TR.32.10.1.4 Response Spectrum Specification per Eurocode 8 1994

This command may be used to specify and apply the `RESPONSE SPECTRUM` loading as per the 1994 edition of Eurocode 8 (EC8) for dynamic analysis.

General Format

```
SPECTRUM comb-method  EURO {ELASTIC | DESIGN} *{ X f1| Y f2| Z f3} ACCELERATION

{DAMP f5| CDAMP | MDAMP } ( {LINEAR | LOGARITHMIC} ) (MISSING f6) (ZPA f7) ({ DOMINANT
f10| SIGN }) (SAVE)  (IMR f11) (STARTCASE f12)
```

Note: The data from `SPECTRUM` through `ACC` must be on the first line of the command, the remaining data can be on the first or subsequent lines with all but last ending with a hyphen (limit of four lines per spectrum).

Starting on the next line, the response spectra is input using following standard input parameters:

```
SOIL TYPE { A | B | C} ALPHA f8 Q f9
```

Unlike the custom defined response spectra, the EC 8 response spectra does not input use frequency-acceleration pairs. Based on the type of Response Spectra (Elastic/Design), Soil Type, Alpha, and Q, the program generates the applicable response spectra curve using the guidelines of section 4.2.2 or 4.2.4 of Eurocode 8 as applicable.

Where:

Table 1. Parameters used for Eurocode 8 1994 response spectrum

Parameter	Default Value	Description
X *f1*, Y *f2*, Z *f3*	0.0	Factors for the input spectrum to be applied in X, Y, & Z directions. Any one or all directions can be input. Directions not provided will default to zero.

Parameter	Default Value	Description
DAMP *f5*	0.05	The damping ratio. Specify a value of exactly 0.0000011 to ignore damping. If `CDAMP` is specified, then composite damping is used as determined by the values for material damping (and spring damping, if specified). Refer to **TR.26.2 Specifying Constants for Members and Elements** If `MDAMP` is specified, then modal damping is calculated using the method defined in a `DEFINE DAMPING INFORMATION` command, which must be included in the input file. Refer to **TR.26.4 Modal Damping Information**
MISSING *f6*		Optional parameter to use "Missing Mass" method. The static effect of the masses not represented in the modes is included. The spectral acceleration for this missing mass mode is the *f6*value entered in length/sec^2 (this value is not multiplied by SCALE). If *f6*is zero, then the spectral acceleration at the `ZPA` *f7*frequency is used. If *f7*is zero or not entered, the spectral acceleration at 33Hz (Zero Period Acceleration, ZPA) is used. The results of this calculation are SRSSed with the modal combination results. **Note:** If the `MISSING` parameter is entered on any spectrum case it will be used for all spectrum cases.
ZPA *f7*	33 [Hz]	The zero period acceleration value for use with `MISSING` option only. Defaults to 33 Hz if not entered. The value is printed but not used if `MISSING f6` is entered.
DOMINANT *f10*	1 (1st Mode)	The dominant mode method. All results will have the same sign as mode number *f10* alone would have if it were excited then the scaled results were used as a static displacements result. Defaults to mode 1 if no value entered. If a 0 value entered, then the mode with the greatest % participation in the excitation direction will be used (only one direction factor may be nonzero). **Note:** Do not enter the `SIGN` parameter with this option. Ignored for the `ABS` method of combining spectral responses from each mode.
IMR *f11*	1	The number of individual modal responses (scaled modes) to be copied into load cases. Defaults to one. If greater than the actual number of modes extracted (`NM`), then it will be reset to NM. Modes one through f11 will be used. Missing Mass modes are not output.

Parameter	Default Value	Description
STARTCASE *f12*	Highest Load Case No. + 1	The primary load case number of mode 1 in the `IMR` parameter. Defaults to the highest load case number used so far plus one. If *f12* is not higher than all prior load case numbers, then the default will be used. For modes 2 through `NM`, the load case number is the prior case number plus one.
ALPHA *f8*		The design ground acceleration expressed in terms of acceleration due to gravity(g). For most of the application of Eurocode 8, the hazard is described in terms of a single parameter (i.e., the value of effective peak ground acceleration in rock or firm soil). This acceleration is termed as the design ground acceleration.
Q *f9*		The behavior factor used to reduce the elastic response spectra to the design response spectra. The behavior factor is an approximation of the ratio of the seismic forces, that the structure would experience, if its response was completely elastic with 5% viscous damping, to the minimum seismic forces that may be used in design- with a conventional linear model still ensuring a satisfactory response of the structure.

comb-method = `{ SRSS | ABS | CQC | ASCE | TEN | CSM | GRP }` are methods of combining the responses from each mode into a total response.

The CQC and ASCE4-98 methods require damping. ABS, SRSS, CRM, GRP, and TEN methods do not use damping unless spectra-period curves are made a function of damping (see File option below). CQC, ASCE, CRM, GRP, and TEN include the effect of response magnification due to closely spaced modal frequencies. ASCE includes more algebraic summation of higher modes. ASCE and CQC are more sophisticated and realistic methods and are recommended.

SRSS Square Root of Summation of Squares method.

ABS Absolute sum. This method is very conservative and represents a worst case combination.

CQC Complete Quadratic Combination method (Default). This method is recommended for closely spaced modes instead of SRSS.
Resultants are calculated as:

$$F=\sum_n \sum_m f_n \rho_{nm} f_m$$

where

ρ_{nm}	=	$8\zeta^2(1+r)r^{2/3}(1-r^2)^2+4\zeta^2r(1+r)^2$
r	=	$\omega_n/\omega_m \leq 1.0$

Note: The cross-modal coefficient array is symmetric and all terms are positive.

ASCE NRC Regulatory Guide Rev. 2 (2006) Gupta method for modal combinations and Rigid/Periodic parts of modes are used. The ASCE4-98 definitions are used where there is no

conflict. ASCE4-98 Eq. 3.2-21 (modified Rosenblueth) is used for close mode interaction of the damped periodic portion of the modes.

TEN Ten Percent Method of combining closely spaced modes. NRC Reg. Guide 1.92 (Rev. 1.2.2, 1976).

CSM Closely Spaced Method as per IS:1893 (Part 1)-2002 procedures.

GRP Closely Spaced Modes Grouping Method. NRC Reg. Guide 1.92 (Rev. 1.2.1, 1976).

Note: If SRSS is selected, the program will internally check whether there are any closely spaced modes or not. If it finds any such modes, it will switch over to the CSM method. In the CSM method, the program will check whether all modes are closely spaced or not. If all modes are closely spaced, it will switch over to the CQC method.

`ELASTIC` or `DESIGN` The response spectrum loading can be based on either **Elastic** or **Design** response spectra. Refer to Eurocode 8.

The capacity of structural systems to resist seismic actions in the nonlinear range generally permits their design for forces smaller than those corresponding to a linear elastic response. To avoid explicit nonlinear structural analysis in design, the energy dissipation capacity of the structure through mainly ductile behavior of its elements and/or other mechanisms, is taken into account by performing a linear analysis based on a response spectrum which is a reduced form of the corresponding elastic response spectrum. This reduction is accomplished by introducing the behavior factor Q and the reduced response spectrum is termed as "Design Response Spectrum." STAAD.Pro generates the Elastic Response Spectra using the guidelines of section 4.2.4 and Table 4.2 of Eurocode 8.

So, if the structure is supposed to resist seismic actions in the nonlinear range the Design Response Spectra is to be used.

`ACCELERATOIN` indicates that the Acceleration spectra will be entered.

Note: Eurocode 8 does not have provisions displacement response spectra.

`DAMP`, `MDAMP`, and `CDAMP` select source of damping input:

- `DAMP` indicates to use the *f2* value for all modes
- `MDAMP` indicates to use the damping entered or computed with the `DEFINE DAMP` command if entered, otherwise default value of 0.05 will be used
- `CDAMP` indicates to use the composite damping of the structure calculated for each mode. You must specify damping for different materials under the `CONSTANT` specification

`LINEAR` or `LOGARITHMIC` Select **Linear** or **Logarithmic** interpolation of the input Spectra versus Period curves for determining the spectra value for a mode given its period. Linear is the default. Since Spectra versus Period curves are often linear only on Log-Log scales, the logarithmic interpolation is recommended in such cases; especially if only a few points are entered in the spectra curve.

When `FILE` *`filename`* is entered, the interpolation along the damping axis will be linear.

Note: The last interpolation parameter entered on the last of all of the spectrum cases will be used for all spectrum cases.

`SIGN` This option results in the creation of signed values for all results. The sum of squares of positive values from the modes are compared to sum of squares of negative values from the modes. If the negative values are larger, the result is given a negative sign. This command is ignored for `ABS` option.

CAUTION: Do *not* enter `DOMINANT` parameter with this option.

`SAVE` This option results in the creation of a acceleration data file (with the model file name and an `.acc` file extension) containing the joint accelerations in g's and radians/sec^2. These files are plain text and may be opened and viewed with any text editor (e.g., Notepad).

`SOIL TYPE` This parameter is used to define the subsoil conditions based on which the response spectra will be generated. Based on the subsoil conditions the soil types may be of three kinds

- Type A: for Rock or stiff deposits of sand
- Type B: for deep deposits of medium dense sand ,gravel or medium stiff clays.
- Type C: Loose cohesionless soil deposits or deposits with soft to medium stiff cohesive soil.

Refer to section 3.2 of Eurocode 8 for detailed guidelines regarding the choice of soil type.

Individual Modal Response Case Generation

Individual modal response (`IMR`) cases are simply the mode shape scaled to the magnitude that the mode has in this spectrum analysis case before it is combined with other modes. If the IMR parameter is entered, then STAAD.Pro will create load cases for the first specified number of modes for this response spectrum case (i.e., if five is specified then five load cases are generated, one for each of the first five modes). Each case will be created in a form like any other primary load case.

The results from an IMR case can be viewed graphically or through the print facilities. Each mode can therefore be assessed as to its significance to the results in various portions of the structure. Perhaps one or two modes could be used to design one area/floor and others elsewhere.

You can use subsequent load cases with TR.32.11 Repeat Load Specification combinations of these scaled modes and the static live and dead loads to form results that are all with internally consistent signs (unlike the usual response spectrum solutions). The modal applied loads vector will be omega squared times mass times the scaled mode shape. Reactions will be applied loads minus stiffness matrix times the scaled mode shape.

With the Repeat Load capability, you can combine the modal applied loads vector with the static loadings and solve statically with P-Delta or tension only.

Note: When the IMR option is entered for a Spectrum case, then a **TR.37 Analysis Specification** & **TR.38 Change Specification** must be entered after each such Spectrum case.

See **TR.32.10.1.1 Response Spectrum Specification - Custom** for additional details on IMR load case generation.

Description

This command should appear as part of a loading specification. If it is the first occurrence, it should be accompanied by the load data to be used for frequency and mode shape calculations. Additional occurrences need no additional information. Maximum response spectrum load cases allowed in one run is 4.

Results of frequency and mode shape calculations may vary significantly depending upon the mass modeling. All masses that are capable of moving should be modeled as loads, applied in all possible directions of movement. For dynamic mass modeling, see sections **TR.32 Loading Specifications** and **G.17.3 Dynamic Analysis**.

Multiple Response Spectra

For special conditions more than one spectrum may be needed to adequately represent the seismic hazard over an area. This happens when the earthquake affecting the area are generated by sources varying widely in location and other parameters. In those cases different values of `ALPHA` as well as `Q` may be required to indicate the different shapes of response spectrum for each type of earthquake.

Example

```
LOAD 2 SPECTRUM X-DIRECTION
SELFWEIGHT X 1.0
SELFWEIGHT Y 1.0
SELFWEIGHT Z 1.0
JOINT LOAD
10 FX 17.5
10 FY 17.5
10 FZ 17.5
MEMBER LOADS
5 CON GX 5.0 6.0
5 CON GY 5.0 6.0
5 CON GX 7.5 10.0
5 CON GY 7.5 10.0
5 CON GX 5.0 14.0
5 CON GY 5.0 14.0
SPECTRUM SRSS EURO ELASTIC X 1 ACC DAMP 0.05 -
```

```
LIN MIS 0 ZPA 40
SOIL TYPE A ALPHA 2 Q 1.5
```