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# ProtaStructure Design Guide

## Loading Generator

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Please contact us for your training and technical support queries

asiasupport@protasoftware.com

globalsupport@protasoftware.com

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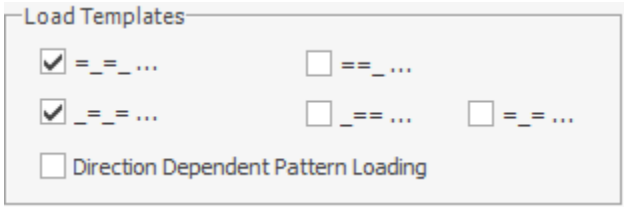
# Scope

ProtaStructure can automatically generate the load combinations as required by different design codes. To generate load combinations automatically use the **Loading Generator** under **Analysis > Building Analysis > Load Combinations**. This document explains the different options in the loading generator.

## Dead and Live Load Cases

Dead and live load cases must exist in all projects. That's why it is not allowed to uncheck these two in ProtaStructure.

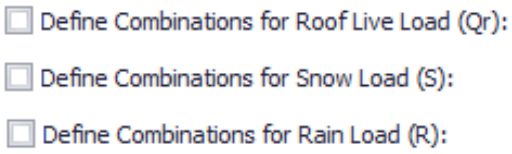
Pattern live loads are optional. By default, only odd and even loaded span pattern is used. You can optionally check the other three patterns and include in the combinations.




Separate pattern load cases are generated for each orthogonal direction if "**Direction Dependent Pattern Loading**" is checked.

## Roof Live Load Cases

Generally in codes, it is recommended to define different load cases for Roof Live Loads and it is recommended to included in the loading combinations with different coefficients. Especially these definitions are important in steel structures where roof loading is prominent.




By checking these options, you can define individual load cases for "**Roof Live Load (Qr, Lr in ASCE-based specifications)**", "**Snow Load (S)**" and / or "**Rain Load (R)**" instead of "**Live Load State (Q)**" to roof level slabs and elements (such as roof cladding, purlin, beam.). For example, if you check the Roof and Snow Load fields, a different set of combinations (in the form of Qr or S or R) will be generated for each of these load cases. Even if you assign loads for all of them, these three load cases will not be automatically considered in the same combination simulatenously. However, you are free to consider these at the same time by editing any combination.

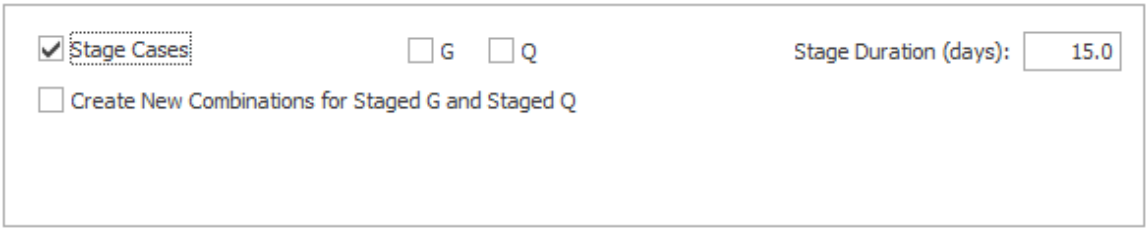
| No | Kombinasyonu | HYA | B/A | Çelik | G | Q | Qs1 | Qs2 | Qr | S | R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | G+Q *F+Qr | ☑ | ☑ | ☑ | 1.40 | 1.60 | 0 | 0 | 1.60 | 0 | 0 |
| 2 | G+Q *F+S | ☑ | ☑ | ☑ | 1.40 | 1.60 | 0 | 0 | 0 | 1.60 | 0 |
| 3 | G+Q *F+R | ☑ | ☑ | ☑ | 1.40 | 1.60 | 0 | 0 | 0 | 0 | 1.60 |
| 4 | G+Qs1 *F+Qr | ☑ | ☑ | ☑ | 1.40 | 0 | 1.60 | 0 | 1.60 | 0 | 0 |
| 5 | G+Qs2 *F+Qr | ☑ | ☑ | ☑ | 1.40 | 0 | 0 | 1.60 | 1.60 | 0 | 0 |
| 6 | G+Qs1 *F+S | ☑ | ☑ | ☑ | 1.40 | 0 | 1.60 | 0 | 0 | 1.60 | 0 |
| 7 | G+Qs2 *F+S | ☑ | ☑ | ☑ | 1.40 | 0 | 0 | 1.60 | 0 | 1.60 | 0 |
| 8 | G+Qs1 *F+R | ☑ | ☑ | ☑ | 1.40 | 0 | 1.60 | 0 | 0 | 0 | 1.60 |
| 9 | G+Qs2 *F+R | ☑ | ☑ | ☑ | 1.40 | 0 | 0 | 1.60 | 0 | 0 | 1.60 |

In some codes (eg Eurocode) these load cases are applied with different coefficients (as Qr and S or Qr and R). No codes apply snow and rain loads together.

If you define a load in the "**Live Load (Q)**" field together with "**Roof Live Load (Qr)**" for a member at roof level, both of these loads will be applied together. Therefore, a load should not be defined in the "Q" field for such elements, unless specifically preferred.

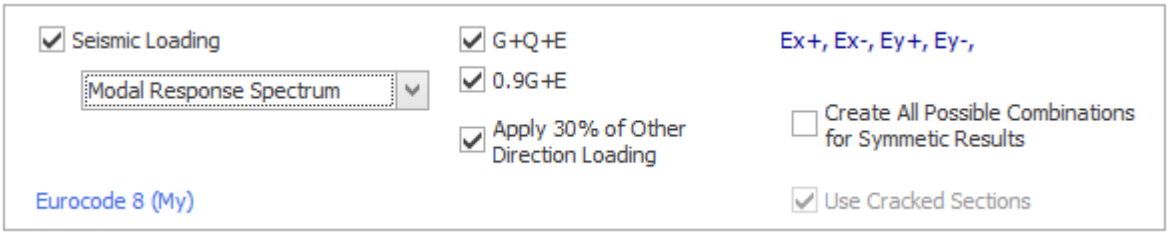
## Construction Stages Load Cases

Dead and live load cases can be defined as a part of construction stage. Optionally, you can have a second independent set prepared for construction stage combinations that will enable you to envelope the results with unstaged cases.




## Seismic Loading

Four load cases **(Ex +, Ex-, Ey +, Ey-)** including **positive** and **negative** eccentricities are defined for earthquake loads calculated in accordance with the selected earthquake codes. The "**+**" and "-" signs in the load case labels indicate the side of the eccentricity with respect to floor mass center. (i.e. rotating the floor CW or CCW)



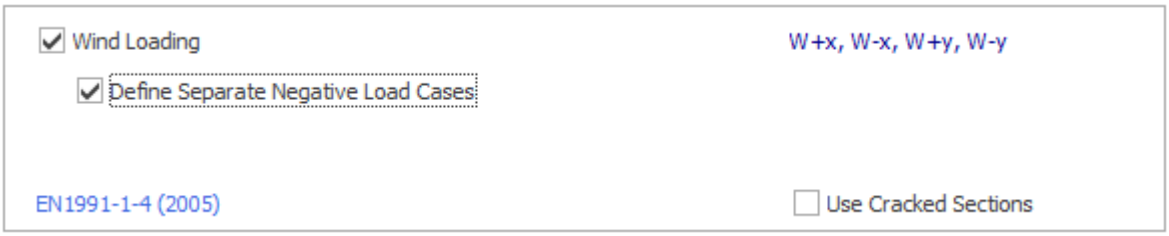

All seismic codes require to include and additional combination, 0.9G + E, that may yield more critical results where G acts favorably. You can optionally include this in loading generator.

## Wind Loading

Generally, two load cases are sufficient for the wind loads for standard buildings where windward and leeward facades are similar. Load combinations are automatically created separately for the positive and negative directions.

However, it is necessary to use different load cases in positive and negative directions to define the wind load, especially for the buildings with different windward and leeward facade areas, the cladding and purlins on the sloping roofs of steel structures, and the girts on their surfaces. For this purpose, you can define 4 load cases by using the "**Define Different Negative Load States**" option.

In the ASCE-based wind loading definition, **4 load cases (Wx, Wmx, Wy, Wmy)** are generated by default since **the torsion moment is calculated for each direction**. If you use the "Define Different Negative Load Cases" option, you can use 8 load cases by creating separate load cases for the negative directions.




## Minimum Horizontal Loading

Especially in non-seismic regions, design codes provision the application of a minimum horizontal load (notional loads) to buildings. By definition, this includes the minimum lateral loads that can be caused by constructional defects in the structure and is usually calculated as a percentage of the building weight.

## Soil Pressure

You can check the “Soil Pressure” load cases to describe the soil pressure effects. (For example, span loads applied to the basement shearwalls, or storey loads defined by storey loads editor)

In case the soil pressure is unilateral, it is sufficient to define one or two load cases. By checking the option for relevant direction, you can create soil pressure load cases and associated combinations.

Design codes suggest different combination coefficients for the soil load cases for situations where the soil pressure is applied favorably or unfavorably with other horizontal loads. In this case, you must specify the direction in which the load is applied. For example, if "negative" is selected for the direction of 1, the soil load coefficient will be "0.9" in the earthquake loading in the positive direction, and "1.6" in the earthquake loading in the same negative direction.

However, if you want to define different positive and negative load cases in both directions, you can check the "**Define Different Negative Load States**" option to create 4 load states (Hx, H-x, Hy, H-y).

## Loading Combinations According to Design and Seismic Codes

The following tables outline the loading combinations used for the strength design, which are automatically generated according to the different codes supported. More combinations will be created depending on the options specified by the user in the loading generator.

### ACI318-14, ASCE07-16, SNI1726-2012, SNI1726-2019, NSCP2015, AISC360 (LRFD)

| | Prime Effect | G | Q | Qr, R, S | W | E | H |
|---|---|---|---|---|---|---|---|
| G | G | 1.4 | | | | | |
| G+Q | Q | 1.2 | 1.6 | 0.5 | | | 1.6 |
| G+Q+(Qr, R, S) | R | 1.2 | 1 | 1.6 | | | 1.6 |
| G+(Qr, R, S)+W | R | 1.2 | | 1.6 | 0.5 | | 1.6 - 0.9 |
| G+W | W | 1.2 | 1 | 0.5 | 1 | | 1.6 - 0.9 |
| G+W | W | 0.9 | | | 1 | | 1.6 - 0.9 |
| G+L+E+Ev+S | E | 1.2 | 1 | 0.2S | | 1 | 1.6 - 0.9 |
| G+E+Ev | E | 0.9 | | | | 1 | 1.6 - 0.9 |

### UBC97 (Cl. 1612.2.1)

| | Prime Effect | G | Q | Qr, R, S | W | E | H |
|---|---|---|---|---|---|---|---|
| G | G | 1.4 | | | | | |
| G+Q | Q | 1.2 | 1.6 | 0.5 | | | 1.6 |
| G+Q+(Qr, R, S) | R | 1.2 | 1 | 1.6 | | | 1.6 |
| G+(Qr, R, S)+W | R | 1.2 | | 1.6 | 0.8 | | 1.6 |
| G+W | W | 1.2 | 1 | 0.5 | 1.3 | | 1.6 |
| G+W | W | 0.9 | | | 1.3 | | 1.6 |
| G+L+E+Ev+S | E | 1.2 | 1 | 0.2S | | 1 | 1.6 |
| G+E+Ev | E | 0.9 | | | | 1 | 1.6 |

### TS500, TBDY2018

| | Prime Effect | G | Q | Qr, R, S | W | E | H |
|---|---|---|---|---|---|---|---|
| G | G | N/A | | | | | |
| G+Q | Q | 1.4 | 1.6 | 1.6 | | | 1.6 |
| G+Q+(Qr, R, S) | R | N/A | | | | | |
| G+(Qr, R, S)+W | R | N/A | | | | | |
| G+W | W | 1 | 1 | 1 | 1.3 | | |
| G+W | W | 0.9 | | | 1.3 | | |
| G+L+E+Ev+S | E | 1 | 1 | 0.2S | | 1 | |
| G+E+Ev | E | 0.9 | | | | 1 | 1 |

## Turkish Steel Code (YDKT)

| | Prime Effect | G | Q | Qr, R, S | W | E | H |
|---|---|---|---|---|---|---|---|
| G | G | 1.4 | | | | | |
| G+Q | Q | 1.2 | 1.6 | 0.5 | | | 1.6 |
| G+Q+(Qr, R, S) | Qr, R, S | 1.2 | 1 | 1.6 | | | 1.6 |
| G+(Qr, R, S)+W | R | 1.2 | | 1.6 | 0.8 | | 1.6 - 0.9 |
| G+W | W | 1.2 | 1 | 0.5 | 1.6 | | 1.6 - 0.9 |
| G+W | W | 0.9 | | | 1.6 | | 1.6 - 0.9 |
| G+L+E+Ev+S | E | 1.2 | 1 | 0.2S | | 1 | 1 |
| G+E+Ev | E | 0.9 | | | | 1 | 1 |

## Turkish Steel Code (GKT)

| | Prime Effect | G | Q | Qr, R, S | W | E | H |
|---|---|---|---|---|---|---|---|
| G-Only | G | 1 | | | | | |
| G+Q | Q | 1 | 1 | | | | 1 |
| G+Q+(Qr, R, S) | Q, Qr, S | 1 | | 1 | | | 1 |
| G+Q+(Qr, R, S) | Q, Qr, S | 1 | 0.75 | 0.75 | | | 1 |
| G+(Qr, R, S)+W | Q, Qr, R, S, W | 1 | 0.75 | 0.75 | 0.75 | | 1 - 0.6 |
| G+W | W | 1 | | | 1 | | 1 - 0.6 |
| G+W | W | 0.6 | | | 1 | | 1 - 0.6 |
| G+L+E+Ev+S | E | 1 | 0.75 | 0.75S | | 0.525 | 0.6 |
| G+E+Ev | E | 0.6 | | | | 1 | 0.6 |

## Eurocodes

ProtaStructure supports **Equation 6.10** for strength design combinations (STR) and **Equation 9.10** for seismic combinations.

$$\sum_{j\geq 1}\gamma_{G,j}G_{k,j}+\gamma_P P+\gamma_{Q,1}Q_{k,1}+\sum_{i\geq 1}\gamma_{Q,i}\psi_{0,i}Q_{k,i} \quad (6.10)$$

$$\sum_{j\geq 1}G_{k,j}+P+A_{Ed}+\sum_{i\geq 1}\psi_{2,i}Q_{k,i}$$

Combination for live (variable) loads, Frequent Use and Semi-Persistence

| | ψ0 | ψ1 | ψ2 |
|---|---|---|---|
| Office Areas, | 0.7 | 0.5 | 0.3 |
| Accessible Roofs, | 0.7 | 0.5 | 0.3 |
| Snow (H>1000 m), | 0.7 | 0.5 | 0.2 |
| Snow (H<1000 m), | 0.5 | 0.2 | 0 |
| Wind, | 0.6 | 0.2 | 0 |

Partial Factors for Dead and Live (Variable) Loads

| | | |
|---|---|---|
| $\gamma_G$ | 1.35 | Unfavorable |
| $\gamma_G$ | 1.1 | Favorable |
| $\gamma_Q$ | 1.5 | Unfavorable |
| $\gamma_Q$ | 0 | Favorable |

| | Leading Variable Effect | Accompanying Variable Effect | G | Q | $Q_{Roof}$ | S | Rain | W | N | E | H |
|---|---|---|---|---|---|---|---|---|---|---|---|
| G | | | | | | | | | | | |
| G+Q | Q | | 1.35 | 1.5 | 1.5 | | | | 1 | | 1.35 |
| G+Q+S | Q | S | 1.35 | 1.5 | 1.5 | 1.05 | | | 1 | | 1.35 |
| G+S+Q | S | Q | 1.35 | 1.05 | 1.05 | 1.5 | | | 1 | | 1.35 |
| G+Q+R | Q | R | 1.35 | 1.5 | 1.5 | | 1.05 | | 1 | | 1.35 |
| G+R+Q | R | Q | 1.35 | 1.05 | 1.05 | | 1.5 | | 1 | | 1.35 |
| G+Q+S+W | Q | S, W | 1.35 | 1.5 | 1.5 | 1.05 | | 0.9 | 1 | | 1.35 - 1 |
| G+S+Q+W | S | Q, W | 1.35 | 1.05 | 1.05 | 1.5 | | 0.9 | 1 | | 1.35 - 1 |
| G+W+Q+S | W | Q, S | 1.35 | 1.05 | 1.05 | 1.05 | | 1.5 | 1 | | 1.35 - 1 |
| G+Q+R+W | Q | R, W | 1.35 | 1.5 | 1.5 | | 1.05 | 0.9 | 1 | | 1.35 - 1 |
| G+R+Q+W | R | Q, W | 1.35 | 1.05 | 1.05 | | 1.5 | 0.9 | 1 | | 1.35 - 1 |
| G+W+Q+R | W | Q, R | 1.35 | 1.05 | 1.05 | | 1.05 | 1.5 | 1 | | 1.35 - 1 |
| G+W (G favorable) | W (unfavorable) | | 1.1 | | | | | 1.5 | 1 | | 1.35 - 1 |
| G+E+Q+S | E | Q, S | 1 | 0.3 | 0.3 | 0.2 | | | | 1 | 1 |
| G+E+Q+R | E | Q, R | 1 | 0.3 | 0.3 | | 0.2 | | | 1 | 1 |

## Thank You…

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