

Version April 2006

Program

RF-COMBI 2006

Generating Load Groups and Load Combinations

User Manual

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© Ingenieur-Software Dlubal GmbH Am Zellweg 2 D-93464 Tiefenbach Germany

 Tel:
 +49 (0) 9673 9203-0

 Fax:
 +49 (0) 9673 1770

 eMail:
 info@dlubal.com

 Web:
 ww.dlubal.com



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I. Introduction

1.1 About RF-COMBI 2006

Dear RF-COMBI users,

The new generations of standards require multiple combinations of load cases to be investigated. For large spatial structures, it can be extremely time-consuming and difficult to compose all combinations manually. The add-on module RF-COMBI automatizes this job.

RF-COMBI generates load groups and load combinations according to German and European standards. These standards are implemented:

- DIN 1055-100 [1]
- DIN 18800 [2]
- EN 1990 [3] together with National Application Documents

RF-COMBI imports the load cases which have been defined in RFEM, allocates them to norm-compliant actions and creates all load groups or load combinations that have to be considered according to the selected standard. These load groups or load combinations can then be exported to RFEM for analysis.

It is not always necessary to consider all generated load groups or load combinations. Thus, they can be limited automatically or manually before exporting them to RFEM. The RFEM calculation will be faster.

RF-COMBI stands out by the following program features:

- Generation of RFEM load groups for non-linear analyses, including imperfections
- Generation of RFEM load combinations for linear analyses
- Option to characterize "alternative" load cases
- Possibility to define imperfection-type load cases dependent on 'genuine' load cases
- Possibility to enter and to save user-defined coefficients in addition to the default values
- Two ways to present the results: *Results by Actions* according to the definition to check the generated results, and *Results by Load Groups/Combinations* according to the layout of the RFEM data navigator.
- Clearly laid-out summary of the results, including the coefficients applied and information on actions and load cases.
- Reduction of load groups to be created by examining RFEM results
- Printout report with individual options for presentation

We wish you much success using RF-COMBI.

Your ING.-SOFTWARE DLUBAL Team



1.2 The RF-COMBI Team

RF-COMBI was developed by the following team.

Program Coordination:

- Dipl.-Ing. Georg Dlubal
- Ing. Vladimír Pátý

Programming:

Mgr. Jaroslav Krul

Program Check, Manual, Translation:

- Bc. Tibor Tóth
- Ing. Vladimír Pátý
- Dipl.-Ing. Frank Faulstich
- Dipl.-Ing. (FH) Robert Vogl

1.3 General Survey of the Manual

This manual is organized in several chapters. Although it is assumed that the basics of the load application according the single standards are known, a couple of details on the theoretical background have been included for a better understanding of the functionality.

Chapter 1: Introduction

This chapter describes the capacities and the range of application of RF-COMBI.

• Chapter 2: Theoretical Background

The theoretical background of RF-COMBI includes the principles and equations of the standards DIN 1055-100, DIN 18800 and EN 1990 that are used to create load groups and load combinations. Also included in this chapter is the possibility to reduce the generated load groups by examining RFEM results.

Chapter 3: Working with RF-COMBI

This chapter explains how to select the design situations, to import load cases from RFEM, and how to allocate load cases to actions and actions to action categories. Furthermore, this chapter includes the handling of user-defined safety and combination coefficients, the presentation of the results, and the export of the generated load groups and load combinations to RFEM.

• Kapitel 4: Examples This chapter includes some examples for reference.

1.4 Installation

The add-on module RF-COMBI is not a separate program but an integrated modul of RFEM. Therefore, the standard installation routine of RFEM has to be started after the purchase of RF-COMBI. Please make sure the new authorization disk is used during the installation as the file on this disk determines which modules are to be activated. The installation process is described in detail in the RFEM manual.



2. Theoretical Background

2.1 General

Especially when applying the new standards DIN 1055-100 [1] and EN 1990 [3], it can be very laborious to consider all potential load situations and to select the decisive one. The add-on module RF-COMBI automatically compiles all possible load groups or load combinations according to the selected standard.

The load cases that have been defined in RFEM provide the basis for RF-COMBI. When importing these load cases, RF-COMBI distinguishes between two categories: genuine load cases and imperfection-type load cases. It is irrelevant for RF-COMBI whether the load cases of the first category are labeled as permanent, variable, accidental, prestress or favorable.

The standards define rules for the combinations of independent actions in various design situations. According to [4], an independent action is given if they result in characteristic values of forces or deformations (e.g. self-weight, live loads, snow and ice loads, wind loads or temperature actions). Actions are independent of one another if they originate from different sources and if their correlation can be neglected with respect to the reliability of the structure.

In RF-COMBI, **actions** are defined. To these actions, RFEM load cases can be allocated. The actions are then assigned to the **action categories** of the selected standard.

2.2 Standards

2.2.1 DIN 1055-100

DIN 1055-100 [1] requires ultimate limit state design and serviceability limit state design.

Ultimate limit states include

- the loss of static equilbrium of the structure or any part of it,
- the failure of the structure or structural members, e.g. due to collapse, excessive deformation, formation of a kinematic chain, loss of stability or gliding,
- the failure of the structure or structural members due to material fatigue or other timedependent effects.

The ultimate limit states have to be analyzed for the following four design situations:

- · Permanent situations which represent the common use of the structure
- Temporary situations which refer to momentary conditions of the structure, e.g. construction level or repair

Combination rule for permanent and temporary situations (basic combination):

$$\sum_{j\geq l} \gamma_{G,j} \cdot G_{k,j} + \gamma_P \cdot P_k + \gamma_{Q,l} \cdot Q_{k,l} + \sum_{i>l} \gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}$$

Equation 2.1

 Accidental situations which comprehend exceptional actions, e.g. fire, explosion or impact

Combination rule for accidental situations:



$$\sum_{j\geq l} \gamma_{GA,j} \cdot G_{k,j} + \gamma_{PA} \cdot P_k + A_d + \psi_{l,l} \cdot Q_{k,l} + \sum_{i>l} \ \psi_{2,i} \cdot Q_{k,i}$$

Equation 2.2

Seismic situations Combination rule for seismic situations:

$$\sum_{j\geq l} G_{k,j} + P_k + \gamma_l \cdot A_{Ed} + \sum_{i\geq l} \psi_{2,i} \cdot Q_{k,i}$$

Equation 2.3

The symbols in these equations are:

- + in combination with
- Σ combination of independent actions due to
- G_{k,j} independent permanent action consisting of one or more characteristic values of permanent forces or deformation parameters
- P_k independent action due to prestress (characteristic value)
- Q_{k,1} prevailing independent variable action consisting of one or more characteristic values of variable forces or deformation parameters
- Q_{k,i} remaining independent variable action consisting of one or more characteristic values of variable forces or deformation parameters
- A_d design value of an accidental action
- A_{Ed} design value of a seismic action
- $\gamma_{\text{G},i}$ partial safety coefficient of an independent permanent action $\text{G}_{k,j}$
- $\gamma_{GA,j}$ same as $\gamma_{G,j}$, applicable to accidental design situations
- $\gamma_{\rm P}$ partial safety coefficient of an independent permanent action due to prestress
- γ_{PA} same as γ_{P} , applicable to accidental design situations
- $\gamma_{Q,1} \qquad \mbox{ partial safety coefficient of the prevailing independent variable action } Q_{k,1}$
- $\gamma_{Q,i}$ partial safety coefficient of a remaining independent variable action $Q_{k,i}$
- γ₁ partial safety coefficient of seismic actions
- Ψ combination factor to determine the representative values of variable actions

The serviceability limit states have to be analyzed for the following three design situations:

• Rare situations with irreversible (lasting) effects on the structure Combination rule for rare situations:

$$\sum_{j \ge l} G_{k,j} + P_k + Q_{k,l} + \sum_{i > l} \psi_{0,i} \cdot Q_{k,i}$$

Equation 2.4

• Frequent situations with reversible (non-lasting) effects on the structure Combination rule for frequent situations:

$$\sum_{j \ge l} G_{k,j} + P_k + \psi_{1,l} \cdot Q_{k,l} + \sum_{i > l} \psi_{2,i} \cdot Q_{k,i}$$

Equation 2.5



• Quasi-permanent situations with long-term effects on the structure Combination rule for quasi-permanent situations:

$$\sum_{j\geq l} G_{k,j} + P_k + \sum_{i\geq l} \psi_{2,i} \cdot Q_{k,i}$$

Equation 2.6

The symbols in these equations are analogous as above.

2.2.2 DIN 18800

DIN 18800 [2] requires ultimate limit state design and serviceability limit state design.

The ultimate limit states have to be analyzed for two design situations – basic combinations and accidental combinations. The following combination rules are significant:

Basic combinations:

 Permanent actions G and all unfavorable variable actions Q_i Combination rule:

$$\sum_{j\geq l} \gamma_{G,j} \cdot G_{k,j} + \sum_{i>l} \gamma_{Q,i} \cdot \psi \cdot Q_{k,i}$$

Equation 2.7

 Permanent actions G and one unfavorable variable action Q_i in each case Combination rule:

$$\sum_{j\geq l} \gamma_{G,j} \cdot G_{k,j} + \gamma_{Q,i} \cdot Q_{k,i}$$

Equation 2.8

Accidental combinations:

 Permanent actions G, all unfavorable variable actions Q_i and one accidental action A Combination rule:

$$\sum_{j\geq l} \gamma_{GA,j} \cdot G_{k,j} + \sum_{i>l} \gamma_{QA,i} \cdot \psi \cdot Q_{k,i} + \gamma_{A,i} \cdot A_{k,i}$$

Equation 2.9

The symbols in these equations are:

- G_{k,j} independent permanent action consisting of one or more characteristic values of permanent forces or deformation parameters
- Q_{k,i} independent variable action consisting of one or more characteristic values of variable forces or deformation parameters
- A_{k,i} independent accidental action consisting of one or more characteristic values of variable forces or deformation parameters
- $\gamma_{G,i}$ partial safety coefficient of an independent permanent action $G_{k,i}$
- $\gamma_{Q,j} \qquad \mbox{ partial safety coefficient of an independent variable action } Q_{k,1}$
- $\gamma_{A,i}$ partial safety coefficient of an independent accidental action $A_{k,i}$
- $\gamma_{\text{GA},j}$ same as $\gamma_{\text{G},j}$, applicable to accidental design situations
- ψ combination factor to determine the representative values of variable actions



2.2.3 EN 1990

EN 1990 [3] makes a destinction between ultimate limit states and serviceability limit states.

Ultimate limit states include:

- EQU: Loss of static equilibrium of the structure or any part of it, where
 - minor variations in the value or the spatial distribution of action from a single source are significant and
 - the strengths of construction materials or ground are generally not governing.
- STR: The internal failure or excessive deformation of the structure or structural members, including footings, piles, basing walls, etc., where the strength of the construction materials governs.
- **GEO**: The failure or excessive deformation of the ground where the strength of soil or rock are significant in providing resistance.
- FAT: The fatigue failure of the structure or structural members.

The ultimate limit states have to be analyzed for the following four design situations:

- Permanent situations which represent the common use of the structure
- Temporary situations which refer to momentary conditions of the structure, e.g. construction level or repair

The combination rule for permanent and temporary situations (basic combination) is either

$$\sum_{j\geq 1} \gamma_{G,j} \cdot G_{k,j} + \gamma_P \cdot P_k + \gamma_{Q,1} \cdot Q_{k,1} + \sum_{i>1} \gamma_{Q,i} \cdot \psi_{0,i} \cdot Q_{k,i}$$

Equation 2.10

or, alternatively for the ultimate limit states STR and GEO, the more unfavorable combination according to equation 2.11 or equation 2.12.

$$\sum_{j\geq l}\gamma_{G,j}\cdot G_{k,j}+\gamma_P\cdot P_k+\gamma_{Q,l}\cdot \psi_{0,l}\cdot Q_{k,l}+\sum_{i>l}\gamma_{Q,i}\cdot \psi_{0,i}\cdot Q_{k,i}$$

Equation 2.11

$$\sum_{j\geq l}\xi_j\cdot\gamma_{G,j}\cdot G_{k,j}+\gamma_P\cdot P_k+\gamma_{Q,l}\cdot Q_{k,l}+\sum_{i>l}\gamma_{Q,i}\cdot \psi_{0,i}\cdot Q_{k,i}$$

Equation 2.12

 Accidental situations which comprehend exceptional actions, e.g. fire, explosion or impact

Combination rule for accidental situations:

$$\sum_{j\geq 1} G_{k,j} + P + A_d + (\psi_{1,1} or \psi_{2,1}) \cdot Q_{k,1} + \sum_{i>1} \psi_{2,i} \cdot Q_{k,i}$$

Equation 2.13

Seismic situations
 Combination rule for seismic situations:

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

Equation 2.14



The symbols in these equations are analogous to DIN 1055-100, cf. chapter 2.2.1. In equation 2.12, ξ_i is the reduction factor of the permanent unfavorable actions.

The serviceability limit states have to be analyzed for the following three design situations:

• Rare situations with irreversible (lasting) effects on the structure Combination rule for rare situations:

$$\sum_{j\geq 1} G_{k,j} + P_k + Q_{k,1} + \sum_{i>1} \psi_{0,i} \cdot Q_{k,i}$$

Equation 2.15

• Frequent situations with reversible (non-lasting) effects on the structure Combination rule for frequent situations:

$$\sum_{j\geq 1} G_{k,j} + P_k + \psi_{1,l} \cdot Q_{k,l} + \sum_{i>1} \psi_{2,i} \cdot Q_{k,i}$$

Equation 2.16

• Quasi-permanent situations with long-term effects on the structure Combination rule for quasi-permanent situations:

$$\sum_{j\geq 1}G_{k,j}+P_k+\sum_{i\geq 1}\psi_{2,i}\cdot Q_{k,i}$$

Equation 2.17

The combination rules are set in the European standard EN 1990, but the individual countries are able to modify the values of the coefficients. When selecting "EN 1990 CEN" in RF-COMBI, the coefficients according to the European committee CEN are applied. Option "EN 1990 CZ" is based on the national Czech coefficients.

2.3 Reducing the Generated Load Groups

The number of generated load groups or load combinations significantly depends on the complexity of the structure and on the quantity of actions and load cases.

RF-COMBI provides an option to effectively reduce the number of load groups by generating only the governing ones. For this purpose, one or more load combinations are generated automatically and analyzed with RFEM. The number of load combinations depends on the selected design situations.

At every FE node, the results are examined for extremal values load case by load case. Only the relevant load cases are then used in RF-COMBI when generating load groups or load combinations.

The reduction via automatically generated load combinations guarantees that the results of RF-COMBI include all governing load groups. When preferred, user-defined load combinations can be created in RFEM and also be used in RF-COMBI to reduce the number of generated load groups.

This reduction is only possible for generating load groups, i.e. not for load combinations.



3. Working with RF-COMBI

3.1 Starting RF-COMBI

RF-COMBI is called up either via menu Additional Modules \rightarrow Others \rightarrow RF-COMBI or via the relevant entry among the additional modules of the Data navigator.



Figure 3.1: Calling up RF-COMBI via menu Additional Modules or the Data Navigator

3.2 Masks

Both the input to define the RF-COMBI cases and the numerical results on the screen are handled in masks.

On the left, the navigator lists all available masks. The list box of all RF-COMBI cases is arranged above it.

The masks can be accessed by either clicking on the entry in the navigator or browsing through entries via the [F2] and [F3] keys or the [<] and [>] buttons.

[Calculation] starts the generation when the input of data has been completed.

[OK] saves all RF-COMBI data before quitting the module, [Cancel] terminates it without saving any data.

[Help] or the [F1] key call up the online help.



[Coefficients...] calls up the dialog to check or edit the partial safety and combination coefficients.

[Check] performs a plausibility check.

Buttons [Calculation], [Coefficients...] and [Check] are only available in the input masks.

In the result masks, button [Export...] is accessible to transfer the generated load groups or load combinations to RFEM.

CA1 - Load Groups	-	2.2 Loa	ad Grou	ps											
nput Data			A	B	С	D	E	F	G	н					
- General Data		16		Design											
- Actions		Lu	Apply	Situation	LUT	LU2	LC3	LU4	LUS	LC6					
 Action Categories 		LG1	Ľ	UB	1.35	1.35	-	•	•	•					
 Imperfections 		LG2	L N	UB	1.35	1.35	1.05	•	•	•					
esults		LG3		UB	1.35	1.35	1.05	1.05	•	•					
- Load Groups by Actions		LG4	<u> </u>	UB	1.35	1.35		1.05		•					
Load Groups		LGS	<u>×</u>	UB	1.35	1.35	1.05	•	1.05	-					
		LGB	×	UB	1.35	1.35	1.05	•	•	1.05					
		LG7		UB	1.35	1.35	1.05	1.05	1.05	•					
		LG8	<u> </u>	UB	1.35	1.35	1.05	1.05		1.05					
		LG9	×	UB	1.35	1.35	•	1.05	1.05	-					
		LGIU	×	UB	1.35	1.35	•	1.05	•	1.05					
		LGTT	×	UB	1.35	1.35	•	•	1.05	•					
		LG12	×	UB	1.35	1.35	•	-	•	1.05					
		Load C	ases in G	enerated Loa	id Group	LG1				U	Iltimate Lin	hit State -	Basic C	ombination	
		LC	Loa	d Case Desci	ription	Act	ion	Category	y De	ominant	ξ	γ	Ψ	ξ.γ.ψ	
		LC1				AC	1	1.				1.35		1.35	
		LC2				AC	1	1.				1.35	-	1.35	

Figure 3.2: Results mask 2.2 Load Groups

3.3 Input Masks

All required data and parameters are defined in input masks.

3.3.1 Combination Rules according to DIN 1055-100

3.3.1.1 Mask 1.1 General Data

When RF-COMBI is called up, mask 1.1 General Data appears.



3 - DIN 1045-100, Load Grot 💌	1.1 General Data					
out Data	Generate			Supplementary Examinat	tion	8
- Actions - Action Categories - Imperfections	 RFEM Load Groups Non-Linear Analyses RFEM Load Combin Linear Analyses 	for ations for		 Reduce Possible Lo- by Examining RFEM From User-Define Combinations 	ad Groups E Results E	
	Combination Rules acco	rding to Code		From Load Comb	inations:	
	DIN 1055-100	•				
	Generating for Design S	ituations		Settings for Combinatoric	s acc. to EN 1990	
	Static Equilibrium:	Basic Combination Accidental Seismic Page Combination	EB EA ES	Basic Combination Apply Combination Rule:	C Equation 6.10 Equations 6.1 and 6.10b	0 10a
	Serviceability	Accidental Seismic Rare	UA US SR	Accidental Combination to Equations 6.11a and I Apply Combination Coefficient:	according 6.11b	Generating
	Limit State:	Frequent	SF	Numbering	*) psrz, i	Load Groups or Load Combinatio
	Generate Suppleme from Favorable Pern	ntary Combinations		Start Number of Generat	ted	
	Comment					
	ULS - EQU					

Figure 3.3: Mask 1.1 General Data

Section *Generate* determines whether *load groups for non-linear analyses* or *load combinations for linear analyses* are to be generated. The difference between load groups and load combinations is described in detail in the RFEM manual.

In section *Combination rules according to code*, the standard can be selected that controls the generation of the load groups or load combinations. *DIN 1055-100*, *DIN 18800* and *EN 1990* are available. This chapter 3.3.1.1 refers to DIN 1055-100.

DIN 1055-100 requires ultimate limit state design and serviceability limit state design. Ultimate limit state design distinguishes between the loss of static equilibrium and failure of the structure. The specifications are set in section *Generating for Design Situations*:

- Static equilibrium (position stability in ultimate limit state, partial safety coefficients of design criterion loss of static equilibrium)
 - Basic combination according to equation 2.1
 - Accidental according to equation 2.2
 - Seismic according to equation 2.3
- Ultimate limit state (failure of the structure, partial safety coefficients of design criterion collapse of the structure)
 - Basic combination according to equation 2.1
 - Accidental according to equation 2.2
 - Seismic according to equation 2.3
- Serviceability limit state (service requirements)
 - Rare according to equation 2.4
 - Frequent according to equation 2.5
 - Quasi-permanent according to equation 2.6

Option Generate supplementary combinations from favorable permanent actions is to distinguish between favorable and unfavorable permanent actions so that different partial safety coefficients are considered, which only applies to the ultimate limit state design situations. The static equilibrium design situations automatically account for the influence of favorable and unfavorable permanent actions, while the serviceability limit state design situations do not differentiate between favorable and unfavorable actions.



In dialog section *Supplementary Examination*, it can be determined whether to *reduce the possible load groups by examining RFEM results*. Via the button next to this option, it is possible to limit the result values that are relevant for this analysis.



Figure 3.4: Dialog Examining Result Values

Either automatically generated combinations can be analyzed in RFEM or previously defined RFEM combinations can be selected. The reduction of results is explained in chapter 2.3.

In dialog section *Numbering*, the *first number of generated load group* or *load combination* can be specified that will be created in RFEM after the export. By clicking on the button right to the input field, the first vacant number is preset.

3.3.1.2 Mask 1.2 Load Cases in Actions

In this mask, actions are defined. The existing RFEM load cases are then allocated to these actions. The mask comprises sections *Actions*, *Existing Load Cases* and *Load Cases in Action*.



Figure 3.5: Mask 1.2 Load Cases in Actions



Section *Actions* lists all actions that have been defined. It is possible to add an *Action Description* or a *Comment*.

A new action is created by clicking on the left button at the bottom of section Actions.

The second button creates as many new actions as existing load cases. Every load case is allocated to exactly one action.

The third button deletes the selected action.

The right button of section Actions deletes all actions that have been created.

When opening this mask, section *Existing Load Cases* lists all load cases that have been defined in RFEM. This means that they are not allocated to any action yet. Load cases that have been defined as imperfections in RFEM are not included in this list.

If the button at the bottom left of this section is pressed (i.e. active), then the load cases which have not been allocated yet are listed. If the button is not pressed (i.e. inactive), all existing load cases are listed.

The second button at the bottom of this section calls up the general data of the selected load case for modification.

Section *Load Cases in Action* lists all load cases that have been assigned to the selected action. The load cases can be allocated by clicking on the arrow buttons between sections *Existing Load Cases* and *Load Cases in Action AC*. It is possible to transfer either only the selected load case(s) or all existing load cases at once. Every load case can be allocated only once, i.e. to only one action. The button at the bottom of this section calls up the general data of the selected load case for modification.

It is possible to include two or more load cases as *alternative* ones. This means that these load cases never simultaneously appear in a load group or load combination. Load cases can be labeled as alternative ones by an identical name in column *Alternative*.



Figure 3.6: Alternative load cases LC5 and LC6



3.3.1.3 Mask 1.3 Actions in Action Categories

Here, the actions AC of the previous mask are allocated to action categories.

- DIN 1045-100, Load Gro	1.3 Actions in Action Categories according to	DIN 1055-100	
Data jeneral Data	Action Categories	Actions	
ctions	1. Permanent Actions	G _{k,j} : AC1	۴.
oction Categories	2. Prestress	P _k :	<u> </u>
	- 3 A Live Loads - Category A - Domestic/Besidential	Bid Out	
	3.B · Category B · Offices	Q _k i:	Traffic Loads ar
	3.C · Category C · Congregation Areas .	Q _{k,i} : AC2	Subsumed as
	3.D - Category D - Shopping Areas	Q _{k,i} :	Action
	3.E · Category E · Storage Buildings	Q _{k,i} :	*
	3. <u>F</u> Traffic Loads · Category F · Vehicle Weight < 30 I	N Q _{k.i} : AC3	*≽
	3.G - Category G - Vehicle Weight > 30	<n q<sub="">k,i:</n>	1
	3. <u>H</u> · Category H · Roofs	Q _{k,i} :	<u>×</u>
	4.A Snow and Ice Loads - Sites Located at H < 1000 r	nasl Q _{k,i} :	*
	4_B · Sites Located at H > 1000 r	nasl Q _{k,i} :	1
	5. Wind Loads	Q _{ki} :	<u></u>
	Emperature Actions (Non Fire)	Due L	
	7. Foundation Subsidence	Qp.:	
	8. Other Actions	Q _{ki} :	
	9 Assidentel Astisus	A	
	 Accidental Actions Seismin Actions 	Ad.	
	To. Seisnic Actions	···· AEd. J	R

Figure 3.7: Mask 1.3 Actions in Action Categories

The actions are assigned in the *Actions* input fields that are supported by the pick buttons: Dialog *Select Actions* is called up which lists all actions that have not been allocated yet.





In this mask, option *Subsume Live Loads and Traffic Loads to be Subsumed as one Independent Action* is available. The possibility to include live loads and traffic loads of a building within one independent action is described e.g. in [4], appendix A, page 37. This option has an effect on the generation of load groups or load combinations according to



equations 2.1, 2.2, 2.4 and 2.5, where the dominant variable action $Q_{k,1}$ is used. If this option is active, then all live loads and traffic loads are either simultaneously considered as the dominant action, or none of them is regarded as dominant. This means that all live loads and traffic loads are consistently multiplied by the same combination coefficient ψ .

3.3.1.4 Mask 1.4 Imperfection-Type Load Cases

Mask 1.4 Imperfection-Type Load Cases is available when load groups are to be generated. Imperfections require 2nd or 3rd order analyses.

This mask consists of sections *Existing Load Cases - Type 'Imperfection'*, *Imperfection-Type Load Cases in Combinatorics* and *Options*.

Ele Settings Help CA3-DIN 1045-100. Load Grost Imput Data General Data Action Categories Imperfection towards +Y Imperfections Imperfections Imperfections Imperfections Imperfection towards +Y Imperfections Imperfec	RF-COMBI 2006 - [RF-KOMBI	_1]							×
CA3-DN 1045-100, Load Grout I.4 Imperfection-Type Load Cases Input Data General Data Actions Action Categories Imperfections Imperfection towards +X Imperfections Imperfection towards +Y Imperfections Imperfection-Type Load Cases Imperfections Imperfection-Type Load Cases Imperfections Imperfection-Type Load Cases Imperfection-Type Load Cases Imperfection-Type Load Cases Imperfection-Type Load Cases	File Settings Help								
Calculation Coefficients Check	CA3 - DIN 1045-100, Load Grou	1.4 Imper Existing Lo LC8 LC9	rfection-Type Load Cas and Cases - Type Imperfection Imperfection towards +X Imperfection towards +Y		Imperfect	ion-Type Load Cases in Con Load Case Description	nbinatorics Alternative Plions I Alcotte Imperior I Include Imperior the Combin Load Cases	Only with LC	Never with LC
	2 🗢 🗣	Calculation	n Coefficients Cł	neck			[ОК	Cancel

Figure 3.9: Mask 1.4 Imperfection-Type Load Cases

Section *Existing Load Cases - Type 'Imperfection'* lists all load cases that have been labeled as imperfections in RFEM. These load cases can be included in the combinatorics via the arrow buttons between sections *Existing Load Cases Cases - Type 'Imperfection'* and *Imperfection-Type Load Cases in Combinatorics*.

RF-COMBI considers only those imperfection-type load cases that are listed in section *Imperfection-Type Load Cases in Combinatorics*.

As soon as at least one imperfection-type load case has been selected, every possible load group is created twofold – with and without imperfections. If only load groups with imperfections are to be generated, option *Allocate Imperfection-Type Load Cases to Every Load Group* must be set active in section *Options*.

In figure 3.10, load cases LC8 and LC9 have been selected. With these settings, all load groups are created without imperfections first. Then, LC8 is included in the generation of further load groups, followed by an extra run with LC9 instead. Finally, LC8 and LC9 are applied simultaneously.



RF-COMBI_2006 [RF-KOMBI_1] Image: Settings_Help Ele_Settings_Help CA3 - DIN 1045-100, Load Group Input Data Actions Action Categories Imperfections
Input Data I.4 Imperfection-Type Load Cases Input Data Existing Load Cases - Type Imperfection' Actions Action Categories Imperfections Imperfection
CA3-DIN 1045-100, Load Grot, 1.4 Imperfection-Type Load Cases Input Data Existing Load Cases - Type Imperfection' General Data Concrete Construction Actions Imperfections Imperfections Imperfection Imperfections Imperfection Imperfections Imperfection Imperfections Imperfection Imperfections Imperfection
Input Data General Data Actions Imperfections Existing Load Cases - Type Imperfection' Existing Load Cases - Type Imperfection' Imperfection-Type Load Cases in Combinatorics LC Load Case Description LC3 Imperfection LC3 Imperfection LC3 Imperfection
Actions Action Categories Imperfections
Action Categories Imperfections LC9 Imperfection
Options
Allocate Imperfection-Type Load Cases
to Every Load Group
Include Imperfection-Type Load Cases in the Combinations Strikers to Defined
Load Cases
Image: Calculation Coefficients Check Image: Calculation Coefficients Cancel

Figure 3.10: Mask 1.4 Imperfection-Type Load Cases in Combinatorics

It is also possible to classify *Alternative* imperfection-type load cases. Then only one imperfection is added per load group, i.e. they are not applied simultaneously.

Columns Only with LC and Never with LC provide the possibility to additionally reduce the number of generated load groups. For this purpose, option Include Imperfection-Type Load Cases in the Combination Subject to Defined Load Cases must be set active. Then the correlation can be specified between an imperfection and a 'genuine' load case.

it=cumbi 2006 - [RF-KUMBI. ile Settings Help	
CA3 - DIN 1045-100, Load Grot 💌	1.4 Imperfection-Type Load Cases
nput Data General Data Actions Action Categories Imperfections	Existing Load Cases - Type Imperfection' Imperfection-Type Load Cases in Combinatorics LC Load Case Description Alternative Only with LC Never with L LC3 Imperfection LC9 Imperfection SEE Options V Allocate Imperfection-Type Load Cases in the Combinations Subject to Defined Load Cases

Figure 3.11: Mask 1.4 Imperfection-Type Load Cases, Option Only with LC



3.3.1.5 Dialog Coefficients

Dialog *Coefficients* is called up via button [Coefficients...]. There are two registers available that contain the default settings of the *Partial Safety Coefficients* and the *Combination Coefficients* according to DIN 1055-100. These factors are applied when load groups or load combinations are generated.

Register *Partial Safety Coefficients* includes both design situations *Static Equilibrium* and *Ultimate Limit State*. The relevant partial safety coefficients are different, though.

DIN 1 Partia	1055-100 - Partial Safety C al Safety Coefficients for S	Coefficients DIN 1055-1	00 - Combination	Coefficients	
Parti	al Safety Coefficients for S	tatic Equilibrium			
Actic					
Actic			D	esign Situation	
ACUC	on Category		Basic Combination	Accidental	Seismic
1	Permanent Actions	unfavorable %G sup	1.10	1.00	1.00
		favorable %G inf.	0.90	0.95	100
		101010010 10,111	0.00	0.00	1.00
2.	Prestress	unfavorable YP,sup	1.10 ≑	1.00 🛨	1.00 ≑
		favorable YP,inf	0.90 🛨	1.00 🛨	1.00 ≑
3					
8.	Variable Actions	unfavorable γο:	1.50 🛨	1.00 🛨	1.00
9.	Accidental Actions	γa:		1.00 +	
10.	Seismic Actions	γı:			1.00
Parti	al Safety Coefficients for U	Iltimate Limit State		enter Obretter	
			Basic	esign situation	
Actic	on Category		Combination	Accidental	Seismic
1.	Permanent Actions	unfavorable YG,sup	1.35 🛟	1.00 +	1.00 ÷
		favorable γ _{G,inf}	1.00 ≑	1.00 ≑	1.00 ÷
2.	Prestress	γp:	1.00 🛨	1.00 🛨	1.00 🛨
3 8.	Variable Actions	unfavorable YQ:	1.50 🛟	1.00 🛨	1.00 +
_					
9.	Accidental Actions	γ A :		1.00 🕂	
10.	Seismic Actions	γ1:			1.00
กไ	~ <u>-</u>				0K C

Figure 3.12: Default Partial Safety Coefficients according to DIN 1055-100

The factors in register Combination Coefficients are dependent on the action categories.

DIN 1055-100 - Partial Safety Coefficients DIN 1055-10	U - Combination Coerr	icients	
Combination Coefficients of Variable Actions			
Action Category	Ψο	Ψ1	Ψ2
3.A Live Loads · Category A · Domestic/Residenti	al Bld. 0.70 🛨	0.50	0.30
3.B · Category B · Offices	0.70 🛨	0.50	0.30 📫
3.C · Category C · Congregation Areas	0.70 🛨	0.70 🛨	0.60 🛨
3.D · Category D · Shopping Areas	0.70 🛨	0.70 🛨	0.60 🛨
3.E · Category E · Storage Buildings	1.00 🛨	0.90 🛨	0.80 🕂
3.F Traffic Loads - Category F - Vehicle Weight < 30) kN 0.70 🛨	0.70 🗧	0.60 🛟
3.G · Category G · Vehicle Weight > 30) kN 0.70 🛨	0.50 🗧	0.30 🛟
3.H · Category H · Roofs	0.00 🛨	0.00	0.00
4.A Snow and Ice Loads - Sites Located at H < 1000) masl 0.50 🛫	0.20 🗧	0.00 🛟
4.B - Sites Located at H > 1000) masi 0.70 🛨	0.50 🛟	0.20 +
5. Wind Loads	0.60 🛨	0.50	0.00
6. Temperature Loads (Non Fire)	0.60 🛨	0.50 🛟	0.00
7. Foundation Subsidence	1.00 🛨	1.00 🐳	1.00 ÷
8. Other Actions	0.80 🛨	0.70	0.50 +

Figure 3.13: Default Combination Coefficients according to DIN 1055-100



Apart from these default values according to the selected code, user-defined sets of coefficients can be created and saved for further use. Button [Save Coefficients] calls up the dialog to define a name for a user-defined set of coefficients.

Part	al Safety Coefficients for	Static Equilibrium	_		
			Basic	esign Situation	
Acti	ion Category		Combination	Accidental	Seismic
1.	Permanent Actions	unfavorable YG,sup	1.20 ÷	1.00 -	1.00 🗧
		favorable YG,inf	0.90	0.95	1.00 🛨
2.	Prestress	unfavorable YP,sup:	1.10 +	1.00 -	1.00 +
		favorable YP,inf	0.90	1.00 🛨	1.00
3 8.	Variable Actions Sa	ve Coefficients		×	1.00 🛨
9.	Accidental Actions	ave Factors as 'Set of Coe	fficients'		
	Ν	lame: User-Defined Set o	f Coefficients		
10.	Seismic Actions				1.00
Part	ial Safety Coefficients	This Set of Coefficients	as Default		
Acti	ion Category	2	ок	Cancel	Seismic
1.	Permanent Actions	unfavorable YG,sup:	1.35	1.00	1.00 +
		favorable γG,inf	1.00 ≑	1.00 🛨	1.00 🛨
2.	Prestress	γp:	1.00	1.00	1.00 🕂
3 8.	Variable Actions	unfavorable γα:	1.50 🛫	1.00 🛨	1.00 🛨
9.	Accidental Actions	γA:		1.00	
10	Calcula Antinas				1.00

Figure 3.14: Dialog Save Coefficients

This set of coefficients can be set as default.

Button [Load Set of Coefficients] calls up the dialog to import a specific user-defined set of coefficients.

Load Coefficients		>
Sets of Coefficients		
Name	Default	
Default		
User-Defined		
	×	
2	ОК	Cancel
<u> </u>		00.1001

Figure 3.15: Dialog Load Coefficients

In column *Name*, the table is headed by the *Default* set of coefficients according to the selected standard. This set can neither be modified nor deleted.

In the column right to it, it is possible to choose a different set of coefficients as default.





3.3.2 Combination Rules according to DIN 18800

3.3.2.1 Mask 1.1 General Data

When RF-COMBI is called up, mask 1.1 General Data appears.

I - Lase I			10
ut Data General Data	Generate	Supplementary Examination	
Actions	 RFEM Load Groups for Non-Linear Analyses 	Reduce Possible Load Groups by Examining RFEM Results	
Imperfections	C RFEM Load Combinations for Linear Analyses	 From User-Defined Combinations 	S n/
	Combination Rules according to Code	C From Load Combinations:	
	DIN 18800		
	Generating for Design Situations	Settings for Combinatorics acc. to EN 1991	
	Static Equilibrium: Basic Combination EB	Basic Ultimate Limit State Combination	
	Accidental EA	Rule: Caluation 6.10	
	Vitimate Limit State: V Basic Combination UB	and 6.10b	
	Serviceability Limit State S	Accidental Combination according	
		Apply Combination 💿 psi-1,1	A PZEN
		Coefficient: C psi-2,1	Generating Load Groups or
		Numbering	Load Combinations
	Generate Supplementary Combinations	Start Number of Generated	
	from Favorable Permanent Actions	- Load Group: 1	
	Comment		

Figure 3.16: Mask 1.1 General Data

This mask is identical to the one which is described in chapter 3.3.1.1 (p. 12), except for section *Generating for Design Situations*.

DIN 18800 requires ultimate limit state design and serviceability limit state design. Ultimate limit state design distinguishes between the loss of static equilibrium and the failure of the structure. The specifications are set in section *Generating for Design Situations*:

- Static Equilibrium (position stability in ultimate limit state, partial safety coefficients of design criterion loss of static equilibrium)
 - Basic Combination according to equations 2.7 and 2.8
 - Accidental according to equation 2.9
- Ultimate Limit State (failure of the structure, partial safety coefficients of design criterion collapse of the structure)
 - Basic Combination according to equations 2.7 and 2.8
 - Accidental according to equation 2.9
- Serviceability Limit State (service requirements) according to equation 2.7

3.3.2.2 Mask 1.2 Actions

In this mask, actions are defined. The existing RFEM load cases can then be allocated to these actions. The functionality which is described in chapter 3.3.1.2 (p. 14) does not depend on a specific standard.



RF-COMBI 2006 - [RF-KOMB	[_1]	<u>×</u>
Elle Settings Help CA1 - Load Groups	1.2 Load Cases in Actions	
Input Data — General Data — Action Categories — Imperfections Results — Load Groups by Actions — Load Groups	Actions AC1 Permanent Actions AC2 Live Loads - Shopping Areas AC3 Traffic Loads - Vehicle Weight Traffic Loads - Vehicle Weight Comments: Comments: Comments: Existing Load Cases Load Cases in Action AC3 LC7 Prestress Image: Comment set of the set of t	Note: Button 'Create New Action' can be used to define 'Actions'. Those are independent of each other. By means of the tables below, Load Cases can then be allocated to each Action. In the following mask (1.3), the Actions are then allocated to the corresponding 'Action Categories'. Alternative Load Position
2 F P	Calculation Coefficients Check	OK Cancel

Figure 3.17: Mask 1.2 Load Cases in Actions

3.3.2.3 Mask 1.3 Action Categories

Here, the actions AC of the previous mask are allocated to action categories. The functionality is described in chapter 3.3.1.3 (p. 16).

RF-COMBI 2006 - [RF-KOM File Settings Help	MBI_1]	<u>×</u>
[CA1 - Load Groups Input Data — General Data — Actions — Imperfections Results — Load Groups by Actions — Load Groups	1.3 Actions in Action Categories Actions Action Categories Actions 1. Permanent Actions Gikgi 2. Variable Actions Gikgi 3. Accidental Actions Add	
2 F B	Calculation Coefficients Check	K Cancel

Figure 3.18: Mask 1.3 Actions in Action Categories

3.3.2.4 Mask 1.4 Imperfections

Mask 1.4 Imperfection-Type Load Cases is available when load groups are to be generated. Imperfections require 2nd or 3rd order analyses.

This mask consists of sections *Existing Load Cases - Type 'Imperfection'*, *Imperfection-Type Load Cases in Combinatorics* and *Options*. Its description is in chapter 3.3.1.2 (p. 14).



RF-COMBI 2006 - [RF-KOMBI	[1]	×
Eile Settings Help		_
CA1 - Load Groups	1.4 Imperfection-Type Load Cases	
CA1 - Load Groups	1.4 Imperfection-Type Load Cases Existing Load Cases - Type Imperfection' LC3 Imperfection Imperfection	s
	Calculation Coefficients Check OK Can	el (

Figure 3.19: Mask 1.4 Imperfection-Type Load Cases

3.3.2.5 Dialog Coefficients

Dialog *Coefficients* is called up via button [Coefficients...]. There are two registers available that contain the default settings of the *Partial Safety Coefficients* and the *Combination Coefficients* according to DIN 18800. These factors are applied when load groups or load combinations are generated.

Register *Partial Safety Coefficients* includes the design situations *Static Equilibrium*, *Ultimate Limit State* and *Serviceability Limit State* with the relevant partial safety coefficients.

effi	icients - Default				
DIN	18800 - Partial Safety Coe	fficients DIN 18800 - Ci	mbination Coeff	icients	
Parl	tial Safety Coefficients for !	Static Equilibrium			
Act	ion Category		Design : Basic Combination	Situation Accidental	
1.	Permanent Actions	unfavorable γG,sup favorable γG,inf	1.10	1.00 🗧	
2.	Variable Actions	unfavorable γQ:	1.50	1.00 📫	
3.	Accidental Actions	γa:		1.00	
Parl	tial Safety Coefficients for I	Jltimate Limit State			
			Design :	Situation	
Act	ion Category		Basic Combination	Accidental	
1.	Permanent Actions	unfavorable γ _{G,sup} favorable γ _{G,inf}	1.35	1.00 ÷	
2.	Variable Actions	unfavorable γQ:	1.50	1.00	
3.	Accidental Actions	γa		1.00	
Parl	tial Safety Coefficients for !	Serviceability Limit State			
Act	ion Category		Design 9 Basic Combination	Situation	
1.	Permanent Actions	γG	1.00		
2.	Variable Actions	unfavorable γο:	1.00		
					Cancel

Figure 3.20: Default Partial Safety Coefficients according to DIN 18800



The factors in register Combination Coefficients are related to the design situation.

DIN 18800 - Partial Safety Coefficients	DIN 18800 - Combination Coefficients	
Combination Coefficients of Variable A	ctions	
Design Situation	Ψi	
Static Equilibrium	0.90	
Ultimate Limit State	0.90 +	
Serviceability Limit State	0.90 🗮	

Figure 3.21: Default Combination Coefficients according to DIN 18800

Apart from these default values according to the selected code, user-defined sets of coefficients can be created. This is described in chapter 3.3.1.5 (p. 19).

3.3.3 Combination Rules according to EN 1990

3.3.3.1 Mask 1.1 General Data

When RF-COMBI is called up, mask 1.1 General Data appears.

CA1 - Load Groups	1 1 General Data		
Call Coops Coops	International Data Generate ● IRFEM Load Groups for Non-Linear Analyses ● RFEM Load Combinations for Linear Analyses Combination Rules according to Code En 1390 CEN ▼ Generating for Design Situations Ø Static Equilibrium: Ø Static Equilibrium: Ø Static Equilibrium: Ø Seismic Ø Static Equilibrium: Ø Seismic Ø Seismic Ø Seismic Ø Seismic Ø Serviceability Rare Ø Generate Supplementary Combinations for from Favorable Permanent Actions Comment	Supplementary Examination Prom User-Defined Combinations From Load Combinations: From Load Combinations: Settings for Combinations cac. to EN 1930 Basic Combination Equations 6.10 and 6.10b Accidental Combination according to Equations 6.11a and 6.11b Apply Combination psi-1.1 Coefficient: psi-2.1 Numbering Start Number of Generated - Load Group: Load Group: Image: 	or nations

Figure 3.22: Mask 1.1 General Data



This mask is identical to the one which is described in chapter 3.3.1.1 (p. 12), except for section *Generating for Design Situations*.

Two variants of EN 1990 are available in RF-COMBI – EN 1990 CEN and EN 1990 CZ – which differ in some default coefficients. The following figures represent the CEN coefficients.

EN 1990 requires ultimate limit state design and serviceability limit state design. Ultimate limit state design distinguishes between the loss of static equilibrium and the failure of the structure. The specifications are set in section *Generating for Design Situations*:

- Static Equilibrium (position stability in ultimate limit state, partial safety coefficients of design criterion loss of static equilibrium)
 - Basic Combination according to equations 2.10, 2.11 or 2.12
 - Accidental according to equation 2.13
 - Seismic according to equation 2.14
- Ultimate Limit State (failure of the structure, partial safety coefficients of design criterion collapse of the structure)
 - Basic Combination according to equations 2.10, 2.11 or 2.12
 - Accidental according to equation 2.13
 - Seismic according to equation 2.14
- Serviceability Limit State (service requirements)
 - Rare according to equation 2.15
 - Frequent according to equation 2.16
 - Quasi-permanent according to equation 2.17

3.3.3.2 Mask 1.2 Actions

In this mask, actions are defined. The existing RFEM load cases can then be allocated to these actions. The functionality which is described in chapter 3.3.1.2 (p. 14) does not depend on a specific standard.



Figure 3.23: Mask 1.2 Load Cases in Actions



3.3.3.3 Mask 1.3 Action Categories

Here, the actions AC of the previous mask are allocated to action categories. The functionality is described in chapter 3.3.1.3 (p. 16).

-			
ut Data General Data	Action Categories	Actions	
Actions Action Categories	1. Permanent Actions	AC1	
Imperfections	2. Prestress Pk:	\$	
	$\label{eq:alpha} 3\underline{A} \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	×	Live Loads and
	3. <u>B</u> · Category B · Offices Q _{k,i} :	<u></u>	Traffic Loads t
	3.C - Category C - Congregation Areas Q _{k,i} :	<u></u>	Independent
	3.D · Category D · Shopping Areas Q _{k,i} :	AC2	Action
	3. <u>E</u> · Category E · Storage Buildings Q _{k,i} :	1	
	3. <u>F</u> Traffic Loads - Category F - Vehicle Weight < 30 kN Q _{k,i} :	×.	
	3.G · Category G · Vehicle Weight > 30 kN Q _{k,i} :	X	
	3.H - Category H - Roofs Q _{k,i} :	4	
	$\underline{4}.A$. Snow and Ice Loads \rightarrow Finland, Island, Norway, Sweden $\mathbb{Q}_{k,i}$:	1	
	$4_{a}B$ - Other CEN Countries - Sites Located at H > 1000 masl $- Q_{{\bf k},i};$	×	
	4.C - Sites Located at H < 1000 masl Q _{k,i} :	4	
	5. Wind Loads	<u>k</u>	
	6. Temperature Actions (Non Fire)	×	
	Z. Accidental Actions	×	
	8. Seismic Actions	AC3	

Figure 3.24: Mask 1.3 Actions in Action Categories

3.3.3.4 Mask 1.4 Imperfections

Mask 1.4 Imperfection-Type Load Cases is available when load groups are to be generated. Imperfections require 2nd or 3rd order analyses.

This mask consists of sections *Existing Load Cases - Type 'Imperfection'*, *Imperfection-Type Load Cases in Combinatorics* and *Options*. Its description is in chapter 3.3.1.2 (p. 14).

Carl Code dividuals Imperfection Type Load Cases in Combinatorics Period Pata - Action Categories Imperfections Existing Load Cases - Type Imperfection ¹ Imperfections Imperfection Imperfection <	CA1 - Load Groups	1.4 Immerfection-Tune Load Cases
	Input Data General Data - Action Categories Imperfections	Imperfection Type Load Cases Existing Load Cases - Type Imperfection' Imperfection Type Load Cases in Combinatorics Imperfection Imperfectin

Figure 3.25: Mask 1.4 Imperfection-Type Load Cases



3.3.3.5 Dialog Coefficients

Dialog *Coefficients* is called up via button [Coefficients...]. There are two registers that contain the default settings of the *Partial Safety Coefficients* and the *Combination Coefficients* according to EN 1990. These factors are applied when load groups or load combinations are generated.

Register *Partial Safety Coefficients* includes both design situations *Static Equilibrium* and *Ultimate Limit State*. The relevant partial safety coefficients are different, though.

	cients - Default				
DIN	EN 1990 CEN - Partial Safe	ety Coefficients DIN EN	1990 CEN - Co	mbination Coeff	icients
Part	tial Safety Coefficients for S	itatic Equilibrium			
			D	esign Situation	
Acti	ion Category		Basic	Accidental	Seismic
Act	lon categoly		Combination	Accidental	Jeisinic
1.	Permanent Actions	unfavorable YG,sup:	1.10	1.00 -	1.00 🛨
		favorable YG,inf	0.90 🛨	1.00 🕂	1.00 🛨
2.	Prestress	unfavorable YP,sup:	1.10 🗧	1.00	1.00 ÷
		favorable YP,inf	0.90 ÷	1.00 ÷	1.00 -
3					
6.	Variable Actions	unfavorable γο:	1.50 🛨	1.00 🕂	1.00 🛨
7.	Accidental Actions	γA:		1.00	
8.	Seismic Actions	γ1 [:]			1.00
Dark	tial Safatu Caofficiante for U	Illimate Limit State			
i ait	ial safety coefficients for a	Nimate Linit State	D	esion Situation	
			Basic		
Act	ion Category		Combination	Accidental	Seismic
1.	Permanent Actions	unfavorable YG,sup	1.35 🜩	1.00 🛨	1.00 🛨
		favorable YG,inf	1.00 🛨	1.00 🛟	1.00
2.	Prestress	γP:	1.00	1.00 🛟	1.00 🛨
2. 3	Prestress	γP	1.00	1.00	1.00
2. 3 6.	Prestress Variable Actions	γp: unfavorable γQ:	1.00 +	1.00 +	1.00
2. 3 6. 7.	Prestress Variable Actions Accidental Actions	γp: unfavorable γQ: γA:	1.00	1.00 ÷	1.00
2. 3 6. 7. 8.	Prestress Variable Actions Accidental Actions Seismic Actions	γP: unfavorable γΩ: γA: γ1:	1.00	1.00 ÷	1.00

Figure 3.26: Default Partial Safety Coefficients according to EN 1990 CEN

The factors in register Combination Coefficients are related to the design situation.

efficients - Default					×
DIN EN 1990 CEN - Par	tial Safety Coefficients DIN EN 1990 CE	N - Combinat	ion Coefficients		
Combination Coefficient	s of Variable Actions				
Action Category		ψο	Ψ1	Ψ2	
3.A Live Loads - (3.B - (3.C - (3.D - (Category A - Domestic/Residential Bld. Category B - Offices	0.70 ÷ 0.70 ÷ 0.70 ÷	0.50 ÷ 0.50 ÷ 0.70 ÷	0.30 ÷ 0.30 ÷ 0.60 ÷	
3.E - 0 3.F Traffic Loads - 0	Category E · Storage Buildings	1.00 +	0.90 +	0.80 +	
3.G - C 3.H - C	Category G · Vehicle Weight > 30 kN Category H · Roofs	0.70 +	0.50 +	0.30 +	
4.A Snow and Ice Loa 4.B - Other CEN Coun	ads - Finland, Island, Norway, Sweden tries - Sites Located at H > 1000 masl	0.70	0.50 +	0.20 +	
 Wind Loads Temperature Load 	Is (Non Fire)	0.60	0.20 +	0.00 ÷	
Combination Rule according to Equations 6.10s and 6.10b					
Reduction Coefficient of for Combination Rule ar	f Permanent Unfavorable Actions	ξ 0.85			
2 🚅 🖬 📽]		OK	Cance	

Figure 3.27: Default Combination Coefficients according to EN 1990 CEN



EN 1990 requires the specification of the reduction coefficient ξ which is applied in equation 2.12, i.e. equation 6.10b according to EN 1990.

Apart from these default values according to the selected code, user-defined sets of coefficients can be created. This is described in chapter 3.3.1.5 (p. 19).

3.4 Results Masks

There are two results masks in RF-COMBI. In the first one, the generated results are listed by actions. This clearly arranged presentation corresponds to the manner of definition within the standard. In the second results mask, all load groups or load combinations are listed separately with the relevant load cases.

3.4.1 Generated Load Groups

3.4.1.1 Mask 2.1 Load Groups by Actions

Mask 2.1 Load Groups by Actions consists of two parts. In the upper part, the generated load groups are generally listed by actions. The details of the selected line are specified in the part below.



Figure 3.28: Mask 2.1 Load Groups by Actions

The upper part of this mask presents several columns. In the first column, the *No.* of every line is specified. Column *Apply* controls whether the load group is to be exported to RFEM, column *Generated Load Groups* shows which load groups belong to each result. Column *Design Situation* specifies the situation for which the load groups have been generated. Here, the short symbols of mask 1.1 are used. In the remaining columns, the actions with the relevant factors are listed.

If an entry in the upper part of this mask is clicked on, further details are displayed in the part below. In section *Actions in Generated Load Group*, the involved actions are listed along with their *Description* and *Category* (cf. mask 1.3).



Column *Dominant* marks the prevailing action. The action is dominant if it is applied as action $Q_{k,1}$ in equations 2.1, 2.2, 2.4, 2.5, 2.10, 2.11, 2.13 or 2.16. The coefficients γ , ψ and ξ in the following columns result from the relevant design situation and action category. The final column lists the factors for each action which are the products of the coefficients.

If a specific action has been selected in section *Actions in Generated Load Group*, the associated load cases are displayed in section *Load Cases in Action*. All possible combinations of these load cases within the action are listed which depend on the action category and the potential definition criteria of alternative load cases.

Figure 3.28 shows that altogether 18 load groups were generated for the design situations "Ultimate Limit State, Basic Combination". Five entries (i.e. lines in the upper part of the mask) show how the associated actions were applied in the equations for those design situations. The third line, for example, is 1.35 AC1 + 1.50 AC2 + 1.05 AC3. When applying the actions in the adequate equation, six load groups are generated: *LG5..LG10*.

The first action AC1 was classified as "permanent" action category 1 in mask 1.3. In the generated load groups, coefficient $\gamma = 1.35$ is therefore used. The second action AC2 was classified as "live load" within action category 3.D (shopping areas) in mask 1.3. For it, coefficient $\gamma = 1.50$ is used in the generated load groups. AC2 is the dominant action which may occur as *LC3* or *LC3* + *LC4* or *LC4*. The third action AC3 was classified as "traffic load" within action category 3.F (vehicle weight < 30 kN) in mask 1.3. In the generated load groups, coefficients $\gamma * \psi = 1.50 * 0.70 = 1.05$ are used (as AC2 is assumed as the dominant action within this third line).

3.4.1.2 Mask 2.2 Load Groups

Mask 2.2 Load Groups consists of two parts. In the upper part, all generated load groups are listed. The details of the selected load group are specified in the part below.



Figure 3.29: Mask 2.1 Load Groups

The upper part of this mask presents several columns. In the first column *LG*, the numbers of the generated load groups are listed. Column *Apply* controls whether the load group is to be exported to RFEM. This column is synchronized with the previous results mask 2.1. Column *Design Situation* specifies the situation for which the load groups have been generated. In the remaining columns, the generated load groups are listed.



If an entry in the upper part of this mask is clicked on, further details are displayed in the part below. In section *Load Cases in Generated Load Group*, all load cases represented in the selected load group are listed along with their possible *Description*. In column *Action*, the action number is shown that the relevant load case was allocated to in mask 1.2. The action category is specified in column *Category*. Column *Dominant* marks the prevailing action within the selected load group. The coefficients γ , ψ and ξ in the following columns result from the relevant design situation and action category. The final column lists the factors for each load case which are the products of the coefficients.

Figure 3.29 shows the first twelve load groups of altogether 18 generated load groups. LG5 consists of 1.35 LC1 + 1.35 LC2 + 1.50 LC3 + 1.05 LC5. Load cases LC1 and LC2 are part of action AC1 which was classified as action category 1 ("permanent actions") in mask 1.3. Thus, both load cases are multiplied by factor $\gamma = 1.35$. Load case LC3 is part of action AC2 which was classified as action category 3.D ("live loads – shopping areas"). In LG5, it is the dominant load case and is thus multiplied by factor $\gamma = 1.50$. Load case LC5 is part of action AC3 that was classified as category 3.F ("traffic loads – vehicle weight < 30 kN"). In LG5, this load case is multiplied by factor $\gamma * \psi = 1.50 * 0.70 = 1.05$.

Comparing figures 3.27 and 3.28, it will be noticed that the third line of the generated load groups 1.35 AC1 + 1.50 AC2 + 1.05 AC3 in figure 3.28 includes load groups LG5..LG10 that are described in detail in figure 3.29:

Action AC1 comprises LC1 and LC2. This is a permanent action so that both load cases can only appear together. Action AC2 which comprises LC3 and LC4 is an accidental action. Thus, three combinations are possible: LC3, LC3 + LC4, LC4. Action AC3 includes LC5 and LC6. This is an accidental action, too. LC5 and LC6 were defined as alternative load cases so that either LC5 or LC6 is possible. Consequently, 1.35 AC1 + 1.50 AC2 + 1.05 AC3 stands for 1 * 3 * 2 = 6 load groups altogether, labeled as LG5..LG10.

In mask 2.2, it is thus possible to determine the associated load groups from every line of the previous mask. All possible combinations are identified unless option *Reduce Possible Load Groups by Examining RFEM Results* has been activated in mask 1.1. By this option, the generation is confined to the relevant load groups only so that a great number of possible load groups are neglected for mask 2.2.



3.4.2 Generated Load Combinations

3.4.2.1 Mask 2.1 Load Combinations by Actions

Mask 2.1 Load Combinations by Actions consists of two parts. In the upper part, the generated load combinations are generally listed by actions. The details of the selected line are specified in the part below.



Figure 3.30: Mask 2.1 Load Combinations by Actions

This mask is analogous to mask *Load Groups by Actions* that is described in chapter 3.4.1.1 (p. 28).

Figure 3.30 shows the results of the example that had been used for figures 3.28 and 3.29. Here, three load combinations were generated for the design situations "Ultimate Limit State, Basic Combination": CO5, CO6 and CO7. This implies that four internal combinations of load cases were generated, too.

Load combination CO6, for example, is 1.15 AC1/p + 1.50 AC2/p + 1.05 AC3. The label "/p" means that the action is considered as "permanent" within the combination. If there is no label, it is a "conditional" action. The first action AC1 in CO6 was classified as "permanent" action category 1 in mask 1.3. In the generated load combination, coefficients $\xi * \gamma = 0.85 * 1.35 = 1.15$ are applied. The second action AC2 was classified as "live load" within action category 3.C (congregation areas) in mask 1.3. For it, coefficient $\gamma = 1.50$ is used in the generated load combination. AC2 is the dominant action which includes the load cases LC3 and LC4. Therefore, the internal load combination CO2 is LC3 + LC4. It contains all possible combinations of these two load cases in action AC2. The third action AC3 was classified as "traffic load" within action category 3.F (vehicle weight < 30 kN). In the generated load combination, coefficients $\gamma * \psi = 1.50 * 0.70 = 1.05$ are used as AC2 is the dominant action.



3.4.2.2 Mask 2.2 Load Combinations

Mask 2.2 Load Combinations consists of two parts. In the upper part, all generated load combinations are listed. The details of the selected load combination are specified in the part below.



Figure 3.31: Mask 2.2 Load Combinations

This mask is analogous to mask Load Groups which is described in chapter 3.4.1.2 (p. 29).

Figure 3.31 shows three load combinations that were generated: CO5, CO6 and CO7. The combination criterion of e.g. CO6 is 1.15 CO1/p + 1.50 CO2/p + 1.05 CO3 or 1.05 CO4. The first internal load combination CO1 includes action AC1 which was classified as action category 1 ("permanent actions") in mask 1.3, consisting of the two permanent load cases LC1 and LC2. Thus, both AC1 and CO1 are multiplied by factor $\xi * \gamma = 0.85 * 1.35 = 1.15$ in load combination CO6. The second internal combination CO2 is part of action AC2 which was classified as action category 3.C ("live loads – congregation areas"). In CO6, it is the dominant action. Thus, CO2 is multiplied by factor $\gamma = 1.50$ and labeled as "permanent" within load combination CO6. The internal load combinations CO3 and CO4 are part of action AC3 that was classified as category 3.F ("traffic loads – vehicle weight < 30 kN"). In CO6, these alternative combinations are multiplied by factors $\gamma * \psi = 1.50 * 0.70 = 1.05$.



3.5 Menus

The menu bar contains all functions to handle the RF-COMBI cases. Any menu is activated by a mouse click or by pressing the [Alt] key in combination with the underlined letter.

3.5.1 File

New Case

A new RF-COMBI case, i.e. an independent set of input and output data, can be created.

New RF-	COMBI 2006-Case	×
No.	Description User-Defined	•
2	ОК	Cancel

Figure 3.32: Dialog New RF-COMBI Case

The *Number* and the *Description* of the new RF-COMBI case have to be specified in this dialog. The description can also be chosen from the list that contains all previous entries.

Rename Case

The current RF-COMBI case can be renamed.

Rename	RF-COMBI 2006-Case	×
<u>N</u> o. 3	Description DIN 1045-100, Load Groups	•
2	ОК	Cancel

It is possible to change the Description and/or the Number.

Copy Case

All data of the current RF-COMBI case can be copied to a new case.

Copy RF-COMBI :	2006-Case	>
Copy from Case		
CA1 - Load Groups	:	-
New Case		
No.: <u>D</u> escriptio	n:	
5 Load Gro	ups EN 1990 CZ	-
1		_
2	OK	Cancel

Figure 3.34: Dialog Copy RF-COMBI Case

It is possible to change the Number of the new RF-COMBI case and to enter a Description.

Delete Case

An RF-COMBI case can also be deleted. Select the specific RF-COMBI case from the list and delete it by pressing [OK].

Figure 3.33: Dialog Rename RF-COMBI Case





Figure 3.35: Dialog Delete RF-COMBI Case

3.5.2 Help

The help function is called up.

4. Results

4.1 Printing the Results

Before the numerical results can be printed, RF-COMBI must be closed. Then, the global RFEM printout report can be called up. It provides all options to select or arrange the printout which are described in detail in the RFEM manual.

There are specific registers available for the RF-COMBI data in the *Selection* dialog. Those registers are shown when *RF-COMBI 2006* is selected in the *Programs* list to the left.

rograms	Main Selection General Data Results	
FEM	Display	
F-CUMBI 2006	 ✓ RF-COMBI Data ✓ 1. Input Data ✓ 2. Results 	
	Cases of RF-COMBI 2006 to Display	
	Display all Cases	
	Existing Cases: Cases to Display:	
	CA3 DIN 1045-100, Load Groups User-Defined CA2 Load Combinations	
isolau	• • •	
Cover 🔝		
Contents Info Pictures		
21		Cancel

Figure 4.1: Dialog Printout Report Selection: RF-COMBI data



5. Examples

5.1 Single-Span Girder with Cantilever according to DIN 1055-100

Construction

A single-span girder with cantilever is charged with permanent load, live loads and traffic loads. The loads are split into two load cases each, i.e. span load and cantilever load.

Load Cases	Actions	Action Categories	
LC1, LC2	AC1	Permanent	
LC3, LC4	AC2	Live Loads, 3.C – Congregation Areas $\psi_0 = 0.70, \psi_1 = 0.70, \psi_2 = 0.60$	
LC5 or LC6	AC3	Traffic Loads, 3.F – Vehicle Weight $<$ 30 kN ψ_0 = 0.70, ψ_1 = 0.70, ψ_2 = 0.60	

Table 5.1: Load Cases, Actions and Action Categories

Basic combination-type load groups are to be generated for ultimate limit state design situations according to DIN 1055-100.

Data Input

In mask 1.1, the generation of load groups according to DIN 1055-100 for the design situations "Ultimate Limit State, Basic Combination" UB is defined. In order to differentiate between favorable and unfavorable permanent actions, option *Generate supplementary combinations from favorable permanent actions* is enabled.



Figure 5.1: Mask 1.1 General Data



When mask 1.2 is called up, action AC1 is defined automatically, and load case LC1 is allocated to this action. It is possible to add an *Action Description*.

LC2 is the permanent cantilever load and can thus be included in action AC1 via the adequate button or a double-click.

RF-COMBI 2006 - [RF-COMBI	_Example1]		×
<u>File S</u> ettings <u>H</u> elp			
CA1 · Example 1	1.2 Load Cases in Actions		
Input Data General Data Actions Chino Categories Imperfections	AC1 Permanent Actions ▲	Action <u>D</u> escription: Permanent Actions <u>Comments:</u> Self weight	Note: Button 'Create New Action' can be used to define "Actions". Those are independent of each other. By means of the tables below, Load Cases can then be allocated to each Action. In the following mask (1.3), the Actions are then allocated to the corresponding 'Action
	Existing Load Cases LC3 Live load span LC4 Live load cantilever LC5 Traffic load span LC6 Traffic load cantilever	Load Cases in Action AC1 Load Case Description LCT Self weight span LC2 Self weight cantilever	Alternative
	Calculation Coefficients Check		OK Cancel

Figure 5.2: Mask 1.2 Load Cases in Action – Action AC1 (LC1 and LC2)

Actions AC2 and AC3 are then created via button [Create new Action] in section Actions.

Load cases LC3 and LC4 are assigned to action AC2, load cases LC5 and LC6 to action AC3. The latter are alternative load cases, as the vehicle is either on the span or on the cantilever. Therefore, load cases LC5 and LC6 are supplemented with an identical description in column *Alternative*.



Figure 5.3: Mask 1.2 Load Cases in Actions - Action AC3 (alternative load cases LC5 and LC6)

•



The actions are then assigned to action categories in mask 1.3 Actions in Action Categories.

1 - Example 1	1.3 Actions in Action Categories according to L	DIN 1055-100	
ut Data General Data	Action Categories	Actions	
Actions	1. Permanent Actions	G _{k,j} : AC1	×.
Action Lategories Imperfections	2. Prestress	P _k :	<u>*</u>
	- 3 A Live Loads - Category A - Domestic /Besidential F	NH Duc	
	3.B · Category B · Offices	Qiki:	Live Loads and
	3.C - Category C - Congregation Areas	Q _{k,i} : AC2	Subsumed as of Independent
	3.D · Category D · Shopping Areas	Q _{k,i} :	Action
	3.E · Category E · Storage Buildings	Q _{k,i} :	1
	3.E Traffic Loads · Category F · Vehicle Weight < 30 kt	N Q _{k,i} : AC3	×.
	3.G · Category G · Vehicle Weight > 30 kM	V Q _{k,i} :	×.
	3.H · Category H · Roofs	Q _{k,i} :	1
	4.A Snow and Ice Loads - Sites Located at H < 1000 m	asi Q _{k,i} :	1
	4_B · Sites Located at H > 1000 m	asi Q _{k,i} :	*
	5. Wind Loads	Q _{ki} :	<u>ک</u>
	6 Temperature Actions (Non Fire)		×1
	7. Foundation Subsidence	Qui:	× ×
	- <u>8</u> . Other Actions	Q _{k,i} :	1
	0 Assidented Astisms	A . [X
	Accidental Actions Accidental Actions	And And	<u></u>
	To: Seisinic Actions	·· · · · · · · · · · · · · · · · · · ·	

Figure 5.4: Mask 3.1 Actions in Action Categories

After this, the input of data is complete. There are no imperfections in this example.

Results

For these design situations, 36 load groups are generated according to equation 2.1. In mask 2.1, they are subsumed in ten lines.



Figure 5.5: Mask 2.1 Load Groups by Actions

The single load groups are listed in mask 2.2.



2.2 L <u>o</u> a	nd Grou	ips		_	_	_		
	A	В	C	D	E	F	G	Н
		Design						
LG	Apply	Situation	LC1	LC2	LC3	LC4	LC5	LC6
LG1	×	UB	1.35	1.35				
LG2	×	UB	1.35	1.35	1.50			•
LG3	×	UB	1.35	1.35	1.50	1.50	•	•
LG4	×	UB	1.35	1.35	•	1.50		•
LG5	×	UB	1.35	1.35	1.50		1.05	
LG6	×	UB	1.35	1.35	1.50	•	•	1.05
LG7	×	UB	1.35	1.35	1.50	1.50	1.05	•
LG8	×	UB	1.35	1.35	1.50	1.50	-	1.05
LG9	×	UB	1.35	1.35		1.50	1.05	•
_LG10	×	UB	1.35	1.35		1.50	•	1.05
_LG11	×	UB	1.35	1.35	•	•	1.50	•
LG12	×	UB	1.35	1.35	•	•	-	1.50
	A	B	C	D	E	F	G	Н
		Design						
LG	Apply	Situation	LC1	LC2	LC3	LC4	LC5	LC6
LG13	×	UB	1.35	1.35	1.05	•	1.50	•
LG14	×	UB	1.35	1.35	1.05	•		1.50
LG15	×	UB	1.35	1.35	1.05	1.05	1.50	
LG16	×	UB	1.35	1.35	1.05	1.05		1.50
LG17	×	UB	1.35	1.35	•	1.05	1.50	
LG18	×	UB	1.35	1.35	•	1.05		1.50
LG19	×	UB	1.00	1.00	1.0	•		•
LG20	×	UB	1.00	1.00	1.50	•	•	•
LG21	×	UB	1.00	1.00	1.50	1.50	•	•
LG22	×	UB	1.00	1.00	1.0	1.50		•
LG23	×	UB	1.00	1.00	1.50	•	1.05	•
LG24	×	UB	1.00	1.00	1.50	•	•	1.05
	A	В	C	D	E	F	G	Н
		Design						
LLi	Apply	Situation	LC1	LC2	LC3	LC4	LC5	LC6
LG25	×	UB	1.00	1.00	1.50	1.50	1.05	
LG26	×	UB	1.00	1.00	1.50	1.50		1.05
LG27	×	UB	1.00	1.00		1.50	1.05	-
LG28	×	UB	1.00	1.00		1.50	-	1.05
LG29	×	UB	1.00	1.00	•	•	1.50	
LG30	×	UB	1.00	1.00		•	•	1.50
LG31	×	UB	1.00	1.00	1.05		1.50	•
LG32	×	UB	1.00	1.00	1.05	•	•	1.50
LG33	×	UB	1.00	1.00	1.05	1.05	1.50	
LG34	×	UB	1.00	1.00	1.05	1.05	•	1.50
LG35	×	UB	1.00	1.00		1.05	1.50	•
LG36		UB	1.00	1.00		1.05		1.50

Figure 5.6: Mask 2.2 Load Groups

Comparing mask 2.1 (figure 5.5) and mask 2.2 (figure 5.6), notice that the third line of the generated load groups 1.35 AC1+1.50 AC2+1.05 AC3 in mask 2.1 includes load groups LG5..LG10 that are described in detail in mask 2.2:

- LG5: 1.35 LC1 + 1.35 LC2 + 1.50 LC3 + 1.05 LC5
- LG6: 1.35 LC1 + 1.35 LC2 + 1.50 LC3 + 1.05 LC6
- LG7: 1.35 LC1 + 1.35 LC2 + 1.50 LC3 + 1.50 LC4 + 1.05
- LG8: 1.35 LC1 + 1.35 LC2 + 1.50 LC3 + 1.50 LC4 + 1.05 LC6
- LG9: 1.35 LC1 + 1.35 LC2 + 1.50 LC4 + 1.05 LC5
- LG10: 1.35 LC1 + 1.35 LC2 + 1.50 LC4 + 1.05 LC6

Action AC1 comprises LC1 and LC2. This is a permanent action so that both load cases must appear together. Action AC2 which comprises LC3 and LC4 is an accidental action. Thus, three combinations are possible: LC3, LC3 + LC4, LC4. Action AC3 includes LC5 and LC6. This is an accidental action, too. LC5 and LC6 were defined as alternative load cases so that either LC5 or LC6 is possible. Consequently, 1.35 AC1 + 1.50 AC2 + 1.05 AC3 stands for 1 * 3 * 2 = 6 load groups altogether, labeled as *LG5..LG10*.

Note

Two permanent loads (LC1 - span, LC2 - cantilever) have been included in action AC1. Thus, both load cases always have the same coefficients within the load groups: 1.35 or 1.00. If LC1 and LC2 are independent from each other, they must be allocated to different actions.



Load Cases	Actions	Action Categories
LC1	AC1	Permanent
LC2	AC2	Permanent
LC3, LC4	AC3	Live Loads, 3.C – Congregation Areas $\psi_0 = 0,70, \psi_1 = 0,70, \psi_2 = 0,60, \psi_2 = 0,60$
LC5 or LC6	AC4	Traffic Loads, 3.F – Vehicle Weight < 30 kN $\psi_0 = 0,70, \psi_1 = 0,70, \psi_2 = 0,60$

Table 5.2: Load Cases, Actions and Action Categories

In this case, load cases LC1 and LC2 are multiplied by different partial safety coefficients, which results in 72 load groups altogether.

2.1 Load Groups by Actions							
	A	В	С	D	E	F	G
		Generated	Design				
No.	Apply	Load Groups	Situation	AC1	AC2	AC3	AC4
1	×	LG1	UB	1.35	1.35	•	
2	×	LG24	UB	1.35	1.35	1.50	
3	×	LG5 10	UB	1.35	1.35	1.50	1.05
4	×	LG11 12	UB	1.35	1.35	•	1.50
5	×	LG13 18	UB	1.35	1.35	1.05	1.50
6	×	LG19	UB	1.00	1.35	•	
7	×	LG2022	UB	1.00	1.35	1.50	
8	×	LG2328	UB	1.00	1.35	1.50	1.05
9	×	LG2930	UB	1.00	1.35		1.50
10	×	LG3136	UB	1.00	1.35	1.05	1.50
11	×	LG37	UB	1.00	1.00		
12	×	LG3840	UB	1.00	1.00	1.50	
13		LG41 46	UB	1.00	1.00	1.50	1.05
14	×	LG47 48	UB	1.00	1.00	-	1.50
15	×	LG4954	UB	1.00	1.00	1.05	1.50
16	×	LG55	UB	1.35	1.00		
17	×	LG56 58	UB	1.35	1.00	1.50	-
18	×	LG5964	UB	1.35	1.00	1.50	1.05
19	×	LG6566	UB	1.35	1.00		1.50
20	×	LG67 72	UB	1.35	1.00	1.05	1.50

Figure 5.7: Mask 2.1 Load Groups by Actions – LC1 and LC2 as different actions (AC1 and AC2)

When the generated load groups are finally to be transferred to RFEM, the enveloping load combination can also be created from these load groups. This can be specified in section *Either/Or Load Combination* in the *Export* dialog.

Export
Statistics
Generated Load Groups to be Exported in RFEM
Number of
- Load Combinations: 1
Either/Or Load Combination
Additionally summarize all generated Load Groups in an 'Either-Or' Load Combination
Number of Generated Load Combination: 1
2 OK Cancel

Figure 5.8: Dialog Export – Either/Or Load Combination

Load combination CO1 is generated: LG1/p or LG2/p or LG3/p or LG4/p or LG36/p



5.2 Framed Structure with Imperfections according to EN 1990 CEN

Construction

A skeleton structure is charged with permanent load, live loads, wind and snow loads. Additionally, imperfections-type loads are applied.

Load Cases	Actions	Action Categories
LC1	AC1	Permanent
LC2, LC3	AC2	Live Loads, 3.B – Offices $\psi_0 = 0.70, \psi_1 = 0.50, \psi_2 = 0.30$
LC4, LC5	AC3	Live Loads, 3.D – Shopping Areas $\psi_0 = 0.70, \psi_1 = 0.70, \psi_2 = 0.60$
LC6 or LC7	AC4	5. – Wind Loads $\psi_0 = 0.60, \psi_1 = 0.20, \psi_2 = 0$
LC8	AC5	4.A – Snow and Ice Loads – Sites Located at H < 1000 masl ψ_0 = 0.50, ψ_1 = 0.20, ψ_2 = 0
LC9, LC10		Imperfections

Table 5.3: Load Cases, Actions and Action Categories

Basic combination-type load groups are to be generated for ultimate limit state design situations according to EN 1990 CEN.

Data Input

In mask 1.1, the generation of load groups according to EN 1990 CEN for the design situations "Ultimate Limit State, Basic Combination" is defined.

When mask 1.2 is called up, action AC1 is defined automatically, and load case LC1 is allocated to this action. It is possible to add an *Action Description*.

Actions AC2 to AC5 are then created via button [Create new Action] in section Actions.

Load cases LC2 and LC3 are assigned to action AC2 (offices), load cases LC4 and LC5 to action AC3 (shopping areas) as different combination coefficients ψ_2 are applicable. When allocating the alternative load cases LC6 and LC7 to action AC4, they are supplemented with an identical description (e.g. *Wind*) in column *Alternative*.





CA1 - Load Groups with Imperfe	1.2 Load Cases in Actions	
Input Data General Data Actions - Action Categories Imperfections	Actions Act Self weight Act AC2 Live Loads M M AC3 Live Loads M M AC5 Snow and Ice Loads Image: Cell Action of the second se	ction Description: Note: wind Loads Those are independent of each other. gamments: By means of the tables below, Load Cases can then be allocated to each Action. Witemative Directions In the following mask (1.3), the Actions are then allocated to the corresponding "Action Categories".
	Existing Load Cases	oad Cases in Action AC4 No. Load Case Description LCE Wrind in +Y LC7 Wind in +X

Figure 5.9: Mask 1.2 Load Cases in Actions - Action AC4

Load case LC8 is finally assigned to action AC5.

In mask 1.3, all five actions are then allocated to the adequate action categories.

A1 - Load Groups with Imperfe	 1.3 Actions in Action Categories accordi 	ng to EN 1990 CEN	
put Data General Data	Action Categories	Actions	
- Actions Action Categories	1. Permanent Actions	G _{k,j} : AC1	×.
- Imperfections	2. Prestress		1
	3.A Live Loads · Category A · Domestic/Res	sidential Bld. Q _{k,i} :	► Live Loads and
	3.B - Category B - Offices	Q _{k,i} : AC2	Traffic Loads to
	3.C - Category C - Congregation	Areas Q _{k,i} :	The Subsumed as or Independent
	3.D · Category D · Shopping Are-	as Q _{k,i} : AC3	Action
	3.E · Category E · Storage Buildi	ngs Q _{k,i} :	1
	3. <u>F</u> Traffic Loads · Category F · Vehicle Weigh	nt < 30 kN Q _{ik,i} :	12
	3.G · Category G · Vehicle Weigh	nt > 30 kN Q _{k,i} :	<u>4</u>
	3. <u>H</u> · Category H · Roofs	Q _{k,i} :	*
	4.A Snow and Ice Loads - Finland, Island, Norw	ay, Sweden Q _{k,i} :	1
	4_B - Other CEN Countries - Sites Located at H >	1000 masi Q _{k,i} :	<u></u>
	4.C - Sites Located at H <	1000 masl Q _{k,i} : AC5	1
	5. Wind Loads		1
	6. Temperature Actions (Non Fire)	Q _{k,i} :	<u> </u>
	7 Accidental Actions	Ar	
	 Seismic Actions 		
	-		

Figure 5.10: Mask 1.3 Actions in Action Categories

When calling up mask 1.4, the imperfection-type load cases LC9 and LC10 are listed. In order to consider the load cases in the generated load groups, they are included in the list *Imperfection-Type Load Cases in Combinatorics*.

As those two imperfections never appear simultaneously, an identical description is entered for both load cases in column *Alternative*.



CA1 - Load Groups with Imperfect 1.4 Imperfection-Type Load Cases Input Data - General Data - Actions - Actions Action Categories Imperfection Imperfections Imperfection towards +Y Imperfection Imperfection towards +X Imperfection Impef	ile <u>S</u> ettings <u>H</u> elp	
nput Data General Data Actions Action Categories Imperfections Existing Load Cases - Type 'Imperfection' Imperfection Type Load Cases in Combinatorics LC Load Case Description Item Imperfection Type Load Cases Item I	A1 - Load Groups with Imperfe 💌	1.4 Imperfection-Type Load Cases
	put Data — General Data — Actions — Action Categories — Imperfections	Existing Load Cases - Type 'Imperfection' Imperfection-Type Load Cases in Combinatorics Imperfection Type Load Case Description Imperfection towards +Y Imp Imperfection towards +X Imp Imperfection towards +X Imp Imperfection-Type Load Cases Imperfection-Type Load Cases Impe

Figure 5.11: Mask 1.4 Imperfection-Type Load Cases – LC9 and LC10 in combinatorics

Load groups are analyzed according to 2nd order theory. Therefore, every load group ought to include an imperfection. This is achieved by enabling option *Allocate Imperfection-Type Load Cases to Every Load Group*.

Results

For these design situations, a total of 514 load groups are generated according to equation 2.10. In mask 2.1, they are subsumed in 33 lines.

2.1 Loa	ad Grou	ps by Actions						
	A	B	С	D	E	F	G	Н
		Generated	Design					
No.	Apply	Load Groups	Situation	AC1	AC2	AC3	AC4	AC5
1	×	LG12	UB	1.35	-	-	-	-
2	×	LG3 8	UB	1.35	1.50	-	-	-
3	×	LG926	UB	1.35	1.50	1.05		
4	×	LG2762	UB	1.35	1.50	1.05	0.90	-
5	×	LG63 98	UB	1.35	1.50	1.05	0.90	0.75
6	×	LG99116	UB	1.35	1.50	1.05		0.75
7	×	LG117128	UB	1.35	1.50	-	0.90	
8	×	LG129140	UB	1.35	1.50		0.90	0.75
9	×	LG141146	UB	1.35	1.50			0.75
10	×	LG147 152	UB	1.35		1.50		
11	×	LG153170	UB	1.35	1.05	1.50		
12	×	LG171206	UB	1.35	1.05	1.50	0.90	•
13	×	LG207242	UB	1.35	1.05	1.50	0.90	0.75
14	×	LG243 260	UB	1.35	1.05	1.50	-	0.75
15	×	LG261 272	UB	1.35		1.50	0.90	
16	×	LG273284	UB	1.35		1.50	0.90	0.75
17	×	LG285290	UB	1.35	•	1.50	-	0.75
18	×	LG291 294	UB	1.35			1.50	
19	×	LG295306	UB	1.35	1.05	-	1.50	•
20	×	LG307342	UB	1.35	1.05	1.05	1.50	-
21	×	LG343378	UB	1.35	1.05	1.05	1.50	0.75
22	×	LG379390	UB	1.35	1.05	-	1.50	0.75
23	×	LG391 402	UB	1.35	•	1.05	1.50	
24	×	LG403414	UB	1.35	•	1.05	1.50	0.75
25	×	LG415 418	UB	1.35	•		1.50	0.75
26	×	LG419420	UB	1.35			-	1.50
27	×	LG421 426	UB	1.35	1.05	-	-	1.50
28	×	LG427444	UB	1.35	1.05	1.05	-	1.50
29	×	LG445480	UB	1.35	1.05	1.05	0.90	1.50
30	×	LG481 492	UB	1.35	1.05	-	0.90	1.50
31	×	LG493 498	UB	1.35	-	1.05		1.50
32	×	LG499510	UB	1.35	-	1.05	0.90	1.50
33	×	LG511514	UB	1.35			0.90	1.50

Figure 5.12: Mask 2.1 Load Groups by Actions



The detailed results of mask 2.2 demonstrate that the imperfections are applied alternately.

CA1 - Load Groups with Imperfe	2.2 Loa	id Grou	ps												
Input Data	_	Α	В	С	D	E	F	G	Н		J	K	L		
- General Data	1.0		Design												
- Actions	LG	Apply	Situation	LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC10		
- Action Categories	LG1	×	UB	1.35	•	•	•	•	•	•	•	1.00	•		
Imperfections	LG2	×	UB	1.35	•	•	•	-	•	•	•	•	1.00		
Results	LG3	×	UB	1.35	1.50	•	•	•	•	•	•	1.00	•		
 Load Groups by Actions 	LG4	×	UB	1.35	1.50	•	•	•	•	•	•		1.00		
Load Groups	LG5	×	UB	1.35	1.50	1.50	•	-	•	•	•	1.00	•		
	LG6	×	UB	1.35	1.50	1.50	•	-	•	•	•	•	1.00		
	LG7	×	UB	1.35	•	1.50	•	•		•	•	1.00			
	LG8	×	UB	1.35	•	1.50	•	-	•	•	•	•	1.00		
	LG9	×	UB	1.35	1.50	•	1.05	-	•	•	•	1.00	•		
	LG10	×	UB	1.35	1.50	•	1.05	•		•	•		1.00		
	LG11	×	UB	1.35	1.50	•	1.05	1.05	•	•	•	1.00	•		
	LG12	×	UB	1.35	1.50	•	1.05	1.05	•	•	•	-	1.00		
	Load C	ases in G	enerated Loa	id Group	LG9				L L	Jltimate	Limit St	ate - Ba	isic Con	nbination	
	LC	L	.oad Case De	escriptio	n	Actic	n C	ategory	Don	ninant	γ		ψ	γ.Ψ	
	LC1	Selfw	eight			AC1		1.	(1.35	5	•	1.35	
	LC2	Live lo	ad - offices			AC2	2	3.B	[×	1.50)	•	1.50	
	LC4	Live lo	ad - shopping	g areas		AC3	}	3.D	[1.50) 0	1.70	1.05	
	LC9	Imperf	ection toward	ls +Y				Imp	erfectio	n-Type	Load C	ase			
	-														

Figure 5.13: Mask 2.2 Load Groups

Note

Often it is evident that specific imperfections depend on certain load cases or do not make sense in combination with other load cases. In our example, LC6 is defined as *Wind in* +*Y*, LC7 as *Wind in* +*X*. Imperfection LC9 is *Drift towards* +*Y*, LC10 is *Drift towards* +*X*. It does not make much sense, therefore, to combine load cases LC6 and LC10 or LC7 and LC9.

This can be used in RF-COMBI to reduce the number of generated load groups via option Include Imperfection-Type Load Cases in the Combinations Subject to Defined Load Cases. For these design situations, 322 load groups are generated instead of 514.



Figure 5.14: Mask 1.4 Imperfection-Type Load Cases – Imperfections subject to specific load cases



5.3 Wall according to EN 1990 CEN

Construction

A wall is charged with permanent load, live loads, traffic loads, snow and wind loads.

Load Cases	Actions	Action Categories
LC1	AC1	Permanent
LC2, LC3, LC4	AC2	Live Loads, 3.D – Shopping Areas
LC5	AC3	Traffic Loads, 3.F – Vehicle Weight < 30 kN
LC6	AC4	Snow and Ice Loads – Sites Located at H > 1000 masl
LC7 or LC8	AC5	Wind Loads

Table 5.4: Load Cases, Actions and Action Categories

Basic combination-type load groups are to be generated for ultimate limit state design situations according to EN 1990 CEN.

Data Input

In mask 1.1, the generation of load groups according to EN 1990 CEN for the design situations "Ultimate Limit State, Basic Combination" is defined. To economize on material, the *Combination Rule according to Equations 6.10a and 6.10b* is selected in section *Settings for Combinatorics*. Equations 6.10a and 6.10b correspond to equations 2.11 and 2.12 in this manual.



Figure 5.15: Mask 1.1 General Data

When mask 1.2 is called up, action AC1 is defined automatically, and load case LC1 is allocated to this action. The remaining load cases are listed in section *Existing Load Cases*.



1 - Example 3 💌	1.2 Load Cases in Actions	
ut Data General Data Actions Action Categories Imperfections	Actions Action Description: Action Description: Permanent Actions Comments: Self weight Self weight Self weight LC3 Live load - shopping areas LC4 Live load - shopping areas LC5 Snow LC7 Wind in +X LC8 Wind in +Y	Note: Button Cireate New Action car be used to define "Actions". Those are independent of each other. By means of the tables below, Load Cases can then be allocated to each Action. In the following mask (1.3), the Actions are then allocated to the corresponding "Action Categories".

Figure 5.16: Mask 1.2 Load Cases in Actions

Actions AC2 to AC6 are then created via button [Create new Action] in section Actions.

Load cases LC2, LC3 and LC4 are assigned to action AC2, load case LC5 to action AC3 and load case LC6 to action AC4. When allocating the alternative load cases LC7 and LC8 to action AC5, they are to be supplemented with an identical description (e.g. *Wind*) in column *Alternative*.





In mask 1.3, all five actions are then allocated to the adequate action categories.

•	



\1 - Example 3	1.3 Actions in Action Categories according	to EN 1990 CEN	
out Data General Data Actions	Action Categories	Actions	
Action Categories	Permanent Actions Prestress		¥_
Imperiections	2. Livelande Category & Demostic/Paride	antial Piel Occur	<u> </u>
	3.B · Category B · Offices	Qiri:	ki □ Live Loads an Traffic Loads t
	3.C · Category C · Congregation Are	as Q _{k,i} :	Subsumed as Independent
	3.D - Category D - Shopping Areas	Q _{k,i} : AC2	Action
	3.E - Category E - Storage Buildings	: Q _{k,i} :	<u>*</u>
	3.E Traffic Loads · Category F · Vehicle Weight <	30 kN Q _{K,i} : AC3	1
	3.G - Category G - Vehicle Weight >	30 kN Q _{k,i} :	<u>*</u>
	3. <u>H</u> - Category H - Roofs	Q _{k,i} :	
	4.A Snow and Ice Loads - Finland, Island, Norway,	Sweden Q _{k,i} :	<u>*</u>
	4_B - Other CEN Countries - Sites Located at H > 100	00 masl Q _{k,i} : AC4	
	4.L - Sites Located at H < Tu	ou masi lu _{k,i} :	
	5. Wind Loads	Q _{k,i} : AC5	12
	6. Temperature Actions (Non Fire)	Q _{k.i} :	
	Z. Accidental Actions	A _d :	<u> </u>
	8. Seismic Actions	A _{Ed} :	

Figure 5.18: Mask 1.3 Actions in Action Categories

After this, the input of data is completed. There are no imperfections in this example.

Results

For these design situations, 341 load groups are generated. Load groups LG1 to LG96 are generated according to equation 2.11:

2.1 Loa	ad Grou	ps by Actions						
	A	В	С	D	E	F	G	Н
		Generated	Design					
No.	Apply	Load Groups	Situation	AC1	AC2	AC3	AC4	AC5
1	×	LG1	UB	1.35	-		-	-
2	×	LG2 8	UB	1.35	1.05		-	-
3	×	LG9 15	UB	1.35	1.05	1.05	-	-
4	×	LG16 22	UB	1.35	1.05	1.05	1.05	-
5	×	LG2336	UB	1.35	1.05	1.05	1.05	0.90
6	×	LG37 50	UB	1.35	1.05	1.05	-	0.90
7	×	LG51 57	UB	1.35	1.05		1.05	-
8	×	LG58 71	UB	1.35	1.05		1.05	0.90
9	×	LG7285	UB	1.35	1.05	-	-	0.90
10	×	LG86	UB	1.35	-	1.05	-	-
11	×	LG87	UB	1.35	-	1.05	1.05	-
12	×	LG88 89	UB	1.35	-	1.05	1.05	0.90
13	×	LG9091	UB	1.35	-	1.05	-	0.90
14	×	LG92	UB	1.35	-	-	1.05	-
15	×	LG9394	UB	1.35	-	-	1.05	0.90
16	×	LG9596	UB	1.35	-		-	0.90

Figure 5.19: Mask 1.2 Load Groups by Actions

Load groups LG97 to LG341 are generated according to equation 2.12:



2.1 Loa	ad Grou	ips by Actions						
	A	В	C	D	E	F	G	H
		Generated	Design					
No.	Apply	Load Groups	Situation	AC1	AC2	AC3	AC4	AC5
17	×	LG97	UB	1.15	-	-	-	
18	×	LG98 104	UB	1.15	1.50	-	-	-
19	×	LG105 111	UB	1.15	1.50	1.05	-	-
20	×	LG112 118	UB	1.15	1.50	1.05	1.05	-
21	×	LG119 132	UB	1.15	1.50	1.05	1.05	0.90
22	×	LG133 146	UB	1.15	1.50	1.05	-	0.90
23	×	LG147 153	UB	1.15	1.50	-	1.05	-
24	×	LG154 167	UB	1.15	1.50	-	1.05	0.90
25	×	LG168 181	UB	1.15	1.50	-	-	0.90
26	×	LG182	UB	1.15	-	1.50	-	-
27	×	LG183 189	UB	1.15	1.05	1.50	-	-
28	×	LG190196	UB	1.15	1.05	1.50	1.05	-
29	×	LG197210	UB	1.15	1.05	1.50	1.05	0.90
- 30	×	LG211 224	UB	1.15	1.05	1.50	-	0.90
31	×	LG225	UB	1.15	-	1.50	1.05	-
32	×	LG226 227	UB	1.15	-	1.50	1.05	0.90
33	×	LG228 229	UB	1.15	-	1.50	-	0.90
34	×	LG230	UB	1.15	-		1.50	-
35	×	LG231 237	UB	1.15	1.05	-	1.50	
36	×	LG238 244	UB	1.15	1.05	1.05	1.50	
37	×	LG245 258	UB	1.15	1.05	1.05	1.50	0.90
- 38	×	LG259272	UB	1.15	1.05	-	1.50	0.90
- 39	×	LG273	UB	1.15	-	1.05	1.50	-
40	×	LG274 275	UB	1.15	-	1.05	1.50	0.90
41	×	LG276 277	UB	1.15	-	-	1.50	0.90
42	×	LG278279	UB	1.15	-	-	-	1.50
43	×	LG280293	UB	1.15	1.05	-	-	1.50
44	×	LG294 307	UB	1.15	1.05	1.05	-	1.50
45	×	LG308321	UB	1.15	1.05	1.05	1.05	1.50
46	×	LG322335	UB	1.15	1.05	-	1.05	1.50
47	×	LG336337	UB	1.15	-	1.05	-	1.50
48	×	LG338339	UB	1.15	-	1.05	1.05	1.50
49	×	LG340341	UB	1.15	-	-	1.05	1.50

Figure 5.20: Mask 1.2 Load Groups by Actions



A: Literature

- [1] DIN 1055-100 Actions on Structures. Edition March 2001
- [2] DIN 18 800 Steel Constructions. Edition November 1990
- [3] EN 1990 Basis of Structural Design
- [4] Grünberg, J.: Basis of Structural Design Principles of Safety and Design Rules for Structural Engineering. Commentary on DIN 1055-100, Edition 2004 (German)