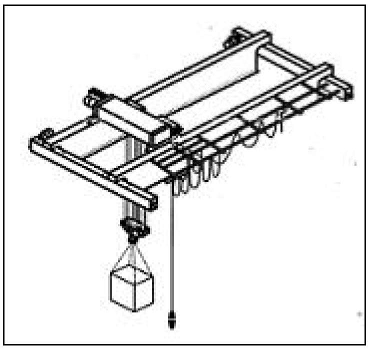
Manual 6.9.6   EN-KRAN



Content

1. General

The programme is used to create proofs in accordance with EN 13001 and EN 15011 for single-girder and double-girder overhead cranes, single-girder and double-girder suspension cranes and cantilever crab cranes.

It requires a Microsoft operating system of Windows 95 or higher.

Set your screen resolution to at least 1024*768 pixels and the taskbar to single line.

The programme has been subjected to intensive testing. Nevertheless, no warranty for correctness can be given.

This manual describes the functions of the programme. Operating errors are indicated by warnings and error messages which are not described in this manual.

The display of windows in this manual shows the windows in “classic view”. Other settings of the screen are possible and will have no influence on the programme.

Installation of updates with minor changes may result in slight modifications of windows as shown in this manual.

Application of the programme creates further subfolders:
All data are stored in ...\EN-Kran\Daten..

- The folder …\Datenbank contains all project-independent data.
- The folder …\Texte contains all window texts, message texts and printer texts.
- The folder …\EPROJEKTE contains all processed single-girder crane projects.
- The folder …\ZPROJEKTE contains all processed double-girder crane projects.

Each crane project is summarized in a folder …\Projektname. Each project refers to one crane respectively. The project name can be chosen at will. A systematic naming convention is, however, recommended, e.g. based on customer names or project numbers.

All project folders may be deleted manually. However, deletion or manipulation of individual files may jeopardise the further operation of the programme. E or Z project folders may be copied to folders or data on other computers (where EN-Kran has been installed); the same applies to folders of single projects. Make sure that the database contains all components used by the copied projects.

Crab and end carriage data generated externally with EN-Kran may be copied into the respective database. This facilitates the provision of component data by component manufacturers.

2. Installation

2.1 Download

When downloading from the internet, some operating systems start the setup automatically. Where this is not the case, installation is started by clicking on “Setup.exe”.

When installing updates (or in re-installation) only those programme parts will be overwritten that have been amended, while stored user data (databanks) and settings remain unaffected.

The folders where the programme is stored may be selected. By default, the folder C:\Programme\EN-Kran is pre-set for the EXE programmes, and the folder C:\ProgramData\EN-Kran for the data.
All programme parts and required libraries install automatically.

The programme can then be started via the start menu.

Navigation in all programme parts is generally carried out via mouse click or keypad (tab key, arrow keys or input end/return key). The respective input fields selected are highlighted in yellow.

You may exit all programme parts at any time and continue working with the programme after a restart.

2.2 First Programme Start

The selection window of the administration programme opens when the programme is started for the first time.

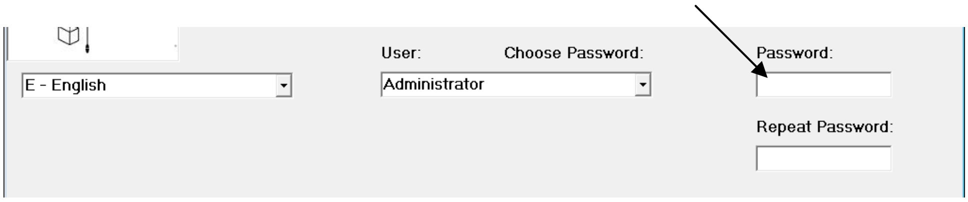
First select the interface language. Subsequently, the required data must be entered into the licence window:

The disclaimer must be accepted.

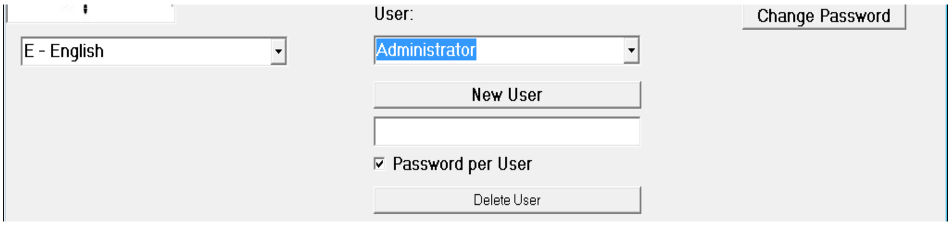
Without a licence password the programme will only run as a limited demo version.

A click on the licence key will save it in the "Clipboard" memory.

After acceptance, a password must be assigned to the administrator:



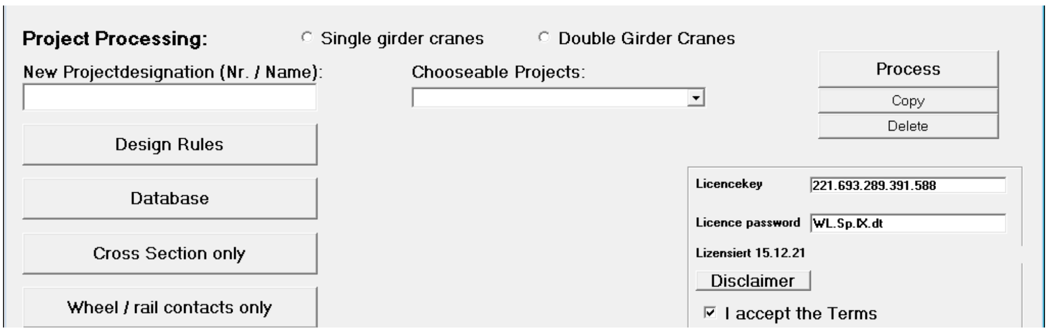
The administrator may create further users, or delete these subsequently:



Enter the username and click on “New User”. If password protection has been activated, then a password has to be entered for the user.

2.3 Following Programme Starts

As soon as the programme has been started for the first time, the following window is displayed after re-start and selection of the user:



In addition to available options, such as presetting design rules, entering data into the database or calculating project-independent cross-section values or wheel-rail contacts, projects for single-girder or double-girder bridge cranes may be

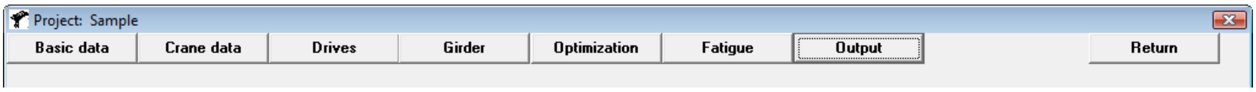
- started (enter name and click on Process)
- re-opened (from the list of chooseable projects)
- copied (under a new project name)
- or deleted.

If more than 15 projects exist a filter allows to choose only from certain crane types and or load capacities.

3. Data Entry for Projects

3.1 Main menu

After opening a project, the selection window for data entry is displayed with the project name in the header (see also Annex 10):

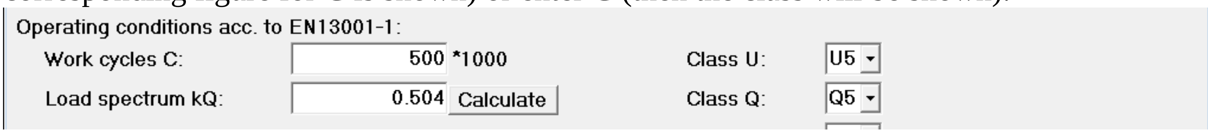


The respective windows are self-explanatory for the most part. But the following chapters address specific features and details.
With a click on the “Return” button you return to the administration programme.

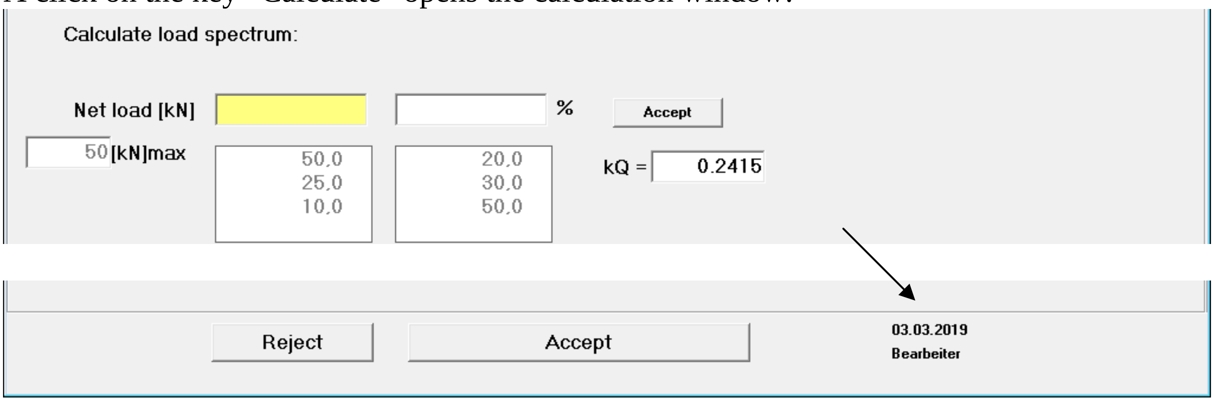
3.2 Basic data

It makes sense to enter basic data as a first step.
In addition to the type of crane (e.g. 4-wheel crane, or 8-wheel crane, 4-wheel crane with suspension crab or suspension crane in case of double-girder bridge cranes , bridge crane, suspension crane or cantilever crab crane in case of single-girder bridge cranes), these are in particular: nominal load capacity, crane span (track) or girder length and all classifications of operating conditions. Optional input of order number and drawing number.

Example of input of classification: Select either Class U of total number of work cycles (the corresponding figure for C is shown) or enter C (then the class will be shown).



The load spectrum kQ can also be calculated:
A click on the key “Calculate” opens the calculation window:

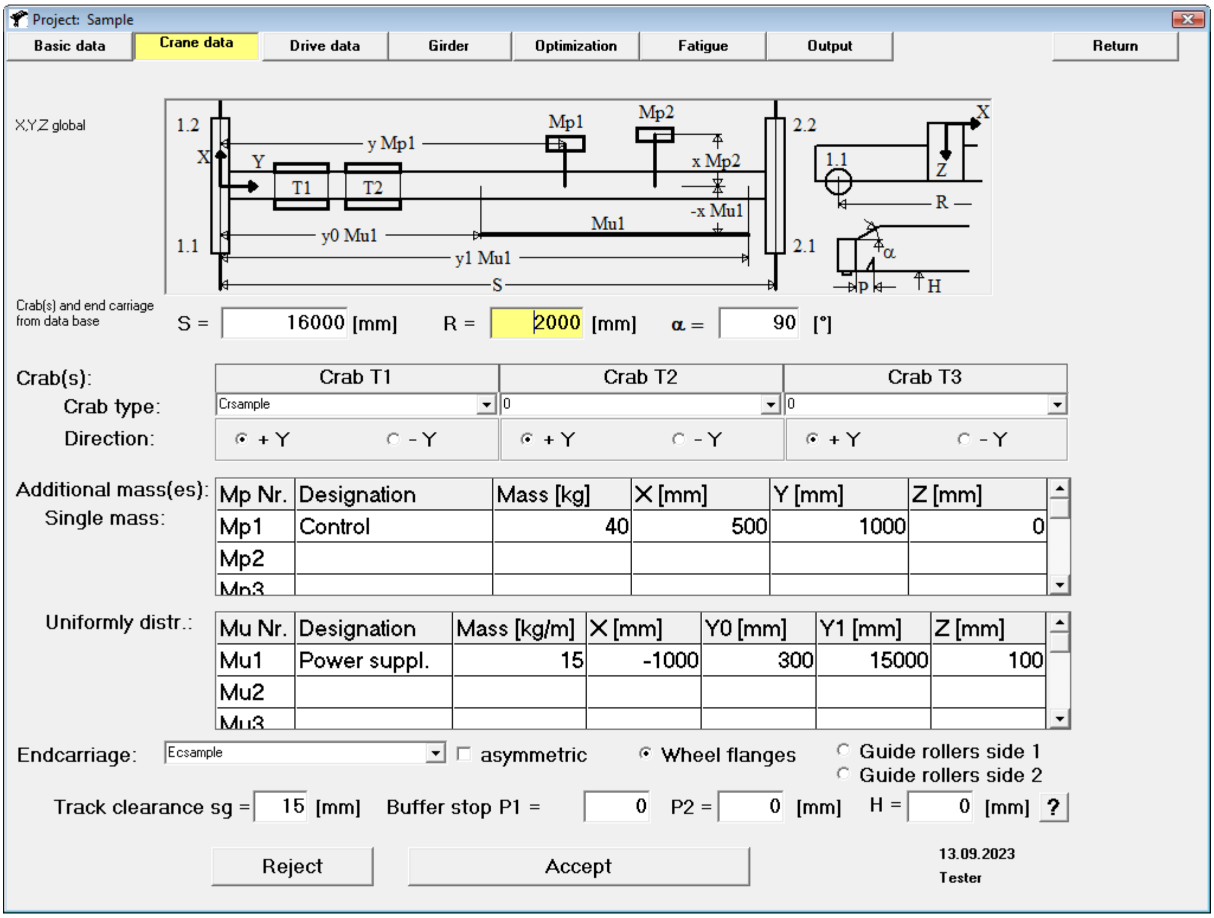


Individual net loads with their respective percentage share of load cycles must be entered and accepted (small key “Accept” in the window). Upon entering all values, all entries must be accepted (large key “Accept” at the bottom of the window). Corrections are made by overwriting the respective values: e.g. enter once again “50” (see example) and a different percentage, or enter 0 as percentage; then the load is deleted.
The user who has made entries last is indicated at the bottom of the window.

Other data to be entered: data for the crane rail, classes D of average paths, factors for test loads, risk factor and the respective wind data for outdoor operation.
Suspension crane: Width of rail head is not required. However, for the purpose of skewing calculations the track tolerance (input under crane data) should contain expected wear.

3.3 Crane data

Clicked keys and also the selected input fields will be highlighted in yellow. Data required here refer to additional masses (single masses or uniformly distributed masses), selection of end carriages and (up to three) crabs.



The location of additional masses in relation to the crane bridge (or for double-girder cranes: to the specified bridge (1) or (2)) must be entered in accordance with the schematic diagram.

<u>End carriages</u> must be selected from the list of end carriages stored in the database.

The <u>crab (or crabs)</u> must also be selected from the database. There they are displayed in global +Y direction (gravity centre, approach dimensions, hook travel). Clicking the radio button you can change the direction to –Y.

The example of a single-girder bridge crane displayed above also shows that all input fields referring to dimensions are explained by a respective schematic diagram.

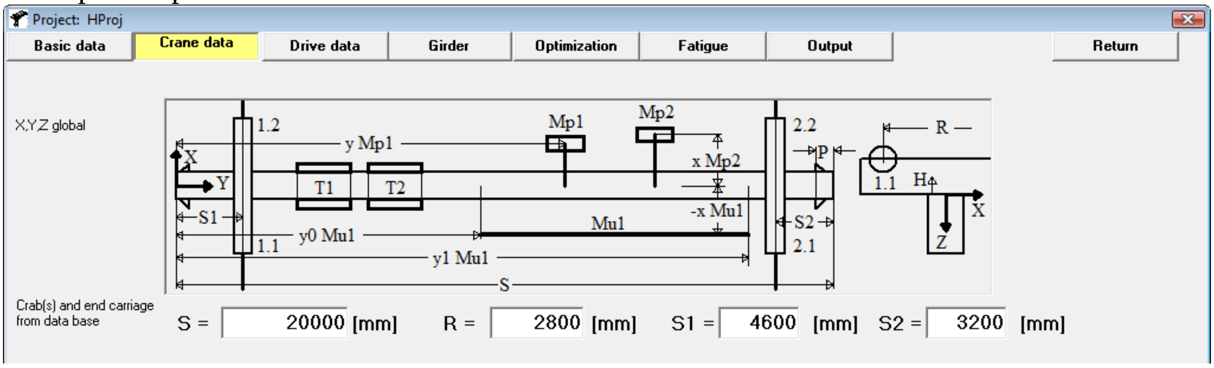
Suspension cranes additionally require the lengths of cantilevers. The location Y of additional masses is measured from the outer edge of cantilever 1 (see example below).

Double-girder bridge cranes and cantilever crab cranes additionally require the height of the top of the girders above the crane rail (data H). In case of underflange crabs the data H defines the position of the bridge underflange relative to the underflange of the end carriage.

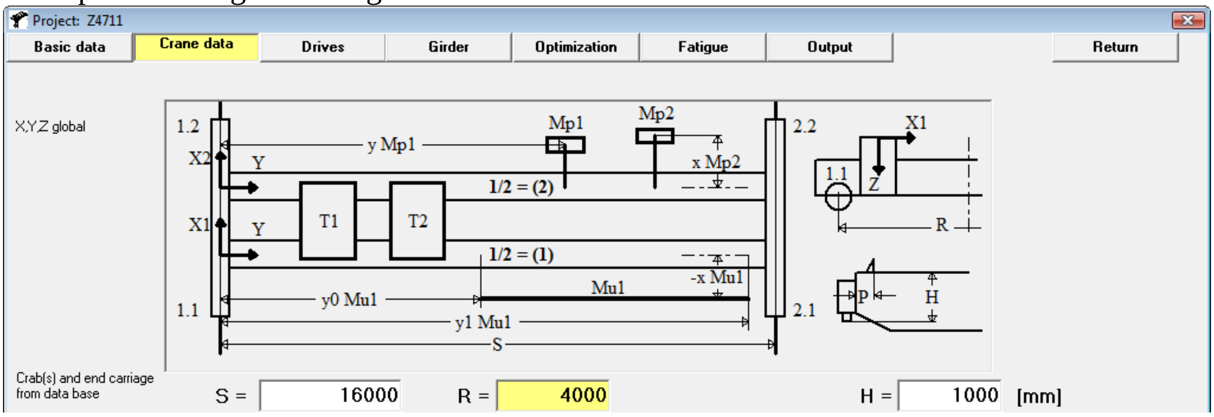
8-wheel cranes additionally require wheel base R1 of end carriages.

Cantilever crab cranes additionally require distance SR between crab rail and crane wheel 1.

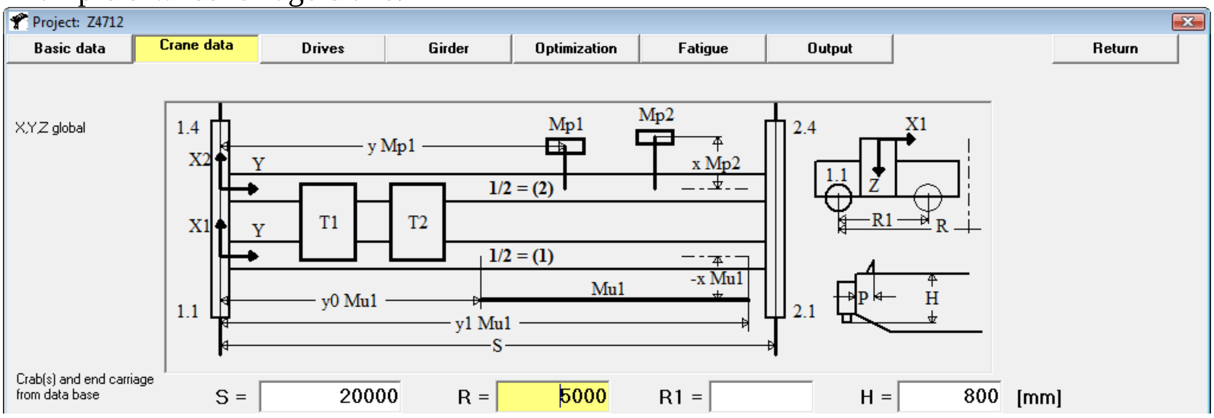
Example Suspension crane:



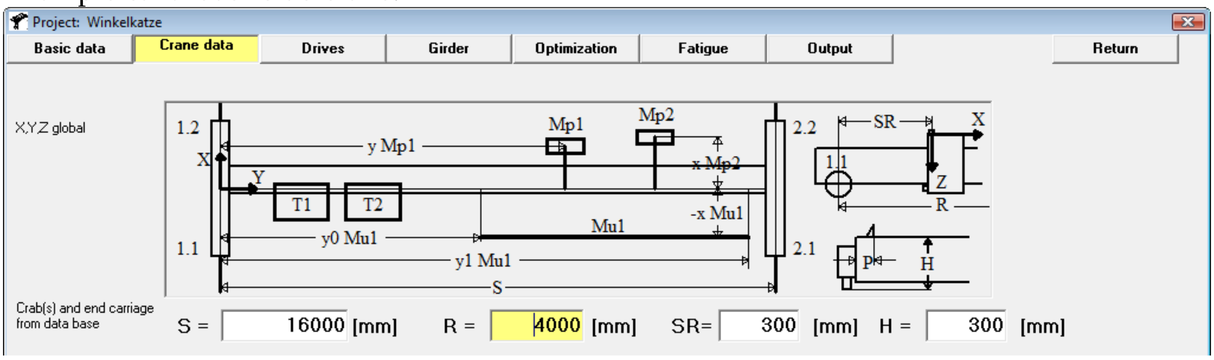
Example Double-girder bridge crane:



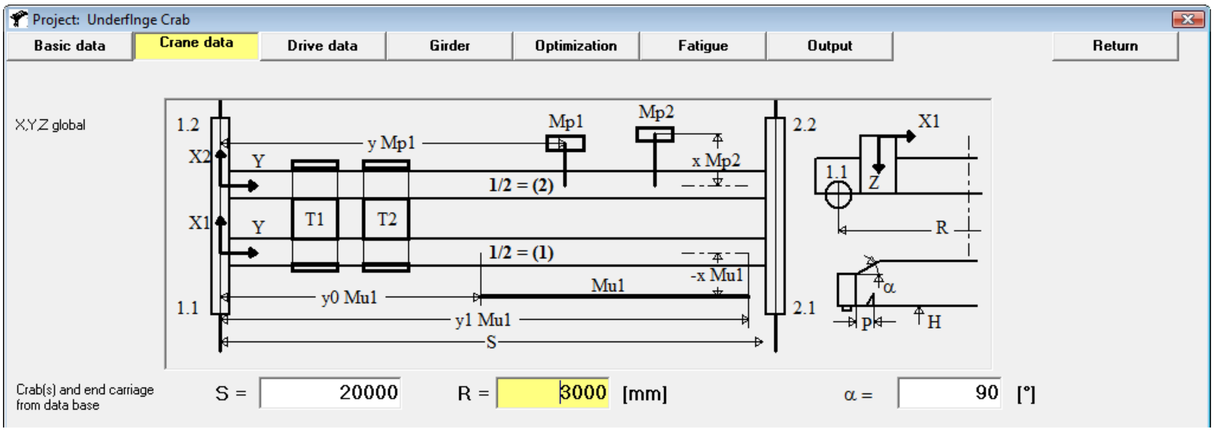
Example 8-wheel bridge crane:



Example cantilever crab crane:



Example Double-girder crane with underflange crab:

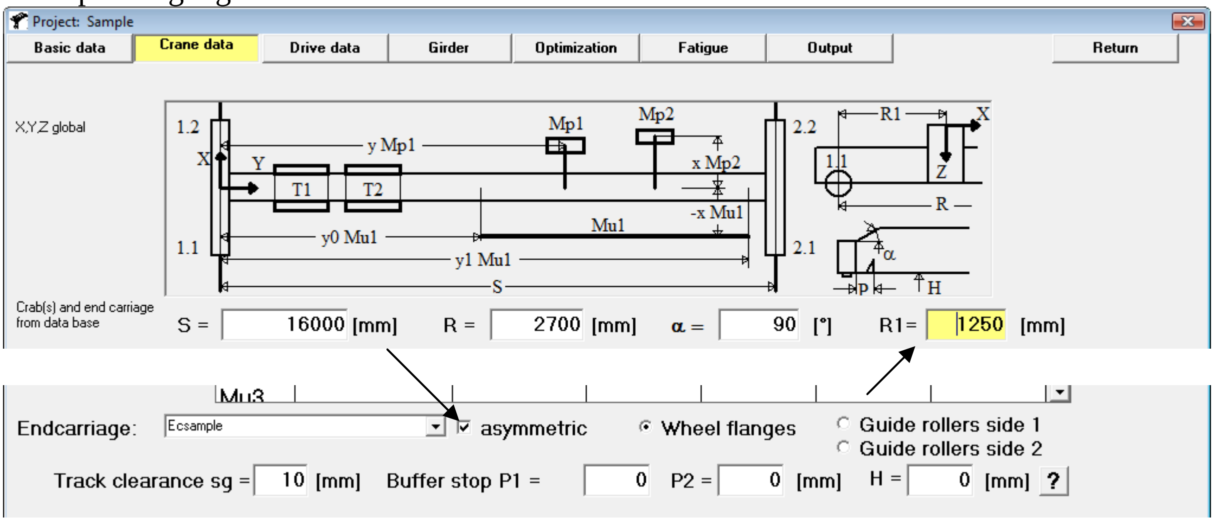


The position of the buffer stops P1 and P2 is measured from the end carriage, for suspension cranes from the end of the cantilevers.

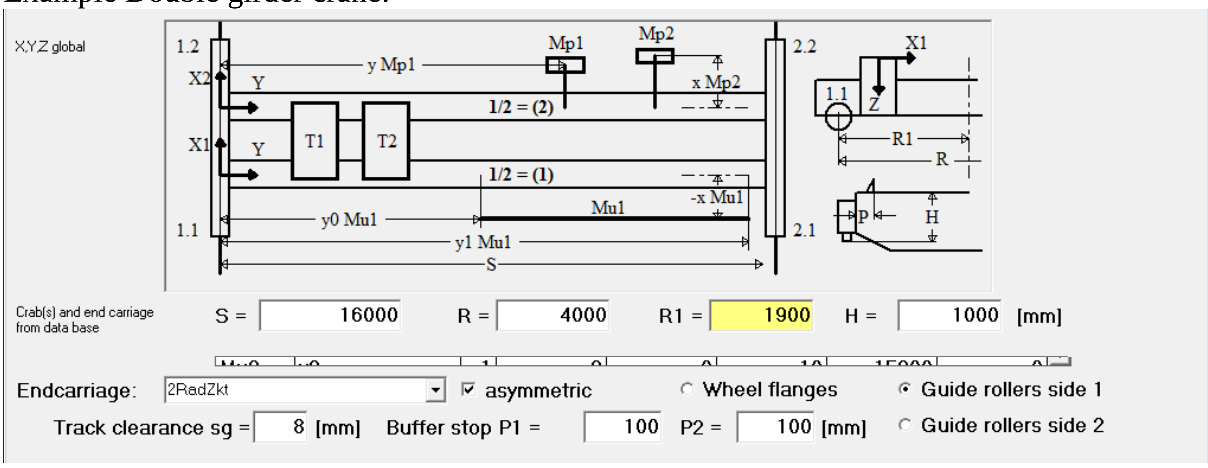
3.3.1 Asymmetric position of bridge girders

You may allocate the bridge girders in asymmetric positions:

Example Single girder crane:



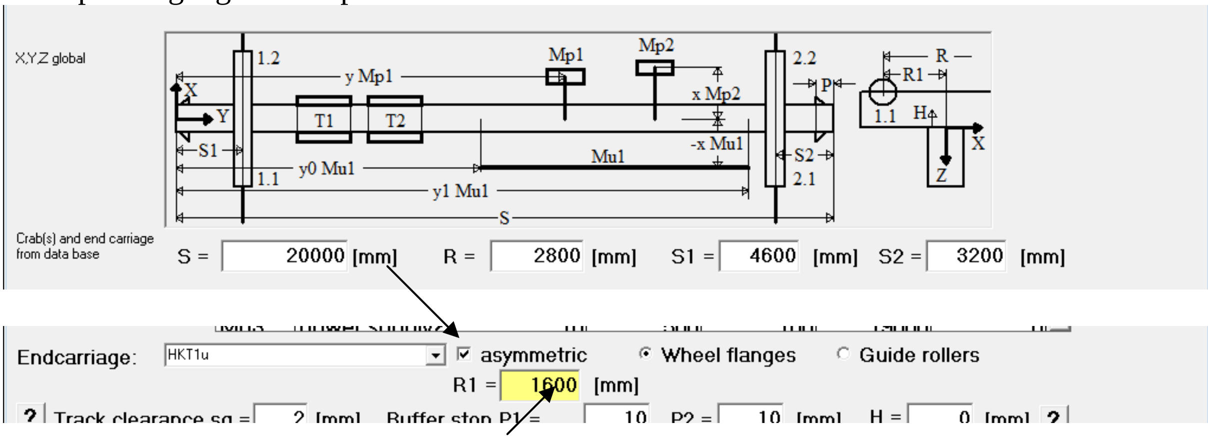
Example Double girder crane:



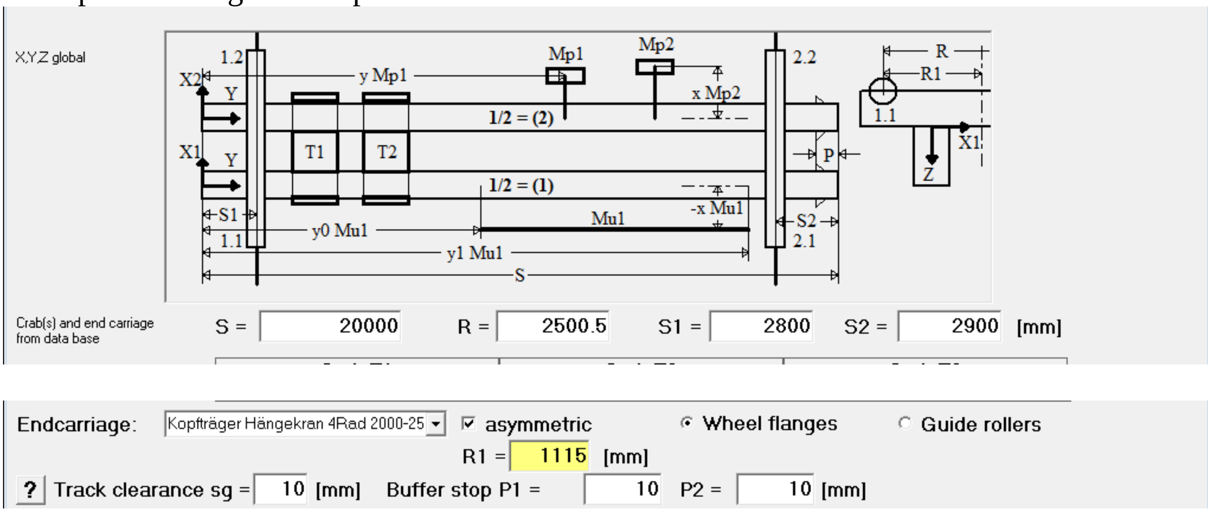
The dimension R1 indicates for single girder cranes the position of girder middle and for double girder cranes the position of crab span middle in relation to crane wheel 1.1.

For other crane types the input of dimension R1 is positioned below the check box.

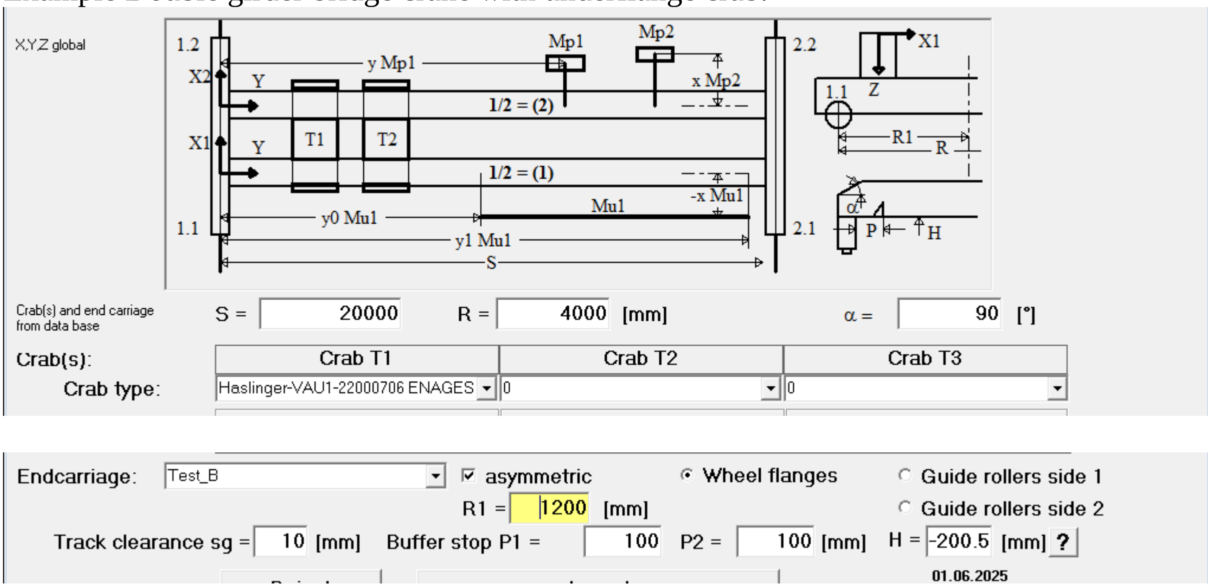
Example Single girder suspension crane:



Example Double girder suspension crane:

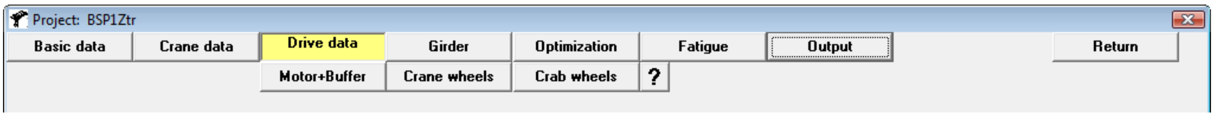


Example Double girder bridge crane with underflange crab:



3.4 Drive data

Here you can entry the data of motors and buffers (always required) and of crane wheels (optional).

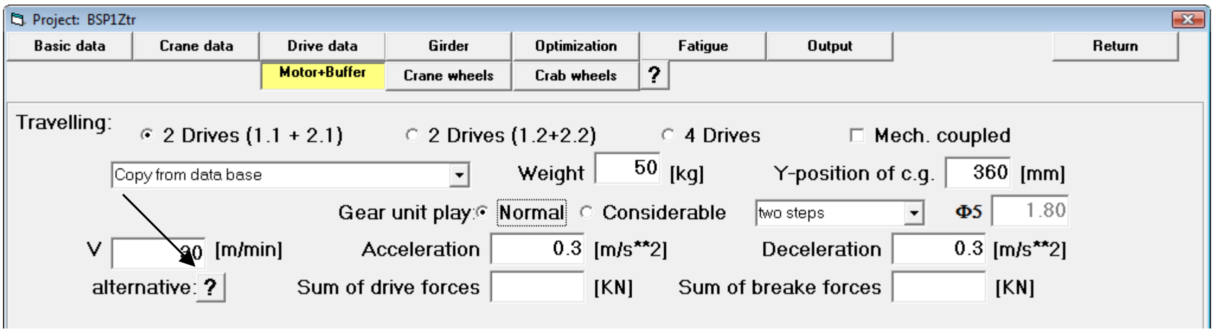


3.4.1 Motor and buffer

This window requires the entry of all relevant data to determine the dynamic coefficients (except the hoist coefficients which are assigned to crabs in the database).

This refers to crane drives (2 or 4), crab drives and buffers. 8-wheel cranes can have either 4 or 8 drives.

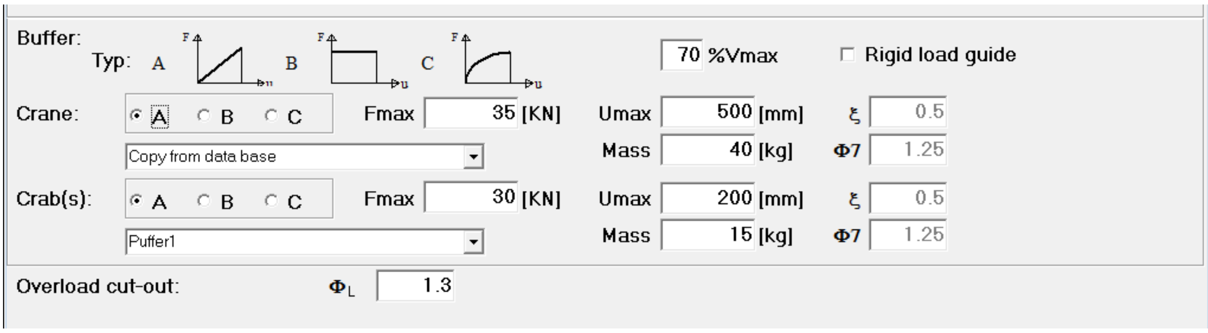
A click on the „?“ key opens a text field with explanations of the drive specification:



Info text:

> Acceleration values refer to the loaded crane. For outdoor operation: If only values for acceleration OR only drive forces have been entered, then these will also be applied to load combinations B. If accelerations AND drive forces are given then load combinations A will be calculated with accelerations, and load combinations B with forces.

Buffer data must be entered in the same manner:



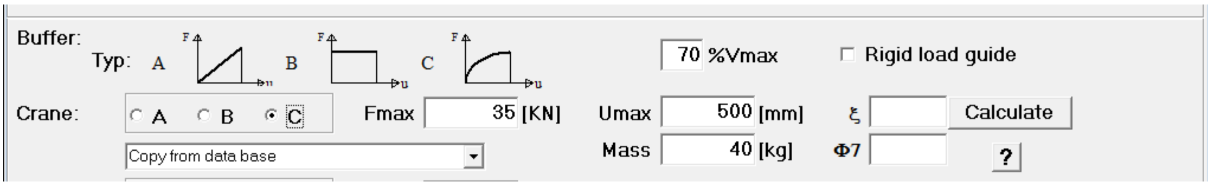
If you select „Rigid load guide“, it will be assumed in the proofs for the buffer impact that the load does not swing and that therefore the deceleration of the load mass is absorbed by the buffer.

Dynamic coefficients Φ7 are generated according to buffer type; the dynamic coefficient ΦL of the overload cut-out needs to be specified.

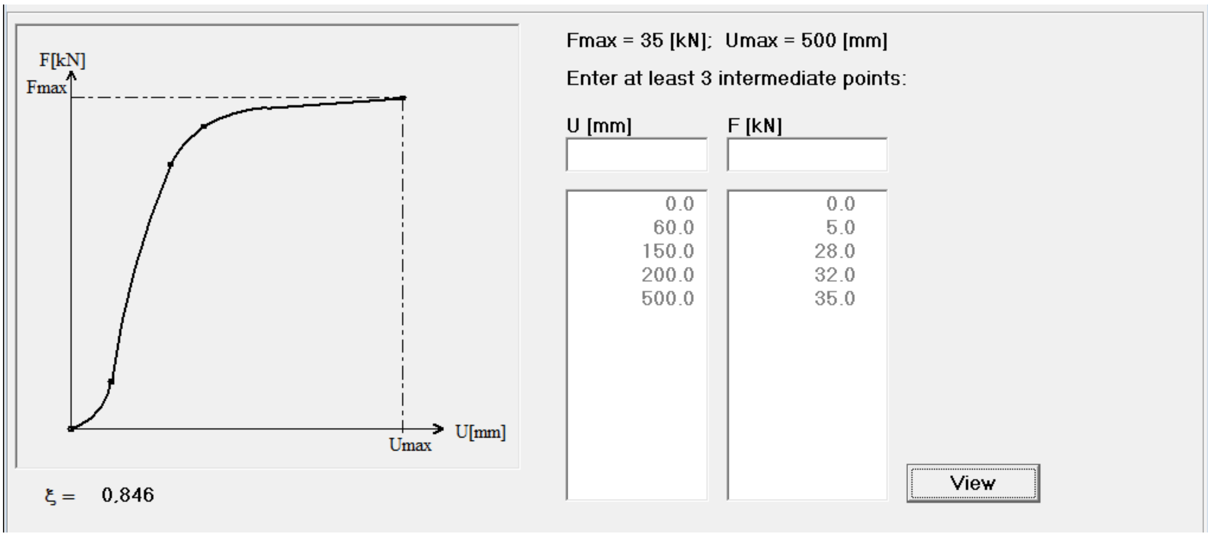
All data for the drive may be taken from the database. In contrast to the data for crabs and end carriages they may be individually amended in the context of each crane project.

3.4.2 Characteristic curve of degressive buffer (type C)

Degressive buffers require input of the factor of relative buffer energy ξ :



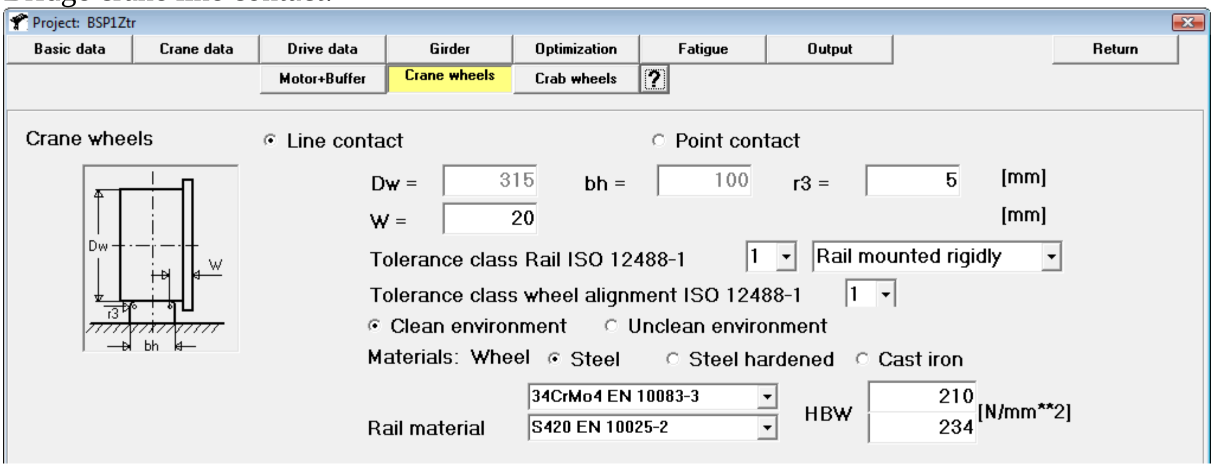
For known characteristic curves this factor may be determined by a click on "Calculate":



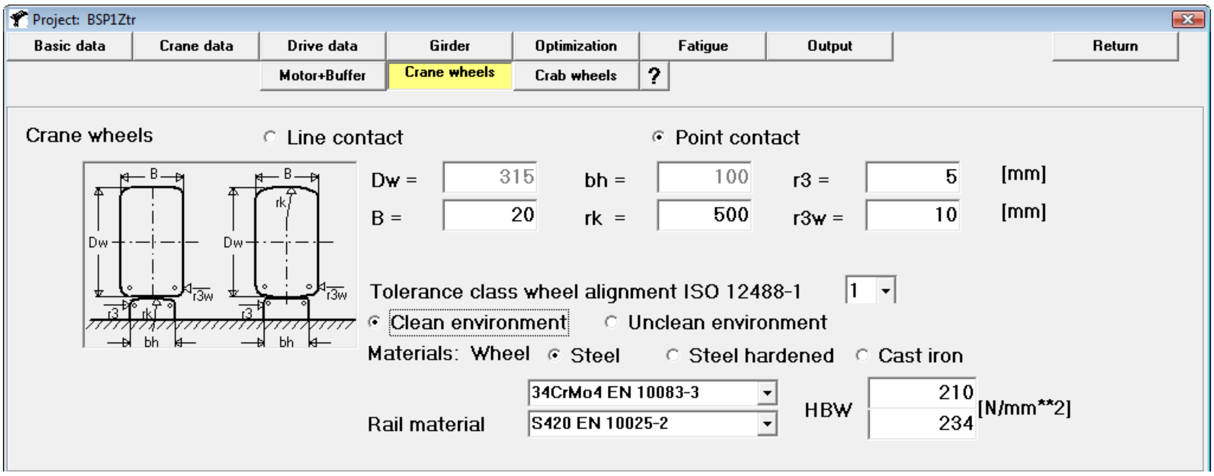
3.4.3 Crane wheels

This window requires the entry of all relevant data to determine the limit design contact force for the static proof of competence and the hardness depth zml according to EN 13001-3.3.

Bridge crane line contact:



Bridge crane point contact:



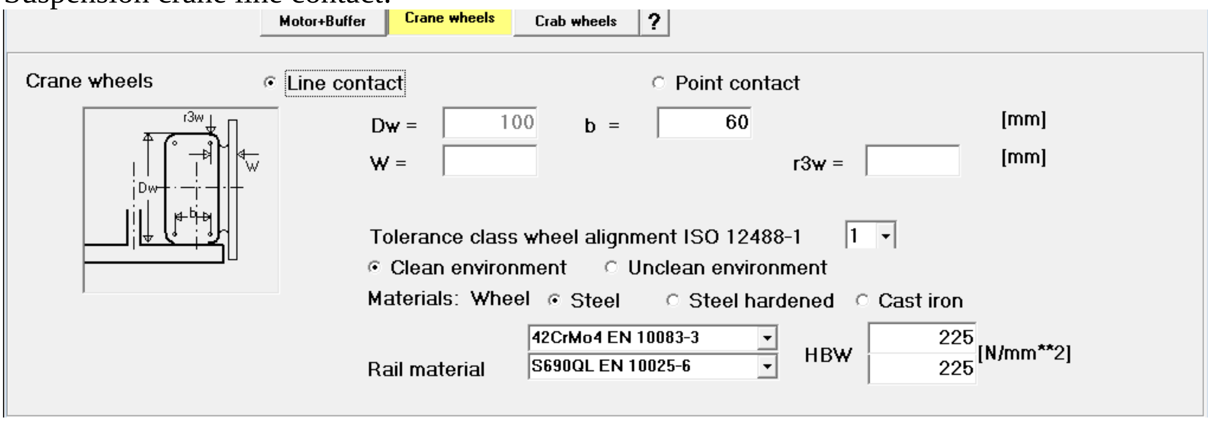
Wheel diameter Dw and the width of rail head bh are automatically transferred from the Basic data end carriage data. The presentation with or without wheel flange is related to the guide means chosen under crane data.

For wheel or rail materials given in EN 13001-3.3 the hardness value HBW is automatically generated. For other materials (whose designation is required) the value HBW shall be entered.

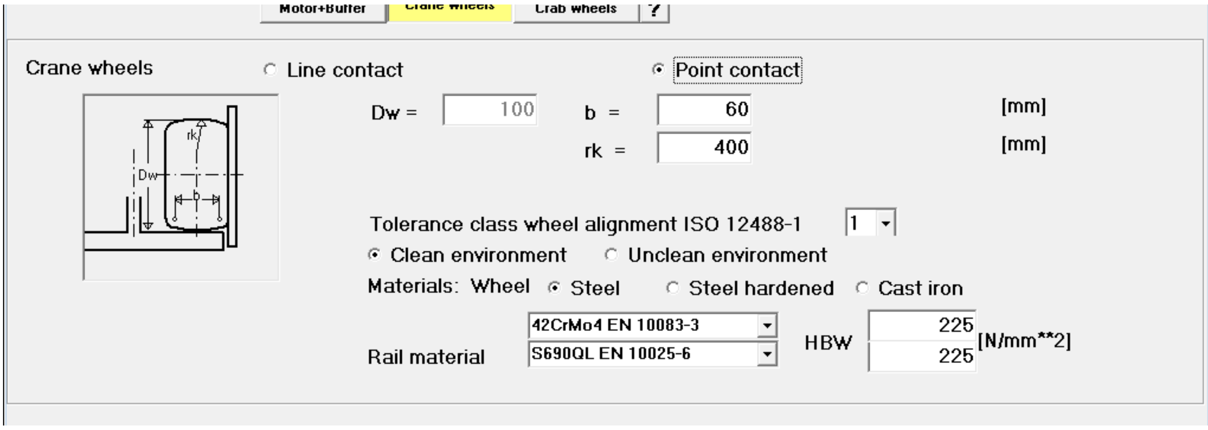
Results will be shown in the output of drive data.

Hint: From the Administration program you may click on "Wheel / rail contacts only" in order to start a project independent calculation of wheel / rail contacts, where the results are immediately shown.

Suspension crane line contact:

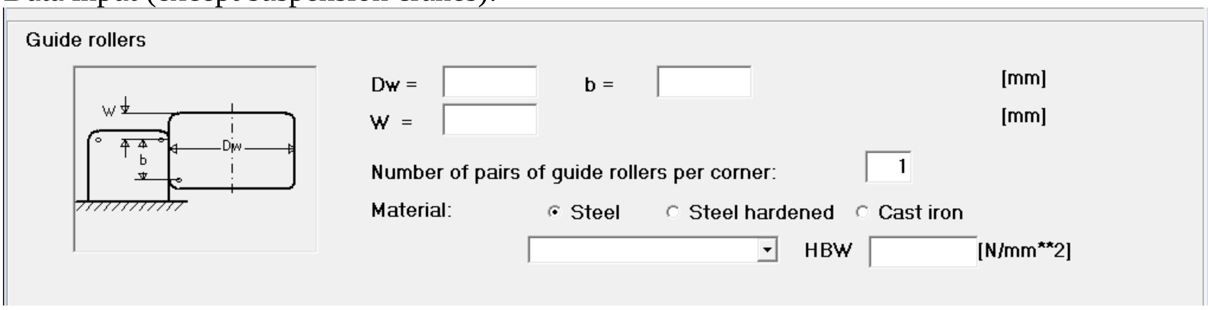


Suspension crane point contact:

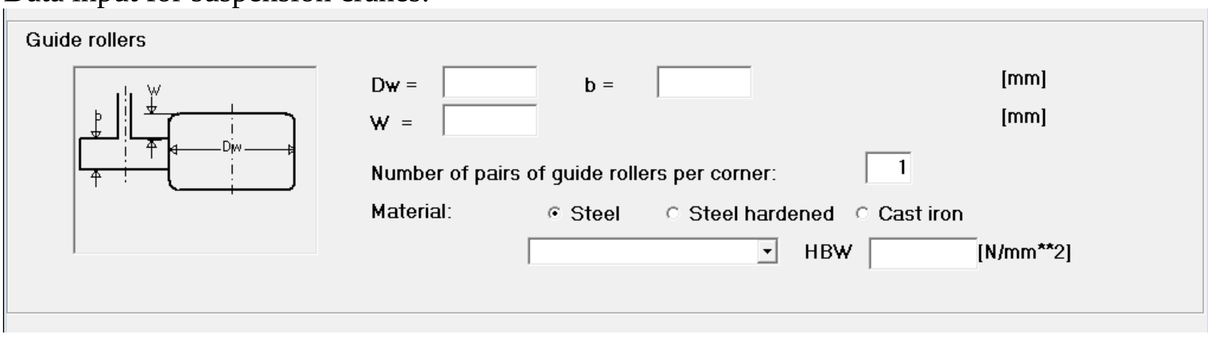


3.4.4 Crane guide rollers

If you selected guide rollers as guide means in the section "crane data", you may optionally enter data for guide rollers below the section where you enter data for the crane wheels.
Data input (except suspension cranes):



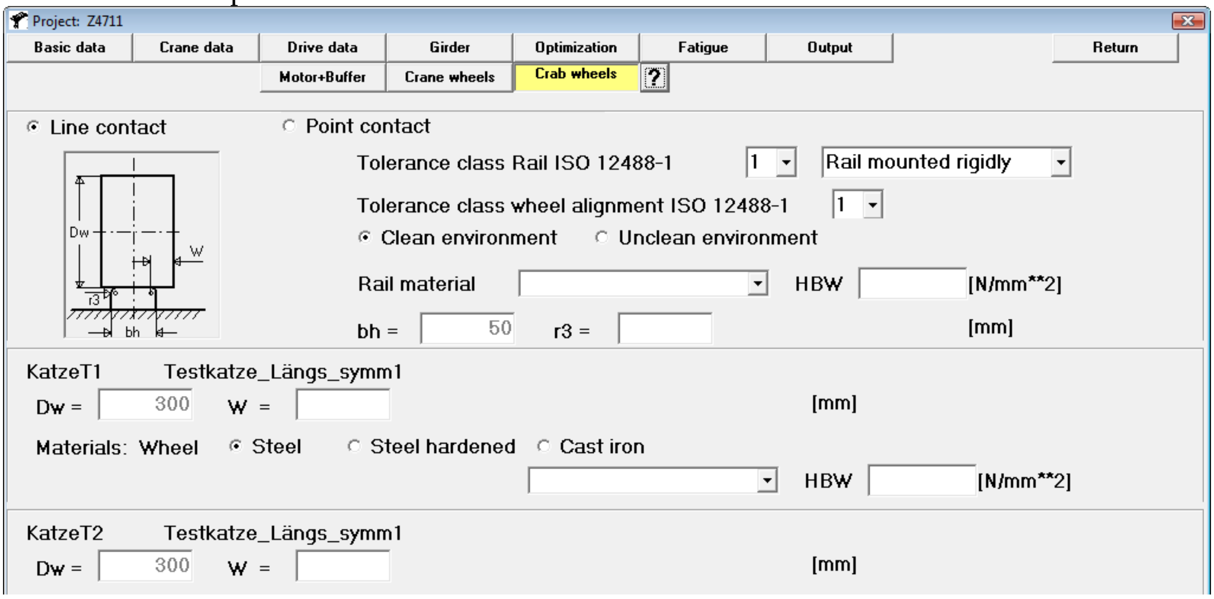
Data input for suspension cranes:



3.4.5 Crab wheels

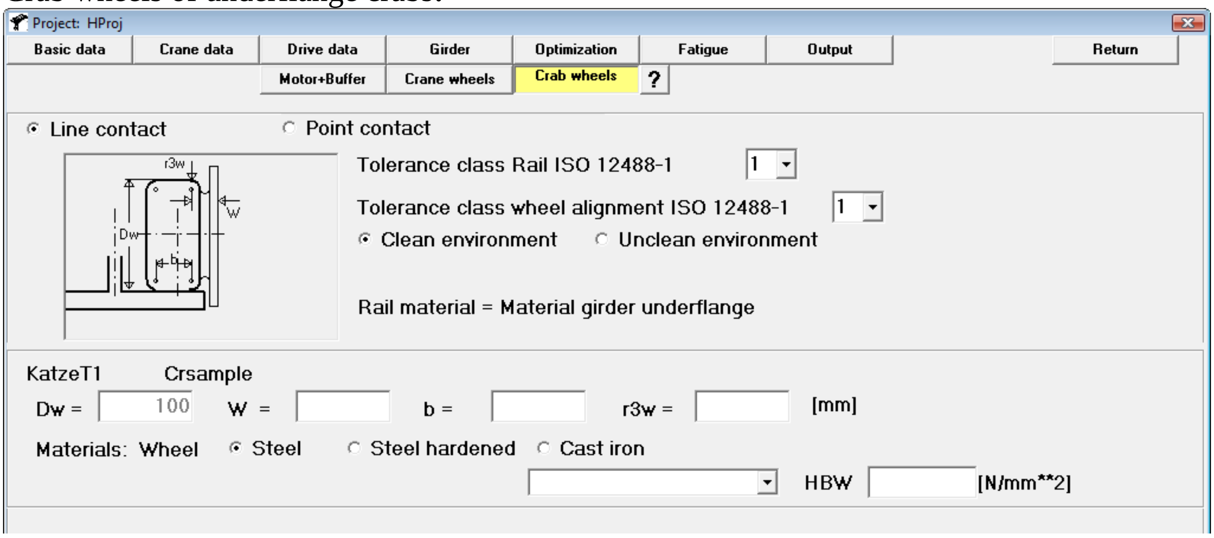
Entry of data (optional) to be performed analogous to entry of data for crane wheels.

Crab wheels of top mounted crabs or cantilever crabs:



In case of several crabs, data have to be entered for each crab separately. If crabs are identical, then the software automatically assumes the same values for all identical crabs. But different values may also be entered. Values for rail width and crab wheel diameter will be automatically selected from girder and crab data.

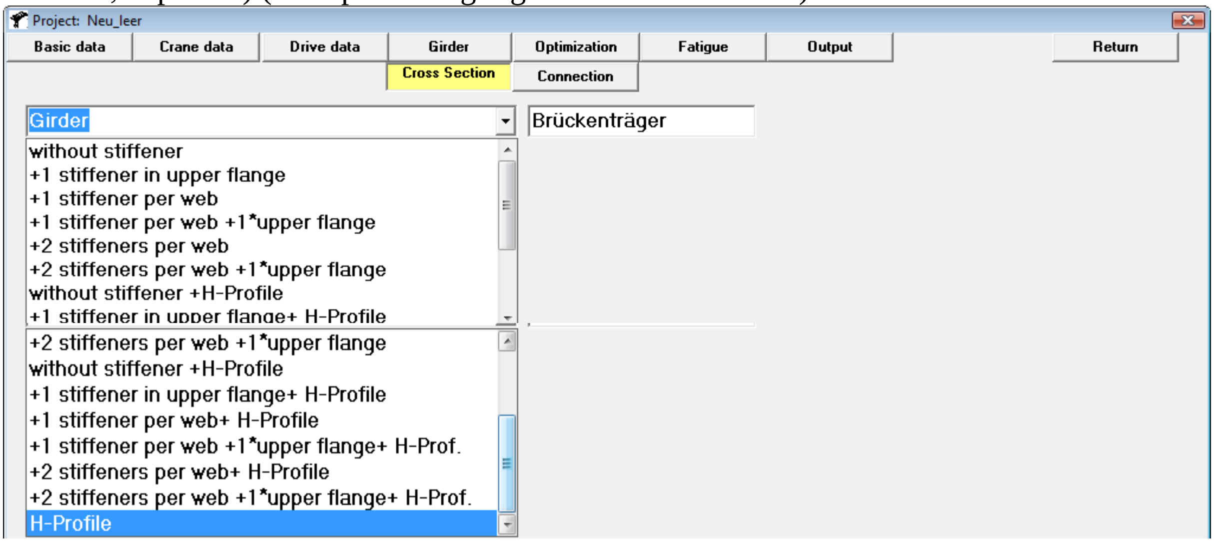
Crab wheels of underflange crabs**:**



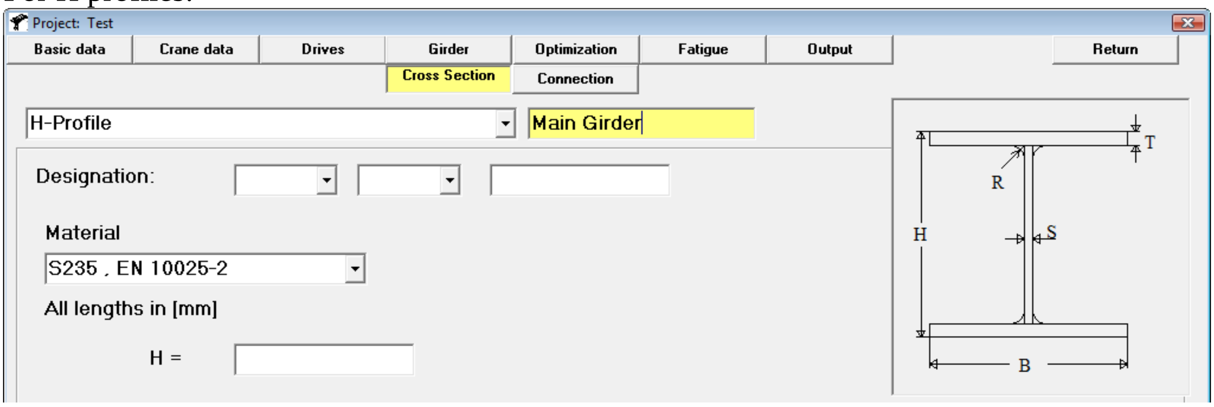
Values for the rail material will be automatically selected from girder underflange data.

3.5 Bridge girders – Cross- sections

Having opened the window, you first need to select the type of girder (box with or without stiffener, H profile) (example of single-girder crane see below):

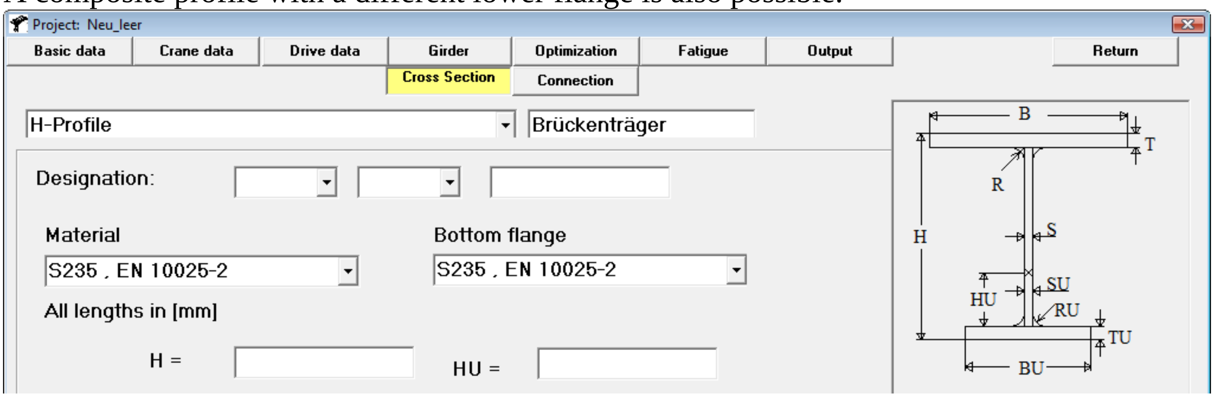


For H profiles:

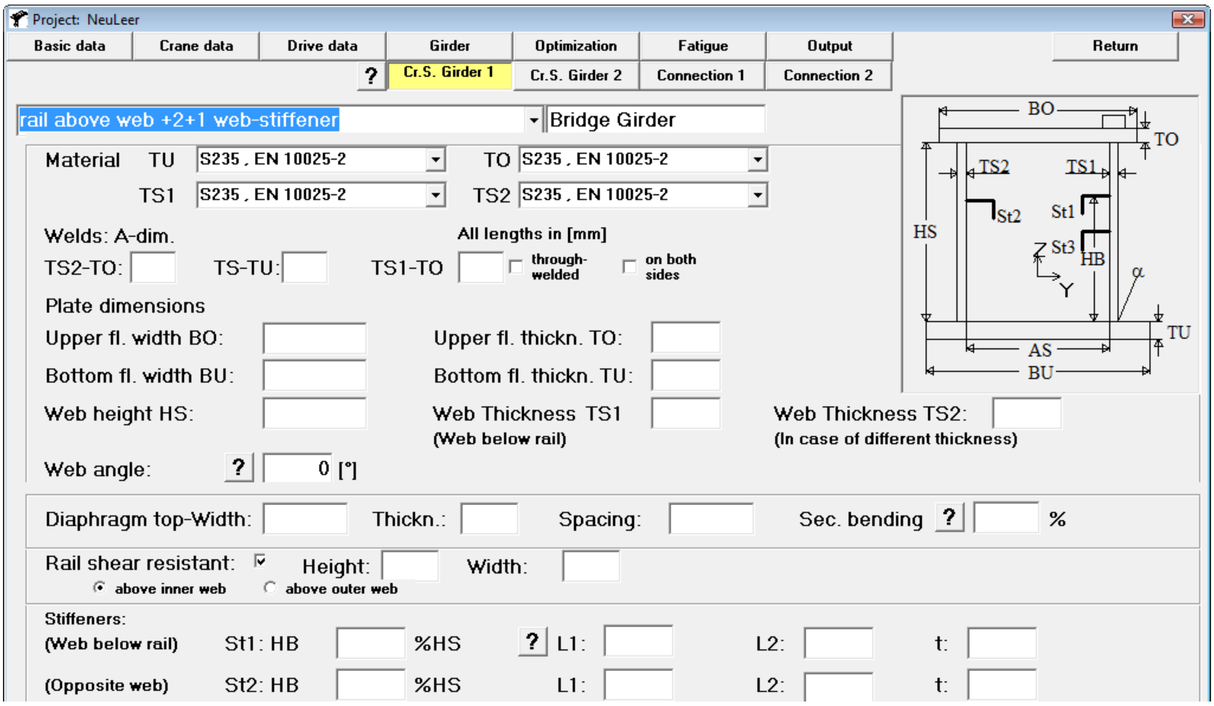


If you select HEA, HEB, HEM or IPE from the drop-down list, the dimensions are set automatically. Other than that, you may enter any values for H, B, T, S and R.
Width and height of rail must in addition be entered for H profiles for double-girder cranes with welded-on rail.

A composite profile with a different lower flange is also possible.



Box girders require additional data. Example of double-girder cranes:



Infoboxes:

- Trapezoidal box cross-sections can be generated via the web angle. In this case the diaphragm width indicates the bottom flange width (single-girder crane or box with rail above one web). For a box girder with the rail in the centre of the upper flange, the diaphragm width at the upper flange must be entered. Positive web angle: diaphragm wider at the top. Negative web angle: diaphragm wider at the bottom. HS is the true width of the web plate.
- To account for secondary bending between flanges, the percentage of the load-bearing flange widths needs to be entered here. A value of 0 means: secondary bending not considered.
- Stiffeners: L1 is the length perpendicular to web or flange.
  L2 may be 0, i.e. the stiffener is a flat bar. .

A click on the key “View” is required before a cross-section will be integrated into the project. Then the results of the cross-section calculation will be displayed.

Annexes to this manual contain examples of result views.

The result displays a scale drawing of cross-sections with dimensions and point numbers for a subsequent proof of static strength. For each point, a result table gives the unit stresses, i.e. the stresses under internal forces =1 kN for forces, and internal forces = 1 Nm for moments.

Now the cross-section may be either discarded or integrated in the crane project.

For box girders with crab rails above web the default position of the rail is "above inner web". Optional the position "above outer web" may be chosen.

Attention: Results for the open profiles (HEA, HEB, HEM or IPE) do not take warping torsion into account. The same applies to the proofs. Separate calculations are required to take the impact of warping torsion into account.

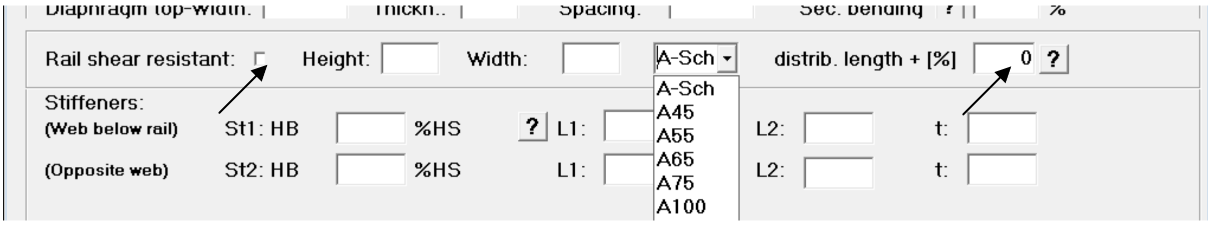
Attention: EN 13001 does not provide information concerning minimum rigidity of stiffeners but presupposes that each partial buckling field may be considered separately. The EN-Kran software checks whether the minimum rigidity meets requirements according to DIN 4114. If this is not the case, then proof of sufficient minimum rigidity is required in a separate calculation.

Specifics for box cross-sections with rails in the centre of the upper flange:
for this design, the transverse stress in the upper flange resulting from introduction of the crab wheel load needs to be factored in as secondary stress. This may be entered directly after external calculation (secondary stress per wheel load); alternately, internal calculation is possible (see Annex 7). For internal calculation, you need to enter the distance between transverse stiffeners. In the absence of stiffeners, the value to be entered is again the distance between diaphragms.

Specifics for box cross-sections for cantilever crab cranes:
On the basis of the chosen crab type (under crane data) a girder with or without lateral rail can be generated**.**

Specifics for box girders with placed below H-profiles:
Instead of data for the bottom flange of the box a H-profile may be chosen. The resulting cross section data (centre of gravity, uniform stresses, area, inertia) are related to a box whose bottom flange is given by the upper flange of the H-profile. The remaining "T-profile" acts below the middle of the bottom flange of the box..
Data for the end carriage connections are relates to the box.

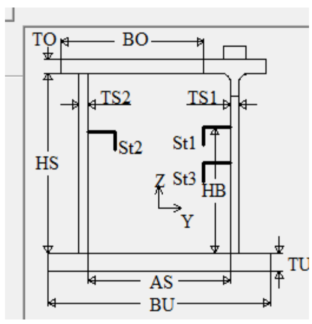
Specifics for the application of A-type rails:
When the option "Rail shear resistant" is deleted the selection of A-type crab rails is shown:



If A-type rails are chosen the weight of rail clamps and elastic padding should be added under crane data as uniformly distributed masses
(at coordinates   X = 0.5*(diaphragm width + web thickness and Z=0).

In cases of non- shear resistant rails the distribution effect of the elastic padding may be taken into account by a value (given in %) for the enlargement of the effective distribution length.

Specifics for cross sections with ½ H-Profile below rails:



The upper flange width BO starts at the H-profile.

Stiffeners shall not be located at the H-profile.

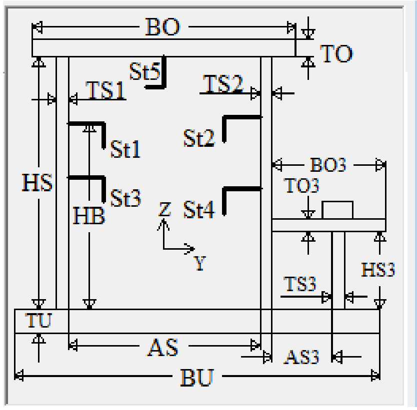
In case of A-rails the rail foot shall be <= the flange width of the H-profile.

Specifics for cross sections with two cells:

Additional dimensions for the second cell required:
Flange BO3, web HS3, diaphragm width AS3 and the plate thicknesses TO3 and TS3.

Stiffeners shall not be located at web HS3.

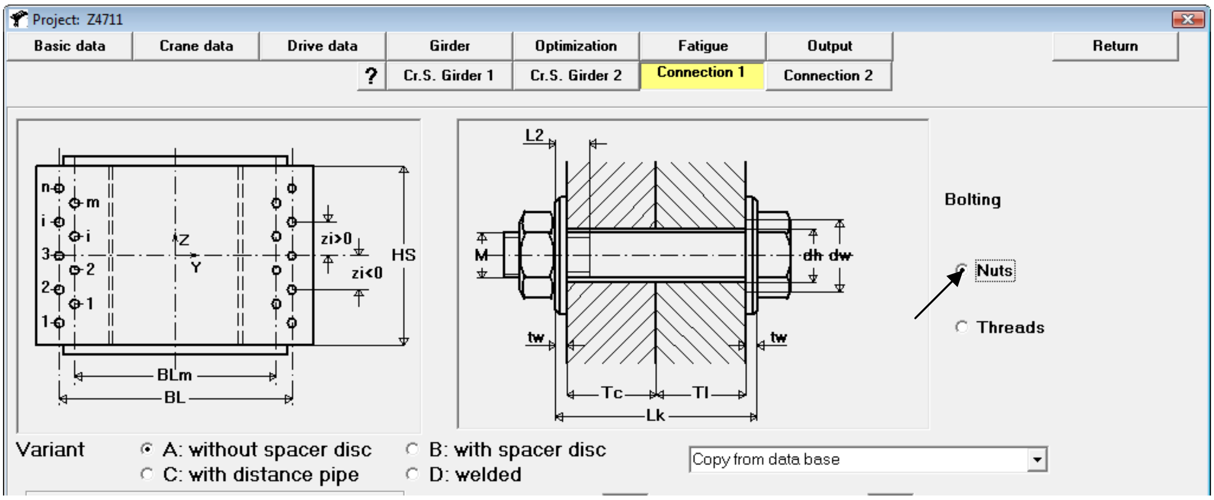
Stiffeners at web TS2 shall be located above the position of flange BO3.
:



3.6 Bridge girders – End carriage connection – (Bolts)

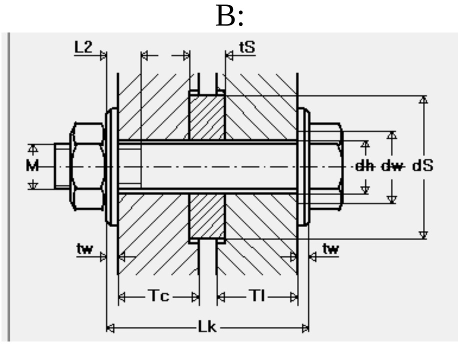
The choice of the end carriage determines whether the bridge is connected laterally or mounted on top. Suspension cranes have suspended connections (see clause 5.5.2)
There are four possible variants connections (3 bolted; 1 welded):

Variant A:

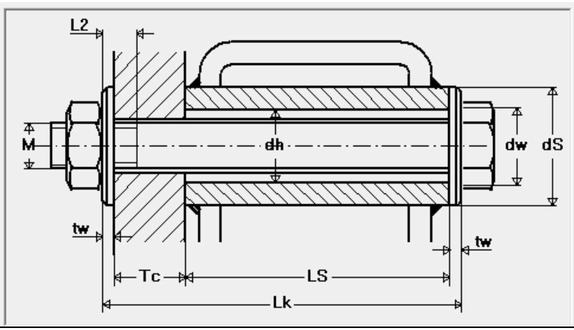


or variants B and C:

B:

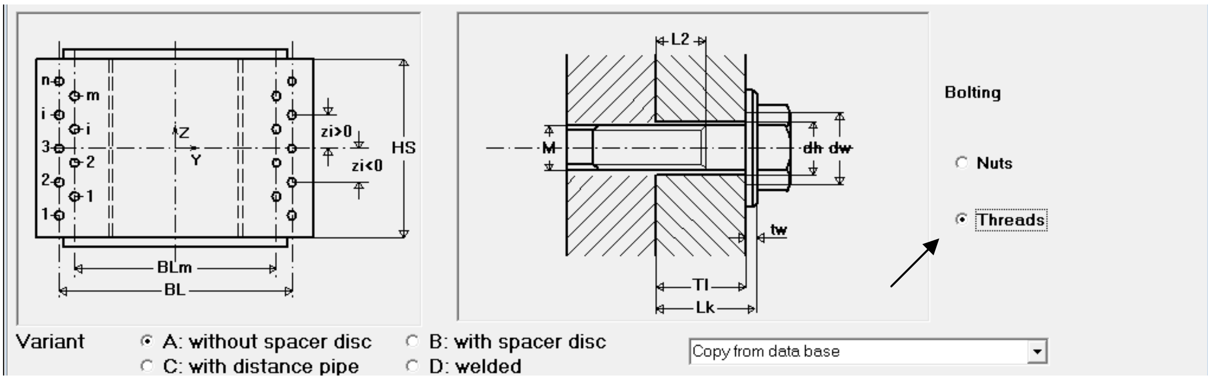


C:

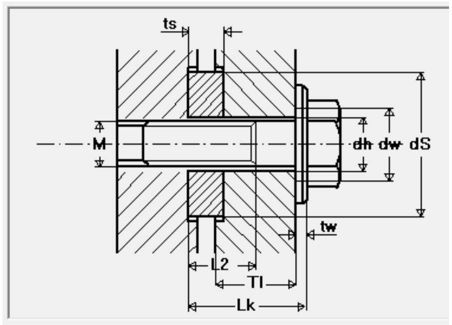


As an alternative to bolts and nuts you may chose bolts and threaded holes in the end carriage plate:

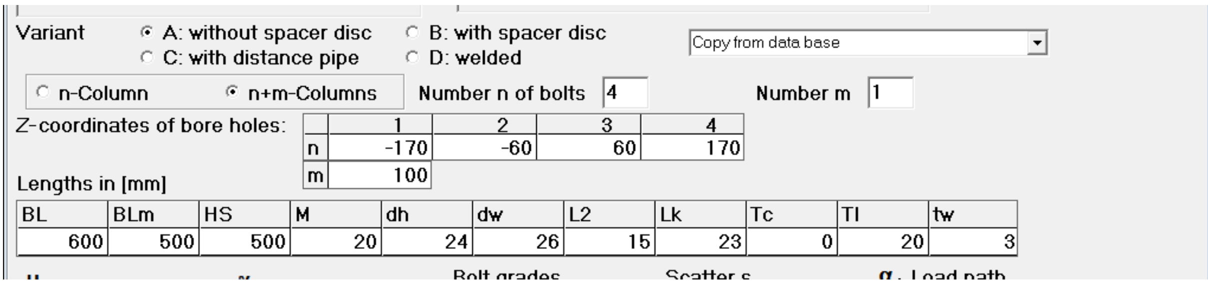
Variant A:



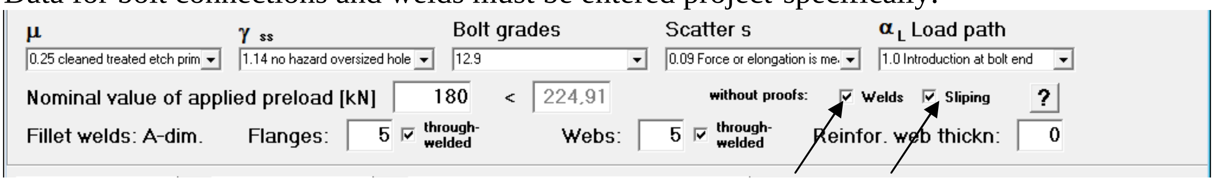
Variant B:



All dimensions may be taken from connection variants stored in the database or may be entered directly in the project.



Data for bolt connections and welds must be entered project-specifically:

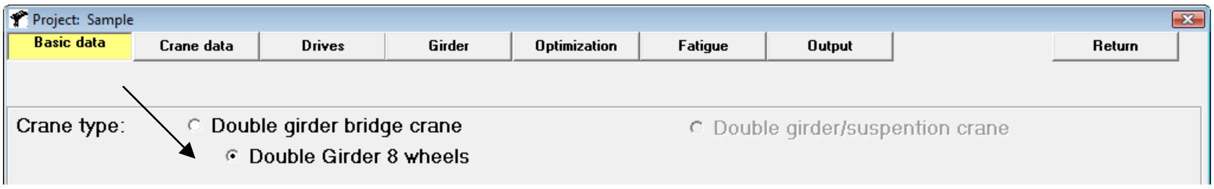


Infotext: Maximum A (weld) dimensions apply if 0.7*Min(t1;t2) cannot be executed. The A dimension of the weld between web and plate is correlated to the reinforced web thickness. If no value has been entered here (or 0), then the A dimension is correlated to the web thickness of the cross-section. If you require a separate proof (option without proofs: welds selected), then the static proof will not include proof of the welds in the bolt connection. If option without proofs: slipping is chosen, then form fit is assumed and only the proof against gaping is performed.

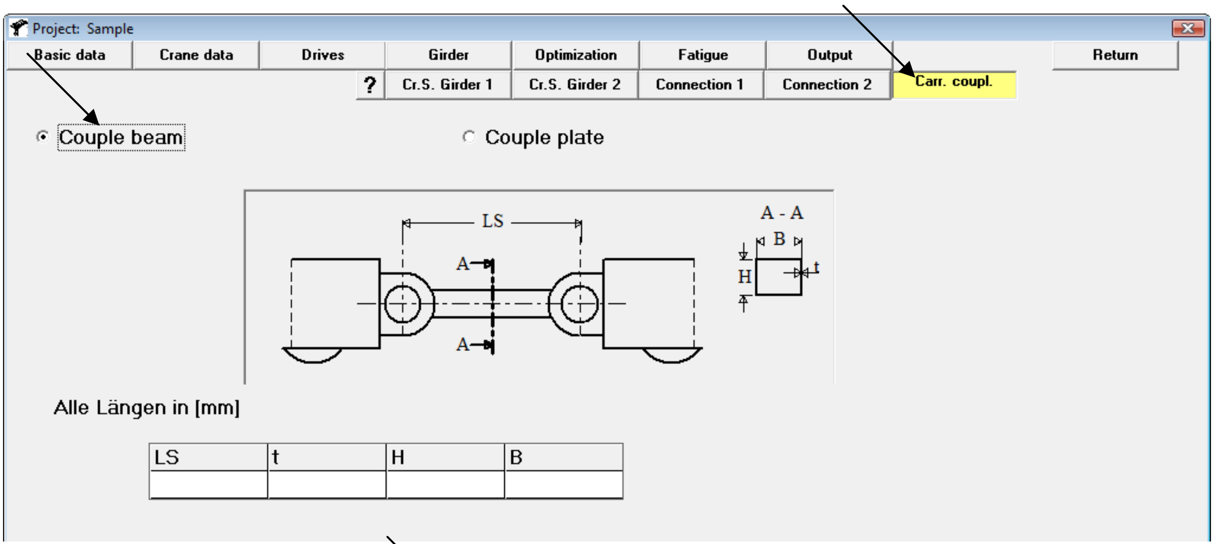
Note: It is possible that the 0.7*Min(t1;t2) requirement contained in EN 13001 will be dropped. In this case, the software EN-Kran will be updated.

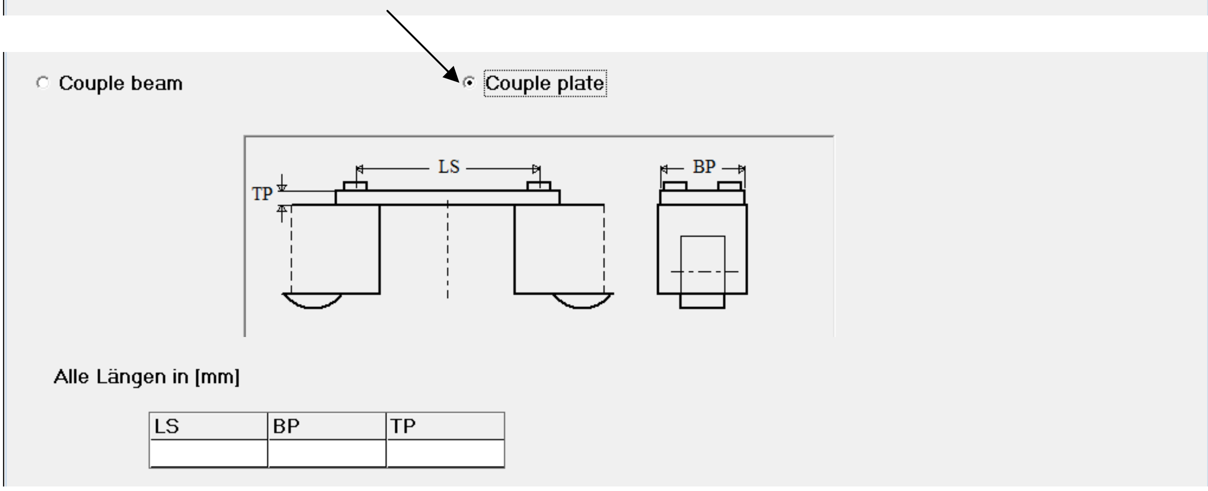
3.7 End carriage coupling

Having selected the crane type “Double girder 8 wheels” in the window „Basic data“ for a double-girder bridge crane, the user must additionally enter the data for the end carriage coupling in the window „Bridge girder“.



Coupling may either take the form of a couple beam with pin joints or a couple plate (elastic joint).

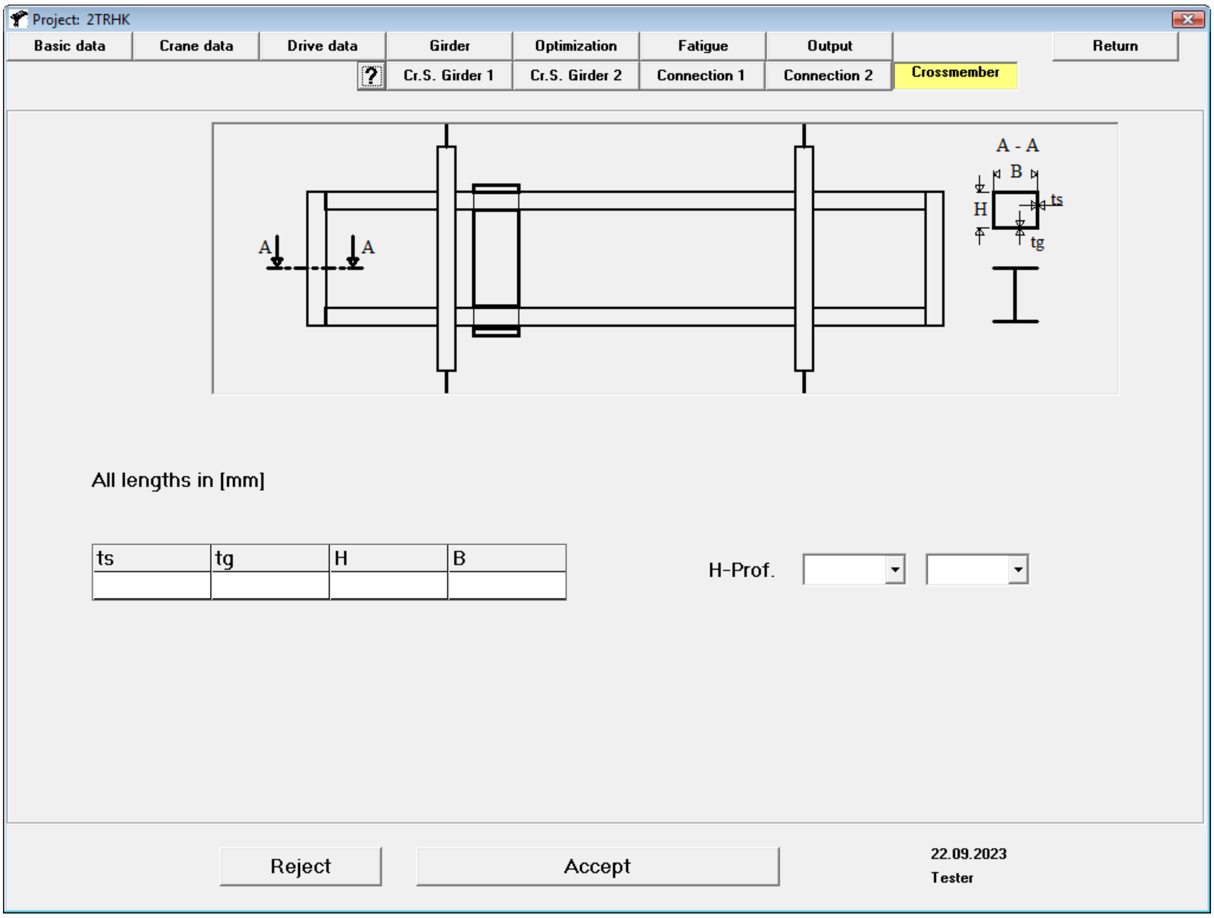




The distance between the crane wheel on the inside and the joint pin or the plate connection is calculated from the wheelbase of the crane, the wheelbase R1 of end carriages, and LS.

3.8 Cross members for double girder suspension cranes

The ends of cantilevers may be connected by crossmembers.

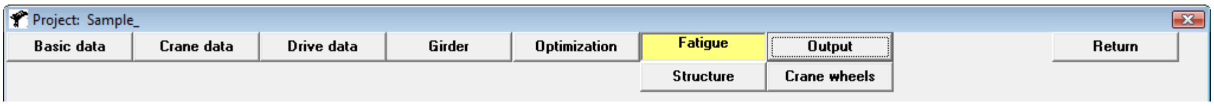


The example above shows the input under "Girder" and "Crossmember". Either H-Profiles or square tubes may be located above the ends of the cantilevers.

If already stored data are to be deleted, simply press "Reject".

3.9 Fatigue

The data input for structure details (according to EN 13001-3.3) or for the crane wheels (according to EN 13001-3.3) shall be performed separately.

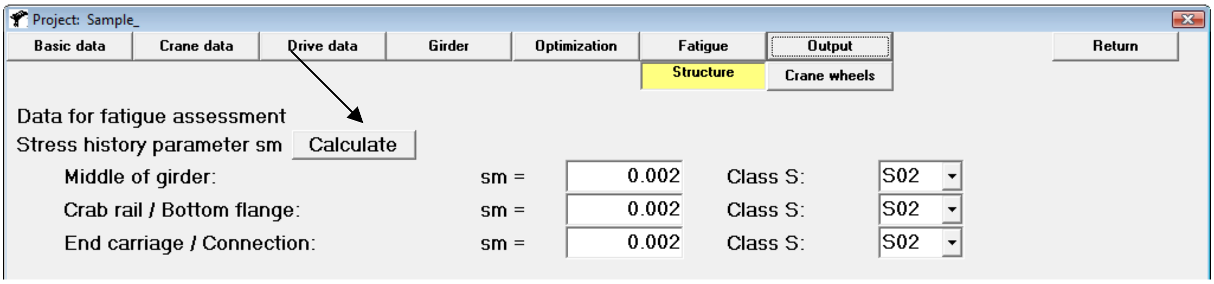


3.9.1 Stress history parameters – Entry for structure details

Proofs of fatigue strength are performed for three stress history parameters (or 3 classes S) which refer to verifications of details (plates, welds, bolts) of the following points:

- Middle of girder
- Crab rail or bottom flange
- End carriage and connection
- Kopfträger und Kopfträgeranschluss

Note: Default values may be preset as design rules (see 4.2.).

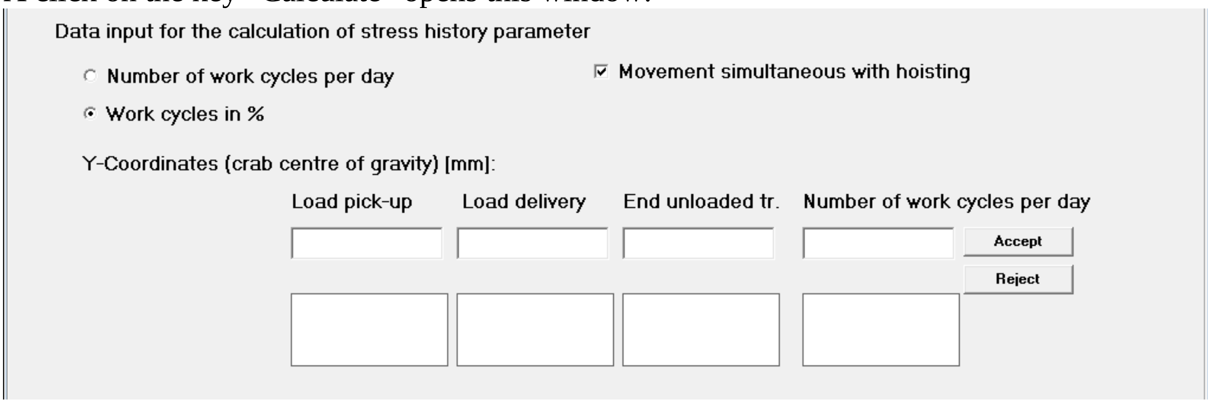


First, enter either the values for sm or the class.

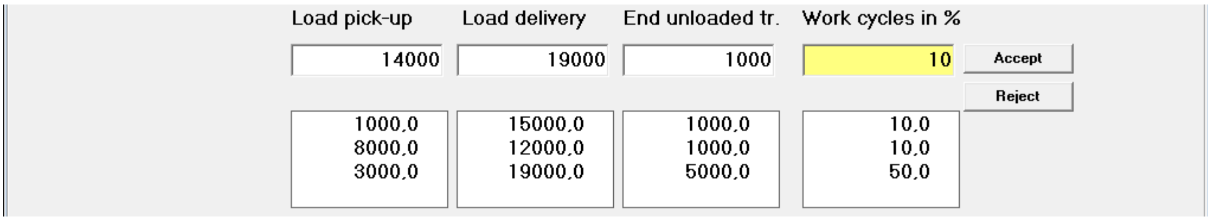
EN-Kran also offers the option of calculating the applicable sm values from crane data and operating conditions.

3.9.2 Stress history parameters - Calculation

A click on the key "Calculate" opens this window:

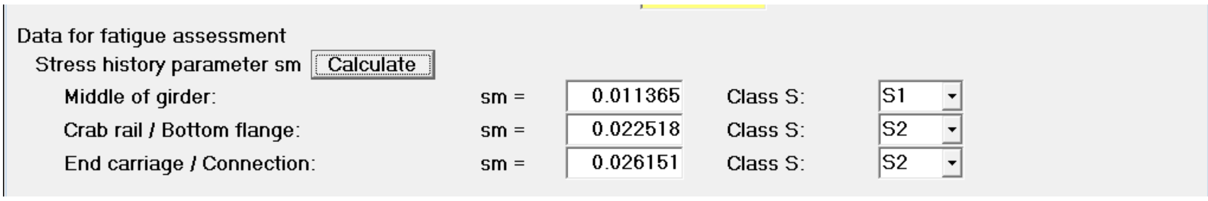


Crab movements and the percentage of all cycles must be entered for each work cycle. The percentage of all cycles may be given either in percent or as number of work cycles per day. Each entry must be stored (or discarded). There is no fixed sequence for these entries. Example:



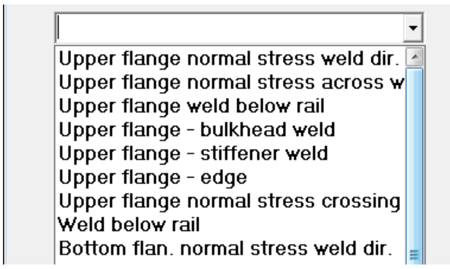
These data together with data for operating conditions, crane bridges, crabs and drives serve as the basis to determine the stress history parameters. Annex 3 contains a description of the methodology.

Having saved all crab movements, you will see a display of the result:



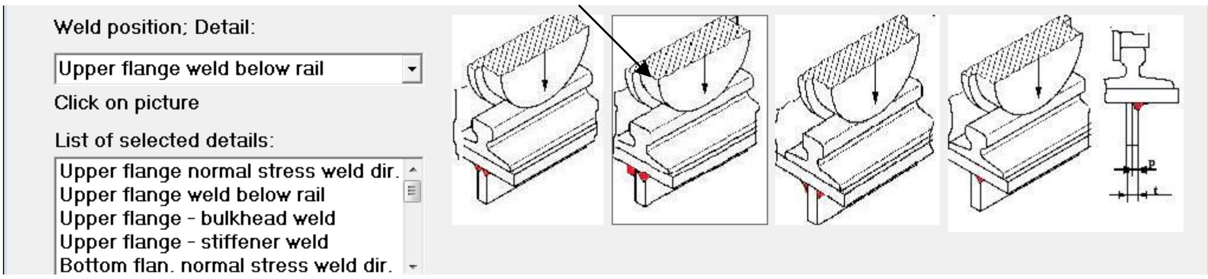
3.9.3 Characteristic values of stress range per detail

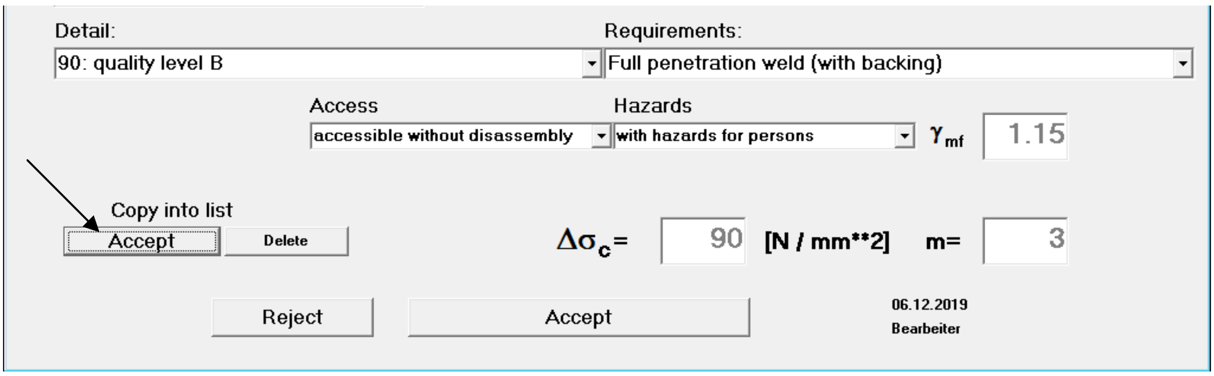
Select the desired weld position and the detail from the dropdown list or the proof list. (Details preset according to design rules are already included in the proof list.) The following display shows the detail or several images.



When there are two or more images, click on the appropriate one.

The selected detail will be marked by a frame.

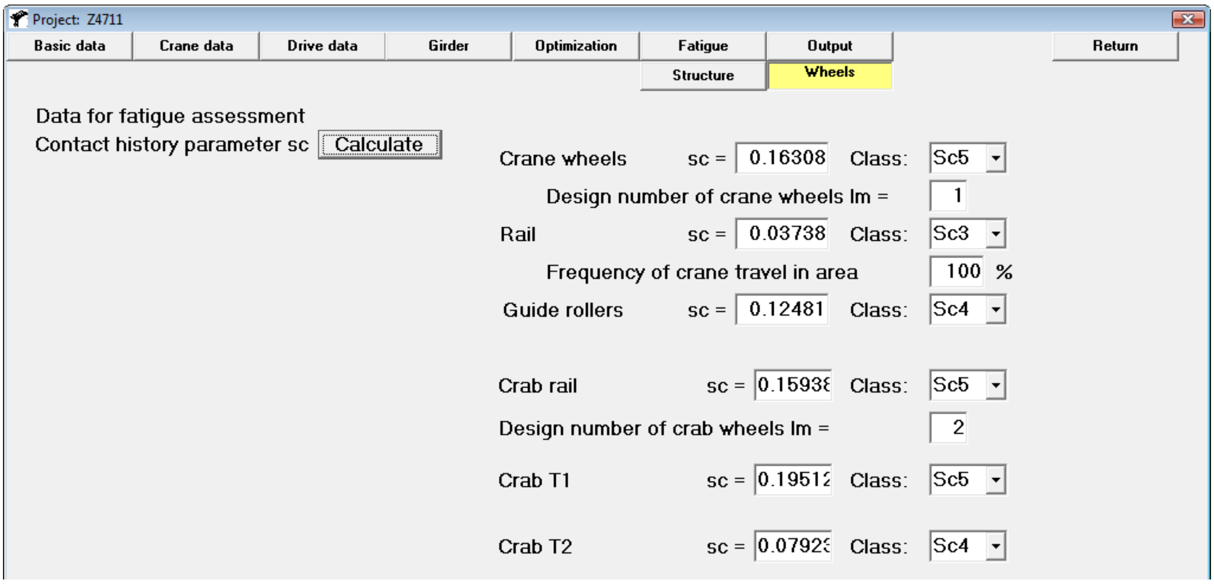




Having selected the details (in the example: quality level B) and – in case of an option – the requirements, access data and risk data, the value for $\Delta\sigma_c$ is calculated and displayed. Now this detail must be copied into the proof list.
As soon as the proof list is complete, click on the key “Accept” at the bottom and all entries are copied into the programme for the proof.

3.9.4 Stress history parameters – Entry for wheels

Proofs of fatigue strength are performed for stress history parameters (or classes Sc) which refer to verifications of crane wheels and crane rails, guide rollers and crab wheels if data were entered for these under "Drive data".



First, enter either the values for sc or the class Sc.
In this case the data for the design number of wheels lm and frequency of crane travel in area are only informative (to be shown in the presentation of results).

EN-Kran also offers the option of calculating the applicable sc values from crane operating conditions data. A click on the key “Calculate” opens the window as has been described above. If the entry was already made under data input for structure, then the same data is automatically used. (And vice versa, input under crane wheels will be used as well for the structure.)

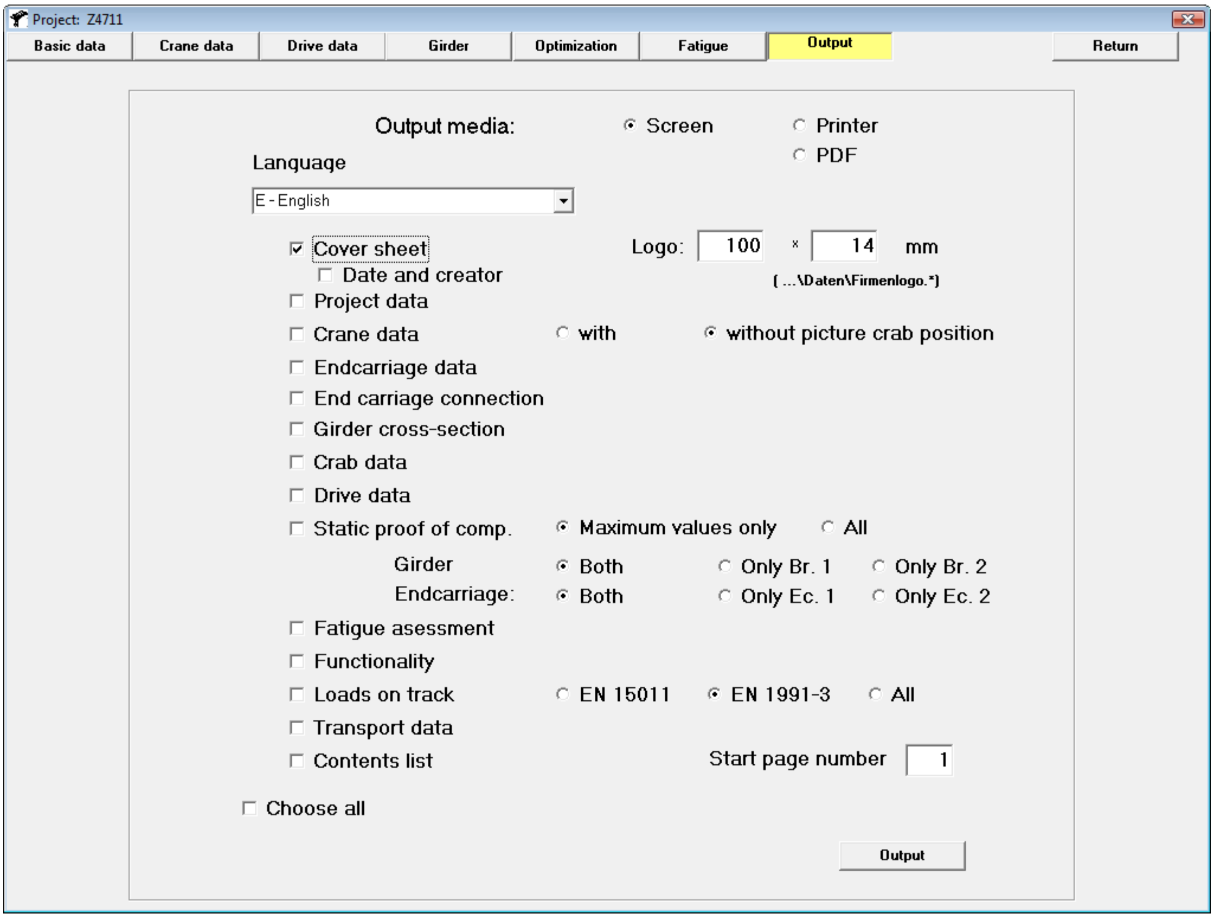
Annex 4 contains a description of the methodology.
In case of calculation the applicable sc values the data for the design number of crane wheels and frequency of crane travel in area are taken into account. Subsequent changes will change the sc values accordingly.

Meaning of "frequency of crane travel in area": The average distance of crane travel was set under basic data. But the length of the crane runway can be different and the crane movements may happen in different areas of the runway. This has no influence on the fatigue of the wheels, though on the number of contacts at a certain point of the runway. Therefore the value "frequency of crane travel in area" determines the proportion of crane movements in the most used area of the runway.

3.10 Results and outputs

Click on the “Output” button and then decide:

– in which language you want the printout of results
– whether you want the output first on the screen, or in pdf format, or directly on the printer
– whether you want the company logo on the cover sheet.



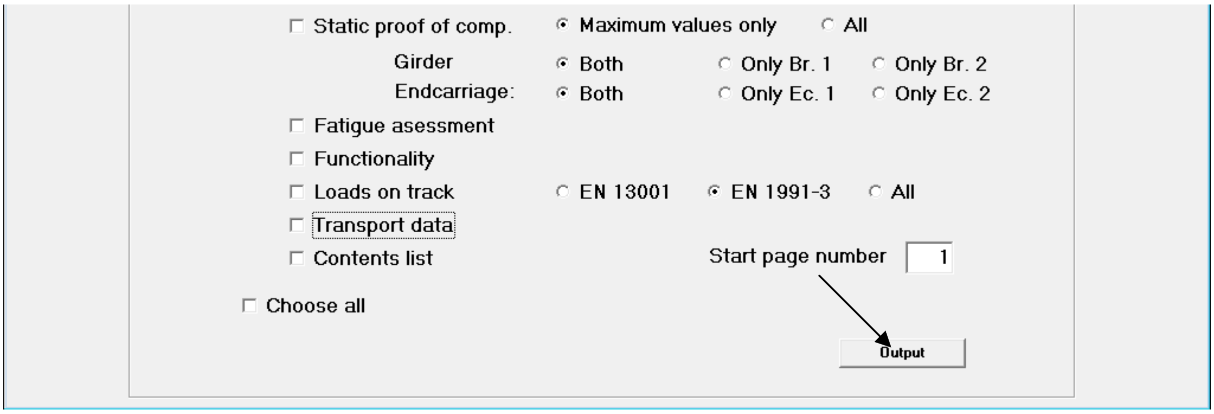
The company logo must be stored in graphic format under …\Daten with the file name "Firmenlogo" (*.bmp;*.ico;*.jpg;*.wmf;*.gif). It will be displayed on the top of the cover sheet within the selected dimensions (in the example: 100x14mm).

The output may contain either all data, or any selection thereof.
The proof of static strength is preset to provide the output of “maximum values”; this means that for every load case, results will be displayed only for those cross-sectional points that show highest stresses.

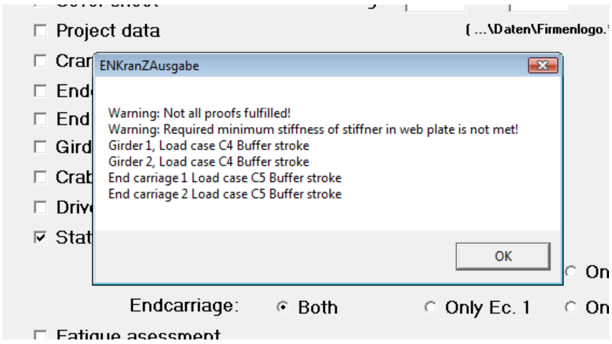
When the output of crane date is chosen you may optionally chose the output of a scaled picture of the crab and girder position.

The output of "Loads on track" may be chosen either in the display of EN 13001-2 or in the display of EN 1991-3 (or both).

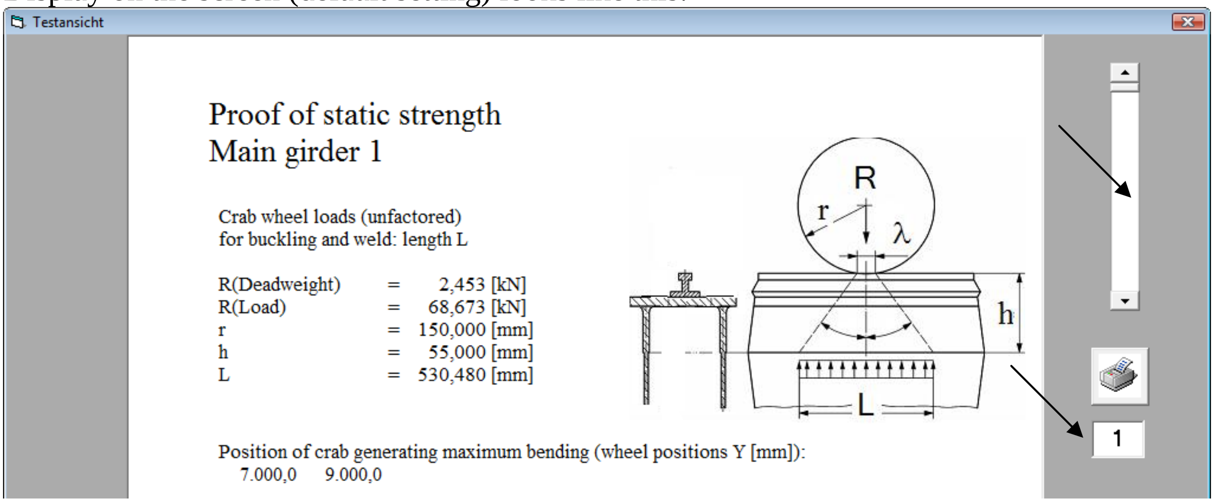
Another default setting is that the printout starts with page number “1”.
Click on the “Output” button to start the printout.



Annexes to this manual contain examples of printouts and interpretations of results.
If not all proofs are fulfilled, then a warning notice appears prior to the output text.
The corresponding items in the output text are marked in red.



Display on the screen (default setting) looks like this:

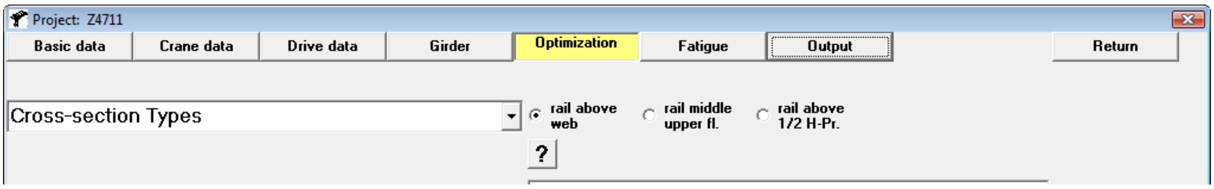


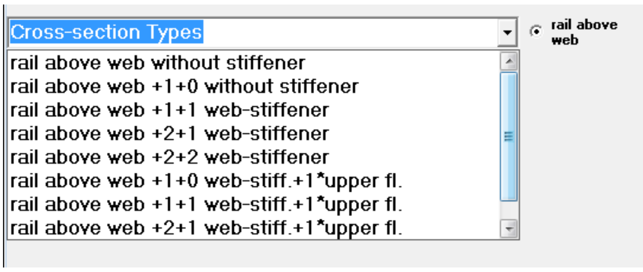
You can scroll over the output either via mouse, Page Up and Page Down keys, or shift register.
With a click on the red Windows – X symbol you return to the output window.

If you want a printout, click on the printer icon. The figure below the printer icon specifies the number of copies to be printed (default setting: 1).

3.11 Optimisation of cross-sections

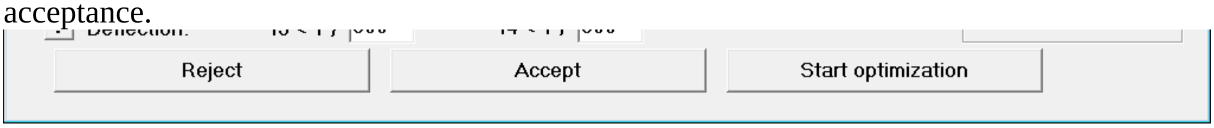
EN-KRAN includes the option of optimising for one project box girders for single and double-girder bridge cranes in terms of costs. This means, pursuant to defined design rules the software specifies a box girder which fulfils the proofs of static strength and fatigue strength under stated conditions of operation.
First, click on the “Optimisation” button. For a double-girder crane, first select the position of the crab rail and then the cross-section type; for a single-girder crane, you select the cross-section type.





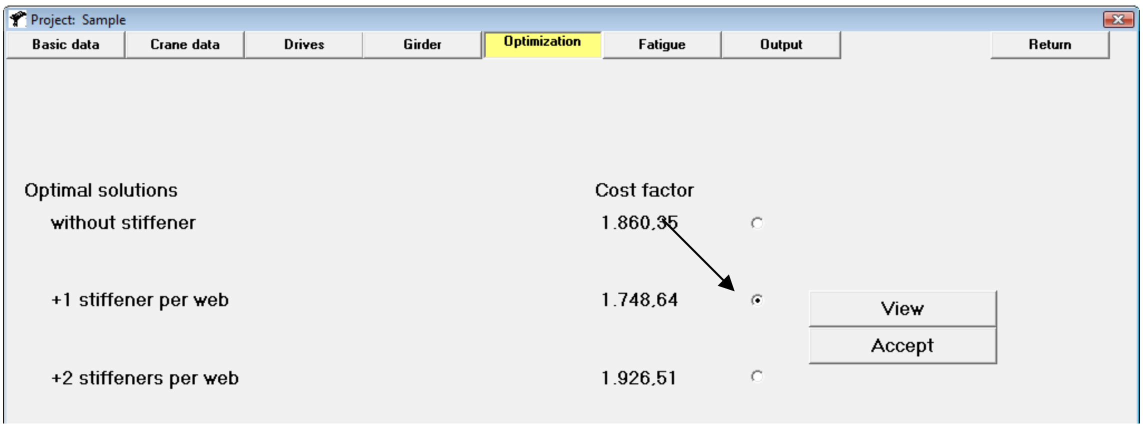
Upon selection of the cross-section type, a window opens which addresses the design rules for this specific cross-section. See chapter on design rules.
Predefined rules can now be amended for the project in question, or if no rules have been preset they must now be set here.

Rules must be complete. The syntax will be checked for completeness and correctness prior to acceptance.



After acceptance of the rules, the software returns to the selection of cross-section types, in order to permit simultaneous optimisation for different cross-section types.

A click on the button "Start optimisation" starts the optimisation process:



Optimisation is performed for all selected cross-section types. The optimisation procedure can be interrupted as long as the progress bar is visible.

The most cost-effective variant is marked after completed calculation and displayed with a click on the “View” button. You can see the other variants if you turn the marker button to a different variant.

Click on the “Accept” button if you want to copy the marked variant into the project.

Click on the button “Renewed optimisation” (at the bottom of the window) to return to the selection of cross-section types. Prior to further optimisation runs, the user can amend the design rules, e.g. with the aim to reduce possible girder heights or to restrict deflection.

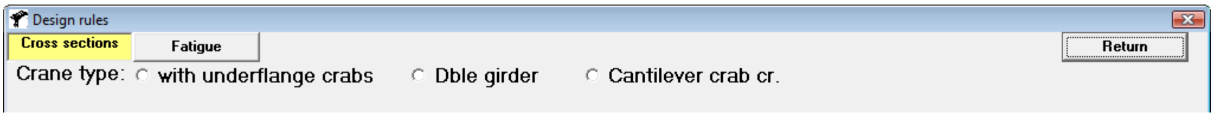
Note: Identified solutions are close to absolute minimum costs. But factors such as initial values and increments of preset rules have an impact on results.

Note: Default values may be preset as „design rules“ (see 4.1).

4. Design rules

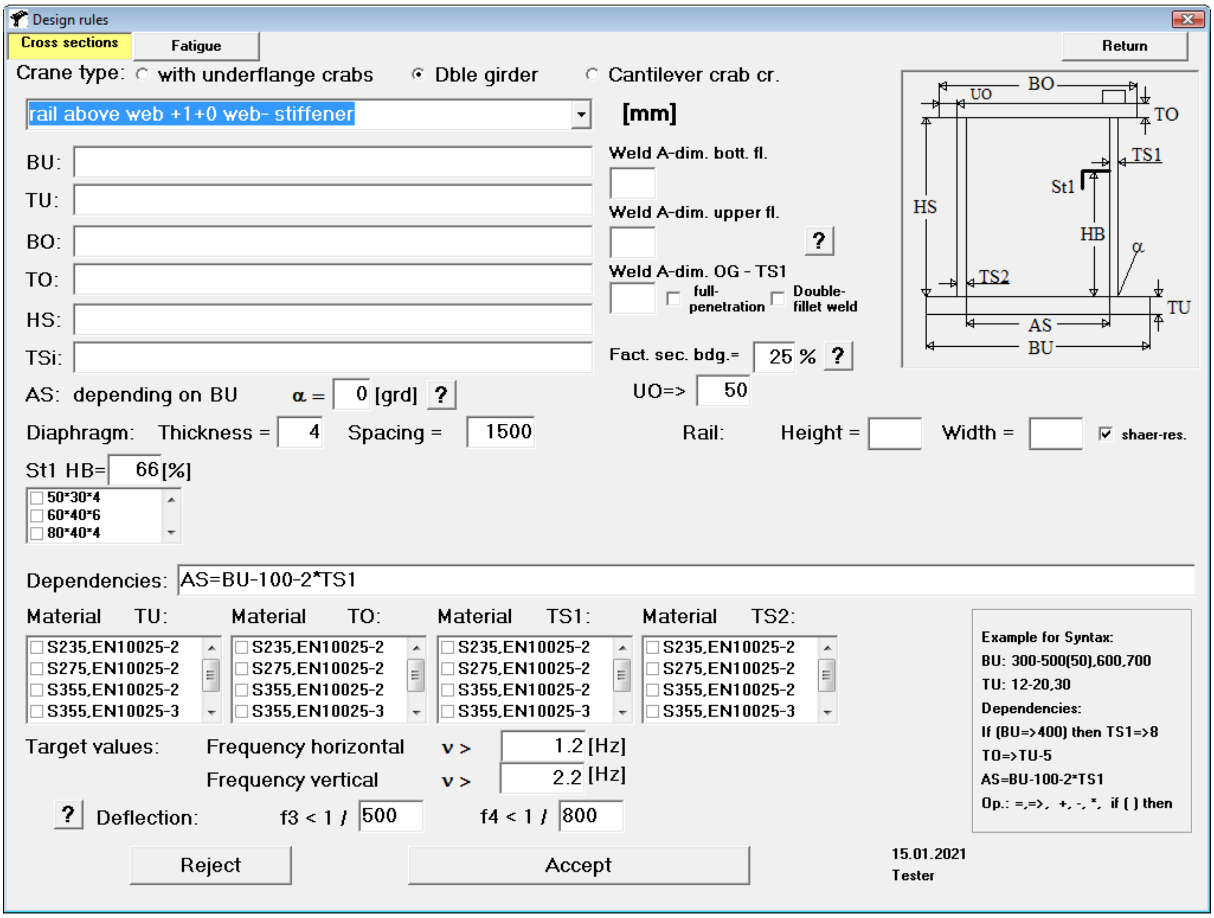
Having started the programme or having returned to the administration programme, the user can start entering the general design rules for optimisation runs.

Design rules need to be entered separately for under flange crab (single or double girder), double-girder (top mounted crabs) and cantilever crab cranes.



4.1 Design rules for cross-sections

In general, windows for entries have the following structure:



<u>Rules for plate thickness</u> TU, TS, TO (schematic diagram):

> Values for thickness must be separated by a comma or semicolon. They may be listed individually (example: 8,10,12) or indicate a numerical range (example: 10-20); in this way all standard thicknesses from 10 to 20 mm are included. Combinations are possible as well (example: 4-10,15,20). Another option is to enter unstandardised values (example: 7.5). Decimal places can only be entered with a dot, since the comma is used as a separator. In optimisation runs, only those plate thicknesses are varied for which strength values and costs have been stored in the database.

<u>Rules for plate width</u> BU, BO, HS (see schematic diagram):

> Values must be separated by a comma or semicolon. They may be listed individually
>
> (example: 500,600,700) or with equidistant values (example: 400-600(50)); in this case, the value in brackets indicates the distances, so that 400,450,500,550,600 are listed. If the

final value is not covered by the distances, it will nevertheless be included (example: 400-600(75) means 400,475,550,600).

Combinations of both entries are possible.

Materials and stiffeners:

At least one value must be specified respectively. If several values are entered, they will be varied in the optimisation of materials. Ascending order according to costs. Stiffeners can be only varied using dependency rules.

Dependency rules:

The diaphragm width AS (for inclined web without rail, or with rail above a web, AS is the lower width; for rails in the middle of the upper flange, AS is the upper diaphragm width) must be specified as a function of the lower flange width (or, for rails in the middle of the upper flange, as a function of the upper flange width). The aim is to generate a box form with the desired flange protrusions.

Example: AS=BU-100-2*TS1 (This is a default value and can be modified.)

For the protrusion UO of the upper flange (or the lower flange for a rail in the middle), it is only necessary to enter the requirement of a minimum value (UO=>). The optimisation run will then yield the specified flange width which at least meets this requirement; i.e. larger protrusions are possible.

Users may enter any number of additional requirements in the command line; these must be separated by a comma or semicolon:

Examples: TS1=>TS2 (web thickness 1 equal or greater than web thickness 2)

IF(BU=>400)THEN TS1=>8 (web thickness from lower flange width 400)

IF (HS=>500)then ST1=>2 (stiffener size St1 from web height 500)

All entries will be checked for correct syntax.

Click on the “Accept” button. Entries are checked for completeness, and a control printout is generated upon entry into the database.

If the entries are complete, then no further entries are required to start the cross-section optimisation in a project for the respective cross-section type. If data are incomplete, or if data are to be changed for the project, the additional entries can be made there. Amendments to design rules in a project do not result in changes in the database, i.e. they will not be saved in the programme module of design rules.

4.2 Design rules for proof of fatigue strength

Similar to design rules for cross-section optimisation, it is possible to make general default settings for the proof of fatigue strength and for the applicable S classes or sm parameters.

Entries are to be made as described in chapter 3.9 Fatigue.

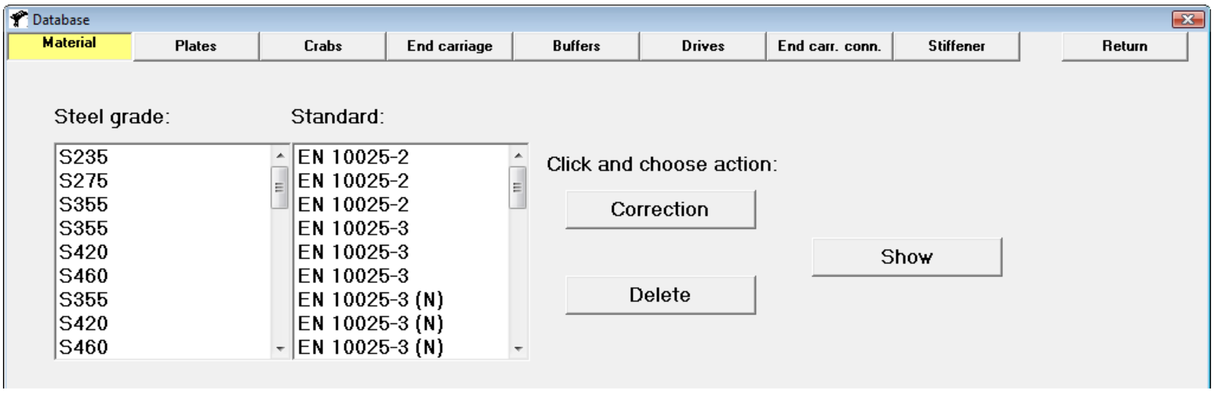
These entries must again be made separately for single, double-girder and cantilever crab cranes.
Data modification is possible in the context of individual projects.

5. Database

Data referring to materials, plates and components (crabs, end carriages, drives, buffers, end carriage connections and stiffeners) that are used in crane projects are stored in a database. Data of drives, buffers and end carriage connections may also be changed in individual crane projects.

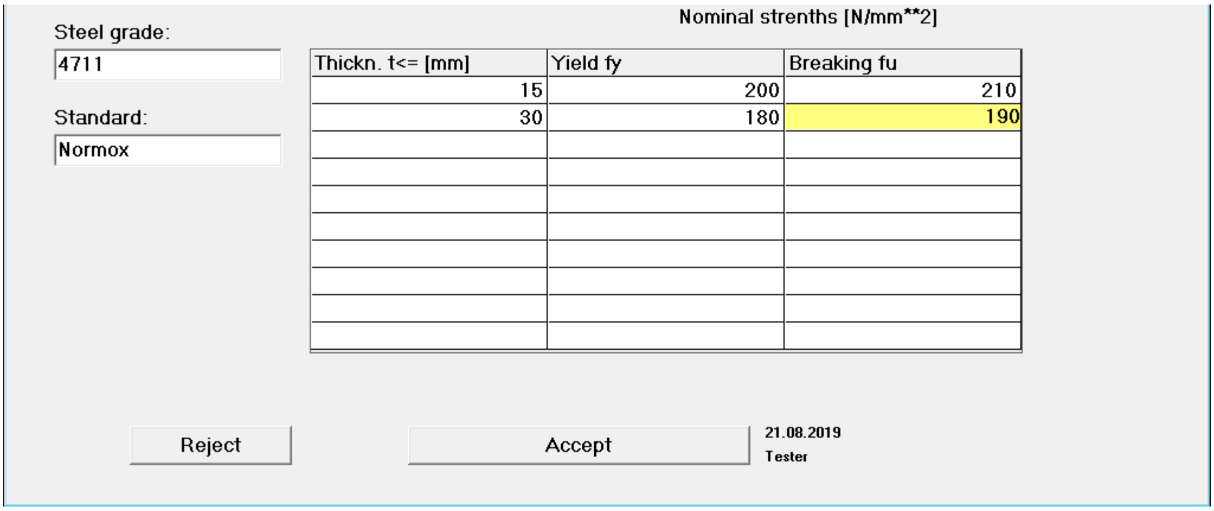
5.1 Database - Materials

Data contained in this database are required to perform proofs of strength and cross-section optimisations.
The materials named as preferable in EN 13001-3-1 and their thickness-dependent strength values are already preset in this database.



Nevertheless, you may modify the data (“Correction” button).

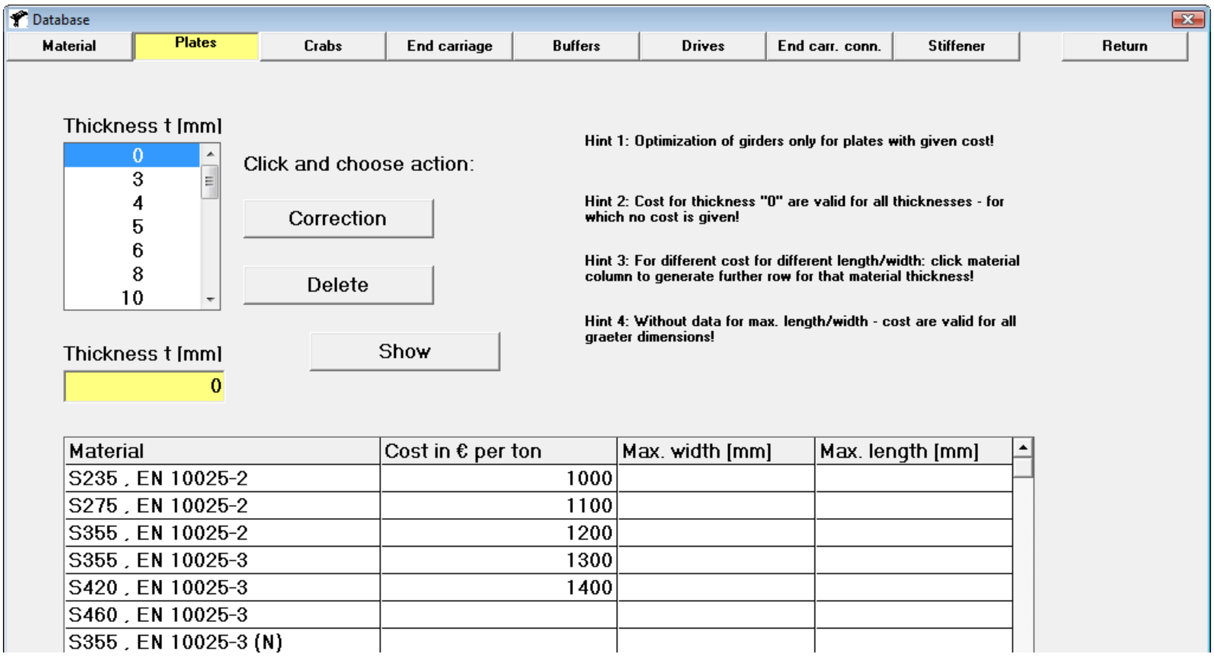
It is possible to enter additional materials in the database. To that end, you must enter the steel grade and the standard. Subsequently you can enter the thickness-dependent strength values:



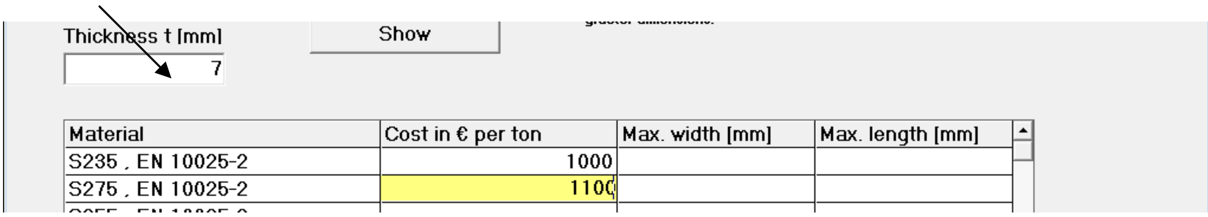
A click on the “Accept” button adds the data to the database.
A click on the “Show” button displays the entire content of the database containing materials.

5.2 Database - Plates

Data contained in this database are only required for cross-section optimisation, since varying costs for plates (depending on material and thickness) are taken into account for the optimisation procedure.



This database is sorted according to plate thickness. Standard plate thicknesses are preset. For correction, you may either select a thickness from the list (click) or add other thicknesses to the list in the respective field (arrow, e.g. 7).



Subsequently, material costs (per ton) must be entered for all desired materials for the respective thickness. Cost values for thickness "0" apply to all thicknesses for which no other cost values have been explicitly specified. Cost values should include not only procurement costs but also handling costs.

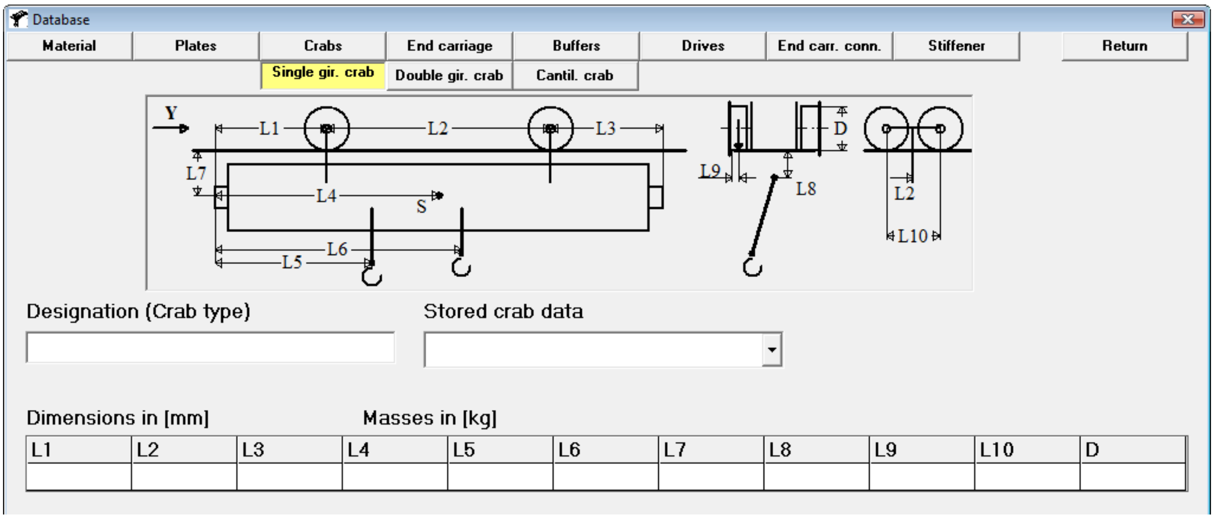
Data for maximum width and length are still optional at this stage of the programme and are not taken into account for optimisation.

5.3 Database - Crabs

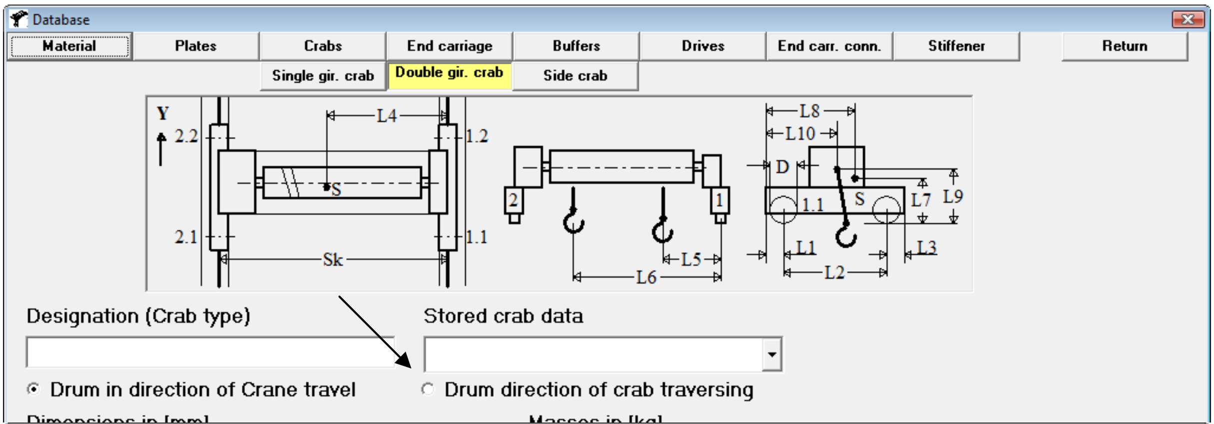
First of all, select either single-girder crab (lower flange crab), cantilever crab or double girder crab; and in the latter cases, also the drum direction and crab support.

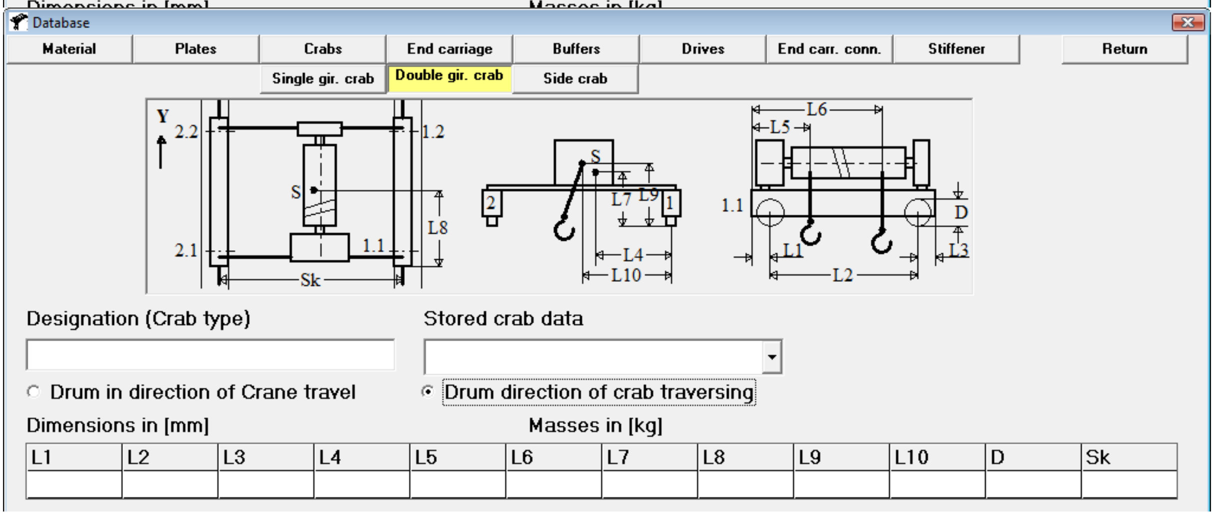
The respective schematic diagram shows the dimensions to be entered into the table.

Single girder underflange crabs:

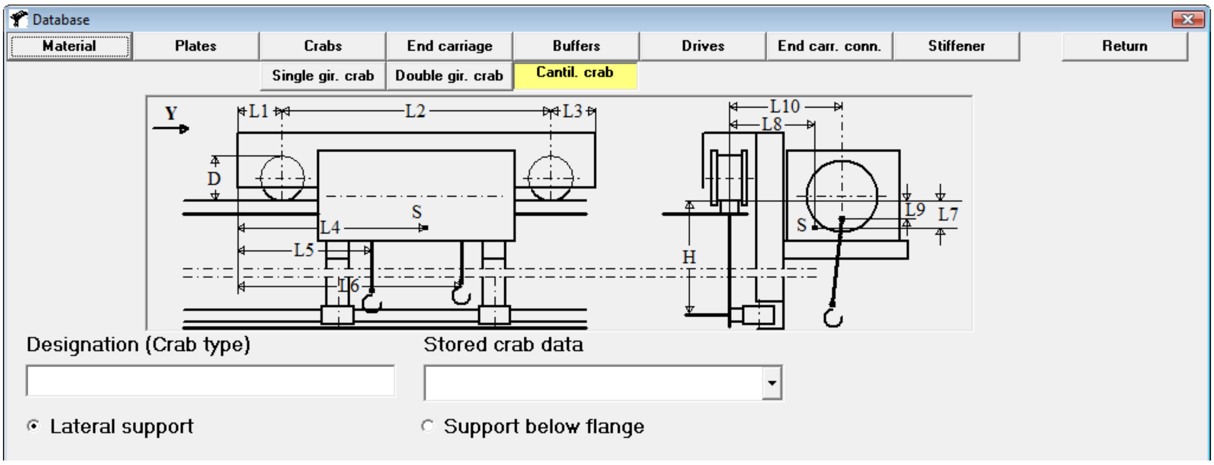


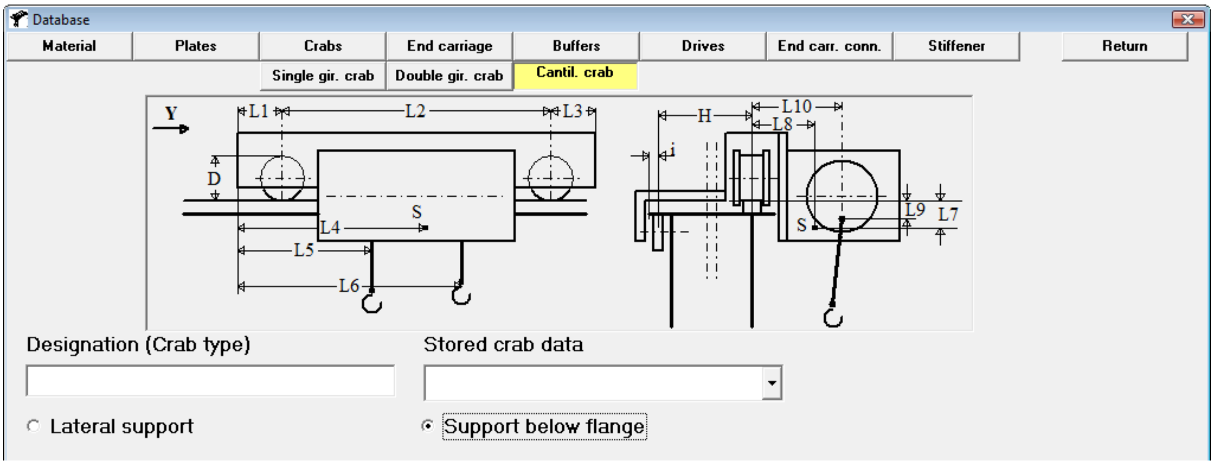
Double girder crabs:



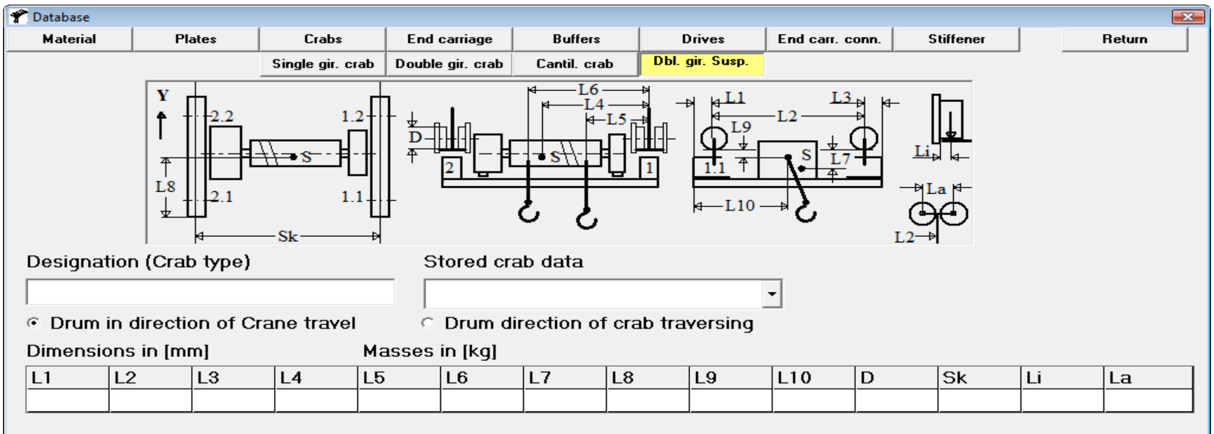


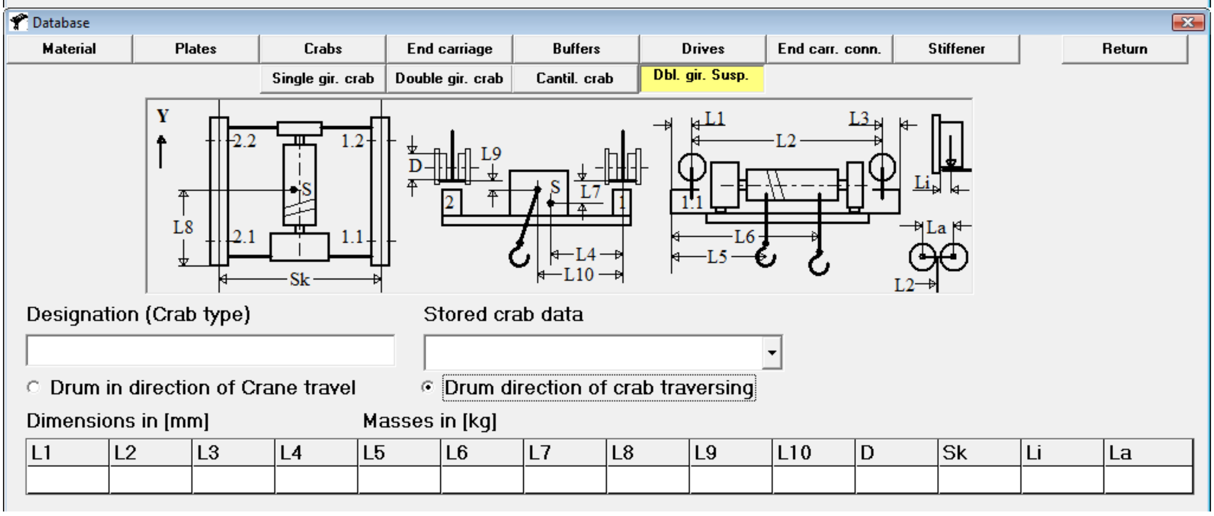
Cantilever Crabs:





Double girder suspension crabs:





When entering a crab for the first time, the designation of the crab needs to be entered that will be used for this crab in the project, before you store the data.

Having selected a crab from the list of stored crabs, you will be offered a choice between “Correction” (i.e. modification of data stored under this designation), “Delete” (i.e. removal from the database) or “Copy”. You can delete only if the crab was not used in any project.

If you select “Copy” you must enter a new designation under which the copied and modified data will be stored.

<u>Specifics of dimensions:</u>

Dimension L10: If this value for single-girder crabs = 0, the crab has 4 wheels. For value > 0, the crab has 8 wheels, with 2 respectively mounted on a rocker arm.

Dimensions L5 and L6: End positions of hook path (independent of hoist travel)

Dimensions L4, L7 and L8: Position of centre of gravity of the crab dead weight for double-girder crabs and cantilever crabs

Dimensions L4 and L7: Position of centre of gravity for single-girder crabs

Dimensions L9 and L10: Position of assumed load application point (together with L5 and L6) for double-girder crabs and cantilever crabs. This is also the load application point in case of fixed load guide (buffer impact).

Dimension L8: Position of assumed load application point for single-girder crabs

Dimension L9: Position of wheel load application to the lower flange

Dimension La: Double girder suspension crab: equivalent to L10 of single girder crab.

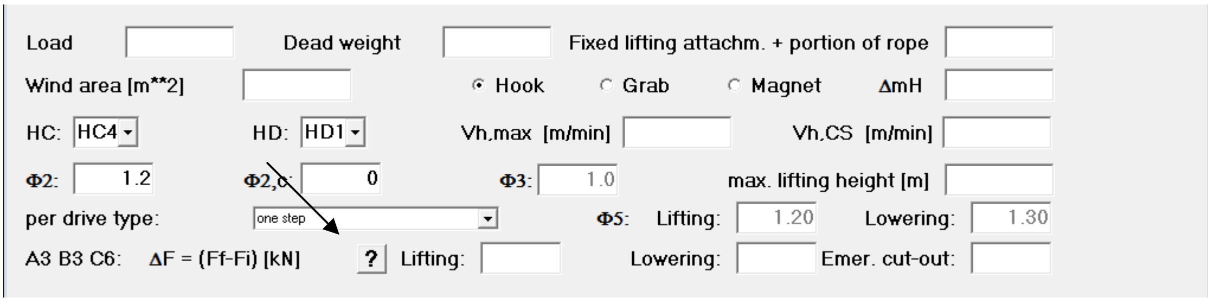
Dimension Li: Double girder suspension crab: equivalent to L9 (.Position of wheel load)

Specifics for L9 and Li: Compatibility checks of width of flanges are made only when a project is processed.

Double-girder crabs require in addition data on lateral guidance: wheel flange or guide rollers.

For cantilever crabs, a maximum value H must in addition be defined for the extent of the torque support.

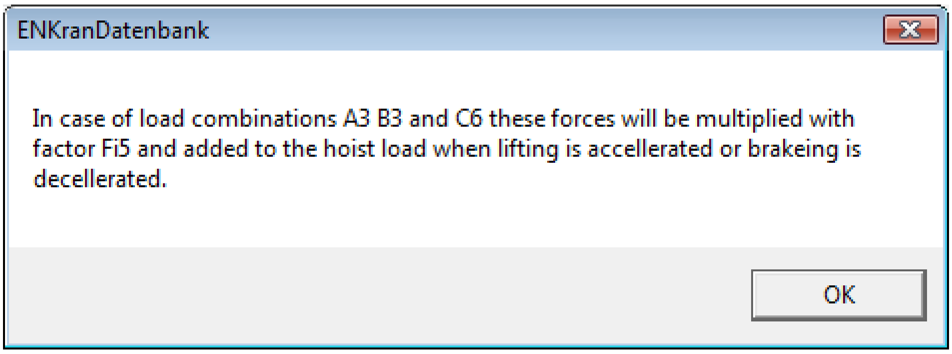
<u>All further data refer to the hoist and are the same for all crab types</u>.



Dynamic coefficients are determined on the basis of HC and HD classes as well as details of operation (hook or grab or magnet).

Coefficient Φ_2 may also be preset; no HC class will be indicated in this case.

Calculation of load cases A3, B3 and C6 in the proof of static strength requires the input of ΔF forces in accelerated lifting or decelerated lowering operations. These forces are multiplied by the coefficient Φ_5 and added to the hoist load (Info text). Zero as a value for ΔF is not allowed.

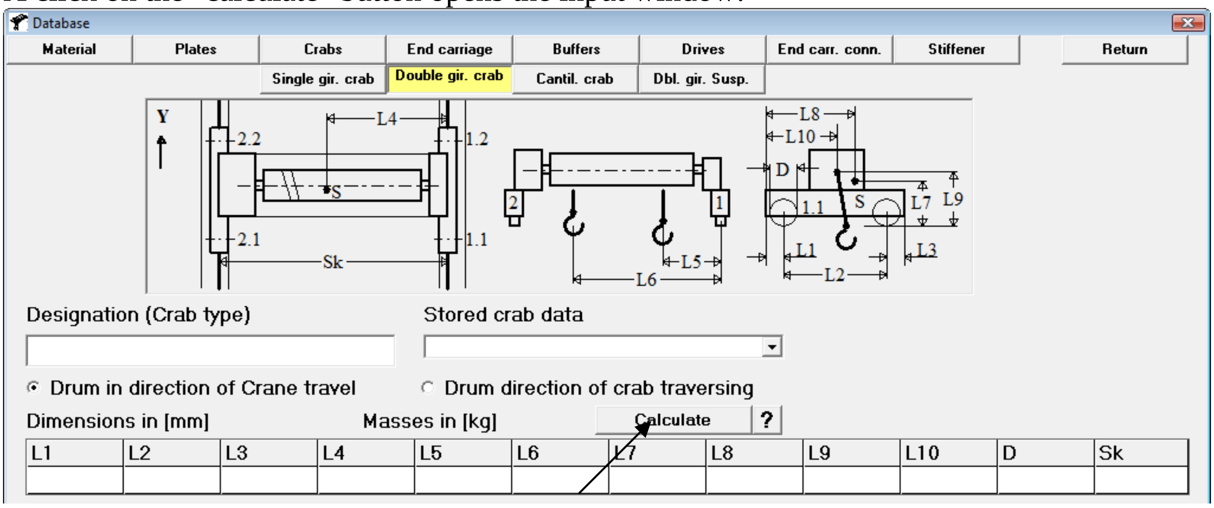


Upon saving of data, a control printout is generated.

Alternative input option for double girder crabs:

If the values of wheel loads of serial manufactured crabs are known they can be entered directly. The positions of the centre of gravity of the crab dead weight (L4 and L8) and the position of the assumed load application point (L5, L6 and L10) are then determined.

A click on the "calculate" button opens the input window:

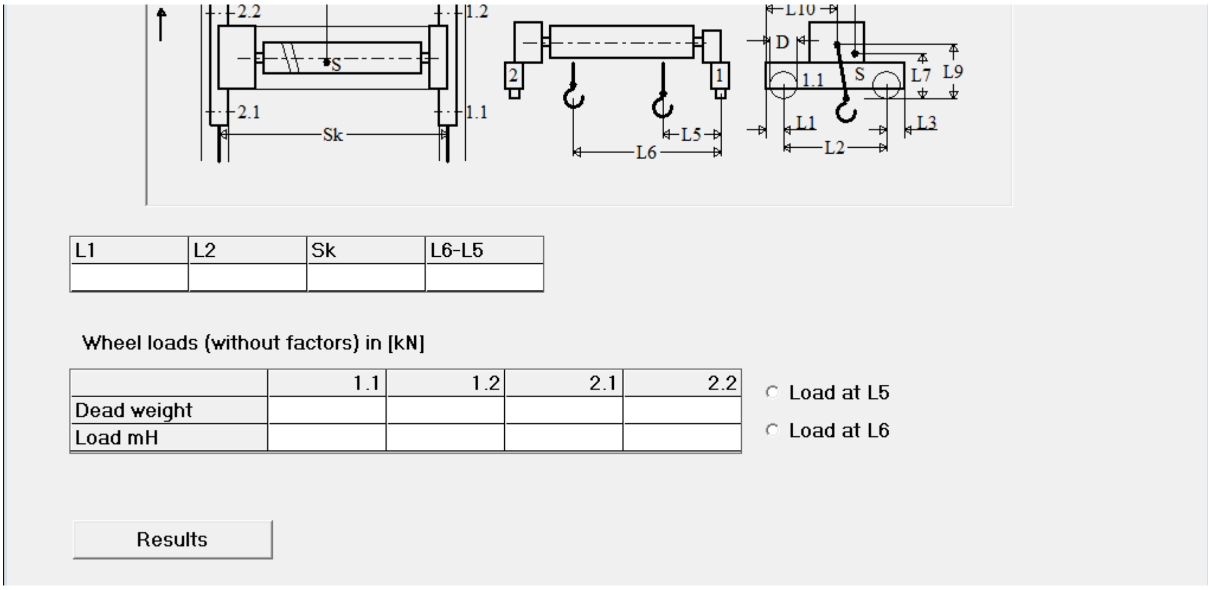


The dimensions L1, L2 and Sk may be entered either prior to the click on the "calculate" button or in the new window.

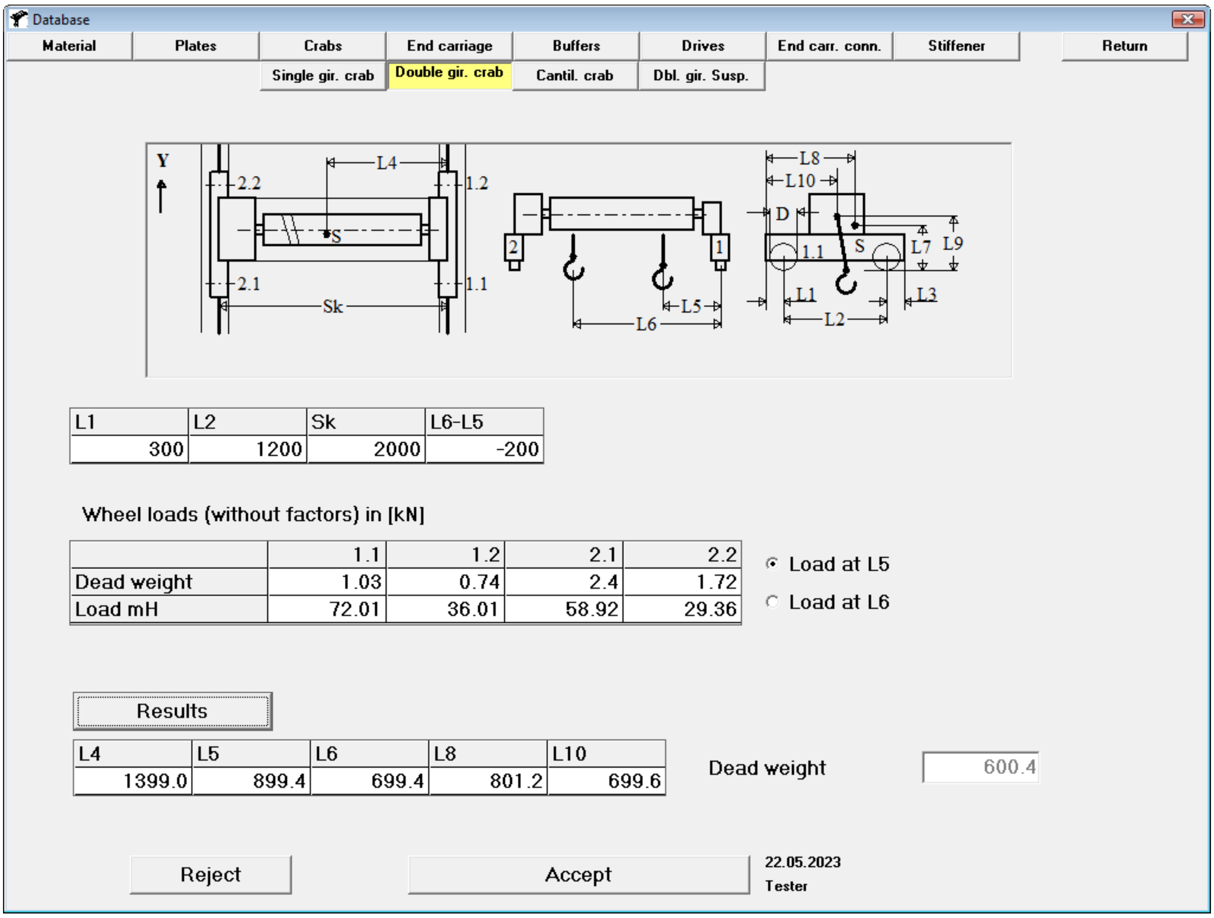
You must also enter the value of the lateral hook travel (L6 – L5). Value zero is allowed for designs without hook travel. A value less than zero is allowed too.

The wheel load values are only required for one end position of the hook travel (position L5 or L6).

After a click on the "results" button the values of the coordinates and the value of the crab dead weight are shown and may be accepted.



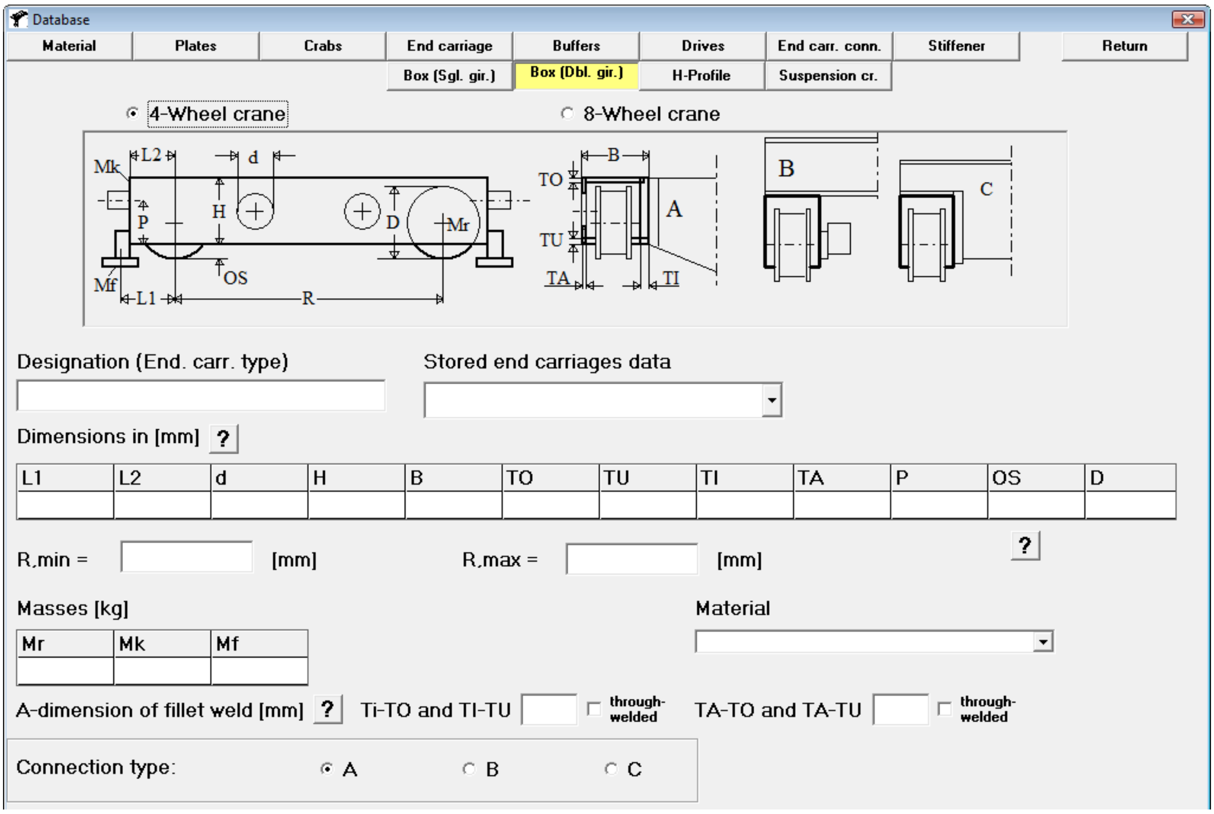
With results:



5.4 Database – End carriages

5.4.1 Bridge Crane

End carriages are the same for single-girder cranes and double-girder cranes with 4 wheels. 8-wheel cranes have buffers and guide rollers at one end only.

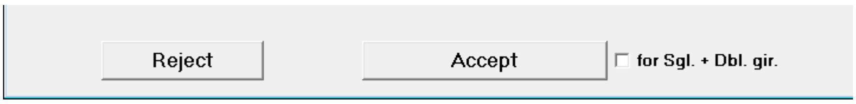


When entering an end carriage for the first time, the designation needs to be entered that will be used for this end carriage in the project, before you store the data.

Having selected an end carriage from the list of stored end carriages, you will be offered a choice between “Correction” (i.e. modification of data stored under this designation), “Delete” (i.e. removal from the database) or “Copy”.

The required dimensions are shown in the schematic diagram.

Box type end carriages can be entered for single or double girder cranes by button "Box (Sgl. gir,)" or button "Box (Dbl. gir.)". If the end carriage shall be available for both crane types the option "for Sgl. + Dbl. gir." shall be activated prior to "Accept".



Specifics:

Diameter d of the mounting hole needs to be entered only if its rim is not stiffened. In this case, the proof of strength is performed for the net section.

The wheel base R is to be entered in the crane projects. Only the range R.min (smallest value) to R.max (largest value) needs to be entered into the database.

If a rectangular tube is used as end carriage profile, the A dimension must be set at zero for both fillet welds. If a folded sheet is used on the outside, top and bottom, then the A dimension for TA-TO and TA-TU must be set at zero.

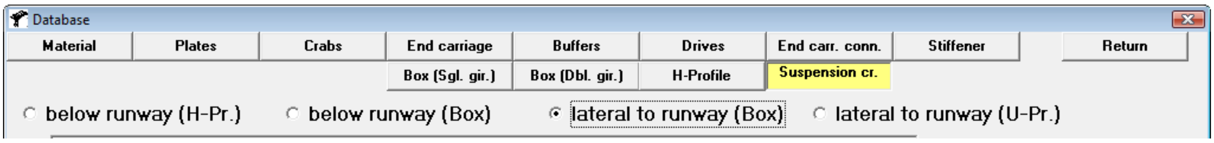
For variant B of the connection, proofs of strength and fatigue checks for bolts are performed only. For variant C, the proof of strength for the connection assumes introduction of vertical loads into the end carriage through the support, and of horizontal forces, bending and torsion moments through the bolt connection.

Details about guide rollers are optional: The final choice of either wheel flange or guide rollers will be made in the context of the project.

Mass data Mr (wheel), Mf (guide roller) and Mk (buffer end plate) apply per corner.

5.4.2 Suspension crane

There is a selection of 4 variants: 2 variants for end carriages below the crane runway and 2 variants for end carriages placed beside the runway.



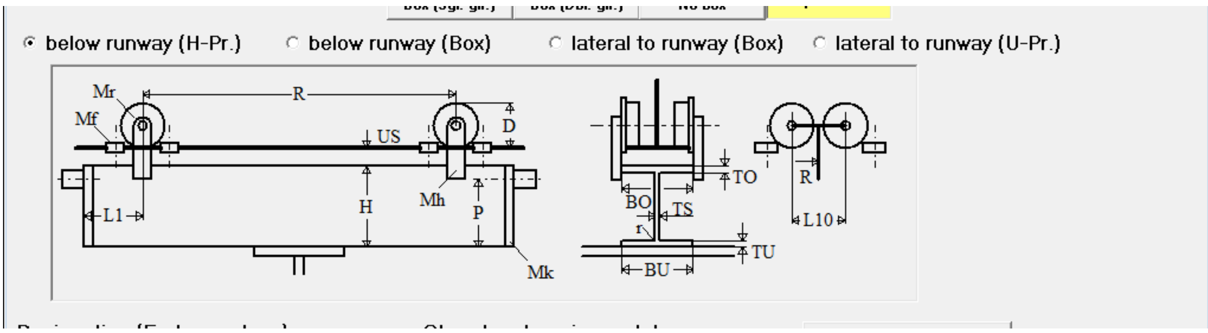
Having selected a variant the procedure is as described (see 5.4.1: Process, copy, delete)

Example below runway (H-Profile):
<u>Specifics:</u>

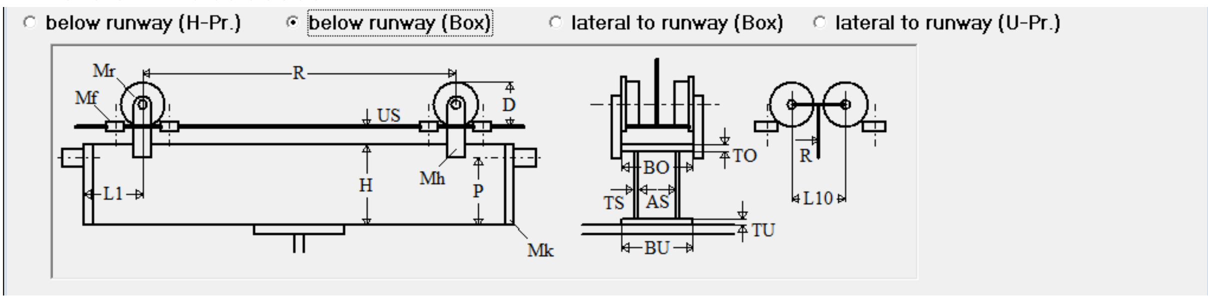
Dimension L10: If this value = 0, the end carriage has 4 wheels. For value > 0, the end carriage has 8 wheels, with 2 respectively mounted on a rocker arm.

For each project the user defines whether the end carriage operates with flanges or guide rollers. Guide rollers are located before and behind the wheels.

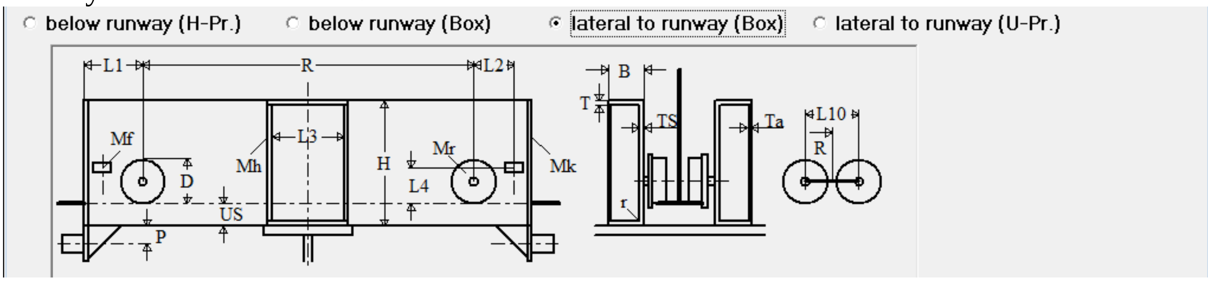
An H-Profile may be selected via dropdown menu from a list of standard profiles or entered directly with its dimensions.



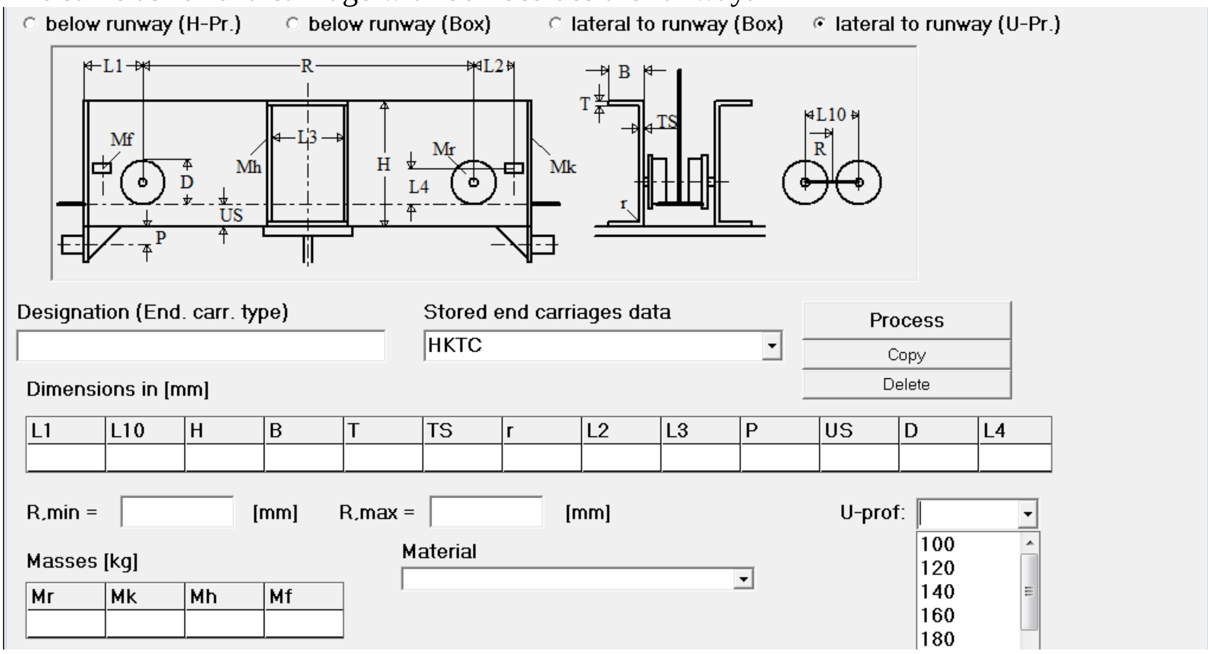
Example below runway (box girder):
<u>Specifics:</u>
Dimension L10 as above



Example lateral to runway (box girder):
Specifics: Guide rollers are located on the insides of the end carriage girder. For each project the user defines whether the end carriage operates with flanges or guide rollers. Guide rollers are located before and behind the wheels respectively.
The positions of guide rollers are defined by L2 and L4.
Dimension L3 defines the distance between vertical stiffeners or the width of an opening for the bolted connection with the bridge girder.
A U-Profile may be selected via dropdown menu from a list of standard profiles or entered directly with its dimensions.

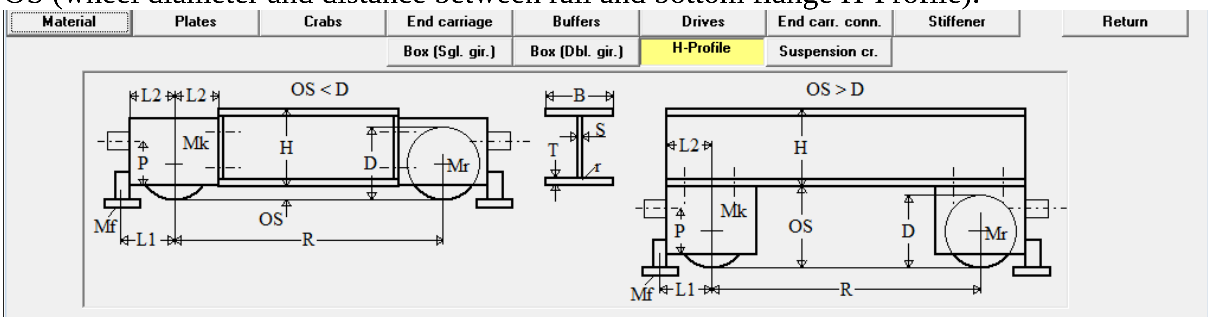


Example lateral to runway (U-Profile):
Specifics:
The same as for end carriage with box besides the runway.



5.4.3 End carriage with H-Profile and wheel blocks

Single girder cranes and 4-wheel double girder cranes may be designed with simple end carriages with H-Profiles and wheel blocks. The configuration depends on the dimensions D and OS (wheel diameter and distance between rail and bottom flange H-Profile).

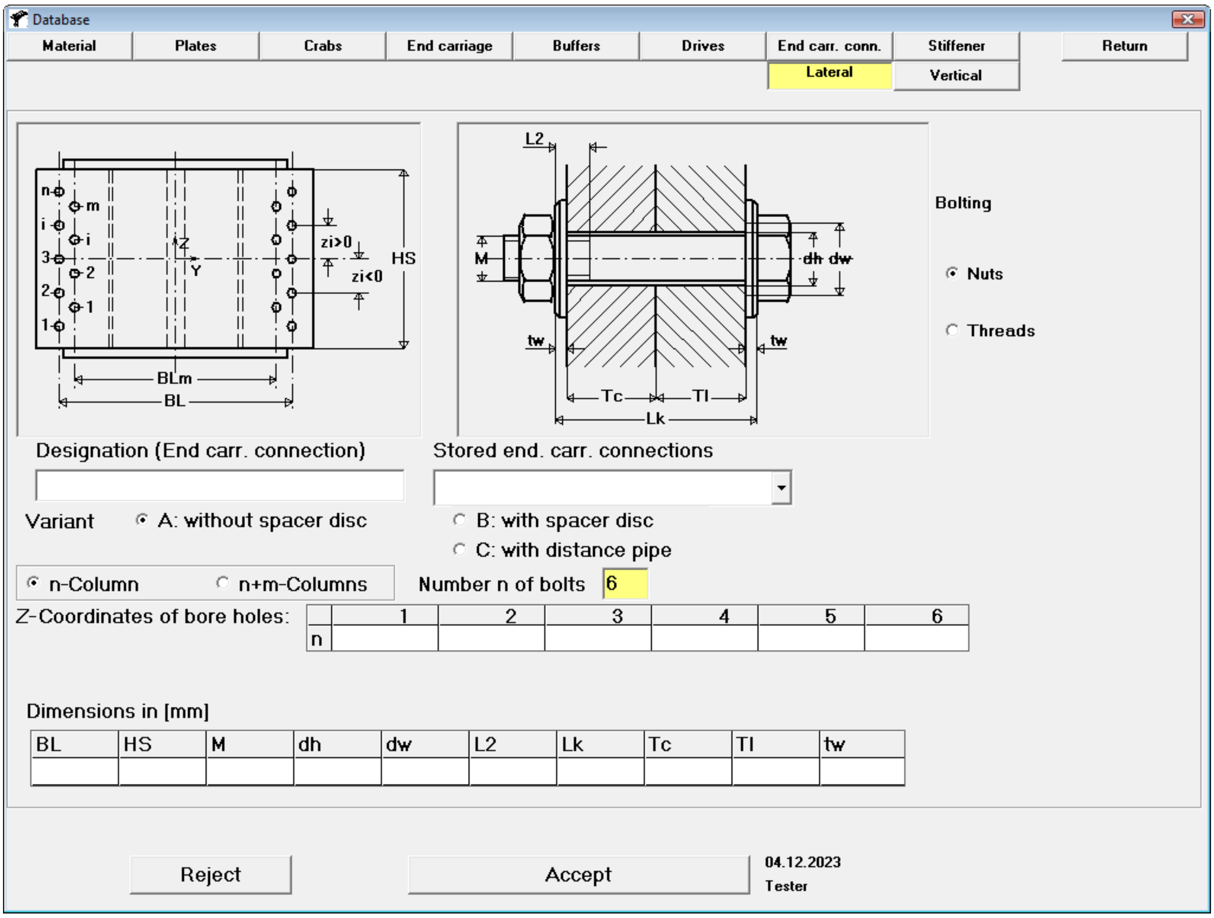


An H-Profile may be selected via dropdown menu from a list of standard profiles or entered directly with its dimensions. The crane bridge shall be mounted on top of the end carriage (vertical connection).

5.5 Database – End carriage connections

The first step is to choose between lateral or vertical connection (mounted on top for bridge cranes, and suspended for suspension cranes).

5.5.1 Lateral connection



If you enter a connection for the first time, you need to enter the designation used for this connection in projects before storing.

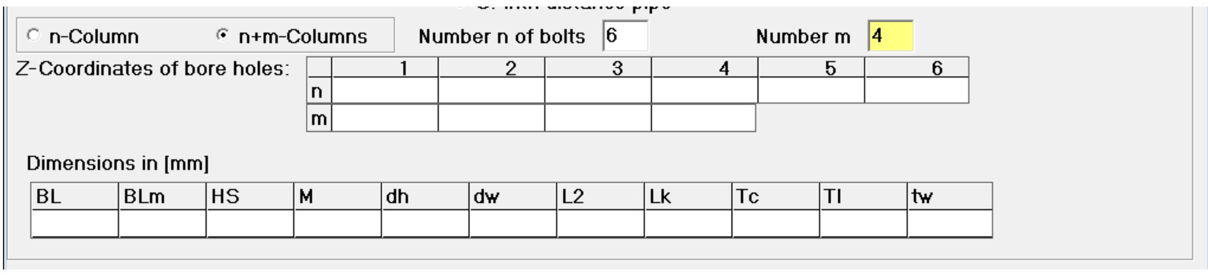
If you select a connection from the list of stored connections, you will be offered a choice of „process“, i.e. change the data stored under this designation, „delete“, i.e. remove from database, or „copy“.

There is a choice from the three variants of bolt connections already described in chapter 3.6 Bridge cranes – End carriage connection.

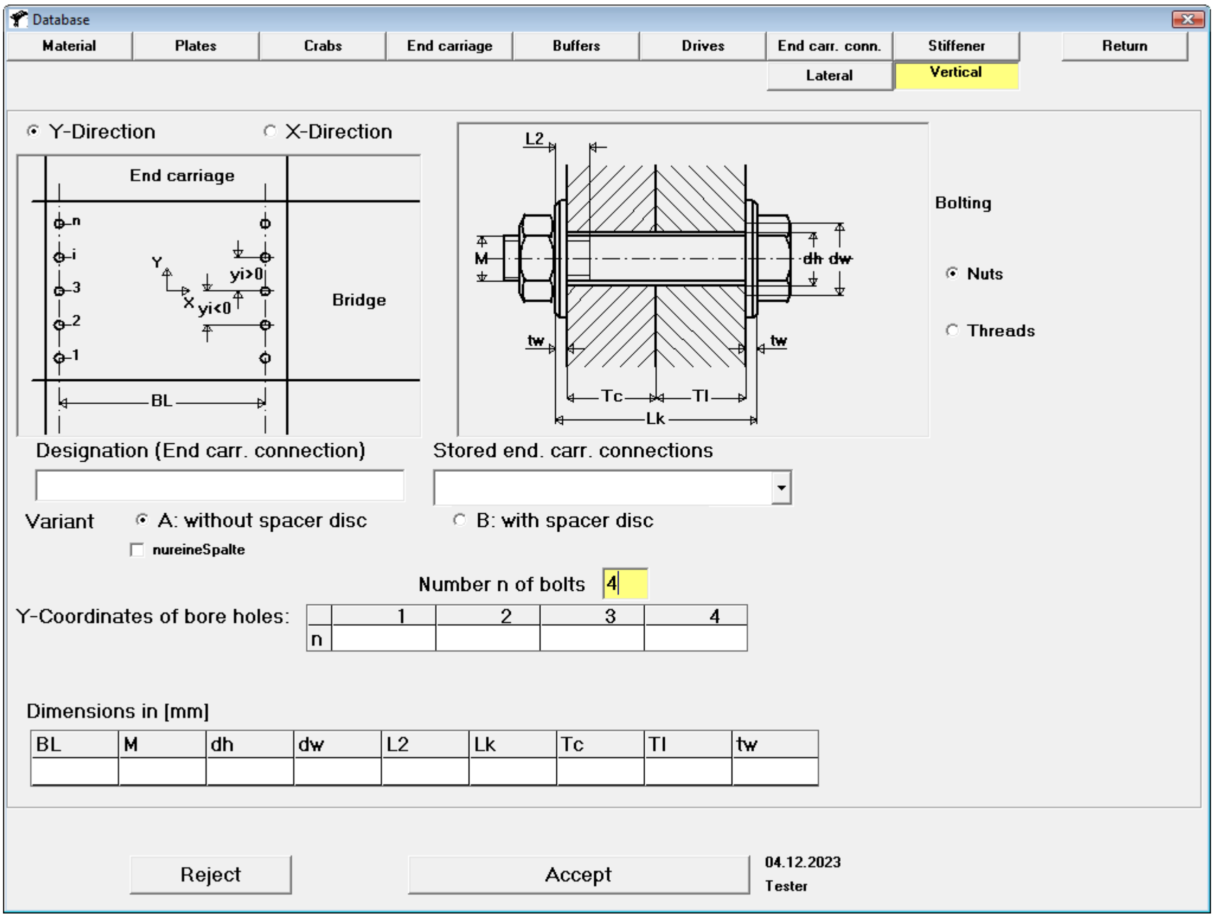
The dimensions required are given in the schematic diagram.

There is the choice between either one (n) or two (n + m) lateral bolt gaps.

In case of two bolt gaps, m must be specified in addition. The amount of m must not be larger than the amount of n. If the inner gap has a larger number of bolts, then the dimension BLm must be selected to be larger than the dimension BL.



5.5.2 Vertical connection



In addition, it is necessary to specify the alignment of the bolt in the direction of the end carriage (in Y direction) or of the bridge (in X direction).

If you select the Y direction, there is the additional option „bolts on one side only“.

5.6 Database – Drives and buffers

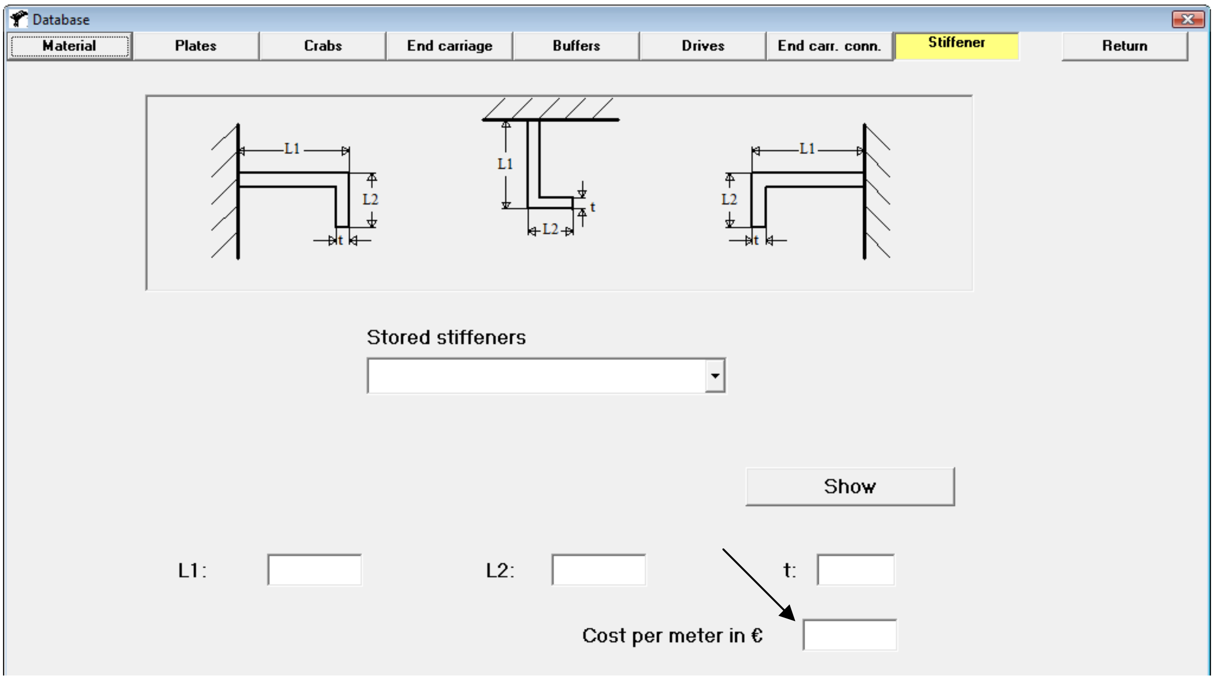
Crab data and end carriage data must be stored in the database; they are imported from the database for the purposes of crane projects, and they cannot be modified in crane projects (exception: wheelbase of end carriages).

Drives (cross travel and long travel) and buffers can be stored in the database. Another option is to enter or modify these data in the context of the crane project, whereby a modification in the crane project will not be resaved in the database.

For description of data see chapter 3.4 .

5.7 Database - Stiffeners

Stiffeners can be saved in the database, the same as drives and buffers.



However, it is not possible to copy the pertinent data into crane projects. Storage in the database is only required for optimisation calculations. Therefore, the costs per meter to be entered should include not only material value but also manufacturing costs from the installation of stiffeners. If no data for stiffeners have been stored, then box girders can only be optimised without stiffeners.

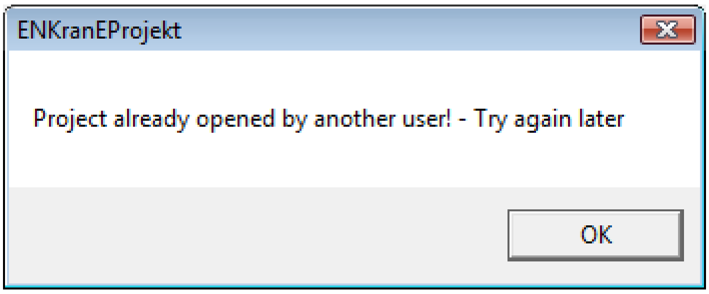
6. Notes

6.1 Error handling

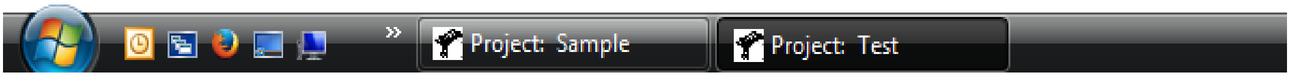
Operating errors (such as entry of invalid values) within the programme can be largely ruled out or will be indicated by error messages.
In case of runtime errors, users are recommended to close and then restart the programme, so that all data will again be correctly imported from the database. If errors occur they should be reported to the programme author, together with a precise description of the error.
In order to help to analyse the error you should send the respective project file in a ZIP-File to the programme author.

6.2 Parallel use

If prior to completion, the programme is started again via the Windows start menu (click on the Windows X icon) or via the network on another computer, it is only possible to work on different projects.
If the same project is started, the second user will see the following error message:



If several different projects have been opened on one computer, the user can switch between projects via the taskbar.



<u>Separate computers</u>

Where the programme has been installed on separate computers, the selected folders for the programme files and the programme data should be identical. In this case, data (complete projects) and the database can be copied from one computer to another.
However, it is always possible to copy a single project into the respective directory (EPROJEKTE or ZPROJEKTE) of another computer (even if the data structure for Program files and ProgramData is different).

<u>Computer network (WLAN)</u>

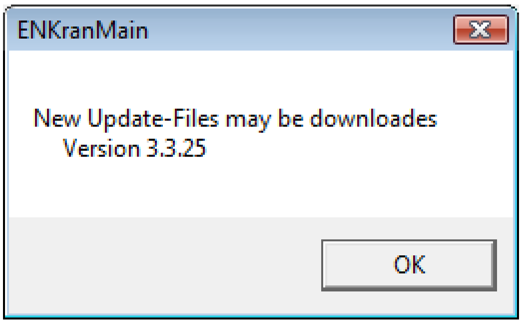
If, within one network, the software EN-Kran is started from other computers via WLAN (on the main computer), then all data are stored on the main computer only. The corresponding folders on the main computer must be accessible or marked as shared.

Depending on the network's performance level, it can take more time to switch between programme parts compared to the main computer. But the operating speed within programme parts depends on the individual computer exclusively.

Additional computers require a licence key as well.

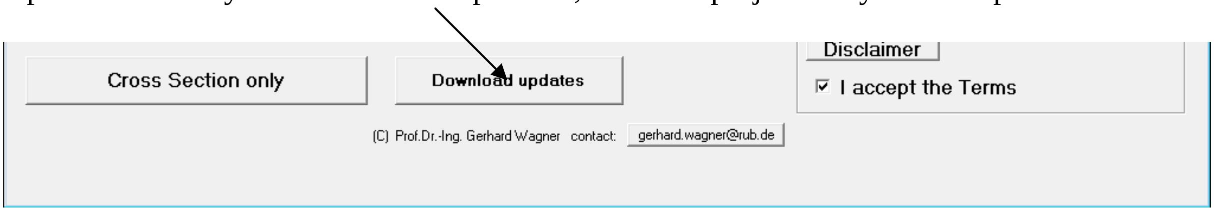
6.3 Updates

If the computer is online, a check for new updates is performed automatically upon programme start, and a corresponding note appears on the display:



A click on the button “Download updates” starts the update programme. This can only be done by the administrator.

Only modified programme parts are transferred. The database and existing projects remain unaffected.
Updates are always “downward compatible”, i.e. older projects may still be opened as well.



It is recommended to perform the update only by using the "Download updates" key.

If problems occur in the download of updates, the programme may be downloaded once again, the same as in first-time installation. However a prior data saving backup is recommended. The database and existing projects will remain unaffected if you select the folders for programmes and data in accordance with the first installation.

Information about changes or program extensions or corrections contained in the Update may be found in the Log-Files on the EN-Kran homepage.

7. Recommendations for reasonable sequence of entries

7.1 Project without optimisation and proof of fatigue strength

1. If the intended crabs or end carriages are not yet contained in the database, they should be entered as a first step.
2. Basic data
3. Crane data, end carriages and crabs to be taken from the database
4. Drive data. (Motor and buffer details may be taken from the database and modified)
5. Bridge girders – cross-section
6. Bridge girders – end carriage connection (stored geometric data may be taken from the data base). Qualities of screw connections and welds need to be entered here.
7. All input data and the static strength verification can now be read out. At this stage, screen display exclusively appears advisable.

7.2 Project with proof of fatigue strength

- First, follow procedure described in 7.1.
- Any data previously stored under design rules will be transferred automatically, and may now be modified for the purposes of the current project.
- If no data have been stored under design rules:

1. Specify or calculate S classes (this requires previous entry of the bridge cross-section.)
2. Select details and start working:
3. Output to screen or intended media.

7.3 Project with optimisation of cross-section

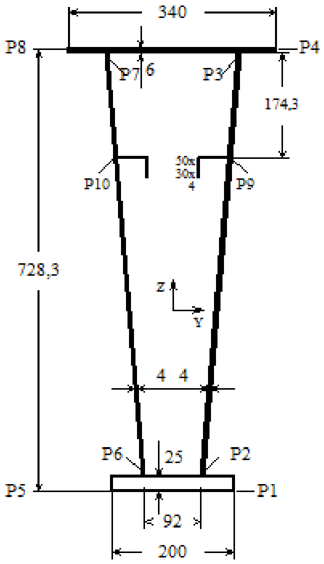
- First, follow procedure described in 7.1, items 1 to 4.
- Now you can execute the optimisation of the cross-section (without consideration of proof of fatigue strength). Any general rules predefined under “Design rules” will now be adopted.
- After adoption of an optimised cross-section it is now possible to calculate the S classes. It is recommended to repeat the optimisation process.
- Now you can execute all proofs and outputs.

Annex 1: Results box girder

Single-girder overhead crane

Brückenträger

Box +1 stiffener per web



Info: Web stiffeners installed perpendicularly on web

Lengths [mm]

Web angle = 5,0 [grd]

Area = 13.280,0 [mm**2]
IY = 1.077.288.000,0 [mm**4]
IZ = 75.596.580,0 [mm**4]
IT = 127.105.300,0 [mm**4]
Shear areas
AY = 1.614,2 [mm**2]
AZ = 5.575,6 [mm**2]
Position of centroid (z=0: bottom, y=0: Mid of bottom flange)
YS = 0,000 [mm]
ZS = 299,819 [mm]

Material: S235,EN10025-2
Material grade bottom flange: Z35/Z25 (EN10164) γ_{sm} = 1.00

A-dimension of welds
Web-Upper flange = 2,2 [mm]
Web-Bottom flange = 2,2 [mm], durchgeschweißt

Bulkhead:
Thickness = 4,0 [mm] Distance = 1.500,0 [mm] Height HK = 10,0 [mm]

Weight/meter = 106,4 [kg]

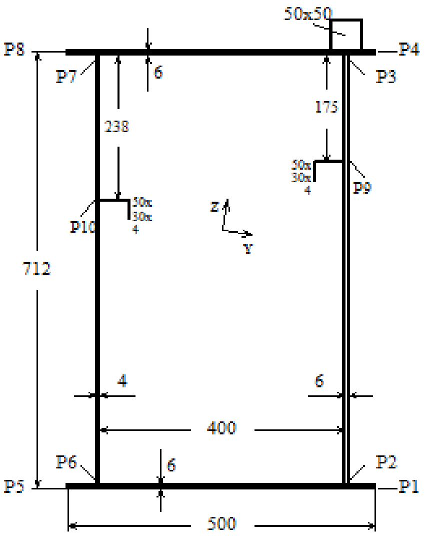
Stesses in [N/mm**2] per unit internal forces =1 in [kN] und [Nm]

Pt.	Sigma-X	Tau-Y	Tau-Z	Tau-X	Sigma-y	Sigma-Z
P1	7,530100e-02	0,000000e+00	3,308729e-10	1,966873e-04	-2,783089e-04	-1,322811e-03
P2	7,530100e-02	3,934440e-01	1,666910e-01	1,120884e-03	-2,551025e-04	-6,349494e-04
P3	7,530100e-02	-4,025111e-01	1,007224e-01	1,120884e-03	3,922050e-04	-1,441984e-03
P4	7,530100e-02	6,401130e-11	-1,030474e-10	4,720497e-05	3,977746e-04	-2,248779e-03
P5	7,530100e-02	0,000000e+00	3,308729e-10	1,966873e-04	-2,783089e-04	1,322811e-03
P6	7,530100e-02	3,934440e-01	-1,666910e-01	1,120884e-03	-2,551025e-04	6,349494e-04
P7	7,530100e-02	-4,025111e-01	-1,007224e-01	1,120884e-03	3,922050e-04	1,441984e-03
P8	7,530100e-02	-6,401130e-11	-1,030474e-10	4,720497e-05	3,977746e-04	2,248779e-03
P9	7,530100e-02	-1,666759e-01	1,551698e-01	1,120884e-03	2,303781e-04	-1,254692e-03
P10	7,530100e-02	-1,666759e-01	-1,551698e-01	1,120884e-03	2,303781e-04	1,254692e-03

Double-girder overhead crane

Bridge Girder (1)

Box rail above web +1+1 web-stiffener



Lengths [mm]

Web angle = 0,0 [grd]
Area = 16.140,0 [mm**2]
IY = 1.366.938.000,0 [mm**4]
IZ = 470.286.800,0 [mm**4]
IT = 760.748.800,0 [mm**4]
Shear areas
AY = 3.720,1 [mm**2]
AZ = 6.900,0 [mm**2]
Position of centroid (z=0: bottom, y=0: Mid of bottom flange)
YS = 49,245 [mm]
ZS = 420,482 [mm]
Main axes PSI= -9,472 grd

Weight/meter = 132,6 [kg]

Material TO: S235,EN10025-2
Material TU: S235,EN10025-2
Material TS1: S275,EN10025-2
Material TS2: S235,EN10025-2

A-dimension of welds
Upper flange-Web TS2 = 2,8 [mm]
Upper flange-Web TS1 = 4,1 [mm], throug welded; Double fillet weld
Web-Bottom flange = 2,8 [mm]

Bulkhead:
Thickness = 4,0 [mm] Distance = 1.500,0 [mm] Flange Widths sec. Bend. = 15,0 %

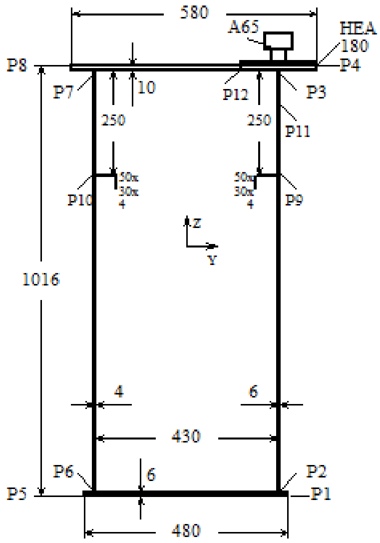
Stesses in [N/mm**2] per unit internal forces =1 in [kN] und [Nm] and crab whell load =1 [kN]

Pt.	Sigma-X	Tau-Y	Tau-Z	Tau-X	Sigma-y	Sigma-Z	Sig-Y-sec
P1	6,19579e-02	-6,92175e-10	-2,38139e-10	7,88697e-06	-2,79277e-04	-5,67138e-04	1,70391e-01
P2	6,19579e-02	1,21008e-01	1,02000e-01	2,92388e-04	-2,80576e-04	-4,67512e-04	1,69326e-01
P3	6,19579e-02	-1,31919e-01	1,16811e-01	2,92388e-04	2,24536e-04	-2,22576e-04	-7,91043e-02
P4	6,19579e-02	-3,10938e-10	1,63720e-10	7,88697e-06	2,34554e-04	-3,20103e-04	-8,01690e-02
P5	6,19579e-02	-4,32610e-10	-2,97673e-10	7,88697e-06	-3,39469e-04	4,81549e-04	0,00000e+00
P6	6,19579e-02	2,13609e-01	-7,73836e-02	4,38582e-04	-3,29332e-04	3,81925e-04	0,00000e+00
P7	6,19579e-02	-1,77028e-01	-1,30797e-01	4,38582e-04	1,75781e-04	6,26861e-04	0,00000e+00
P8	6,19579e-02	3,46088e-10	4,16743e-10	7,88697e-06	1,74362e-04	7,28585e-04	0,00000e+00
P9	6,19579e-02	-8,76102e-02	1,45056e-01	2,92388e-04	9,82582e-05	-2,83810e-04	-1,69967e-02
P10	6,19579e-02	-3,77451e-02	-1,52196e-01	4,38582e-04	4,04248e-06	5,43583e-04	0,00000e+00

Double-girder overhead crane

(1)

Box rail above web +1+1 web-stiffener+1/2 H-Prof.



Lengths [mm]

Web angle = 0,0 [grd]
Area = 19.328,1 [mm**2]
IY = 2.941.820.000,0 [mm**4]
IZ = 699.578.300,0 [mm**4]
IT = 1.431.171.000,0 [mm**4]

Shear areas
AY = 4.359,7 [mm**2]
AZ = 9.819,9 [mm**2]
Position of centroid (z=0: bottom, y=0: Mid of bottom flange)
YS = 28,274 [mm]
ZS = 590,870 [mm]
Shear centre
YM = 57,000 [mm]
ZM = 610,739 [mm]
Main axes PSI= -0,184 grd

Weight/meter = 203,8 [kg]
Rail not load carrying

Material TO: S235,EN10025-2
Material TS1: S235,EN10025-2
Material TU: S235,EN10025-2
Material TS2: S235,EN10025-2
Material H-Pr: S235,EN10025-2

A-dimension of welds
Upper flange-Web TS2 = 2,8 [mm]
H-Pr. - TS1 = 2,4 [mm], on both sides; throug welded
Web-Bottom flange = 2,8 [mm]
Expansion of effective distribution length + 18,0 [%]

Diaphragm:
Thickness = 4,0 [mm] Distance = 1.500,0 [mm]
Sec. stress upper flange per crab wheel load [kN] = 25 [N/mm**2]

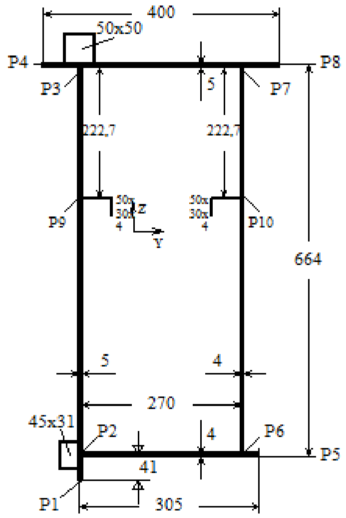
Stesses in [N/mm**2] per unit internal forces =1 in [kN] und [Nm] and crab wheel load =1 [kN]

Pt.	Sigma-X	Tau-Y	Tau-Z	Tau-X	Sigma-y	Sigma-Z	Sig-Y-sec
P1	5,17382e-02	-2,25385e-10	2,07474e-11	4,19237e-06	-2,00619e-04	-3,05348e-04	1,00214e-01
P2	5,17382e-02	1,32375e-01	5,39443e-02	1,90791e-04	-1,98604e-04	-2,73887e-04	9,96690e-02
P3	5,17382e-02	-1,51085e-01	7,96501e-02	1,90791e-04	1,41405e-04	-2,69291e-04	-8,19269e-02
P4	5,17382e-02	-7,31256e-10	1,65433e-10	6,63792e-06	1,44733e-04	-3,97917e-04	-8,27892e-02
P5	5,17382e-02	-1,45409e-10	1,97100e-10	4,19237e-06	-2,01144e-04	3,80776e-04	0,00000e+00
P6	5,17382e-02	1,77910e-01	-5,95701e-02	2,86187e-04	-1,99079e-04	3,47913e-04	0,00000e+00
P7	5,17382e-02	-1,96476e-01	-8,43683e-02	2,86187e-04	1,40845e-04	3,52508e-04	0,00000e+00
P8	5,17382e-02	5,38742e-10	1,50419e-10	6,98728e-06	1,44184e-04	4,31150e-04	0,00000e+00
P9	5,17382e-02	-7,17473e-02	1,07294e-01	1,90791e-04	5,63390e-05	-2,70441e-04	-3,64939e-02
P10	5,17382e-02	-1,08493e-01	-1,08957e-01	2,86187e-04	5,58637e-05	3,51359e-04	0,00000e+00
P11	5,17382e-02	-1,30606e-01	8,94152e-02	1,90791e-04	1,15571e-04	-2,69640e-04	-6,81290e-02
P12	5,17382e-02	-1,43891e-01	2,45618e-02	1,20500e-04	1,42921e-04	-1,40621e-04	0,00000e+00

Cantilever crab crane

Bridge

Box 1+1 web-stiffener



Lengths [mm]

Web angle = 0,0 [grd]

Area = 13.855,0 [mm**2]
IY = 1.030.840.000,0 [mm**4]
IZ = 207.270.700,0 [mm**4]
IT = 311.152.000,0 [mm**4]
Shear areas
AY = 1.960,3 [mm**2]
AZ = 5.875,9 [mm**2]
Position of centroid (z=0: bottom, y=0: Mid of bottom flange)
YS = -48,007 [mm]
ZS = 380,827 [mm]
Main axes PSI= 0,955 grd

Material: S235,EN10025-2

A-dimension of welds
Web1-Upper flange = 2,5 [mm], durchgeschweißt; Double fillet weld
Fillet welds = 2,2 [mm]
Distance between upper flange and weld NA = 10,0 [mm]

Diaphragm:
Thickness = 4,0 [mm] Distance = 1.550,0 [mm] Flange Widths sec. Bend. = 21,0 %

Weight/meter = 112,5 [kg]

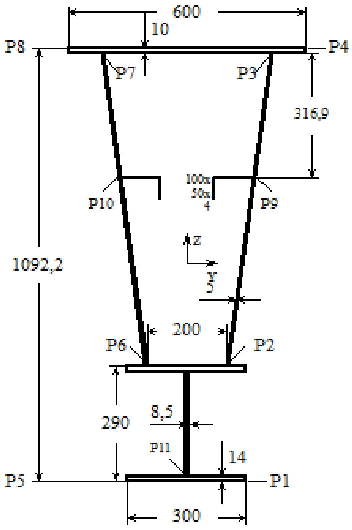
Stesses in [N/mm**2] per unit internal forces =1 in [kN] und [Nm] and crab wheel load =1 [kN]

Pt.	Sigma-X	Tau-Y	Tau-Z	Tau-X	Sigma-y	Sigma-Z	Sig-Y-sec
P1	7,21761e-02	0,00000e+00	0,00000e+00	-1,60693e-05	-4,07703e-04	4,65626e-04	1,23233e-01
P2	7,21761e-02	1,44242e-01	-1,30302e-01	-5,53614e-04	-3,65995e-04	4,62168e-04	1,12517e-01
P3	7,21761e-02	-1,58808e-01	-1,58271e-01	-5,53614e-04	2,71261e-04	4,09339e-04	-5,12064e-02
P4	7,21761e-02	0,00000e+00	0,00000e+00	-1,60693e-05	2,77121e-04	7,10634e-04	-5,18294e-02
P5	7,21761e-02	0,00000e+00	0,00000e+00	-1,28555e-05	-3,72826e-04	-9,97073e-04	0,00000e+00
P6	7,21761e-02	3,14656e-01	9,59926e-02	-6,92017e-04	-3,68493e-04	-8,62164e-04	0,00000e+00
P7	7,21761e-02	-3,25762e-01	1,25617e-01	-6,92017e-04	2,66823e-04	-9,14832e-04	0,00000e+00
P8	7,21761e-02	0,00000e+00	0,00000e+00	-1,60693e-05	2,70654e-04	-1,21894e-03	0,00000e+00
P9	7,21761e-02	-6,56539e-02	-1,94629e-01	-5,53614e-04	5,52532e-05	4,27246e-04	4,29016e-03
P10	7,21761e-02	-1,24023e-01	1,60986e-01	-6,92017e-04	5,08151e-05	-8,96925e-04	0,00000e+00

Single girder crane: Box girder + H-Profile:

Brückenträger

Kasten 1 Steife in Stegen+ H-Profil



Info: Beulsteifen stehen senkrecht auf den Stegblechen

Längen [mm]

Stegwinkel = 8,0 [grd]

Fläche = 26.452,8 [mm**2]
IY = 4.275.467.000,0 [mm**4]
IZ = 466.948.600,0 [mm**4]
IT = 679.774.500,0 [mm**4]
Schubflächen
AY = 5.296,4 [mm**2]
AZ = 9.874,0 [mm**2]
Schwerpunktslage (z=0: Boden, y=0: Mitte Untergurt)
YS = 0,000 [mm]
ZS = 550,099 [mm]

Werkstoff: S235 , EN 10025-2

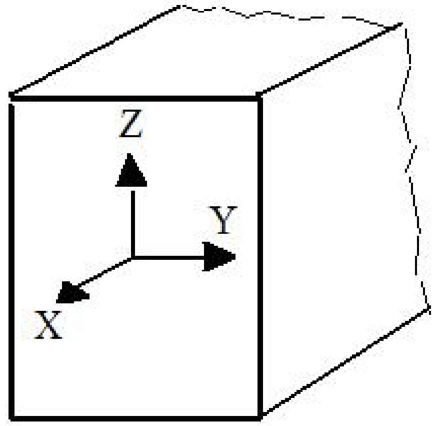
A-Maß der Schweißnähte
Steg-Obergurt = 2,8 [mm]
Steg-Untergurt = 2,8 [mm], durchgeschweißt

Schottdaten:
Dicke = 4,0 [mm] Abstand = 2.000,0 [mm]
Metergewicht = 211,5 [kg]

Einheitsspannungen in [N/mm**2] für Schnittgrößen =1 in [kN] und [Nm]

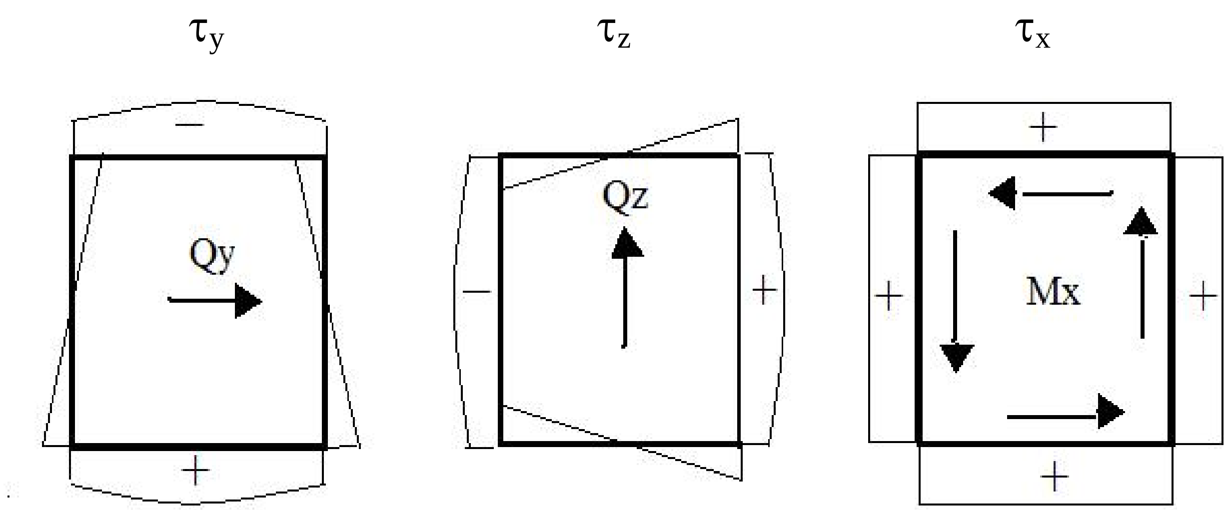
Pt.	Sigma-X	Tau-Y	Tau-Z	Tau-X	Sigma-y	Sigma-Z
P1	3,78032e-02	0,00000e+00	1,03601e-09	2,05951e-05	-1,30960e-04	-3,21235e-04
P2	3,78032e-02	1,60509e-01	1,03130e-01	3,94729e-04	-6,31310e-05	-2,19510e-04
P3	3,78032e-02	-1,37931e-01	7,39989e-02	3,94729e-04	1,22162e-04	-4,57949e-04
P4	3,78032e-02	1,28326e-09	3,52207e-10	1,47108e-05	1,24501e-04	-6,42469e-04
P5	3,78032e-02	2,39014e-09	4,17665e-09	2,05951e-05	-1,30960e-04	3,21235e-04
P6	3,78032e-02	1,60509e-01	-1,03130e-01	3,94729e-04	-6,31310e-05	2,19510e-04
P7	3,78032e-02	-1,37931e-01	-7,39989e-02	3,94729e-04	1,22162e-04	4,57949e-04
P8	3,78032e-02	-1,28326e-09	3,52207e-10	1,47108e-05	1,24501e-04	6,42469e-04
P9	3,78032e-02	-6,36598e-03	1,01220e-01	3,94729e-04	4,80448e-05	-3,64680e-04
P10	3,78032e-02	-6,36596e-03	-1,01221e-01	3,94729e-04	4,80448e-05	3,64680e-04
P11	3,78032e-02	3,93670e-09	-6,39006e-02	1,25042e-05	-1,27685e-04	0,00000e+00

Annex 2: Internal forces and resulting stresses

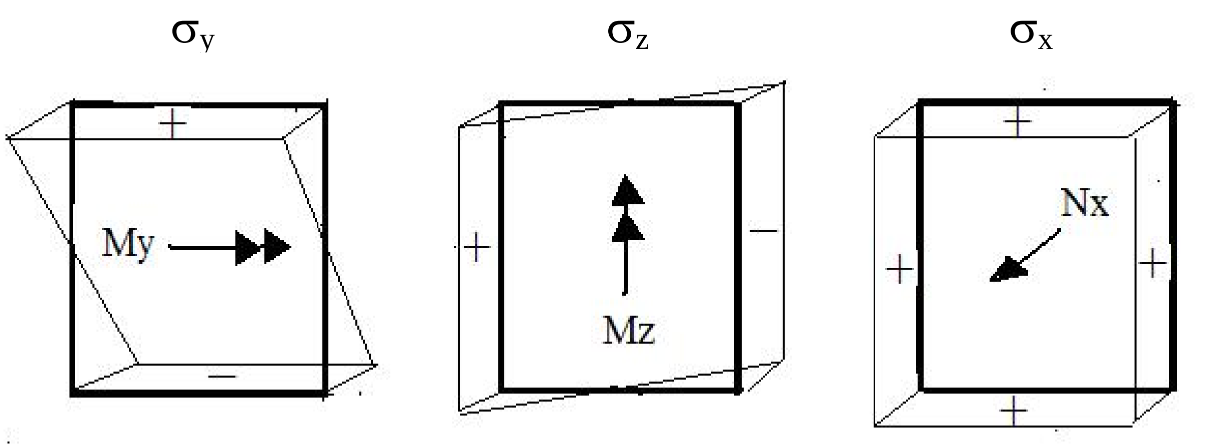


Stresses in the edge points refer to internal forces with the following signs:

Shear stresses τ resulting from transverse forces Qy and Qz as well as torsion Mx



Normal forces σ resulting from normal force Nx, bending moments My and Mz



Annex 3: Method of calculating s_m parameters

If S classes (or sm factors respectively) are not specified directly but calculated using the computation module, the following method is used to calculate the stress history parameters sm:

Each work cycle (out of the sum C of work cycles) is described in terms of the following data:

- Load spectrum kQ
- Crab position at load pick-up (start of the lifting process)
- Crab position at load delivery and start of unloaded travel
- Crab position at end of unloaded travel
- Average crane travel (class Dc)
- Average hoisting path (class Dh)
- Speeds (and accelerations)
- Positioning class
- Indication whether hoisting and travelling motions overlap
- Load guide (if fixed)
- Dynamic coefficients Φ_2 and Φ_5

A3.1 Factor s_m for crab rail or bottom flange:

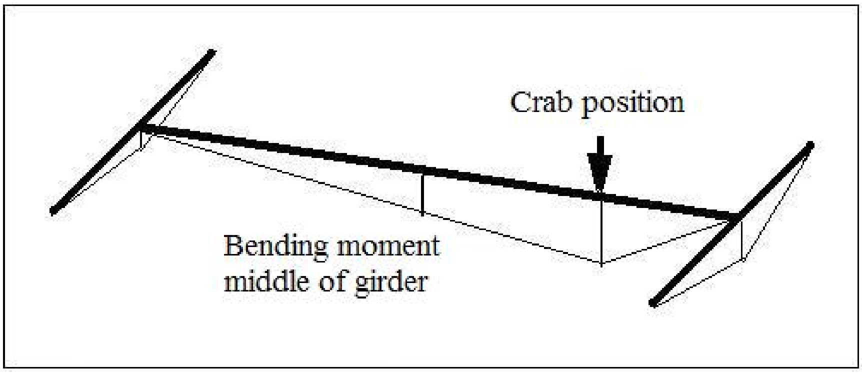
For each point on the girder (divided into 10 locations) the programme determines how often it is passed by crab wheels with and without load. Hereby the load is given without lifting coefficient, and the dead weight with the mass coefficient $\Phi_{1.}$ Each overrolling corresponds to a stress cycle. The maximum stress range $\Delta\sigma_{max}$ results from wheel load, maximum load and dead weight. The stress range at overrolling with load $\Delta\sigma_{Last}$ results from maximum wheel load *kQ + wheel load from dead weight; the stress range without load $\Delta\sigma_{Leer}$ results from wheel load from dead weight only.
Using n_{iLast} and n_{ileer} (calculated overrolling with and without load), a parameter s_m can therefore be determined for each point on the girder as follows:

$$s_m = \sum\left[\left(\frac{\Delta\sigma_{Last}}{\Delta\sigma_{\max}}\right)^m \cdot n_{iLast} + \left(\frac{\Delta\sigma_{leer}}{\Delta\sigma_{\max}}\right)^m \cdot n_{ileer}\right] \cdot N_{ref}$$

The maximum value s_m from all points on the girder is then used in the proof of fatigue strength for the weld below the rail or the flange welds / flange bending, in order to determine the permissible stress range $\Delta\sigma_{Sd}$.

A3.2 Factor s_m for the crane bridge (centre of the bridge):

The bending moment at the bridge centre depends on the respective position of the crab:

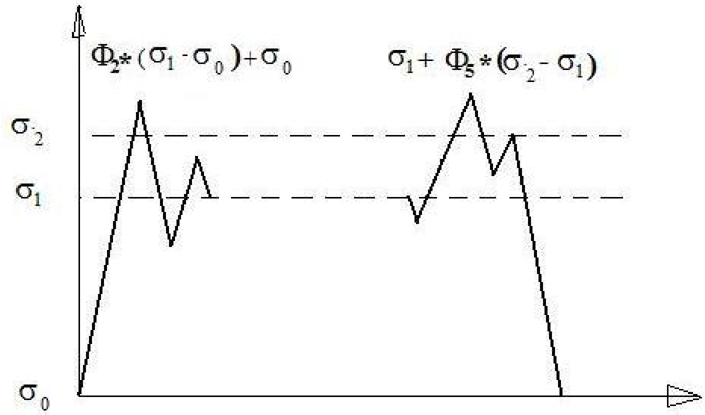


Lifting the loads results in a bending stress curve in the centre of the bridge, with qualitative peaks as displayed.

σ_0 stands for bending stress without load (prior to lifting and after delivery),

σ_1 stands for bending stress with suspended stationary load.

σ_2 stands for bending stress with constant deceleration (lowering and braking.)



Dynamic coefficients ϕ_2 and ϕ_5 serve to determine the two stress peaks when lifting and lowering/braking the load. By analogy with the Rainflow method, individual stress cycles can now be detected:

- A maximum stress cycle between σ_0 and $\phi_2*(\sigma_1-\sigma_0)+\sigma_0$ or $\sigma_1+\phi_5*(\sigma_2-\sigma_1)$,
- Stress cycles around σ_1 and
- Stress cycles around σ_2.

For an undampted stress cycle around σ_1, the result is a stress range $\Delta\sigma=2*\phi_2*\sigma_1$. Damping reduces the actual stress range. Further stress cycles have practically no damaging impact. In the case shown here, a maximum stress cycle plus one undamped stress cycle for lifting and lowering respectively are assumed, and further subsiding stress cycles will be neglected.
For the simplified case of a load cycle without crane travel, the highest stress range $\Delta\hat{\sigma}$ is found for either a stress cycle starting with a lifting of the load in the centre of the bridge and ending after delivery of the load in the approach dimension of the crab, or for a stress cycle starting with lifting in the approach dimension and ending with delivery in the centre of the bridge – depending on which dynamic coefficient (ϕ_2 or ϕ_5) has a stronger effect.

Three situations have to be distinguished for crab movements under load:

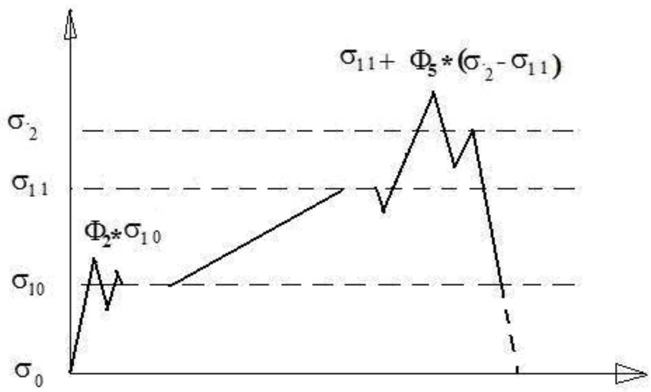
a) Crab movement towards centre of bridge, but not beyond:

σ_0 stands for bending stress without load (prior to lifting),

σ_{10} stands for bending stress with suspended stationary load prior to crab movement

σ_{11} stands for bending stress with suspended stationary load after crab movement

σ_2 stands for bending stress under constant deceleration (lowering and braking).



Individual stress cycles may again be detected:

– A maximum stress cycle between $\sigma_{11}+\phi_5*(\sigma_2-\sigma_{11})$ and σ_0 ,

– Stress cycles around σ_{10} and

– Stress cycles around σ_2.

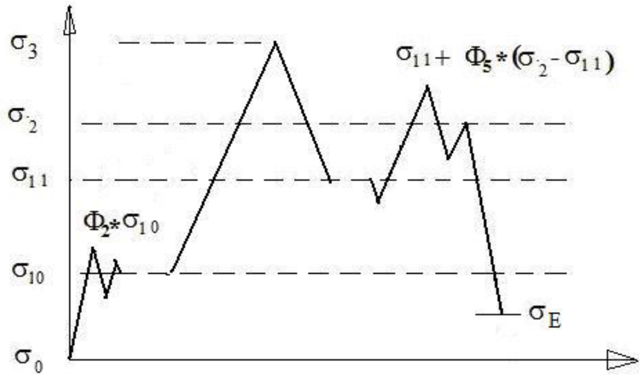
As explained above, only one undamped stress cycle respectively around σ_{10} and around σ_2 is taken into consideration, apart from the maximum stress cycle.

b) Crab movement towards approach dimension, but not beyond centre:

This corresponds to the stress curve of case a, whereby now $\sigma_{10} > \sigma_{11}$, and the maximum stress cycle is to be assumed to be between $\phi_2*\sigma_{10}$ and σ_0. Hereby, σ_0 is the bending stress after delivery of the load.

c) Crab movement beyond centre of bridge:

In this case, the bending stress increases after lifting in the course of the crab movement up to σ_3 in the centre of the bridge, and then decreases.



Now the decisive point is which stress is highest. If σ_3 exceeds $\phi_2*\sigma_{10}$ and exceeds $\sigma_{11}+\phi_5*(\sigma_2-\sigma_{11})$, then the maximum working stroke is the stress cycle between σ_0 (prior to lifting or after delivery) and σ_3.
If, on the other hand, σ_3 is below $\phi_2*\sigma_{10}$ or $\sigma_{11}+\phi_5*(\sigma_2-\sigma_{11})$, then the maximum stress cycle is between $\sigma_{11}+\phi_5*(\sigma_2-\sigma_{11})$ and σ_0 , or between $\phi_2*\sigma_{10}$ and σ_0 respectively. In addition to the two stress cycles around σ_{10} and around σ_2 , another stress cycle needs to be taken into consideration:

– Stress range $\sigma_3 - \sigma_{11}$ if $\sigma_{11} > \sigma_{10}$ or

– Stress range $\sigma_3 - \sigma_{10}$ if $\sigma_{11} < \sigma_{10}$.

Crab movement without load:

For crab movement without load, two different cases are to be considered:

a) Return movement towards start position of work cycle:
If the movement does not go beyond the centre of the bridge (in combination with cases a and b of crab under load), no further stress cycle occurs. If the movement goes beyond the centre, then a stress cycle occurs with a stress range between σ_E and the stress resulting from unloaded crab in centre of bridge.

b) Onward movement of empty crab:
No further stress cycle occurs if the crab does not pass the centre of the bridge. If it passes the centre, again a stress cycle between σ_E and the stress from empty crab at centre of bridge can be assumed.

Crane movement;

The bending stress resulting from the dead weight of the bridge is of no relevance to the stress range from hoisting movement and crab movement. However, depending on the work cycle of the crane, the following actions generate stress cycles of bending stresses in the horizontal plane:

– Acceleration of crane with crab under load: horizontal bending from mass of bridge and mass of crab + load + lifting device in crab position at start of crane movement

– Deceleration of crane with crab under load: horizontal bending from mass of bridge and mass of crab + load + lifting device in crab position at end of crane movement (decisive factor: duration of crane movement and crab movement)

– Possibly: positioning according to EN 15011

– Acceleration of crane with empty crab: horizontal bending from mass of bridge and mass of crab + lifting device in crab position at start of crane movement

– Deceleration of crane with empty crab: horizontal bending from mass of bridge and mass of crab + lifting device in crab position at end of crane movement (decisive factor: duration of crane movement and crab movement)

Depending on the type of drive, the stress range is determined using the dynamic coefficient ϕ_5 pursuant to EN 13001. EN-Kran is premised on the assumption that in normal practice the duration of the crane acceleration t_b in seconds exceeds the duration of horizontal vibration (with frequency f_h in Hz). The number of stress cycles n_i will then result as:

$$n_i = t_b \times f_h$$

However, since t_b and f_h depend on load and crab position, and the stress ranges are small compared to the stress ranges resulting from lifting operations, and on the assumption of damping factors, a value of n_i =2 is applied here.

In cases where lifting operations and crane movement overlap, stresses need to be superposed. If the lifting operation is performed without driving movements, then only crab and crane movement are superposed.

A3.3 Factor s_m for end carriages and end carriage connections:

The same approaches are to be applied here as for bending in the centre of the bridge. However, in this context it is of no relevance whether the crab movement goes beyond the centre of the bridge or not.

Hint: The values of sm and sc for rails are not identical: EN13001-3-1 requires to calculate sm with all dynamic Φ factors and N_{ref} = 2.000.000. However, according to EN13001-3-3 the sc-values shall be calculated with all Φ_i set to 1 and N_{ref} =6.400.000.

Annex 4: Method of calculating s_c parameters

If Sc classes (or sc factors respectively) are not specified directly but calculated using the computation module, the following method is used to calculate the stress history parameters sc:

Each work cycle (out of the sum C of work cycles) is described in terms of the following data:

- Load spectrum kQ
- Crab position at load pick-up (start of the lifting process)
- Crab position at load delivery and start of unloaded travel
- Crab position at end of unloaded travel
- Average crane travel (class Dc)
- Speeds (and accelerations) of crane and crabs
- Load guide (if fixed)
- Diameter of crane wheel

According to EN 13001-3.3 each contact per wheel shall be calculated separately and then the spectrum factor is determined as

$$k_c = \frac{1}{i_{tot}} \sum_{i=1}^{i_{tot}} \left(\frac{F_{Sd,f,i}}{F_{Sd,f}} \right)^m$$

The number of contacts (of one point at the circumference of a wheel) per crane movement is determined by length of crane path / wheel circumference. Taking into consideration crane speed and crane acceleration the time t_i of a contact can be calculated.

For each time t_i the corresponding crab position between start and stop of the crab movement can be derived from crab acceleration and crab speed.

The contact force $F_{Sd,f,i}$ (of one wheel) at time t_i can be determined from

- Crane dead weight
- Mass forces from crane acceleration
- Crab position
- Crab loaded or without load
- Effect of crane acceleration on mass of crab and load

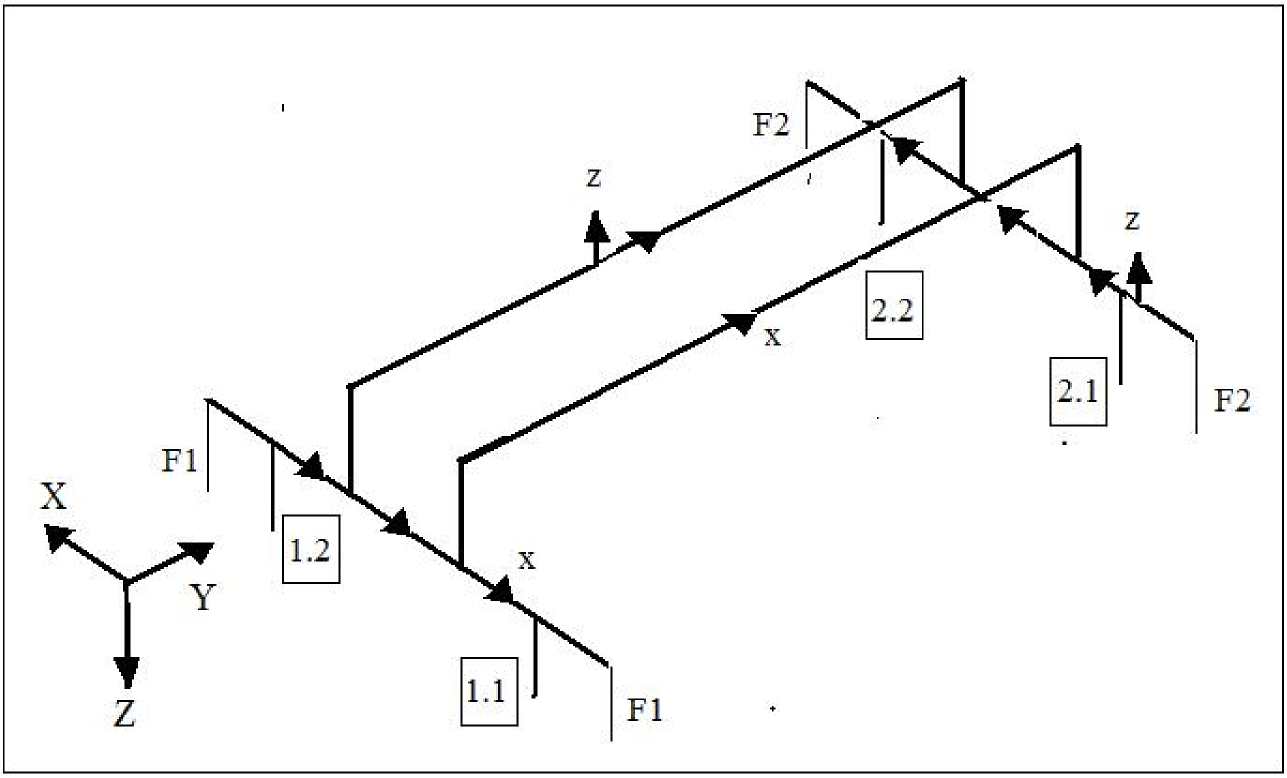
Method for the crane runway:
Division of average crane travel path into sections of length crane wheel base / 20.
Determination of time t_i when a crane wheel passes over a certain contact point and calculation of the contact force from the parameters stated above.

The proof of fatigue strength will be calculated for the wheel and the position at the runway with most unfavourable sc-values.
Calculation of crab wheels is performed accordingly.

Special consideration for guide rollers: The software assumes the corresponding HM lateral forces for respective crab position during acceleration and deceleration. In crane travel with constant speed, the software assumes a rolling resistance of 5%o of the wheel load per crane wheel resulting from the respective crab position. Guide forces are calculated from the different rolling resistances of both crane axes.

Annex 5: Static system of double-girder bridge cranes

The calculation is based on the deformation energy method for a spacial beam structure. The diagram shows the global X, Y, Z coordinate system, the system lines of beams (bridge girders and end carriages) including the orientation of the local x and z axes (local z and y axes depend on the main axes of cross-sections).



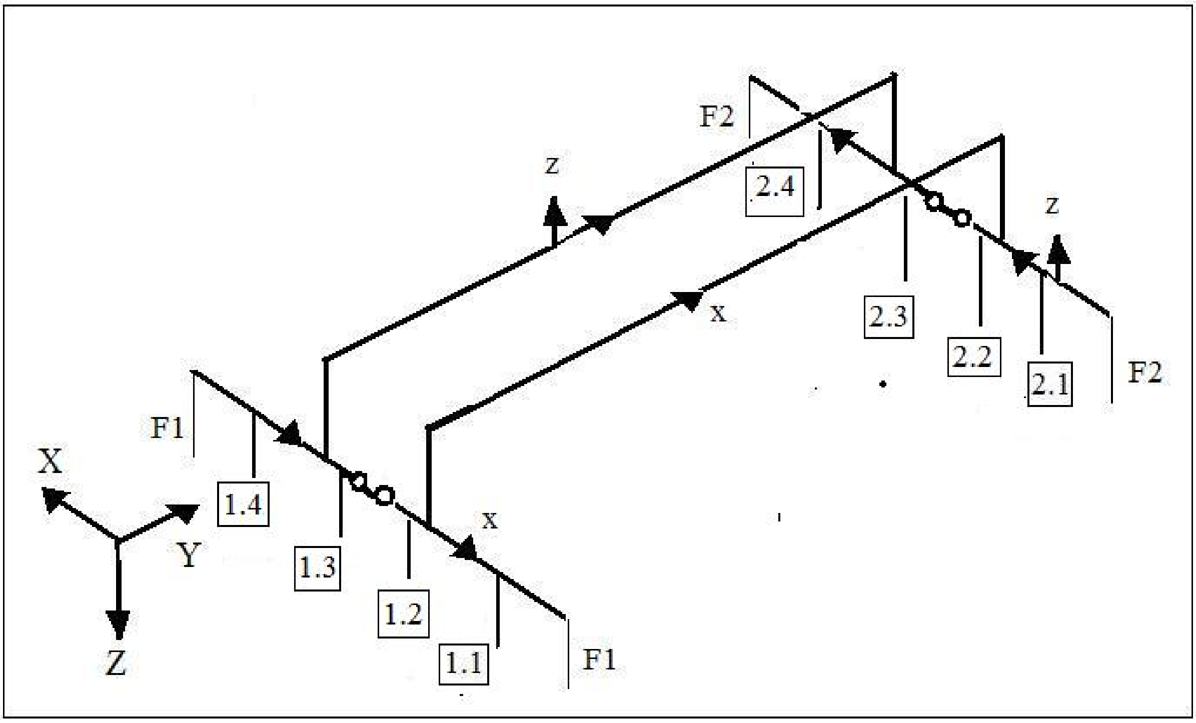
All support beams and the height difference between system lines of bridge girders and end carriages are assumed to be rigid beams.

The support beams correspond to the height of the end carriage system line above the crane rail.
(End carriages mounted on wheel blocks may be taken into account by a specified value for the dimension "OS". See 5.4 Database – End carriages)

The support points 1.1, 1.2, 2.1 and 2.2 are fixed in the global Z direction, and freely movable in the global X direction as well as in all XX, YY and ZZ rotations (support1.2 is fixed in the X direction for computational reasons, to avoid singularities).
Lateral guidance is provided by guide rollers at bearing points F1 or F2 – depending on the position of rollers - by fixation in the Y direction.
If flanged wheels are used, a fixation in the Y direction at bearing points 1.1 and 1.2 is assumed for the calculation of internal forces in the centre of the bridge girders. For the calculation of internal forces in the end carriages, the Y fixation is assumed as given at the respective end carriage.

Driving forces are assumed to act on the support points in the X direction (depending on number and location of drives).

The static system for 8-wheel cranes contains the following enhancements compared to 4-wheel cranes:



The additional supports 1.2, 1.3, 2.2 and 2.3 are fixed only in the global Z direction.

Guidance via flanged wheels occurs in the Y direction only at the outside supports of end carriages 1.1 and 1.4, or 2.1 and 2.4.

Assuming a coupling with couple beam, local y joints are assumed to be mounted to the ends of the couple beam. All other internal forces are transmitted through the couple beam.

Assuming a coupling with couple plate, this will be assumed to be rigidly connected to the ends of end carriages. The “joint effect” occurs only elastically through the small geometrical moment of inertia of the plate around the y axis.

Annex 6: Presentation of results from proof of static strength

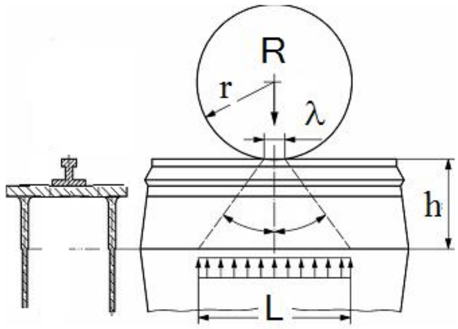
Double-girder crane:

The heading indicates the respective bridge, followed by information on the maximum crab wheel load resulting from crab dead weight and hook load (both without dynamic coefficients) and weld length L.

Proof of static strength
Main girder 1

Crab wheel loads (unfactored)
for buckling and weld: length L

R(Deadweight)	=	2,453 [kN]
R(Load)	=	68,673 [kN]
r	=	150,000 [mm]
h	=	55,000 [mm]
L	=	530,480 [mm]



Next comes information on crab position or positions in the centre of the bridge and on internal forces (unfactored) resulting from:

- Dead weights of bridges, additional masses, crab masses (all crabs)
- Load effect per crab in the most unfavourable position for the respective bridge girder
- Mass effects of dead weights resulting from starting (acceleration in crane direction +x)
- Mass effect per crab resulting from startup of hook loads
- Where relevant: aerodynamic wind loads acting on bridge, crabs and loads

Position of crab generating maximum bending (wheel positions Y [mm]):
7.000,0 9.000,0

Internal forces (Normal N, Bend. moments My, Mz, Torsion Mx, Shear Qy, Qz) without factors:
(Startup direction +X with acceleration = 1 m/s**2)

	N [kN]	Qy [kN]	Qz [kN]	Mx [Nm]	My [Nm]	Mz [Nm]
Deadweight	-5,907270e-02	8,269141e-10	4,905000e+00	-1,074456e-07	-9,439818e+04	5,907270e+01
Load	-3,193221e-11	2,888008e-04	-1,716836e+01	-6,948933e+01	-3,433672e+05	-7,430197e-08
Startup masses	3,768683e+00	-5,541615e-08	-8,597318e-09	-2,535320e-08	-7,520167e+02	1,580801e+03
Startup load	1,678082e+01	-3,465760e-01	-1,065998e+00	-3,624132e+00	-1,473397e+04	-7,393126e+02
In-service wind + X	-8,063730e+00	1,808976e-07	2,778538e-08	8,319309e-08	1,520430e+03	-4,402354e+03

Indices for partial safety factors are listed in explanation of all subsequent load cases:

Used indices for coefficients:
γ_{p1}: Mass of crane
γ_{p2}: Masse of hoist load
γ_{p3}: Rail joint
γ_{p4}: Acceleration from drives
γ_{p5}: Wind
γ_{p6}: Skewing
γ_{p7}: Exceptional loads

Then follow results for all load combinations pursuant to EN 13001, in this order: regular load combinations, non-regular load combinations, exceptional load combinations.

The heading for load combinations indicates the respective load case and its numerical designation in EN 13001 (e.g. A1) and also whether braking or starting is the decisive factor (and in which direction).

The next item is a list of partial safety factors to be used for this load combination, and of dynamic coefficients. Indices for several crabs refer to the crabs (e.g. Φ_2 for crab 1 is given as Φ_{21}).

Results from the multiplication of the individual internal forces with the applicable coefficients are presented. The last figure indicates the maximum wheel load R calculated with factors on dead weight and load.

Regular load combinations:

A1 (Starting + X)

Φ_1 =1,1 Φ_2 =1,222667 Φ_{5kr} =1,8 Φ_{pos} =1,15 acc = 0,4[m/sec**2]

γ_{p1} =1,22 γ_{p2} =1,34 γ_{p4} =1,34 γ_{risk} =1,05

N [kN]	Qy [kN]	Qz [kN]	Mx [Nm]	My [Nm]	Mz [Nm]	R [kN]
2,385685e+01	-4,032628e-01	-2,386484e+01	-1,237641e+02	-7,417495e+05	1,063570e+03	1,266330e+02

The numerical display of internal forces (the same as for cross-sections of unit stresses is provided in the so called "scientific format", i.e. giving powers of ten).
(The fact that very small values are provided may serve as indication of computing precision.)

The following tables give stresses, weld stresses and buckling stresses (depending on load combination) in N/mm^2 in decimal notation.

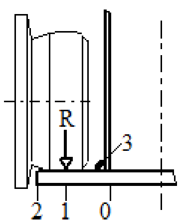
Single-girder crane:

The display of results corresponds to that for double-girder cranes. However, the presentation of results starts with data for flange bending (examples refer to box girder and H profile):

Box girder:

Flange bending in [N/mm**2] acc. to EN15011 for wheel load = 1 kN

Position 2:	Sigma-X2 = 2,75	
Position 1:	Sigma-X1 = 2,88	Sigma-Y1 = 0,47
Position 0:	Sigma-X0 = 0,87	Sigma-Y0 = -1,51
Position 3:	Sigma-Z3 = 6,13	

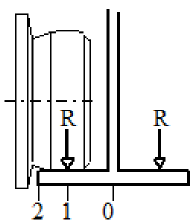


Position of crab generating maximum bending (wheel positions Y [mm]):

H profile:

Flange bending in [N/mm**2] acc. to EN15011 for wheel load = 1 kN

Position 2:	Sigma-X2 = 2,34	
Position 1:	Sigma-X1 = 2,53	Sigma-Y1 = 0,64
Position 0:	Sigma-X0 = 0,21	Sigma-Y0 = -2,1



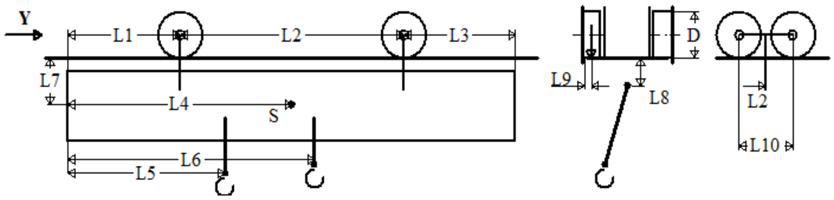
Position of crab generating maximum bending (wheel positions Y [mm]):

Annex 7: Effect of crab wheel loads

Crab frames are assumed to be elastic (with rigidities => 0); this means that loads from dead weight of crabs, hook loads depending on hook position, inertia forces from masses during acceleration, and wind loads (on crabs and hook loads) act on the crane bridges only as resulting forces and moments, without consideration of deformations in crab frames and crane bridges.

Vertical wheel loads (unfactored) are presented in the output section for crab data:

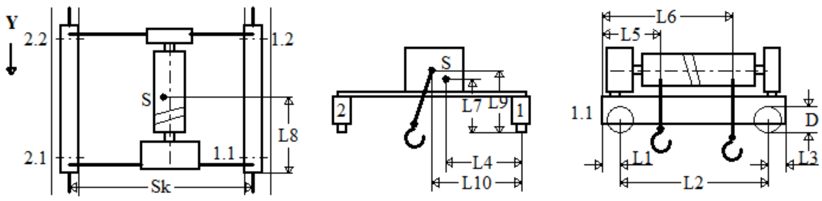
Example monorail crab:



Wheel loads (witout factors) in [kN]:

	Wheel at L1	Wheel at L2
Weight of crab	0,37	0,37
Load at L5	22,15	2,46
Load at L6	7,38	17,23

Example double-rail crab:



Wheel loads (witout factors) in [kN]:

	1.1	1.2	2.1	2.2
Weight of crab	2,45	2,45	2,45	2,45
Load at L5	68,67	29,43	68,67	29,43
Load at L6	29,43	68,67	29,43	68,67

For double-girder cranes, the following applies to horizontal forces:

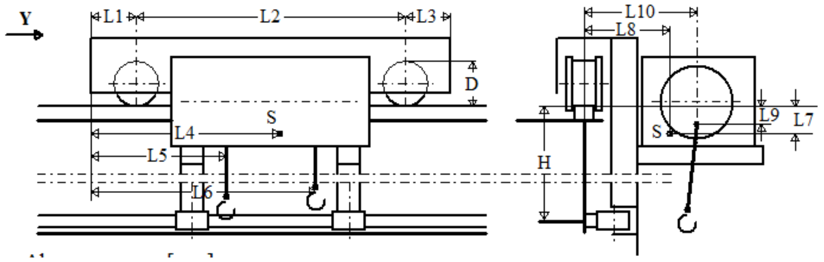
In case of single-sided guidance of crab with guide rollers, all horizontal forces are transmitted to the respective bridge girder via the guide rollers only. (principle: contact overrules friction).

In case of crabs with flanged wheels, horizontal forces are transmitted to both bridge girders at the wheel contact point, proportional to the assigned vertical wheel loads.

Tortional moments acting on the crane bridges and different vertical forces of the wheel loads result from the horizontal forces, depending on centre of gravity and assumed load application.

Example cantilever crab:

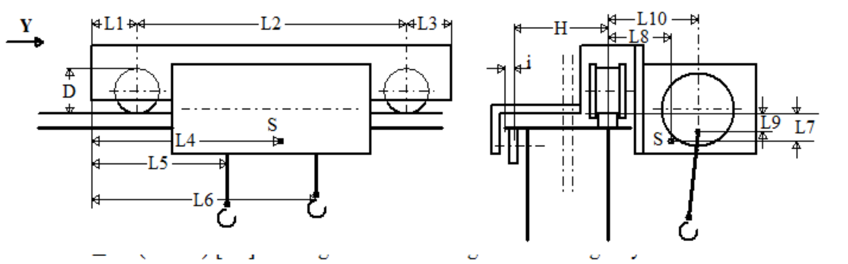
Torsion acting on the bridge is displayed in addition.



Wheel loads (without factors) in [kN] and Torsion (without factors) in [Nm]:

	Wheel at L1	Wheel at L2	Torsion at L1	Torsion at L2
Weight of crab	1,96	2,94	1.177,20	1.765,80
Load at L5	39,38	9,85	31.505,01	7.876,25
Load at L6	9,85	39,38	7.876,25	31.505,01

The wheel loads of supports below upper flange depend also on the dimension H:

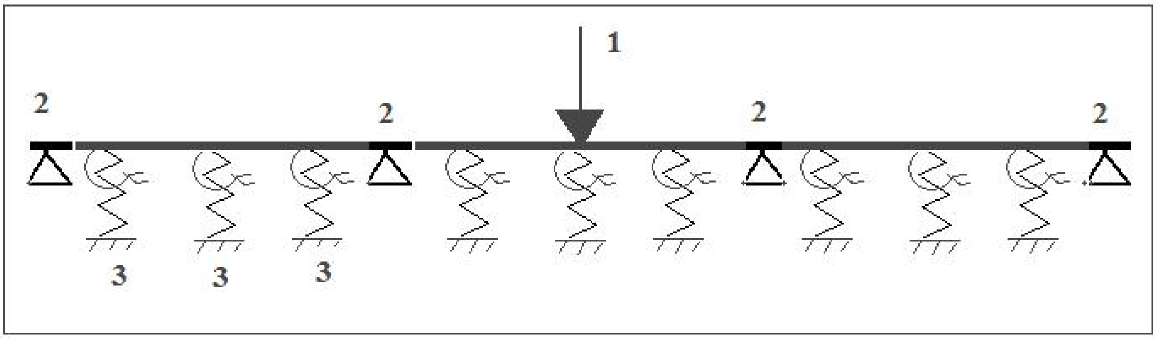


Wheel loads - Torsion/H in [kN] and Torsion in [Nm] (without factors):

	Wheel at L1	Wheel at L2	Torsion at L1	Torsion at L2
Weight of crab	1,57	2,35	392,40	588,60
Load at L5	11,92	7,95	3.575,75	2.383,83
Load at L6	3,97	15,89	1.191,92	4.767,66

Annex 8: Model assumptions for plate stressing

For the calculation of secondary stresses in the upper flange with rails in the centre, the rail and the stiffener mounted under the upper flange are considered as a bending beam with flexible supports on the transverse stiffeners and – between them - elastic support on the upper flange.



Legend: 1 : Wheel load
2 : Transverse stiffener
3 : Spring and torsion spring

Between the transverse stiffeners (2) the upper flange is divided into n (>20) strips (bending beams supported on the web plates), the flexibilities of which are used to calculate the spring constant of the elastic spring and torsion spring (3).

With wheel load (1) impacting on the system, it is necessary to determine for each point the equilibrium resulting from deformation (lowering and inclination angle) of rail beam and strips of upper flange (lowering and torsion) as well as from reaction forces between components.

The stress from tension and bending in the upper flange strip under wheel load is assumed to act as secondary stress at right angles to the bridge girder.

Annex 9: Differences between EN 13001 and EN 1991-3

The two standards use different approaches in the calculation of crane runway data. This has an impact, notably when fixed load lifting appliances (e.g. traverses, grabs or magnets) are employed .

EN 13001 differentiates between payload and lifted load:

Case 1: Fixed load lifting appliance , crane can only operate in this mode:

Payload: load to be lifted with the fixed load lifting appliance. This corresponds to the load carrying capacity indicated on the crane.

Lifted load: sum of payload and fixed load lifting equipment.

Only the payload is included in the calculation of the load spectrum kQ and class Q.

Case 2: Non fixed load lifting appliance , crane can also operate without lifting equipment.

The lifting appliance is considered as part of the payload.

EN 13001 does not split up the horizontal forces HM from asymmetric load distribution between both sides of the crane runway

EN-Kran follows the same procedure. The table of crane runway wheel loads shows that the fixed load lifting appliance is added to the mass of the crab. Horizontal forces HM are only given as a sum total and not split up between both sides of the crane.

The lifted load is used for static calculations. In calculations of cases without payload (deflection, fatigue of wheels unloaded), the lifting appliance is added to the mass of the vrab.

EN 1991-3 does not differentiate between payload and lifted load:

Horizontal forces (here: HT) are split up between both sides of the crane proportional to the wheel loads.

Classification S of fatigue impact is defined from classes U and Q of EN 13001.

EN-Kran specifies the crane runway loads in the tables according to EN 1991-3.

However, since EN 1991-3 does not differentiate between payload and lifted load, the class S indicated for the crane runway would be too low in cases of heavy fixed load lifting appliances and low payloads. This is the reason why EN-Kran substitutes a classification Q for crane runway loads according to EN 1991-3 which adds the fixed load lifting appliance to the payload. In a subsequent step, class U and substitute class Q are then used to determine class S in accordance with regulations specified in EN 1991-3.

EN 1991.3:2024:

A new class C is introduced: Classification of fatigue actions from cranes.

Table 5.7 clearly formulates "The definition of U and Q classes is identical to that of EN 13001-1".

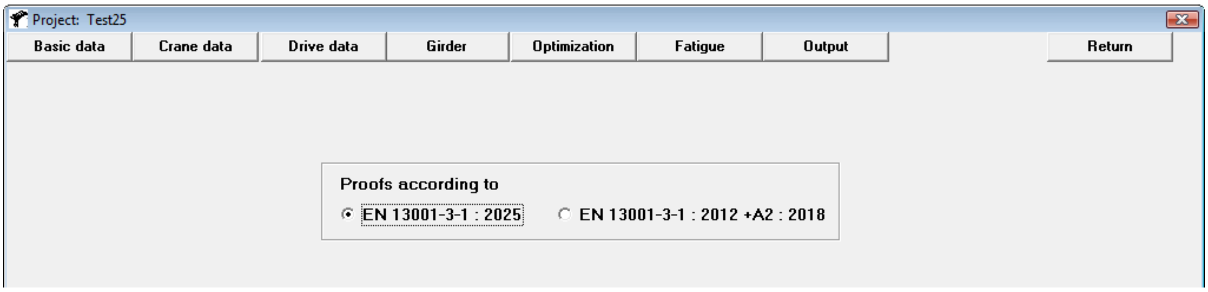
Therefore class C is only related to the payload.

En-Kran shows both classes S and C.

Annex 10: Differences between EN 13001-3-1:2025 and EN_13001-3-1:2028

The most significant differences concern the static proofs of fillet welds.
EN-Kran offers the possibility to choose between the application of the two editions:
Default setting:

- Restart of older projects starts with edition 2018
- Start of new projects begins with edition 2025
-

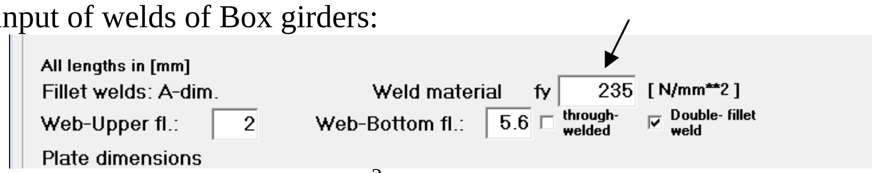


Now the other edition can optionally be chosen. Further starts of the project begin with the last chosen edition.

Consequences of the edition EN 13001-3-1:2025

The Table 8 — Factors α_w for limit weld stresses and the requirement for A-dimensions of fillet welds $a \le 0.7 * t_{min}$ are dropped, i.e. greater A-dimensions are allowed and the proof of static strength may be verified with these welds.

However, an additional value is necessary: f_{yw} the yield strength of the weld material (property of filler metal). Everywhere where EN-Kran expects input of A-dimensions the input of f_{yw} is necessary, too:
Example of input of welds of Box girders:



EN-Kran uses as default value 235 N/mm^2 (equivalent to the minimum values of plate material S235). You should change this value to the actual value of used weld material.

The previous weld stress sigma-z is vectorially splitted into $\sigma\perp$ and $\tau\perp$. For the proof of static strength it must be shown (according to equation 28 if EN 13001-3-1:2025) , together with $\tau = \tau\parallel$ that

$$\sqrt{\left(\sigma\perp^2 + 3*(\tau\perp^2 + \tau^2\right)} \le f_{yw} / \gamma_m \quad \text{and} \quad \sigma\perp \le f_y / \gamma_m$$

Important:

- A-dimensions that were in compliance with the requirements of the sum formula of EN13001-3-1:2018 may no longer be sufficient due to the multiplication with factor 3 of $\tau\perp^2$. In such cases either the A-dimension or f_{yw} shall modified.
- However, in the proof of fatigue strength for fillet welds below the crab rail the details 3.13 and 3.14 of Annex D still require $0.5*t \le a \le 0.7*t$.