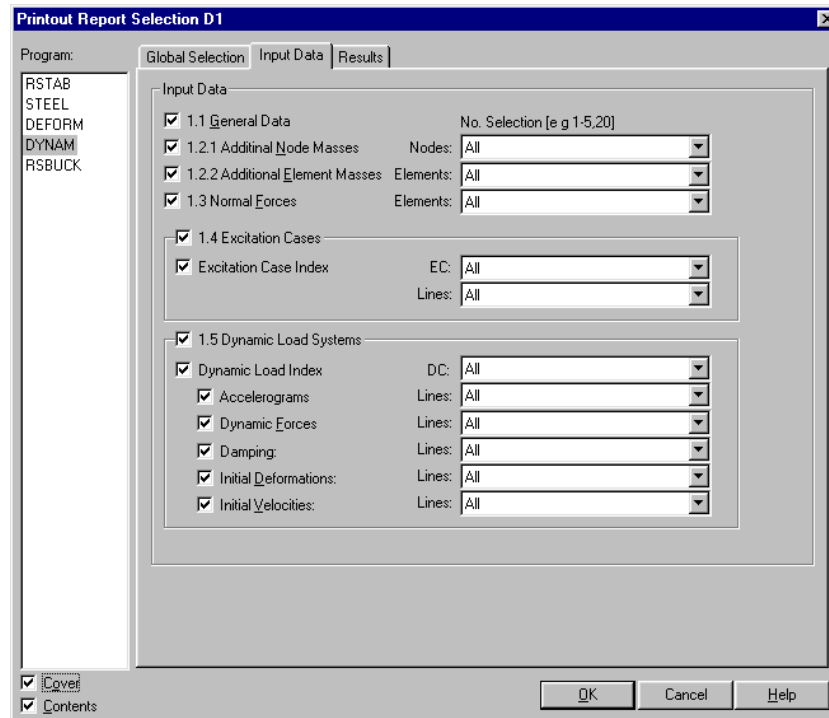
The printout report has all editing and organization possibilities described in the RSTAB User Manual. Note that the data can increase drastically with increasing number of nodes, elements and load systems. We recommend making selections before opening the *New Printout Report* dialogue as described in the RSTAB manual. In the global selection dialogue are additional options for the DYNAM data.



Printout Report Global Selection Dialogue with DYNAM Global Selection Data

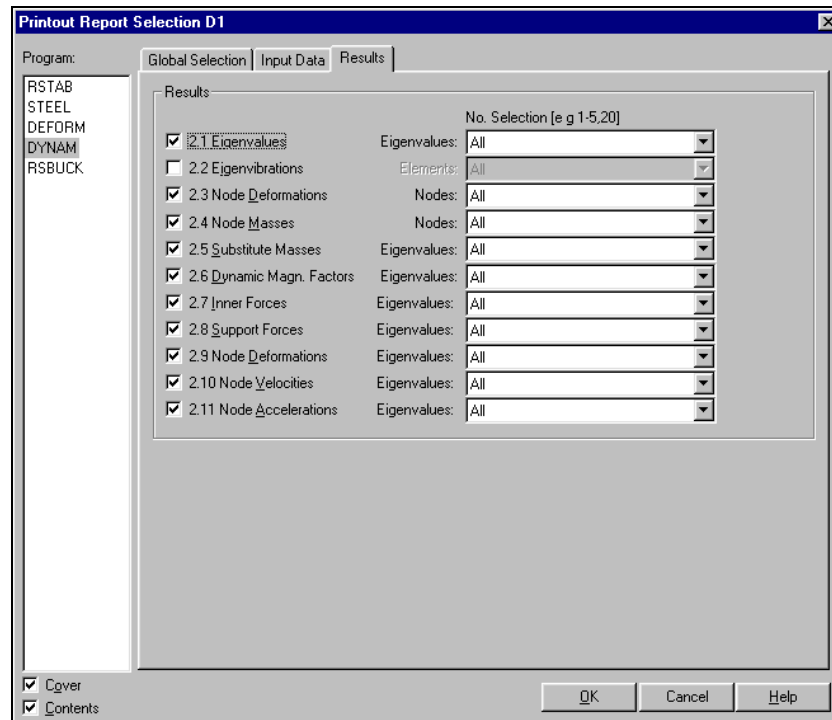


In the **Main Selection** folder, check whether you want a *Display of Input Data* and/or *Results*. Under *DYNAM Cases to Display*, you can check the box to *Display All DYNAM Cases*, or make specific selections by moving *Existing DYNAM Cases* on the left to *DYNAM Cases to display* on the right. To move cases from one list to the other, highlight a case by clicking on it. Then click on the [Add >], [Add All], [Remove] or [Remove All] buttons. Checking the *Show Contents* box in the lower left mask corner will display the entire table of contents in the printout report.



DYNAM Selection – Input Data

In the **Input Data** folder, you can select whether information from the *General Data*, *Additional Node Masses*, *Additional Element Masses* and/or the *Element Normal Forces* masks should be in the printout report. For each topic you can also specify single lines from mask tables. Just enter the line numbers under *No.-Selection* or use the [Downward Arrow] beside the input fields. The same principle is used to define the data of the *Excitation Cases* and *Dynamic Load Systems*. The dialogue may look different depending what DYNAM modules are activated.



DYNAM Global Selection – Results

In the *Results* folder you can select data from masks 2.1-2.11 for inclusion in the printout report. Use the same procedure as in the input data folder.



5. Theory

To better understand DYNAM, some theory is presented in this chapter. It is meant as a refresher, not as a substitute for a textbook. The information is limited to the framework of this program. First we will briefly look at the Eigenvalue analysis. Then the calculation of the kinetic equivalent masses, participation factors and substitute masses will be reviewed in separate paragraphs. An example is at the end of this chapter.

Equilibrium Equation for Static Systems

A structure reacts to static acting forces with deformations. It is generally assumed that the system is still before and after the loading application.

In general, you need to consider a proportional correlation between the load and the deformation of the system. This correlation is generally non-linear, but it can be assumed as linear in most user cases. The proportional factor between the load and the deformation is the stiffness K of the system so that the equation for static cases is:

$$K_{ij} x_i = f_j$$

with

K_{ij} Stiffness matrix

x_i = Deformation

f_i = Load

$i = j = 1$ in systems with one degree of freedom.

Calculating the Eigenfrequency

If a structure is stimulated for free vibration, you can see that the system always oscillates between 2 energy conditions. So, $E_{\text{kinetic}} = E_{\text{potential}}$ resulting in the following:

Equation 4.1:

$$M_{ij} \ddot{x}_i + K_{ij} \cdot x_i = \underline{0}$$

In this equation the damping is not considered. This dissipation effect is not relevant to determine the Eigenfrequency and Eigenshape.

Equation 4.1 will be solved when the following assumption is made for x_i :

Equation 4.2:

$$x_i = C_i e^{\lambda t} = u_i(x) c \cos(\omega t - \alpha)$$

When Equation 4.2 is merged within Equation 4.1, and assuming that the $c \cos(\omega t - \alpha)$ expression is generally unequal to zero the result is:

Equation 4.3:

$$\left[M_{ij}(-\omega^2) + K_{ij} \right] u_i(x) = \underline{0}$$

When the equation of the $u_i(x)$ Eigenshape is unequal to zero, the Eigenfrequencies are determined from the equation:

Equation 4.4:

$$\det \left(K_{ij} - \omega^2 M_{ij} \right) = \underline{0}$$

The Eigenfrequency ω was already pointed out to us in equation 4.3. It is connected with the Eigenfrequency of the structure through the relationship:

$$f = 2\pi\omega.$$



After inserting the Eigenfrequency in equation 4.3, it results in the corresponding $u_i(x)$ Eigenshape.

Kinetic Equivalent Masses

Structures with more degrees of freedom that have either concentrated or continuous mass distributions can be reduced to a one mass oscillator with an equivalent kinetic mass by energetic deliberations. Typical examples are structures with vibration dampers or narrow, tower-type structures. DYNAM calculates the kinetic equivalent mass for each single Eigenfrequency.

An example of a pipe mast will illustrate the theory more closely.

The movement of a pipe mast will be described through the following relationship:

$$y(x,t) = y(x) \cdot \sin(\omega t) = Y \cdot \eta(x) \cdot \sin(\omega t)$$

with

$y(x,t)$: Displacement at x location in the mast in dependence of time

ω : Angular frequency of the structure

$\eta(x)$: Eigenshape, standardized to one in the location of the largest deformation

Y : Displacement in the location of the wanted kinetic equivalent mass.

DYNAM always takes for that the location of the largest deformation which is always standardized to 1 in the graphic display of the of the Eigenshapes. From this, the kinetic energy of the structure results.

Equation 4.5:

$$E_{\text{kin}} = \frac{\omega^2 Y^2}{2} \left[\int_0^L \mu(x) \eta^2(x) dx \right] \cos^2 \omega t$$

with

$\mu(x)$: Continuous mass distribution.

Equation 4.5 shows the kinetic energy of the self-weight of the structure and the additional element masses. The energy of the additional node masses still has to be added on so that:

Equation 4.6:

$$E_{\text{kin}} = \frac{1}{2} \sum_{i=1}^n m_i \omega^2 Y^2 \eta^2(x_i) \cos^2 \omega t$$

All n additional masses must be summarized.

Then the entire kinetic energy of the structure will be:

Equation 4.7:

$$E_{\text{kin}} = \omega^2 Y^2 \cdot \frac{1}{2} \left[\int_0^L \mu(x) \eta^2(x) dx \right] \cos^2 \omega t + \frac{1}{2} \sum_{i=1}^N m_i \cdot \omega^2 \eta^2(x) \cos^2 \omega t$$

The kinetic energy of an equivalent one mass oscillator structure will be:

Equation 4.8:

$$E_{\text{kin}} = \frac{1}{2} M \omega^2 Y^2 \cos^2 \omega t$$



After setting equations 4.7 und 4.8 equal the kinetic equivalent mass results in:

Equation 4.9:

$$M = \int_0^l \mu(x) \eta^2(x) dx + \sum_{i=1}^n m_i \eta^2(x_i)$$

To calculate the kinetic equivalent masses in a different location, equation 4.9 is multiplied with $Y^2/\eta^2(x)$.

Example:

The kinetic equivalent mass will be calculated for a fixed pipe mast. We will assume that in examples KINEQ1 to KINEQ3 undivided elements are used. A division will be done in KINEQ4.

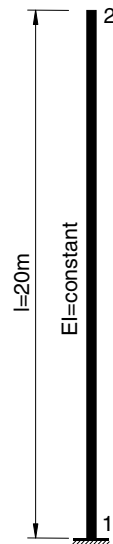
Data of the pipe:

Cross-section: Pipe 508x11 [mm] with a cross-section area of $A=0.0172 \text{ m}^2$

Height: $l = 20 \text{ m}$

Specific Weight: DYNAM $\gamma = 7.85 \cdot 10^4 \text{ N/m}^3$

Mass distribution: $\mu = \gamma / g \cdot A = 135 \text{ kg/m}$



Fixed Pipe Mast

KINEQ1:

The self-weight, $M = l \mu = 20 \text{ m } 135 \text{ kg/m} = 2700 \text{ kg}$, is distributed evenly over the mast.

KINEQ2:

The entire mass, $M = l \mu = 20 \text{ m } 135 \text{ kg/m} = 2700 \text{ kg}$, is distributed equally on the end nodes 1 and 2.

KINEQ3:

The self-weight is applied evenly as an external load on the mast.

Because in all cases we assume diagonal mass matrixes, the sum of the kinetic equivalent mass in each case is the same as the effective mass. (Therefore: 1350 kg on Node 2)

KINEQ4:

The mast will be subjected to a partition (division) of 5. What occurs is a more exact calculation of the kinetic equivalent mass. For the calculation of the kinetic equivalent mass according to equation 4.7, the Eigenshape is:

$$\eta(\xi) = \frac{1}{2,72423} \left[\sin \lambda \xi - \sinh \lambda \xi + (\cos \lambda \xi - \cosh \lambda \xi) \frac{\sinh \lambda - \sin \lambda}{\cosh \lambda - \cos \lambda} \right]$$

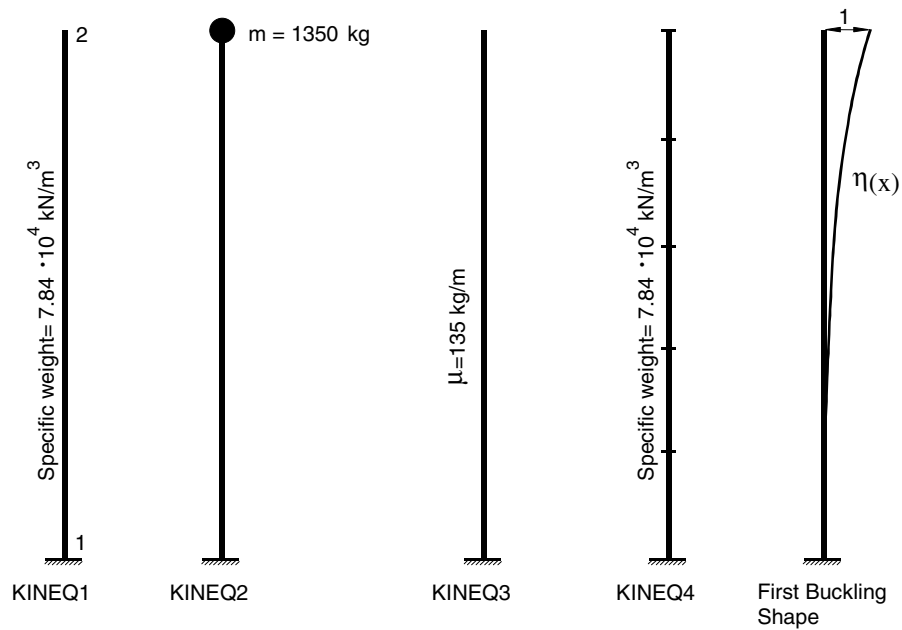
with $\lambda = 1.875$ from which the integral

$$\int_0^L \mu(x) \eta^2(x) dx = 0,25$$

and so the size of the kinetic equivalent mass results as

$$M = \mu \cdot L \int_0^L \eta^2(x) dx = 135 \frac{\text{kg}}{\text{m}} \cdot 20\text{m} \cdot 0,25 = 675 \text{ kg}$$

The calculation of the kinetic equivalent mass in DYNAM results in the numerical value of $M = 675,1 \text{ kg}$.



Mass distribution of elements in KINEQ1 to KINEQ4

Equivalent masses and participation factors

If the user checked the box to determine the substitute masses in the mask 1.1, *General Data*, before starting the calculation, the values for the following parameters would be given in mask 2.5, *Substitute Masses* mask: Kinetic equivalent mass, Modal mass, Participation factor and Substitute mass.

The most important information about the structure is the distribution of the inertia force H_i that, dependent on Eigenshape V_i , has a typical shape.

The inertia forces meet the following conditions:

Equation 4.10

$$H_i = \frac{(V_i^T m)^2}{(V_i^T m V_i)} \cdot S_a \cdot (T_i)$$

with

V_i : Eigenshape

M : Mass matrix

$S_a(T_i)$: Acceleration Spectrum of the Angular Frequency ω_i



With the expressions

$$M_i = V_i^T m V_i \text{ Modal Mass}$$

$$L_i = V_i^T m \text{ Participation factor}$$

equation (4.10) leads to

Equation 4.11

$$H_i = \frac{L_i^2}{M_i} \cdot S_a \cdot (T_i) = m_{ei} \cdot S_a \cdot (T_i)$$

with

$$m_{ei} = I_i^2 / M_i; \text{ Substitute mass of the Eigenshape } V_i$$

As in equations 4.10 and 4.11 apparent, the substitute mass is dependent on the standardized Eigenshape V_i . Therefore DYNAM standardizes the Eigenshape to the location of the largest deformation:

Equation 4.12

$$\sum_{j=1}^n V_{ij}^2 = 1$$

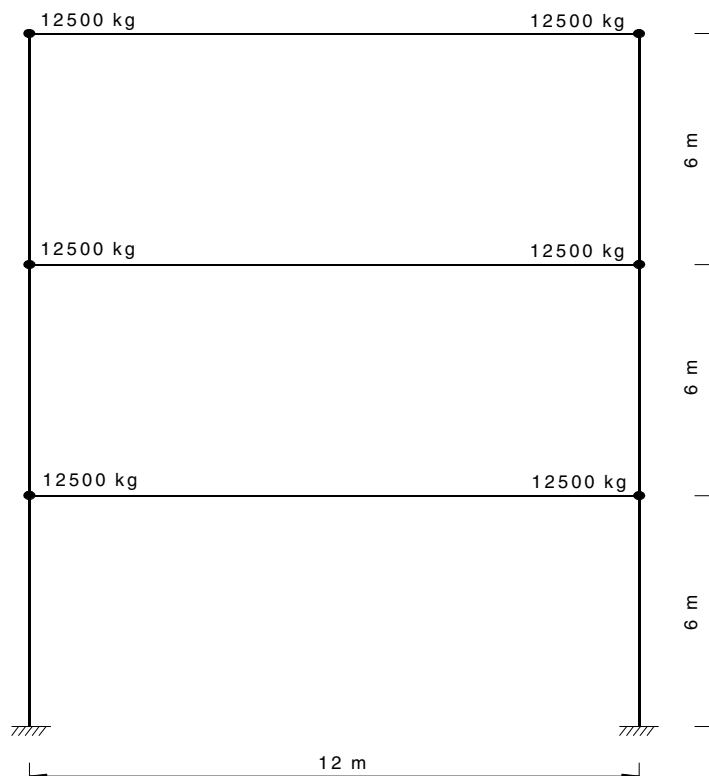
(i, j shows all displacement degrees of freedom for the Eigenshape V_i)

and calculates the Modal mass matrix and the participation factors with this as the basis.

A practical application is the following example. Further information can be found on page 678 of reference [11].

Example:

A 2D three-story structure has columns and beams considered to be without mass. The moment of inertia is $I_{2, \text{col}} = 25000 \text{ cm}^4$ for all columns and $I_{2, \text{beam}} = 150000 \text{ cm}^4$ for the beams. The mass of the beam will be distributed equally as 12500 kg on both end nodes.





Calculating the Substitute Masses of a 3-story Structure

Because it is a symmetric structure we get the same Substitute Masses for the left and right nodes as results.

Eigen Shape No.	Substitute Masses [kg]	
	DYNAM	Literature Reference [11]
1	66592,9	$2,66369 \cdot 25000 = 66592,25$
2	6989,7	$0,2769 \cdot 25000 = 6990,00$
3	1417,4	$0,05669 \cdot 25000 = 1417,25$



6. Examples

This chapter contains examples highlighting DYNAM's functions.

The first examples are single and a multi-story frames. Another example calculates the Eigenfrequency of a tower with tapered cross-sections. Using element partitions during the calculation process allows an exact calculation of the Eigenfrequencies.

The examples here are borrowed from literature. You will see how results from literature compare with results calculated with DYNAM.

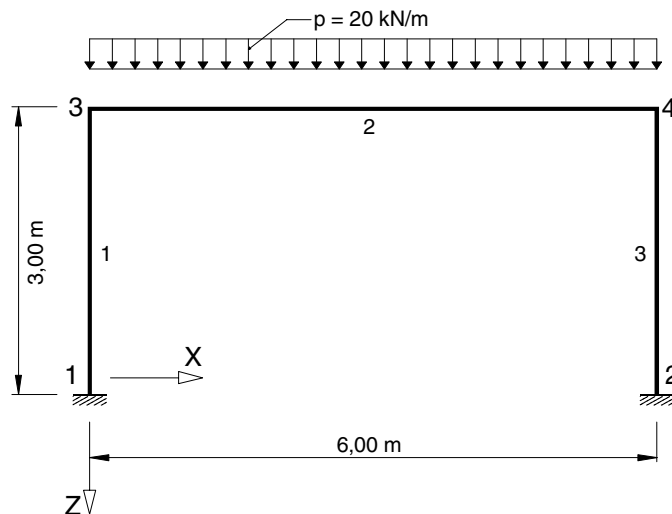
6.1 Eigenfrequency of a Single-Story Structure

We'll use a simple frame with dimensions as shown below. The stiffness and load conditions are:

$$\begin{aligned} \text{Columns: } E_{\text{Steel}} &= 21000 \quad \text{kN/cm}^2 \\ I_{\text{Col}} &= 16270 \quad \text{cm}^4 \\ A_{\text{Col}} &= 72,70 \quad \text{cm}^2 \end{aligned}$$

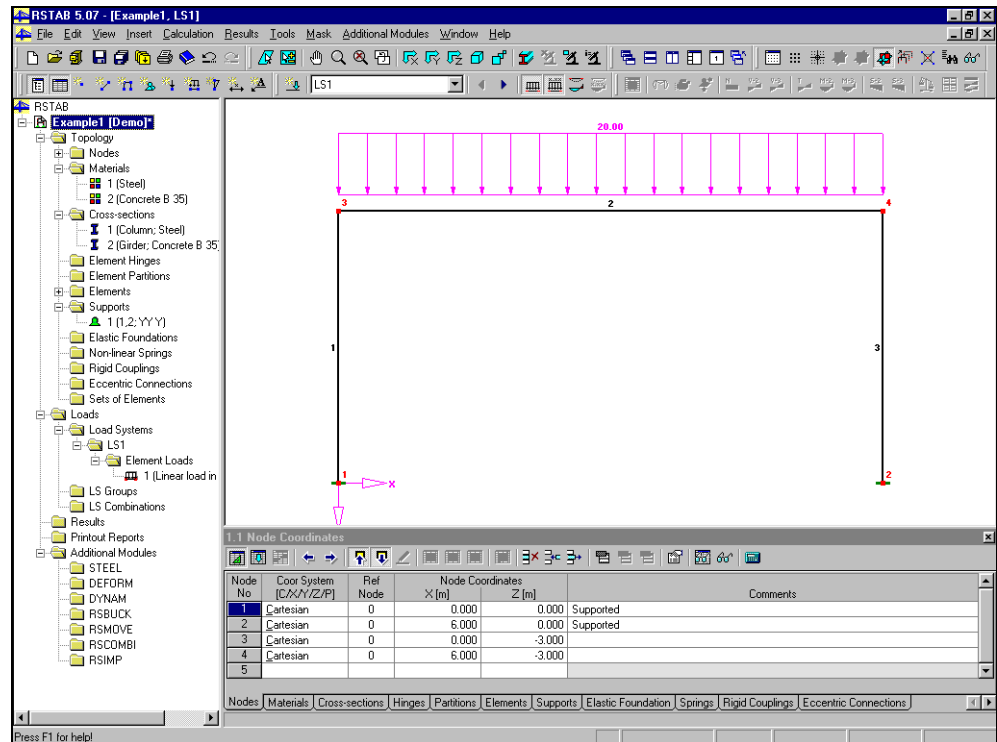
$$\begin{aligned} \text{Girder: } E_{\text{Concrete}} &= 3400 \quad \text{kN/cm}^2 \\ I_{\text{Gird}} &= 352940 \quad \text{cm}^4 \\ A_{\text{Col}} &= 4147,00 \quad \text{cm}^2 \end{aligned}$$

A load of $p = 20 \text{ kN/m}$ is applied on the girder.



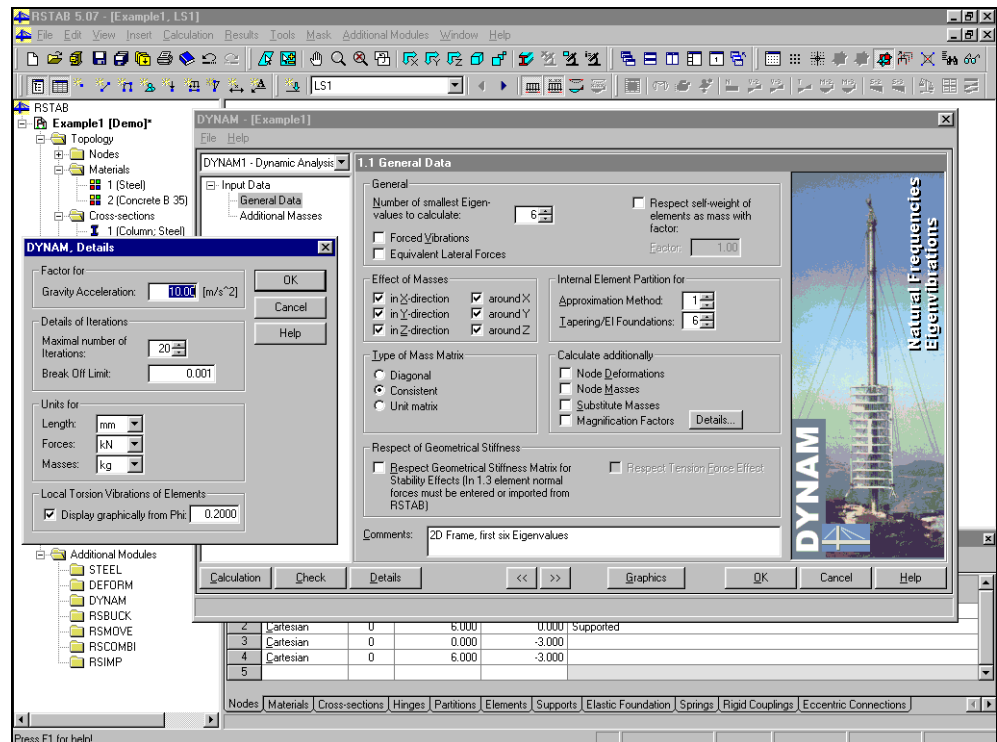
Example No. 1: Simple Frame with Steel Columns and Concrete Girder

The input in RSTAB is seen in the next figure.



RSTAB: Example 1 Input

In DYNAM BASIC the first six Eigenfrequencies will be calculated. The input in the DYNAM 1.1 mask are as seen in the next figure. Besides the *Number of smallest Eigenvalues to calculate* and the *Respect self-weight of the elements as mass with factor* options the default settings of the program can be left unchanged.

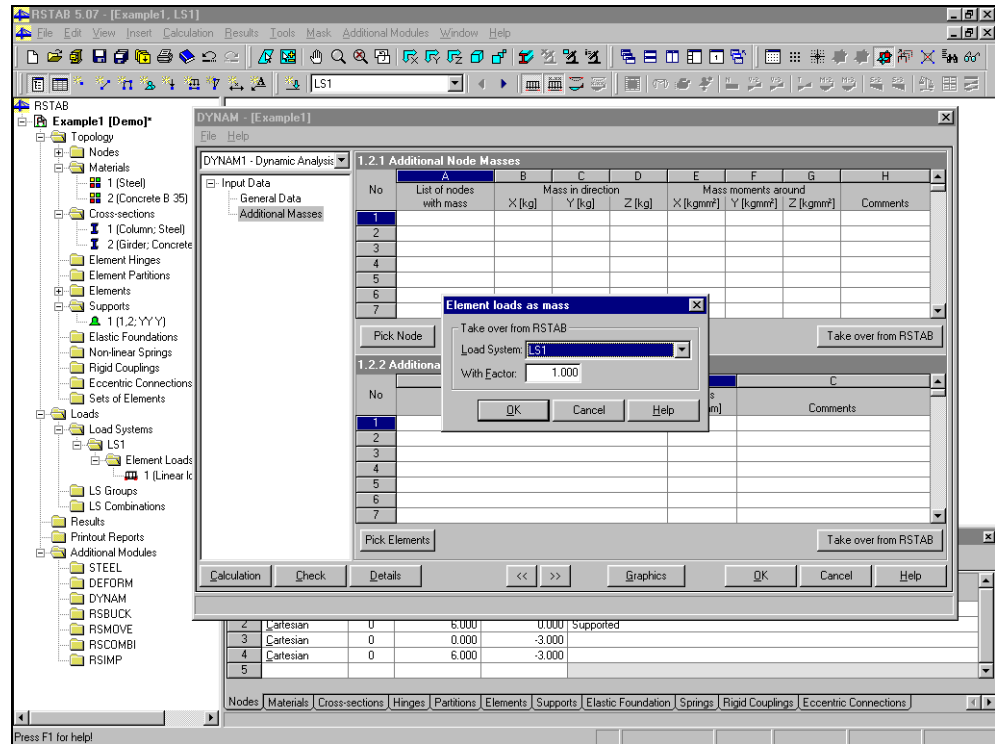


Input Mask 1.1 in DYNAM with Details Dialogue

The loads in RSTAB load systems are not always a result of masses. It is therefore possible to decide which loads shall be considered as mass and respected in the DYNAM analysis.

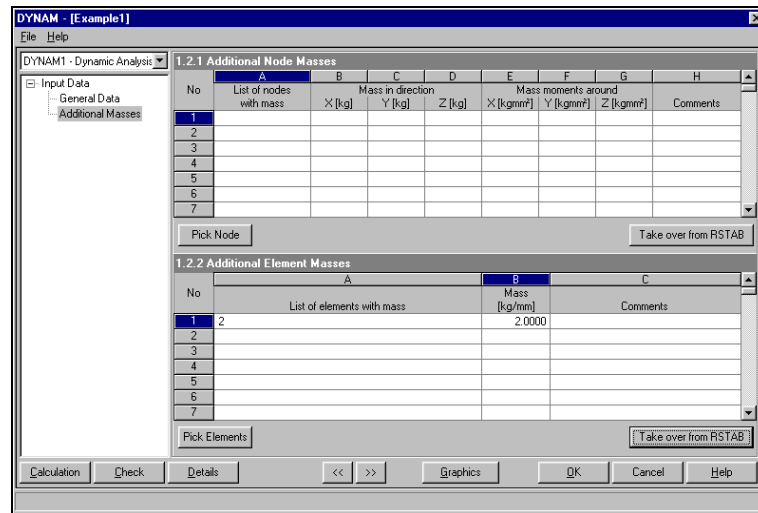


Click on the *Import from RSTAB* button in the *1.2 Additional Masses* mask to convert the loads to masses and enter the values in the input mask.



Importing RSTAB Loads as Masses

The loads in the corresponding RSTAB load system are then divided by the *Gravity Acceleration* constant as set in the *Details* dialogue of mask 1.1 and entered as mass.



Additional Masses Mask after Importing Loads as Mass

You could just enter the single value in this basic example, but the import possibility is a useful tool with more complicated structures.

Now the input is finished and the analysis can be started with [Calculate]. The following masks list the results.



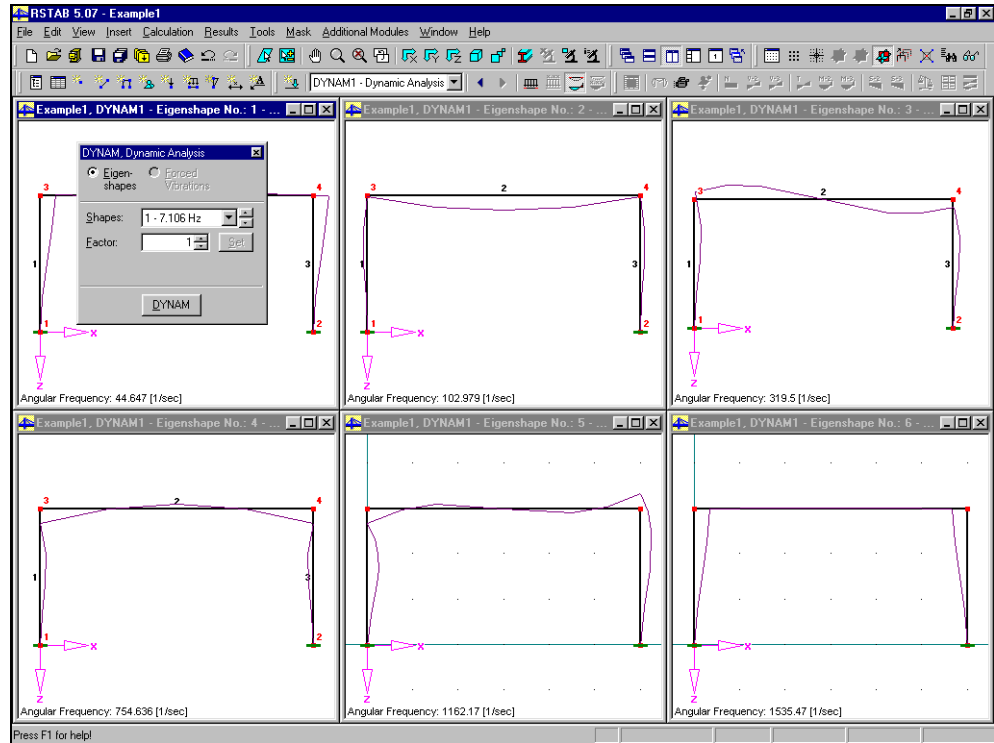
Eigen No	A Eigenvalue [1/sec ²]	B Angular Frequency [1/sec]	C Frequency [Hz]	D Eigenperiod [sec]	E
1	1993.34005	44.64684	7.10576	0.1407308	
2	10604.60925	102.97868	16.38957	0.061014	
3	102080.46814	319.50034	50.89006	0.019666	
4	963474.82700	754.63956	120.10398	0.008326	
5	1.351E+06	1162.16901	184.96494	0.005406	
6	2.358E+06	1535.47270	244.37807	0.004092	

First Six Eigenvalues in the 2.1 Eigenvalues and Eigenfrequencies Results Mask

Element No	Node No	Eigen No	Standardized Deformation			Standardized Rotation		
			uX	uY	uZ	PhiX	PhiY	PhiZ
1	1	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	3	1	1.00000	0.00000	-0.01012	0.00000	-0.14160	0.00000
		2	0.00485	0.00000	0.14290	0.00000	-1.00000	0.00000
		3	0.03814	0.00000	-0.52280	0.00000	1.00000	0.00000
		4	-0.00542	0.00000	1.00000	0.00000	0.85106	0.00000
		5	0.00282	0.00000	0.59868	0.00000	1.00000	0.00000
		6	1.00000	0.00000	0.01066	0.00000	0.01028	0.00000
3	4	1	1.00000	0.00000	0.01012	0.00000	-0.14160	0.00000
		2	-0.00485	0.00000	0.14290	0.00000	1.00000	0.00000
		3	0.03814	0.00000	0.52280	0.00000	1.00000	0.00000
		4	0.00542	0.00000	-1.00000	0.00000	-0.85106	0.00000
		5	0.00282	0.00000	-0.59868	0.00000	-1.00000	0.00000
		6	1.00000	0.00000	-0.01066	0.00000	-0.01028	0.00000

Eigenvibrations – Standardized - Largest Value is 1

Finally the graphic view of the Eigenvalues is activated with the [Graphic] button.

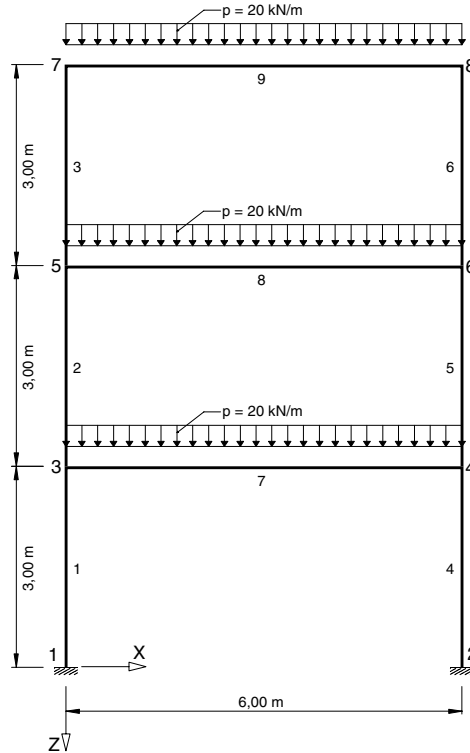


Graphic View of All Six Eigenvibrations in Six RSTAB Windows

The above view is reached by opening six working windows in RSTAB with the *Window*→*New* menu and individually adjusting all six windows. Use the *Window*→*Tile Vertically* menu to arrange them equally. Remember that the first DYNAM Case must be activated and the *Display Results* button used to view the results. The procedure is identical to display results of load systems. An additional floating window allows the selection of the Eigenshape to be displayed as well as the adjustment of the distance of the Eigenshape to the original structure.

6.2 Multi-story Frame

A multi-story frame will be analyzed as described in the first example. The topology and loads are described below:



Columns:

$$E_{\text{Steel}} = 21000 \text{ kN/cm}^2$$

$$I_{\text{Col}} = 16270 \text{ cm}^4$$

$$A_{\text{Col}} = 72,70 \text{ cm}^2$$

Girders:

$$E_{\text{Concrete}} = 3400 \text{ kN/cm}^2$$

$$I_{\text{Gird}} = 352940 \text{ cm}^4$$

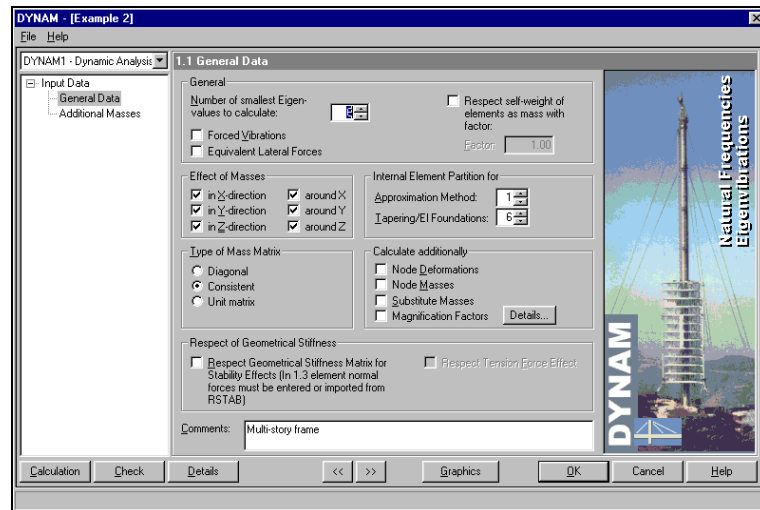
$$A_{\text{Col}} = 4147,00 \text{ cm}^2$$

On each girder a load of

$p = 20 \text{ kN/m}$ is applied

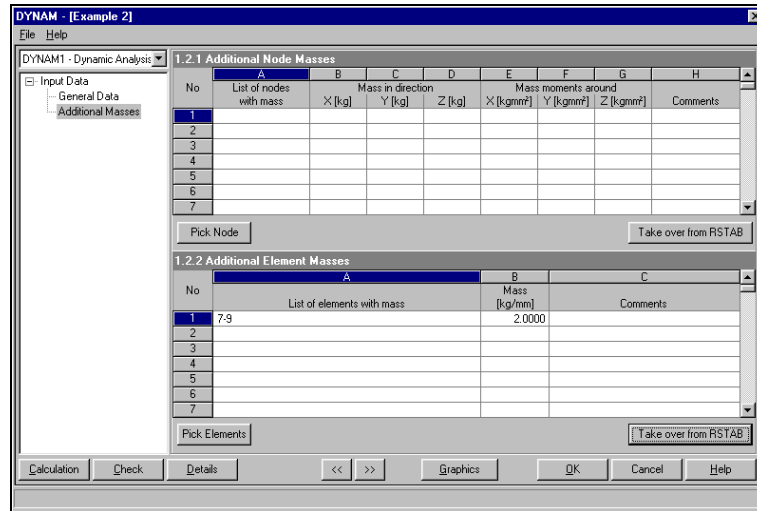
Example No. 2: Multi-story Frame

The following pictures describe the step by step input and analysis of the structure in DYNAM BASIC:



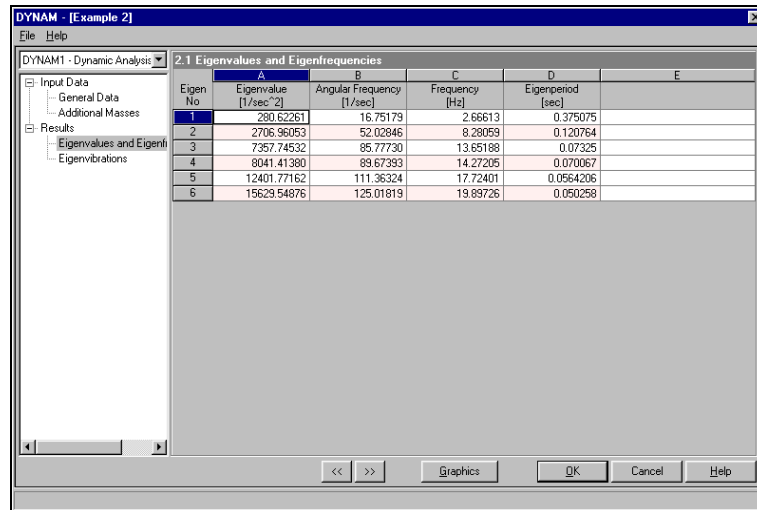
Mask 1.1 General Data

Use mask 1.1 to set the six smallest Eigenvalues to calculate and disable the respect of self-weight as in example 1. In the 1.2 *Additional Masses* mask, import the loads from RSTAB LS 1as masses in DYNAM.

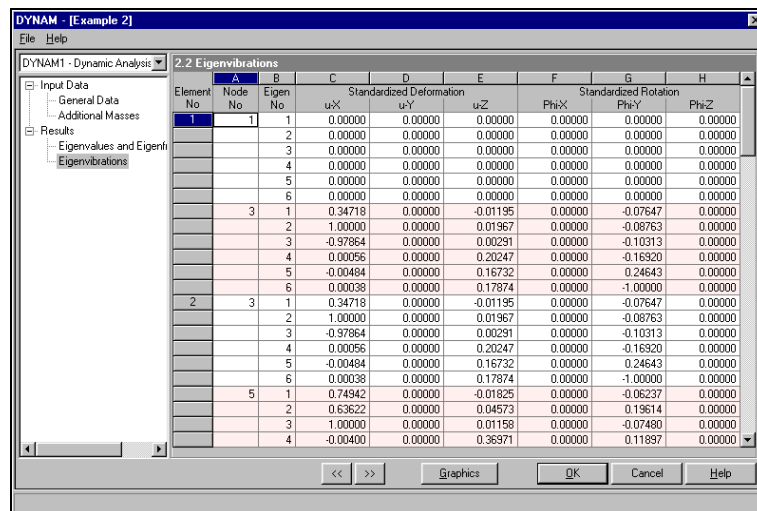


Masses Imported from RSTAB Loads

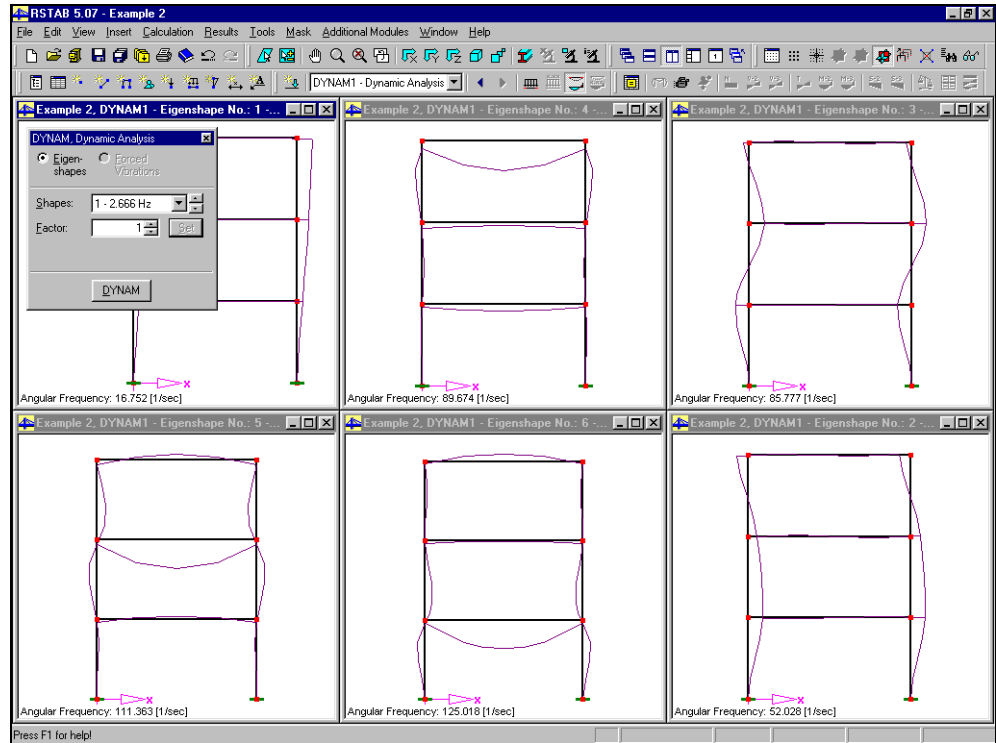
Start the analysis with [Calculate] and view the results as below:



Eigenvalues and Eigenfrequencies Result Mask

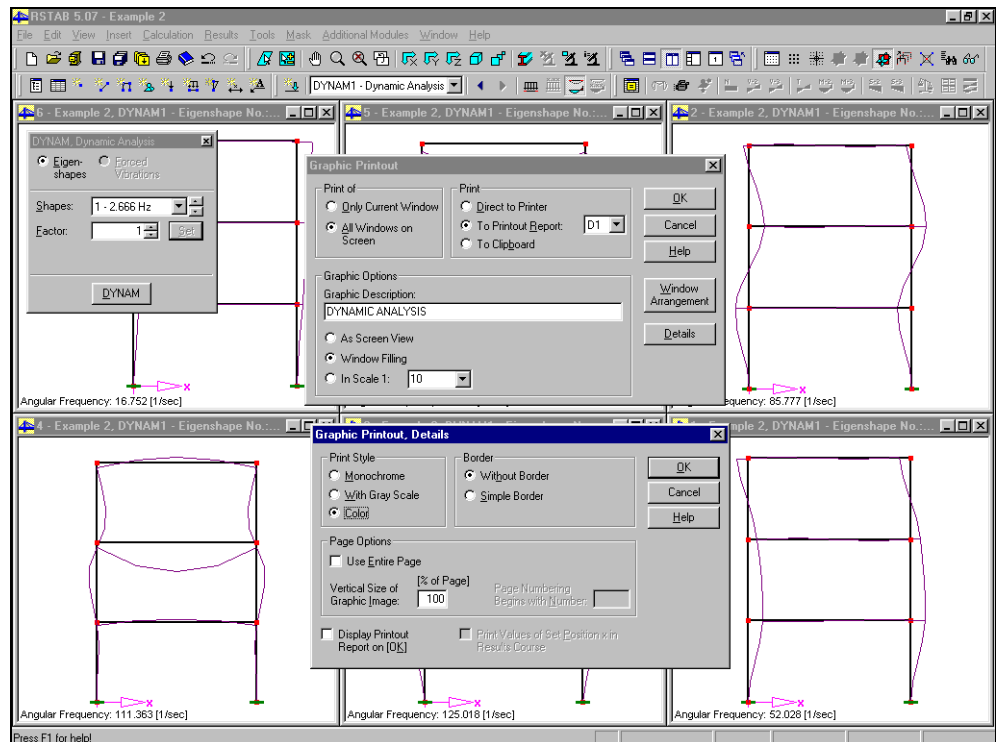


Eigenvibrations Result Mask



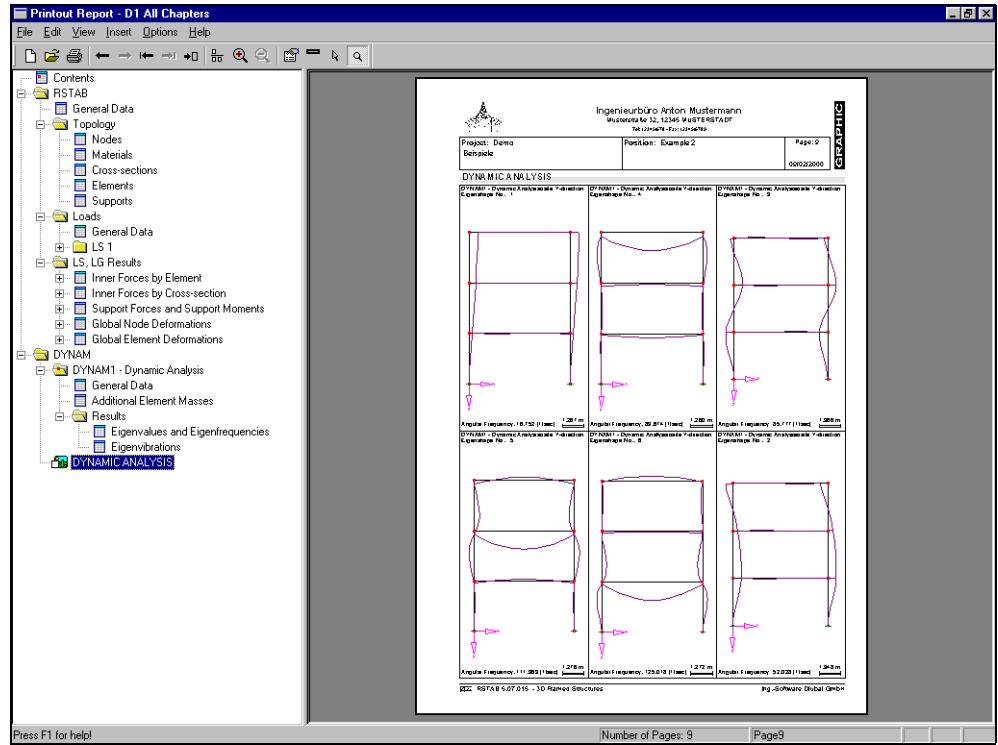
Graphic Display of All Six Calculated Eigenshapes in RSTAB

Now all six shapes should be printed to the printout report. Press the printer symbol in the toolbar and follow these settings:



Graphic Printout and Corresponding Details Dialogue Set to Print All Six Windows on One Page

Open the printout report in RSTAB to preview the document.

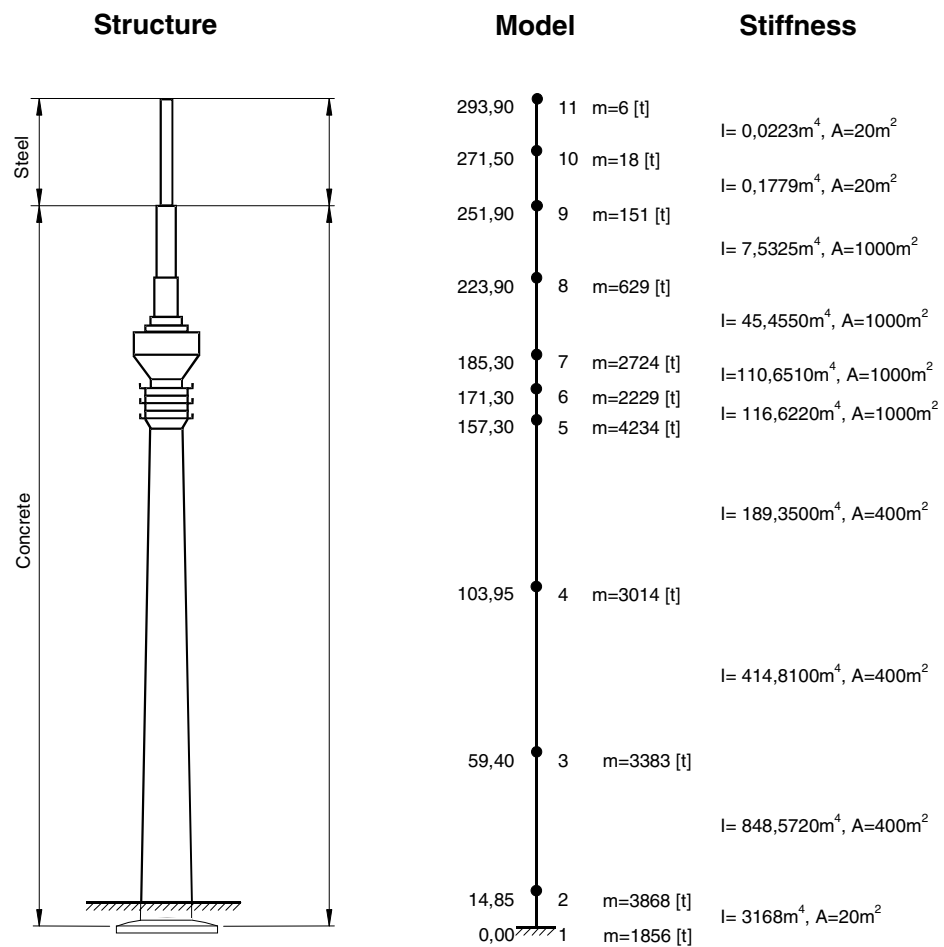


Preview of DYNAM Data in RSTAB Printout Report



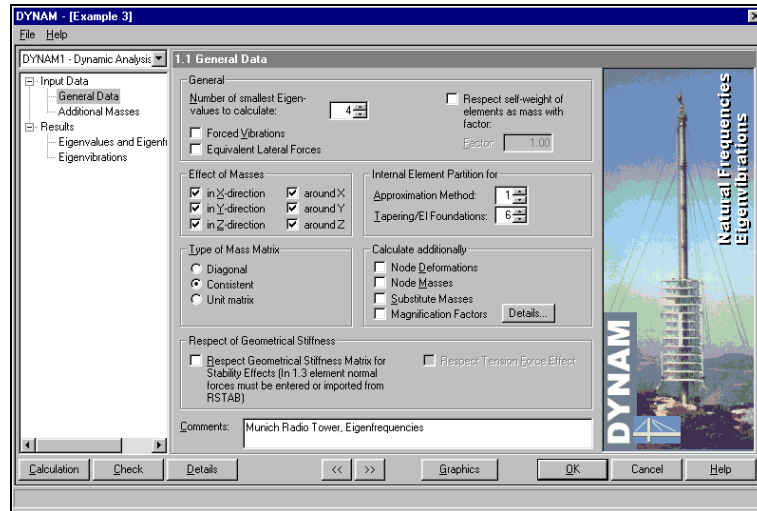
6.3 The Munich Radio Tower

A tower structure like the radio tower in Munich, Germany will be analyzed with tapered cross-sections and elements from various materials regarding its Eigenfrequencies. In this example the stiffness is entered as a constant to each element. However, DYNAM can also handle tapered cross-sections through its internal element partition feature. It simplifies input because the stiffness only needs to be entered at the beginning and ending of an element. The internal stiffness distribution will be calculated automatically. This example also demonstrates that dynamic analysis can be done when just a few input parameters are known (Geometry, stiffness and mass distribution). Even if the exact shape of the cross-sections aren't known, it is possible to describe its stiffness by the modulus of elasticity and the moment of inertia in RSTAB.

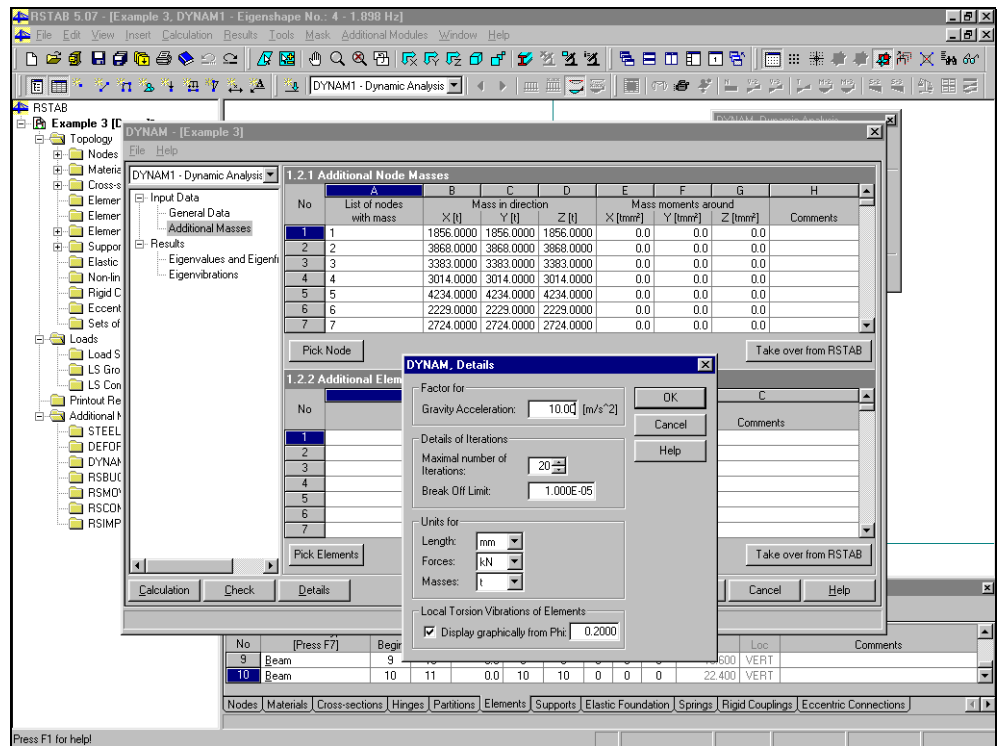


Example No. 3: Munich Radio Tower

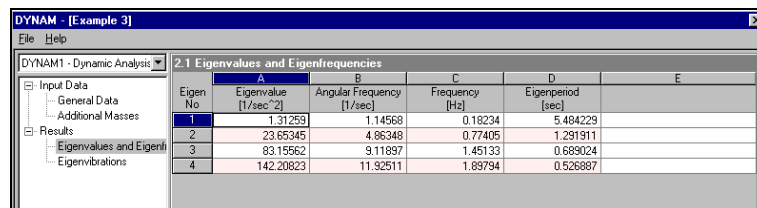
The equivalent input in DYNAM is shown in the following pictures:



Input Mask 1.1 General Data



Mask 1.2 Additional Masses and DYNAM, Details Dialogues; All Masses Active in X-, Y- and Z-Directions



Eigenvalues and Eigenfrequencies Result Mask

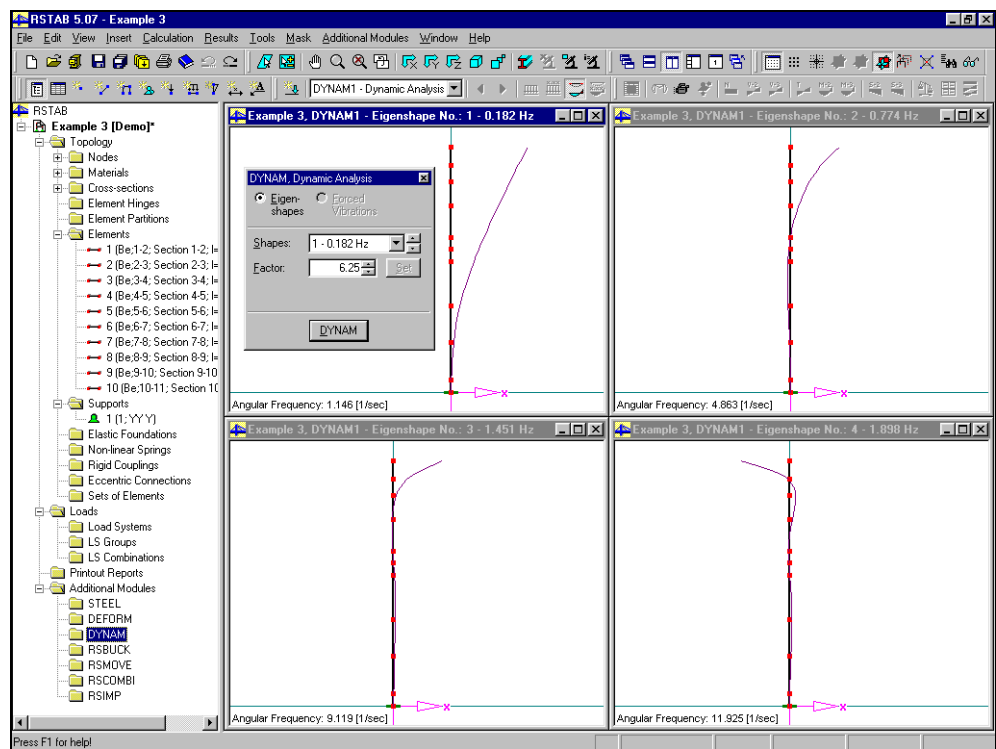


DYNAM - [Example 3]

2.2 Eigenvibrations

Element No.	Node No.	Eigen No.	u _X	u _Y	u _Z	Phi _X	Phi _Y	Phi _Z
2	4	1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		2	0.00082	0.00000	0.00000	0.00000	-0.00011	0.00000
		3	-0.00059	0.00000	0.00000	0.00000	0.00008	0.00000
		4	0.00094	0.00000	0.00000	0.00000	-0.00007	0.00000
2	2	1	0.00082	0.00000	0.00000	0.00000	-0.00011	0.00000
		2	-0.00059	0.00000	0.00000	0.00000	0.00008	0.00000
		3	0.00095	0.00000	0.00000	0.00000	-0.00007	0.00000
		4	0.00094	0.00000	0.00000	0.00000	-0.00012	0.00000
3	1	1	0.02908	0.00000	0.00000	0.00000	-0.00110	0.00000
		2	-0.01766	0.00000	0.00000	0.00000	0.00060	0.00000
		3	0.01448	0.00000	0.00000	0.00000	-0.00045	0.00000
		4	0.02306	0.00000	0.00000	0.00000	-0.00067	0.00000
3	3	1	0.02908	0.00000	0.00000	0.00000	-0.00110	0.00000
		2	-0.01766	0.00000	0.00000	0.00000	0.00060	0.00000
		3	0.01448	0.00000	0.00000	0.00000	-0.00045	0.00000
		4	0.02306	0.00000	0.00000	0.00000	-0.00067	0.00000
4	1	1	0.11116	0.00000	0.00000	0.00000	-0.00247	0.00000
		2	-0.05026	0.00000	0.00000	0.00000	0.00071	0.00000
		3	0.03248	0.00000	0.00000	0.00000	-0.00023	0.00000
		4	0.04283	0.00000	0.00000	0.00000	-0.00004	0.00000
4	4	1	0.11116	0.00000	0.00000	0.00000	-0.00247	0.00000

Eigenvibrations Result Mask



Eigenshapes Graphic Display



Appendix: Literature Reference

- [1] Klingmüller, O. Lawo, M., Thierauf, G. (1983)
Stabtragwerke, Matrizenmethoden der Statik und Dynamik, Teil 2: Dynamik
Fr. Vieweg & Sohn, Braunschweig
- [2] Klotter, K. (1981)
Technische Schwingungslehre, Bd. 1, Teil A: Lineare Schwingungen,
Teil B: Nichtlineare Schwingungen,
Bd. 2: Schwingen von mehreren Freiheitsgraden,
Springer, Berlin
- [3] Kolousek, V. (1962)
Dynamik der Baukonstruktionen
VEB-Verlag f. Bauwesen, Berlin
- [4] Krämer, E. (1984)
Maschinendynamik
Springer, Berlin
- [5] Lehmann, T. (1979)
Elemente der Mechanik IV: Schwingungen, Variationsprinzipie
Fr. Vieweg & Sohn, Braunschweig
- [6] Lipinski, J. (1972)
Fundamente und Tragkonstruktionen für Maschinen
Bauverlag, Wiesbaden
- [7] Lorenz, H. (1960)
Grundbau-Dynamik
Springer, Berlin
- [8] Müller, F. P. (1978)
Baudynamik, Betonkalender 1978
Ernst & Sohn, Berlin
- [9] Natke, H. G. (1989)
Baudynamik
B. G. Teubner, Stuttgart
- [10] Nowacki, W. (1974)
Baudynamik
Springer, Berlin
- [11] Petersen, Ch. (1996)
Dynamik der Baukonstruktion
Vieweg Verlag, Wiesbaden
- [12] Flesch, R. (1993)
Baudynamik, praxisgerecht
Bauverlag GmbH, Wiesbaden und Berlin
- [13] Meskouris, K. (1999)
Baudynamik, Modelle Methoden Praxisbeispiele
Ernst & Sohn, Berlin



- DIN 1311 Schwingungslehre
Bl. 1 Kinematische Begriffe, Febr. 1974
Bl. 2 Einfache Schwinger, Dez. 1974
Bl. 3 Schwingungssysteme mit endlich vielen Freiheitsgraden, Dez. 1974
Bl. 4 Schwingende Kontinua, Wellen, Febr. 1974
- DIN 4024 Maschinenfundamente
Bl. 1 Elastische Stützkonstruktionen für Maschinen mit Entwurf rotierender Massen, Mai 1983
- DIN 4024 Stützkonstruktionen für rotierende Maschinen
(vorzugsweise Tisch-Fundamente für Dampfturbinen), Jan. 1955
- DIN 4025 Fundamente für Amboßhämmer (Schabotte-Hämmer).
Hinweise für die Bemessung und Ausführung, Okt. 1958
- DIN 4112 Fliegende Bauten. Richtlinie für Bemessung und Ausführung, Febr. 1983
- DIN 4131 Antennentragwerke aus Stahl. Berechnung und Ausführung, März 1969
- DIN 4132 Kranbahnen, Stahltragwerke. Grundsätze für Berechnung,
bauliche Durchführung und Ausführung, Febr. 1981
Beiblatt Erläuterungen, Febr. 1981
- DIN 4133 Schornsteine aus Stahl. Statische Berechnung und Ausführung, Aug. 1973
- DIN 4149 Bauten in deutschen Erdbebengebieten
Teil 1: Lastannahmen, Bemessung und Ausführung üblicher Hochbauten,
April 1981
Beiblatt 1 DIN 4149, Teil 1: Zuordnung von Verwaltungsgebieten
zu den Erdbebenzonen, April 1981
- DIN 4150 Erschütterung im Bauwesen
Teil 1: Grundsätze, Vorermittlung und Messung von Schwingungsgrößen
Vornorm, Sept. 1975
Teil 2: Einwirkungen auf Menschen in Gebäuden, März 1986
Teil 3: Einwirkungen auf bauliche Anlagen, Mai 1986
- DIN 4178 Glockentürme. Berechnung und Ausführung, Aug. 1978
- VDI 2056 Beurteilungsmaßstäbe für mechanische Schwingungen von Maschinen,
Okt. 1964
- VDI 2057 Beurteilung der Einwirkung mechanischer Schwingungen auf den Menschen,
Mai 1987
Bl. 1 Grundlagen, Gliederung, Begriffe
Bl. 2 Bewertung
Bl. 3 Beurteilung
Bl. 4.1 Messung und Bewertung von Arbeitsplätzen in Gebäuden
Bl. 4.2 Messung und Bewertung von Arbeitsplätzen auf Landfahrzeugen
Bl. 4.3 Messung und Beurteilung für Wasserfahrzeuge
- VDI 2062 Schwingungsisolierung
Bl. 1 Begriffe und Methoden, Jan. 1976
Bl. 2 Isolierelemente, Jan. 1976
- VDI 3831 Schutzmaßnahmen gegen die Einwirkung mechanischer Schwingungen auf
den Menschen, allgem. Schutzmaßnahmen, Beispiele, Nov. 1985
- KTA 2201 (Kerntechnische Anlagen): Auslegung von Kernkraftwerken
gegen seismische Einwirkungen
Teil 1 Grundsätze, Jan. 1975
Teil 2 Baugrund, Nov. 1982
Teil 4 Auslegung der maschinenelektrotechnischen Anlagenteile, Nov. 1983
Teil 5 Seismische Instrumentierung, Jan. 1977