Ing. Software
Dlubal

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Add-on Module

RF-MOVE

Load Case Generation from Moving Loads on Members

Program Description

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1. Introduction

1.1 Add-on Module RF-MOVE

RF-MOVE is one of the numerous add-on modules of the RFEM program family. The program facilitates the generation of load cases determined from the various positions of moving loads running along members or sets of members. These loads can be relevant in different fields, for example crane loads or vehicle loads on bridge constructions.

The RFEM program concept does not include the direct analysis of influence lines. However, RF-MOVE allows for modeling such type of lines. Please note that RF-MOVE cannot create any surface loads.

The individual load positions of a moving load can be defined easily with the add-on module RF-MOVE. You only need to specify the load parameters (such as type of load, space between load positions) and the moving distance. During the process of load case generation, it is also possible to create the enveloping load combination resulting from the single load positions.

RF-MOVE offers you sophisticated control parameters for the load generation. Various types of loads, for example, can be applied parallel as well as offset to sets of members or added to already defined loads of existing RFEM load cases.

All load specifications can be saved in a library to make them available for further structures.

The table input can be exported directly to MS Excel or OpenOffice.org Calc for further use or storage.

Like other add-on modules, RF-MOVE is completely integrated in RFEM. Thus, the program is not only an integral part of the main program in its appearance.

We hope you will enjoy working with RF-MOVE.

Your team from ING.-SOFTWARE DLUBAL

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1.2 RF-MOVE Team

The following people were involved in the development of RF-MOVE:

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1.3 Using the Manual

Topics like installation, graphical user interface, results evaluation and printout are described in detail in the manual of the main program RFEM. The present manual focuses on typical features of the RF-MOVE add-on module.

The descriptions in this manual follow the sequence and the structure of the module tables. The text of the manual shows the described **buttons** in square brackets, for example [New]. At the same time, they are pictured on the left. **Expressions** appearing in dialog boxes, tables and menus are set in *italics* to clarify the explanations.

At the end of the manual, you find the index. However, if you don't find what you are looking for, please check our website **www.dlubal.com** where you can go through our *FAQ* pages by selecting particular criteria.

1.4 Open the Add-on Module RF-MOVE

RFEM provides the following options to start the add-on module RF-MOVE.

Menu

To start the program in the menu bar,

point to **Others** on the **Additional Modules** menu, and then select **RF-MOVE**.

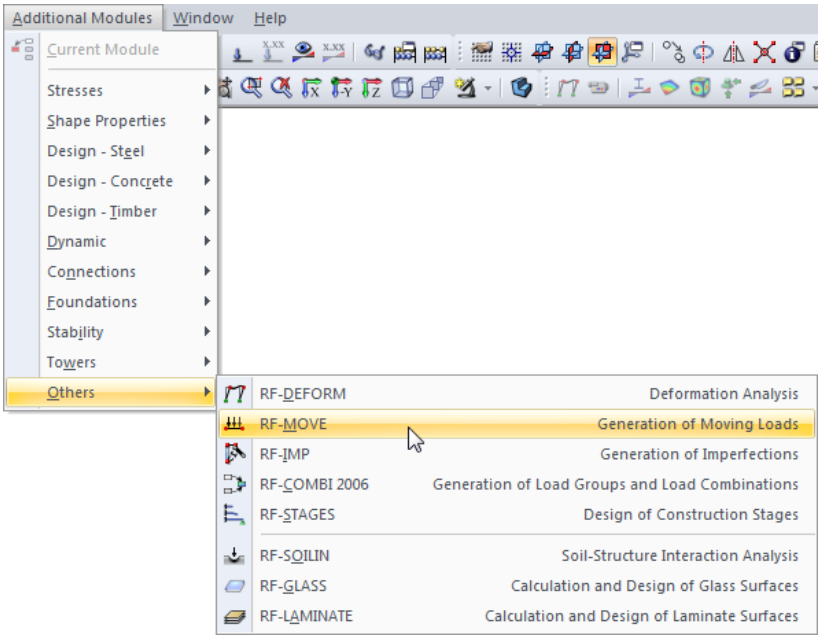

Figure 1.1: Menu: *Additional Modules* → *Others* → RF-MOVE

Navigator

To start RF-MOVE in the *Data* navigator,

open the **Additional Modules** folder and select **RF-MOVE Members**.

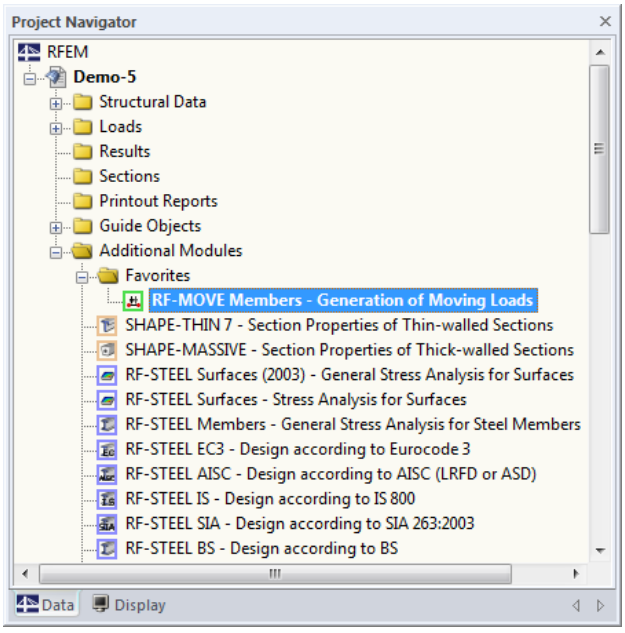

Figure 1.2: Data navigator: *Additional Modules* → *RF-MOVE Members*

2. Input Data

All data required for the definition of design cases is entered in tables. The [Pick] button allows for a graphical selection of the relevant members or sets of members.

When you have started the add-on module, a new window opens where a navigator is displayed on the left, managing all available tables. The pull-down list above the navigator contains the generation cases (see chapter 4.1, page 19).

If you open RF-MOVE in an RFEM structure for the first time, the module will import the following data automatically:

- Members and sets of members
- Load cases and load combinations

To select a table, click the corresponding entry in the RF-MOVE navigator or page through the tables by using the buttons shown on the left. You can also use the function keys [F2] and [F3] to select the previous or subsequent table.

Click [OK] to save the entered data and quit the add-on module RF-MOVE. When you click [Cancel], you quit the module but without saving the data.

The data in RF-MOVE is entered in two input tables. As the results of the load case generation will be transferred directly to RFEM, RF-MOVE requires no result tables.

2.1 General Data

In table 1.1 *General Data*, you define the relevant sets of members as well as important parameters for the generation of load cases.

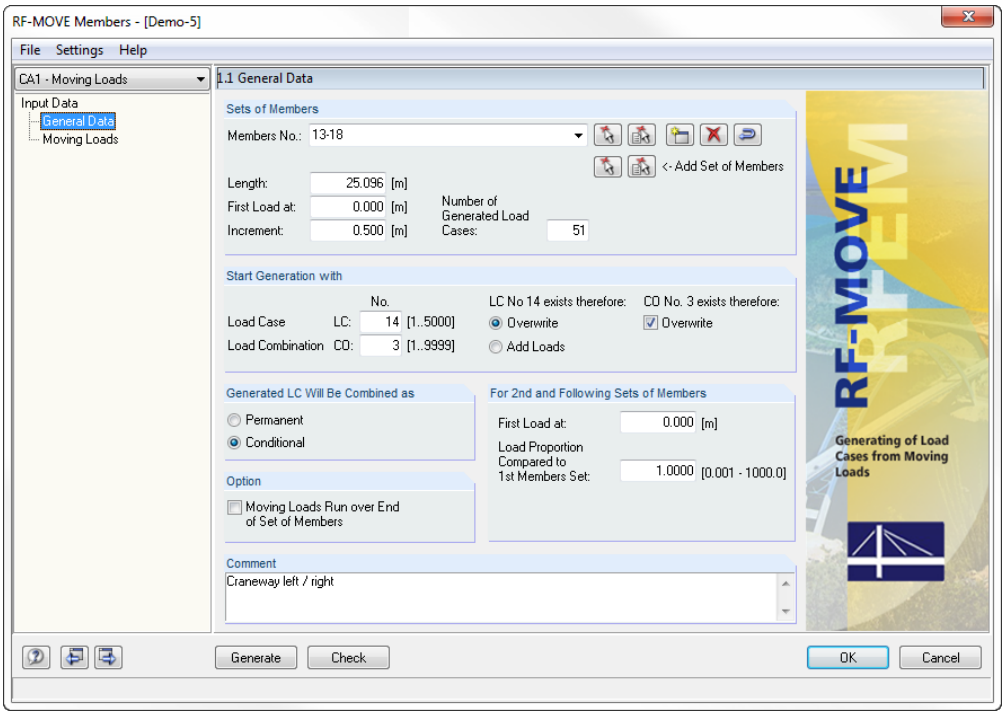

Figure 2.1: Table 1.1 *General Data*

Sets of Members

The ***Members*** to which moving loads are applied can be defined manually by entering the member numbers. To select the objects graphically in the RFEM work window, use the buttons [Pick Member(s)] or [Pick Continuous Members].

In case no set of member has yet been defined in RFEM, you can create a new set of members in the add-on module RF-MOVE by using the [New] button. The dialog box *New Set of Members* appears where you can specify further data. Please note that only *Continuous Members* are allowed for defining the member set type: It is not possible to assign moving loads to branching groups of members.

Furthermore, you have to take care that the members in the set of members are connected to one another. Therefore, groups of members or unconnected members are not accepted in the *Members No.* list. The member orientation, however, has no relevance for the load generation.

Use the [Delete] button to remove a set of members from the list. In case you have defined several sets of members for the application of parallel moving loads (see below), you first have to select the set of members that you want to delete by means of the [▼] button in the list in order to set it active.

When you click the button [Reverse Orientation], the program arranges the members contained in the set of members in reverse order. In this way, you can set the moving loads to be running along the set of members in the opposite direction.

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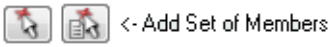
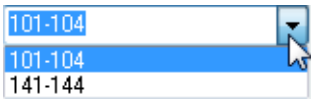


The two [Pick] buttons for *Add Set of Members* have a special meaning. They are not used for a new definition of an RFEM set of members, but for adding a set of members to the RF-MOVE list *Members No.* in terms of a new row in the list. In this way, it is possible that the same moving load runs parallel or simultaneously along different sets of members. A second or subsequent set of members is defined graphically.



The individual sets of members for which loads are generated can be displayed in the list by means of the [▼] button. Find an example with several sets of members described in chapter 3.3.

The ***Length*** refers to the longest set of all sets of members defined in the *Members No.* list.

In the input field ***First Load at***, you enter the first position of the load. It describes the distance of the first load position from the first node of the first member.

The ***Increment*** defines the (same) spacing between the individual load positions.

A moving load starting to enter the runway of a set of members can be modeled by a negative start value. In the table section below, RF-MOVE provides an *Option* to determine additionally that the *Moving Loads Run over End of Set of Members*.

Based on the length of the set of members and the increment, RF-MOVE determines the *Number of Generated Load Cases* indicating how many load positions are possible. RFEM allows for 5,000 load cases.

Start Generation with

In this table section, you enter the *No.* that you want to use for the first generated load case. The subsequent load positions of a generation case will receive load case numbers in ascending order.

Based on the different load cases, RF-MOVE creates a load combination where the load cases are superimposed with the 'Or' setting as acting alternatively. The number of this enveloping load combination must be defined in the *No.* input field.

In case you enter load case or combination numbers that already exist in RFEM, additional selection fields and check boxes are activated (see Figure 2.1): For load cases you decide whether RF-MOVE will *Overwrite* the existing load cases or *Add Loads* that have been generated. For load combinations the program offers you only the *Overwrite* option. If the check box is not ticked, RF-MOVE won't generate a new combination.

RFEM allows for 5,000 load cases and 9,999 load combinations.

Generated LC Will Be Combined as

The two options define the type of load case superposition in the generated load combination. The *Permanent* combination takes into account the individual load cases as permanent actions. The *Conditional* setting considers the load cases only when the results have an unfavorable effect on the values of the internal forces and deformations.

The load cases resulting from the individual load positions are always linked with the 'Or' criterion, this means that they are mutually exclusive.

For 2nd and Following Sets of Members

This table section is only active if several sets of members have been defined (see above). For the second set of members, and further sets of members where applicable, you can specify the *First Load at* and the *Load Proportion Compared to 1st Members Set* in order to compensate for example an unbalance in the model or load distribution.

Option

With the check box *Moving Loads Run over End of Set of Members*, you can control how far the load runs along the set of members: If the check box is ticked, which means that the load exceeds the end of the set of members (linear load, N forces of a bridge), RF-MOVE takes into account the portion of the loading which is still on the set of members. If you clear the check box, RF-MOVE generates the final load case when all loads are still on the set of members (concentrated loads of a crane runway).

Comment

In this input field, you can enter user-defined notes describing in detail, for example, the parameters applied to the current RF-MOVE generation case.

2.2 Moving Loads

In the second input table, you enter the moving loads row by row. Thus, you can define several moving loads to be acting simultaneously in one RF-MOVE case. Subsequent to the generation, RF-MOVE exports each load position, that may consist of several loads, as separate load case to RFEM. The numbering runs in ascending order according to the data specified for *Start Generation with Load Case No.* in the previous input table.

Table 1.2 *Moving Loads* contains all data specifying the type, distribution and direction of the load. The input can be edited by using the common keyboard functions, for example deleting the active table row (where the cursor is placed) with [Ctrl] + [Y] (see RFEM manual, chapter 4.4.8).

To modify the units and decimal places of lengths and loads, select **Units and Decimal Places** in the module's **Settings** menu (see chapter 4.2, page 21).

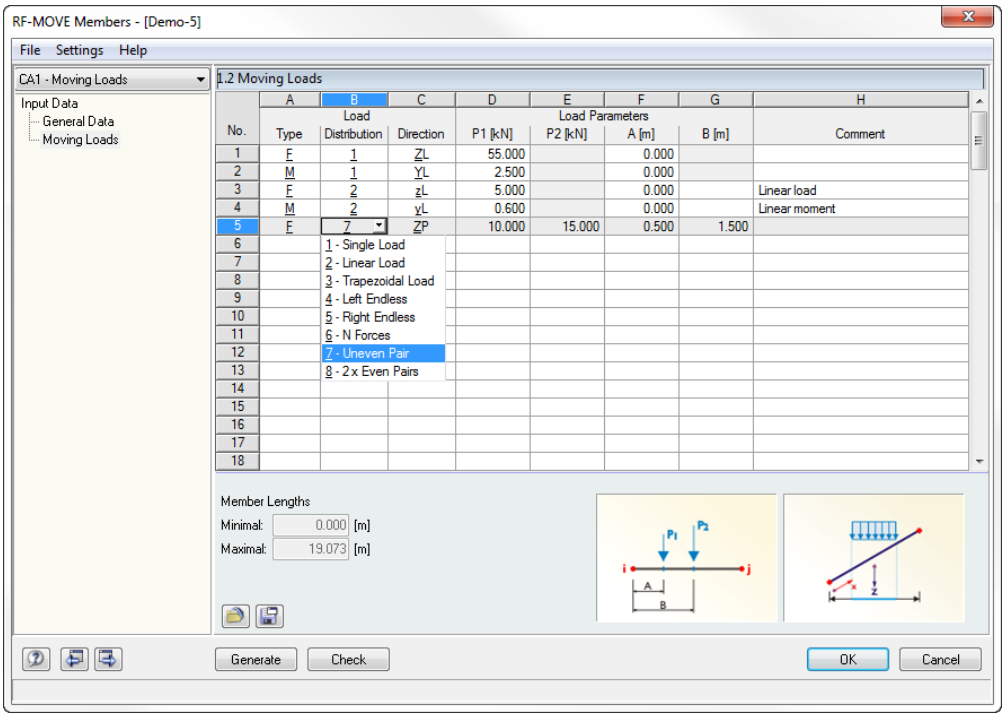


Figure 2.2: Table 1.2 *Moving Loads*

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Load Type

In table column A, you define the load to be either a *Force* or a *Moment*. Click into the input field to activate the [▼] button. Use this button to select the corresponding entry from the list. You can also use the function key [F7] to open the list.

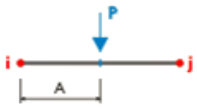
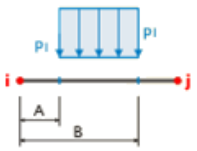
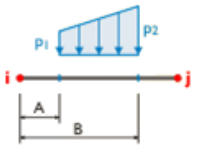
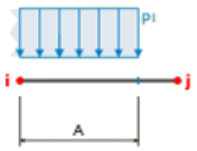
The load type can be defined also directly by entering the letter **F** (for force) or **M** (for moment).

It depends on your selection which headings are shown in the subsequent table columns and which graphics are displayed in the lower table section.

Load Distribution

Eight different load types are available for selection by means of the list. Each load specification is represented graphically in the left picture in the lower table section.

The following table describes the load distributions in detail. The loads refer to the load type 'Force'.

Load distribution	Load specification	Description
Single load		Single force, concentrated moment The *Load Parameters* to be entered in the table are the size of the concentrated load or moment and the load distance from the moving start.
Linear load		Uniformly distributed load, uniformly distributed moment The *Load Parameters* to be entered in the table are the size of the linear load or moment as well as the distances of the linear load's beginning and end from the moving start.
Trapezoidal load		Trapezoidal load, trapezoidal moment In case of a linearly variable load distribution, the *Load Parameters* to be entered are the two load values as well as the distances of the trapezoidal load's beginning and end from the moving start.
Left endless		Uniformly distributed load, uniformly distributed moment This type of load distribution allows you to apply a uniform load for each load position until the start of the member set is reached (see example in chapter 3.4.2). The *Load Parameters* to be entered in the table are the size of the linear load or moment as well as the distance of the right load edge from the moving start.

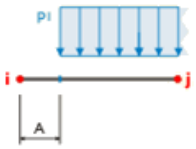
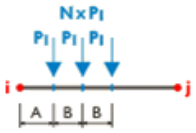
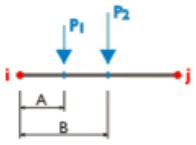
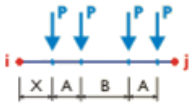
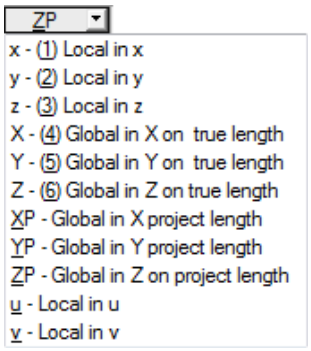
Right endless		Uniformly distributed load, uniformly distributed moment This load is used to apply a uniform load to the end of the member set for each load position. The *Load Parameters* to be entered in the table are the size of the linear load or moment as well as the distance of the left load edge from the moving start.
N forces		Single forces, concentrated moments Single loads that are equal in size are acting in a uniform spacing. The *Load Parameters* to be entered are the load value, the distance of the first load from the moving start as well as the spacing between the single loads among each other.
Uneven pair		Single forces, concentrated moments Two single loads that are unequal in size are running along the set of members. The *Load Parameters* to be entered in the table are the two load values and their distances from the moving start.
2 x even pairs		Single forces, concentrated moments Two load pairs with single loads that are equal in size are running along the set of members, for example axle loads. The *Load Parameters* to be defined are the load value, the distance of the first load from the moving start, the spacing between the single loads of a force pair as well as the spacing between the force pairs themselves.

Table 2.1: Load distributions



Load Direction

Table column C offers you the possibility to choose from eleven different load directions. Click into the input field to activate the [▼] button. Use this button to select the corresponding entry from the list. You can also use the function key [F7] to open the list. The load's direction of action is represented in the picture at the bottom right.

The load can be effective in *Local* direction of the member axes x, y, z or u, v, and in the *Global* direction of the axes X, Y, Z. The local axis *x* is represented by the longitudinal member axis, the *y*- or *u*-axis represents the 'strong' axis. Accordingly, the *z*- or *v*-axis represents the 'weak' axis of the member cross-section. If the load acts in direction of an axis of the global coordinate system X ,Y , Z, the orientation of the local member axes is irrelevant for applying loads.

In case the load is not acting perpendicular to the member, the load impact can be related to either the entire length of the member, the *true length* or the *project length* of the member in one of the global directions.

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Load Parameters

In the table columns D to G, you enter the load values and spacings. The input settings depend on the load distribution selected in column B, the input fields are labeled accordingly. The load pictures in the lower table section facilitate the input of the various parameters.

Load P_1 / P_2

The size of the load is entered in the two table columns. The signs are resulting from the global or local axis directions. In case of a trapezoidal load or an uneven load pair, you have to enter two load values.

Distance A / B / X

The input field *A* defines the distance of the load from the moving start. Linear and trapezoidal loads require additionally the specification of the distance *B* from the moving start describing the propagation length of the load. In case of multiaxial single loads, *B* indicates the spacing between the individual loads (see Table 2.1, page 12).

Comment

In this input field, you can enter user-defined notes describing in detail, for example, the load defined in the current table row.

Save and import load specifications

The loads defined in table 1.2 can be saved as load specification in order to use the input data also in other structures. The two buttons below the table are reserved for the following functions:

Button	Description	Function
	Save As Loads	Saves all loads defined in the table
	Read Loads	Imports a saved load specification

Table 2.2: Buttons in table 1.2 *Moving Loads*

The two buttons open the dialog boxes *Save Loads* and *Read Loads* where you can specify the corresponding data.

3. Generation

This chapter describes how the load cases and load combinations are generated and how these loads can be synchronized, if required, with the RFEM load data.

3.1 Starting the Generation

Before you start the generation, it is recommended to [Check] the input data by using the button shown on the left. If no input error is detected, the following message will be displayed:

Figure 3.1: Message after successful check

The button [Generate] is available in both RF-MOVE input tables. Use this button to generate the load cases and load combinations for RFEM. It is not possible to start the generation of RF-MOVE load cases out of the graphical RFEM user interface.

Subsequent to the successful generation, a window appears showing the numbers of the new load cases and combinations for information.

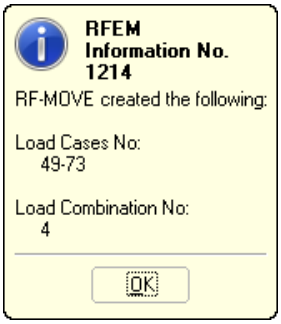

Figure 3.2: Message after generation

Thus, the generation of load cases and load combinations is complete.

When you have created several RF-MOVE cases, you have to perform the generation for each RF-MOVE case separately.

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3.2 Checking the Results

The add-on module RF-MOVE does not display any results tables when the generation is done. You can check the created load cases including loads in RFEM.

Quit RF-MOVE by clicking the [OK] button to return to the RFEM user interface where you have the following options to check the generated load cases:

- *Data* navigator: **Loads** → **Load Cases**
- Toolbar: *Loads and/or Results* list
- **File** menu → **Structure Data**

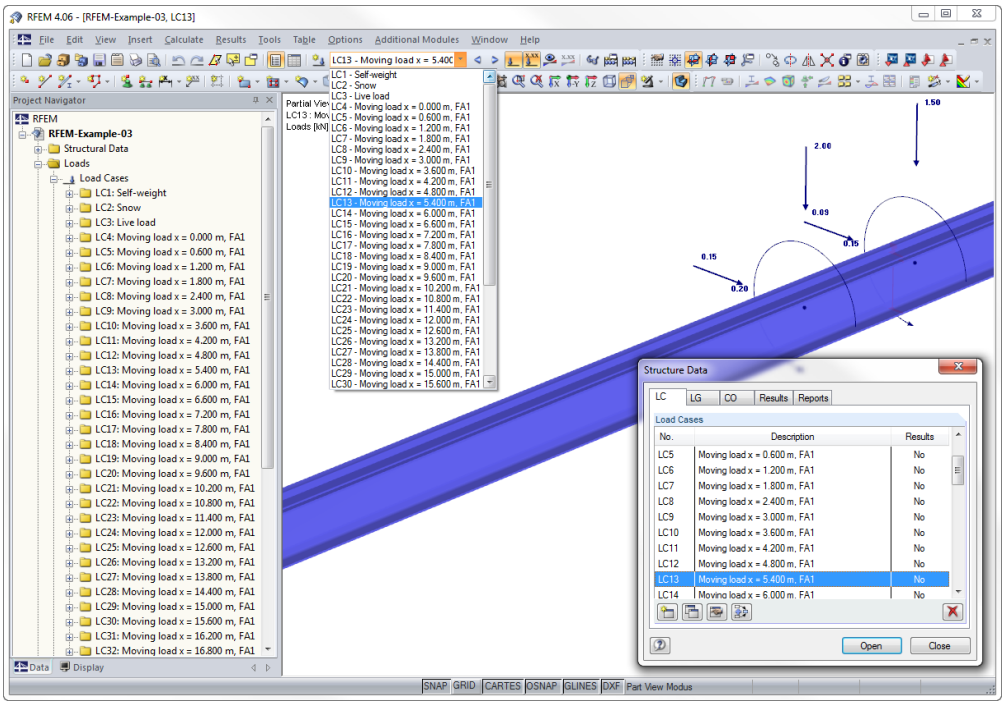
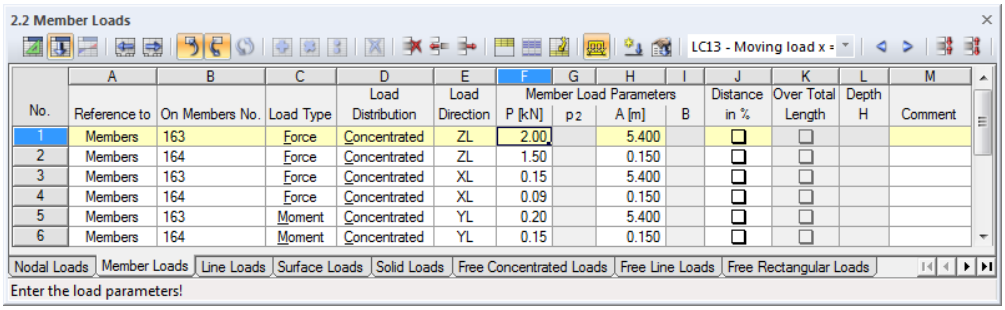


Figure 3.3: Generated load cases in *Data* navigator, list and dialog box

The *Descriptions* of the moving loads are deduced automatically from the respective load increment number. You can replace them, if necessary, by your own descriptions in the general data of the load cases.

The loads that have been generated in the individual load cases can be checked as usual in RFEM by means of the graphic, the edit dialog boxes or in table 2.2 *Member Loads*.



No.	Reference to	On Members No.	Load Type	Load Distribution	Load Direction	Member Load Parameters P [kN]	p2	A [m]	B	Distance in %	Over Total Length	Depth H	Comment
1	Members	163	Force	Concentrated	ZL	2.00		5.400		☐	☐		
2	Members	164	Force	Concentrated	ZL	1.50		0.150		☐	☐		
3	Members	163	Force	Concentrated	XL	0.15		5.400		☐	☐		
4	Members	164	Force	Concentrated	XL	0.09		0.150		☐	☐		
5	Members	163	Moment	Concentrated	YL	0.20		5.400		☐	☐		
6	Members	164	Moment	Concentrated	YL	0.15		0.150		☐	☐		

Figure 3.4: Table 2.2 *Member Loads* with generated moving loads

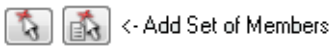
The generated load combination can be checked as well in the *Data* navigator or in the *CO* tab of the dialog box *Structure Data* (**File** menu → **Structure Data**).

3.3 Adding Load Positions

It is possible to apply moving loads simultaneously as parallel loads to different sets of members (for example crane runway), or to link existing RFEM loads with RF-MOVE generation results.

Add a set of members

When moving loads are running simultaneously across several sets of members, they can be managed together in one load case for generation - provided that the loads are comparable in their size and impact. This RF-MOVE feature can be used in particular for crane girders with parallel running loads on both hall sides.



The sets of members stressed by simultaneously running loads are defined in the RF-MOVE input table 1.1 *General Data*, section *Sets of Members*. If the first set of member is defined, click one of the [Pick] buttons shown on the left to select the members or the continuous members for the second set of members graphically in the RFEM work window.

With this selection, you add another set of members to the RF-MOVE list *Members No.* in the form of a new row. The individual sets of members can be displayed in the list by means of the [▼] button.

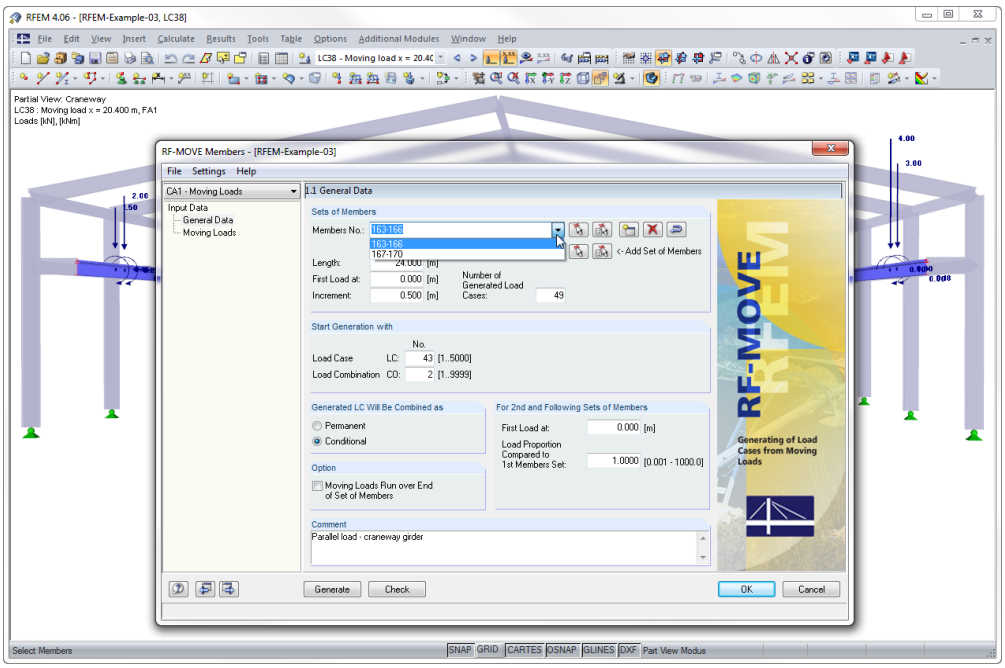


Figure 3.5: RF-MOVE with sets of members list and generated parallel loads in RFEM

If the loads are running offset, for example because of an unbalance in the structural model, you can specify the *First Load at* for the second set of members deviating from the moving start of the first member set in the table section below. In addition, it is possible to scale the loads of the second set of members by specifying a *Load Proportion* factor in order to model an eccentricity (see figure above).

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Complete RFEM loads

The generated loads can be edited like normal loads in the RFEM load cases. They can also be completed by further loads.

Vice versa, RFEM loads that have already been defined can be completed by generated loads: In RF-MOVE, table 1.1 *General Data*, section *Start Generation with*, enter the number of the relevant RFEM load case as start number. A selection field will be displayed where you decide whether the data of the load case and all subsequent load cases will be overwritten or added to the existing ones.

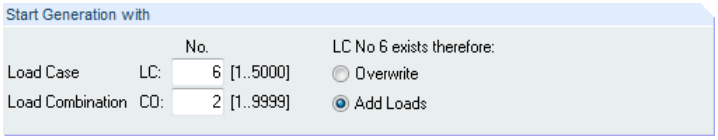

Figure 3.6: Table 1.1 *General Data* - Completing load case by generated data

3.4 Examples

3.4.1 Set of Members

A concentrated load runs along the structure shown below. Depending on the definition of the set of members, the load is moving in completely different ways.

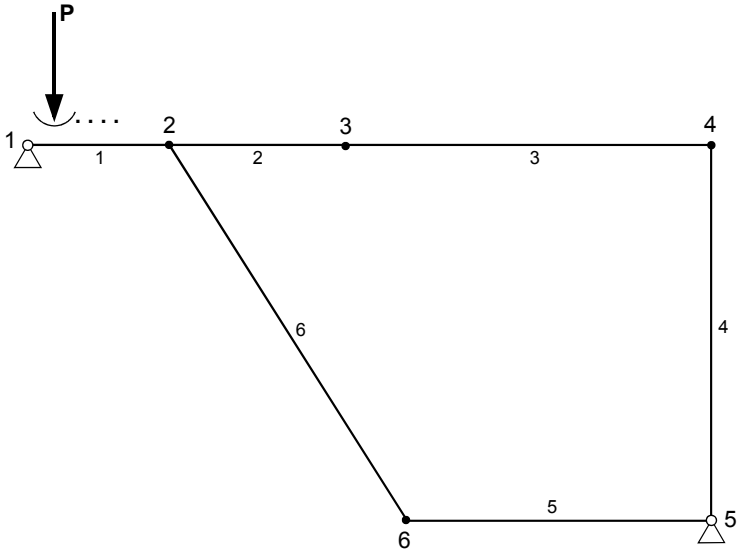

Figure 3.7: Set of members with moving load

In table 1.1 *General Data*, the following input is entered in the *Members No.* list.

Members No.	Runway of moving load
1-6,1	The load moves from node 1 along member 1, 2, 3 etc. to member 6 and returns along member 1 to node 1.
1,6-2,1	The load moves from node 1 to node 2, runs along member 6, 5, 4 etc. and returns to node 1.
1,2 4,5	The load runs simultaneously along the member sets 1, 2 and 4, 5. The second set of members 4, 5 must be defined separately by using the [Pick] button.

Table 3.1: Definitions for sets of members in table 1.1 *General Data*

3.4.2 Bridge

A vehicle load moves along a bridge represented by a set of members. At the same time, the set of members is stressed by a traffic surface load, corresponding to a linear load of 5 kN/m. The linear load is not applied where the vehicle load is moving.

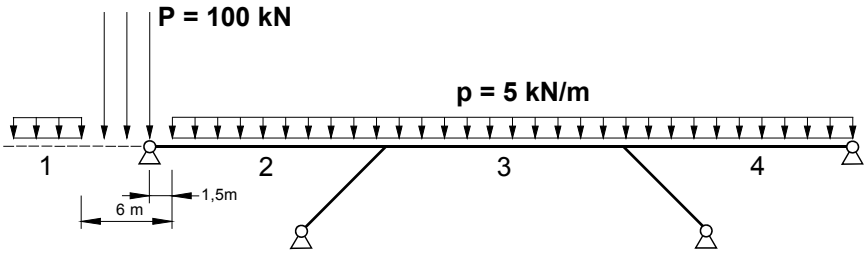

Figure 3.8: Bridge with vehicle load and traffic load p = 5 kN/m

To define the starting settings for the figure above, enter the following data in both RF-MOVE tables, considering an increment assumed with 1.50 m.

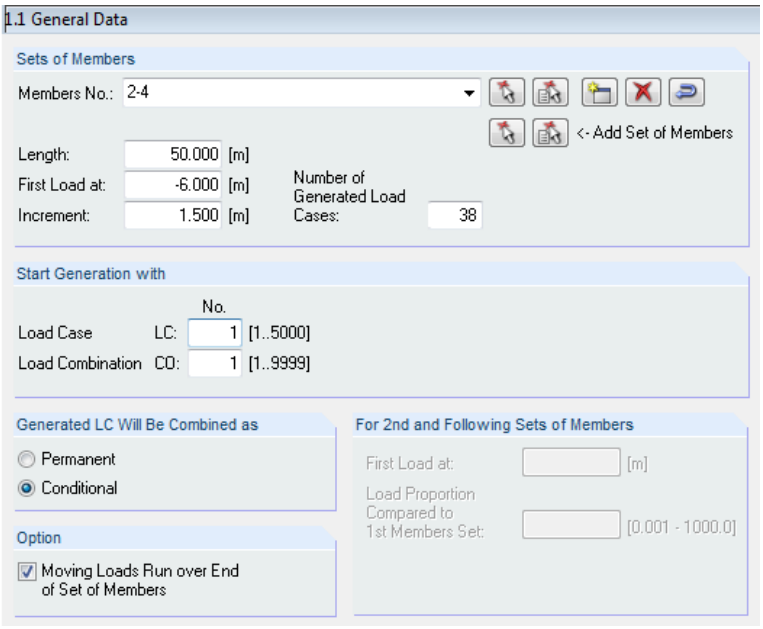

Figure 3.9: Table 1.1 *General Data*

1 - Single Load
2 - Linear Load
3 - Trapezoidal Load
4 - Left Endless
5 - Right Endless
6 - N Forces
7 - Uneven Pair
8 - 2 x Even Pairs

1.2 Moving Loads

No.	A Load Type	B Load Distribution	C Load Direction	D Load Parameters P1 [m]	E P2 [kN/m]	F A [m]	G B [m]	H Comment
1	F	4	ZL	5.000		0.000		left endless
2	F	6	ZL	100.000	3	1.500	1.500	3 equal single forces
3	F	5	ZL	5.000		6.000		right endless

Figure 3.10: Table 1.2 *Moving Loads*

The load entering the runway of the continuous members is represented by the negative value for the moving start. Thus, a pure linear load is created as the first load case on the set of members. In the second load case, the first single load stands exactly above the support, as shown in the sketch above. The linear load is only effective in a distance of 1.50 m to the right.

In load case 4 with x = -1.50 m, the final of the three single loads appears above the support. The uniform load 'Left Endless' is effective for the first time in load case 6 with x = 1.50 m as the left single load is now in a distance of 3.0 m from the support.

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4. General Functions

This chapter describes some menu functions as well as export options for the generation cases.

4.1 RF-MOVE Generation Cases

You can group members or load specifications in separate generation cases. It is no problem to use the same set of members in different generation cases. However, please concentrate on the assigned start numbers of load cases and load combinations as well as the corresponding generation options to avoid accidental overwriting.

Create a new RF-MOVE case

To create a new generation case,

select **New Case** on the **File** menu in the RF-MOVE add-on module.

The following dialog box appears.

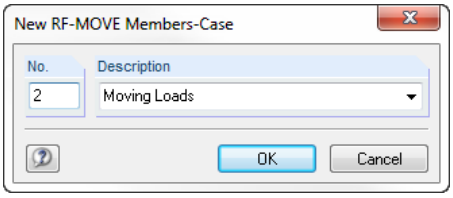

Figure 4.1: Dialog box *New RF-MOVE Members-Case*

In this dialog box, enter a *No.* (which is not yet assigned) and a *Description* for the new generation case. When you click [OK], table 1.1 *General Data* opens where you can enter the new parameters.

Rename an RF-MOVE case

To change the description of a generation case subsequently,

select **Rename Case** on the **File** menu in the RF-MOVE add-on module.

The dialog box *Rename RF-MOVE Members-Case* appears.

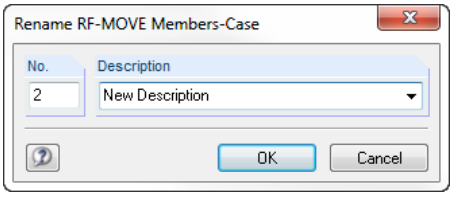

Figure 4.2: Dialog box *Rename RF-MOVE Members-Case*

Copy an RF-MOVE case

To copy the input data of the current generation case,

select **Copy Case** on the **File** menu in the RF-MOVE add-on module.

The dialog box *Copy RF-MOVE Members-Case* appears where you can specify the number and description of the new case.

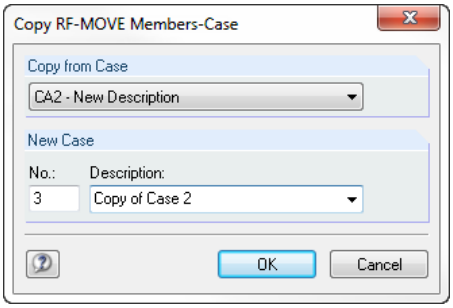

Figure 4.3: Dialog box *Copy RF-MOVE Members-Case*

Delete an RF-MOVE case

To delete a generation case,

select **Delete Case** on the **File** menu in the RF-MOVE add-on module.

In the dialog box *Delete Cases*, you can select the relevant generation case in the *Available Cases* list to delete it by clicking [OK].

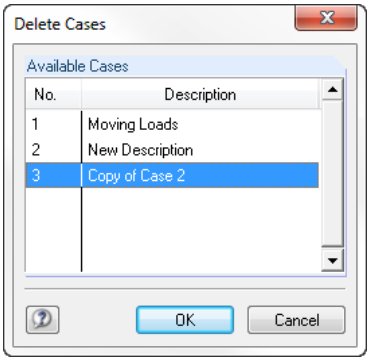

Figure 4.4: Dialog box *Delete Cases*

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4.2 Units and Decimal Places

The units and decimal places for RFEM and all add-on modules are managed in one global dialog box. In the add-on module RF-MOVE, you can use the menu to define the units. To open the corresponding dialog box,

select **Units and Decimal Places** on the **Settings** menu.

The following dialog box opens, which you already know from RFEM. The add-on module RF-MOVE is preset.

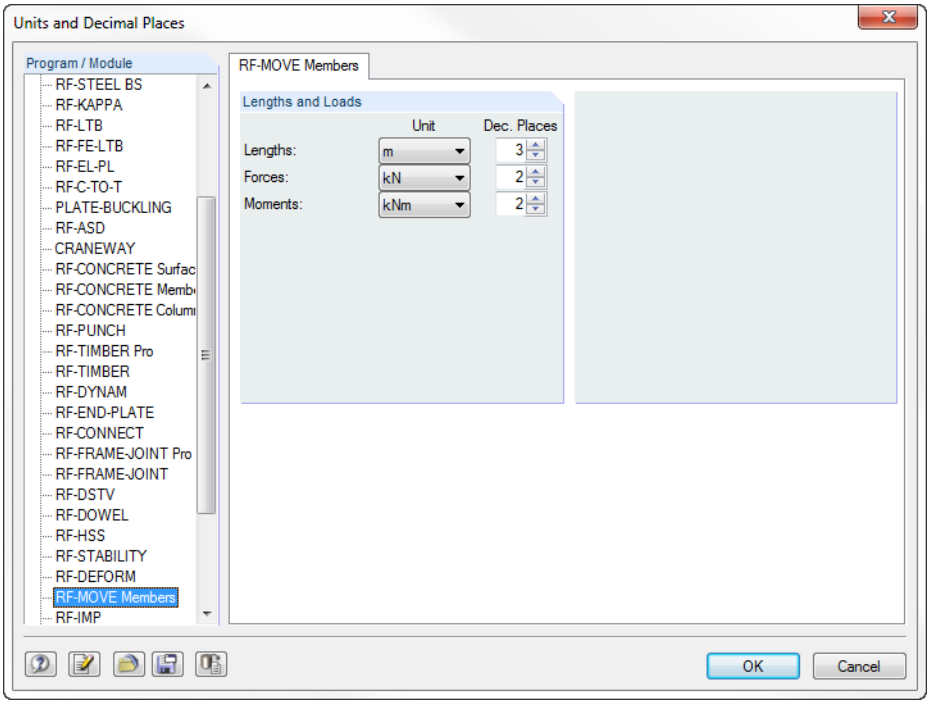


Figure 4.5: Dialog box *Units and Decimal Places*

The settings can be saved as user profile to reuse them in other structures. The functions are described in the RFEM manual, chapter 12.6.2, page 453.

4.3 Data Export

Data of the generation results is exported primarily in direction of the main program RFEM where the load cases and combinations are created, which can be adjusted, added or combined with further loadings. With some restrictions, it is also possible to prepare data from RF-MOVE directly for other programs.

Clipboard

To copy cells selected in table 1.2 *Moving Loads* to the clipboard, use the keyboard keys [Ctrl]+[C]. To insert the cells, for example in a word processing program, press [Ctrl]+[V]. The headers of the table columns won't be transferred.

Printout report

Data from RF-MOVE is not integrated in the printout report, but you can export the load cases and combinations generated in RFEM. To use the corresponding report function,

select **Export to RTF File or BauText** on the **File** menu.

The function is described in detail in the RFEM manual, chapter 11.1.11, page 350.

Excel / OpenOffice

RF-MOVE provides a function for the direct data export to MS Excel, OpenOffice.org Calc or the file format CSV. To open the corresponding dialog box,

select **Export Tables** on the **File** menu in the RF-MOVE add-on module.

The following export dialog box appears.

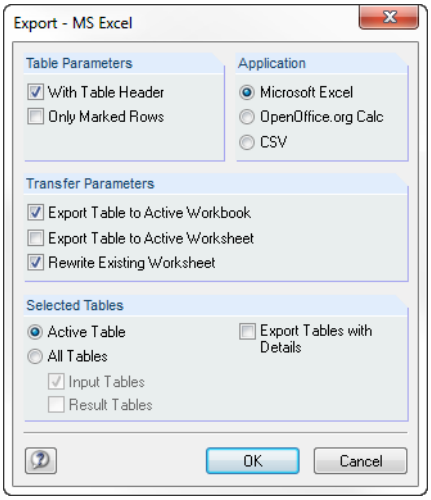
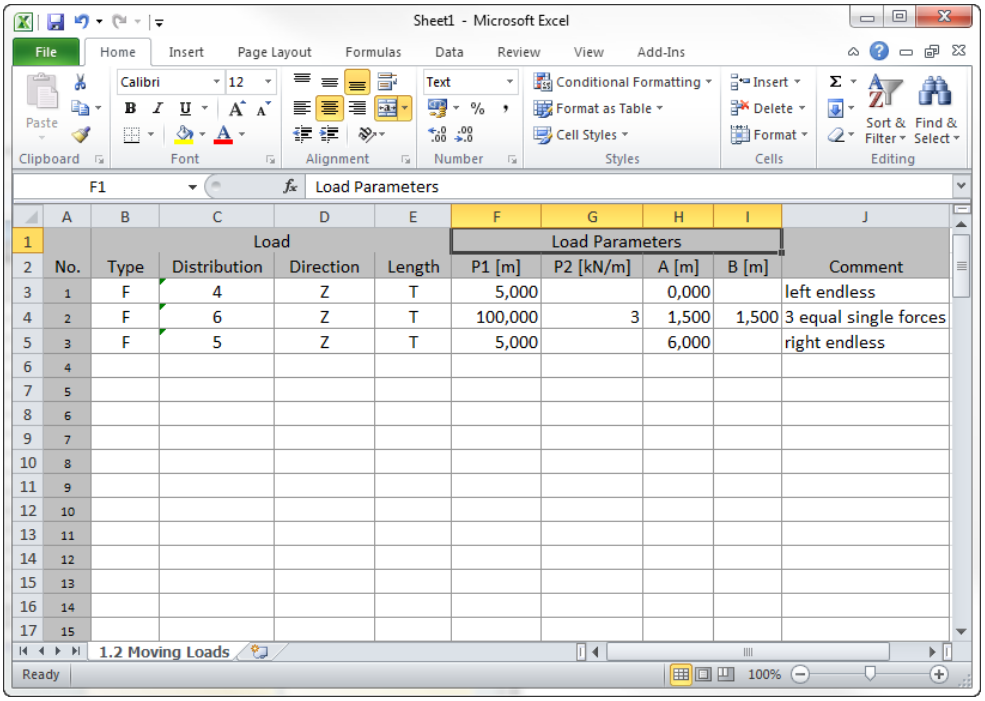


Figure 4.6: Dialog box *Export - MS Excel*

According to the program concept, only table 1.2 *Moving Loads* is relevant for the export. Start the data export by clicking the [OK] button. Excel or OpenOffice will be started automatically. It is not necessary to run the programs in the background.



	A	B	C	D	E	F	G	H	I	J
1		Load				Load Parameters				
2	No.	Type	Distribution	Direction	Length	P1 [m]	P2 [kN/m]	A [m]	B [m]	Comment
3	1	F	4	Z	T	5,000		0,000		left endless
4	2	F	6	Z	T	100,000	3	1,500	1,500	3 equal single forces
5	3	F	5	Z	T	5,000		6,000		right endless
6	4									
7	5									
8	6									
9	7									
10	8									
11	9									
12	10									
13	11									
14	12									
15	13									
16	14									
17	15									

Figure 4.7: Result in MS Excel, table 1.2 *Moving Loads*

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