CDTire

User Manual
Version 4.1

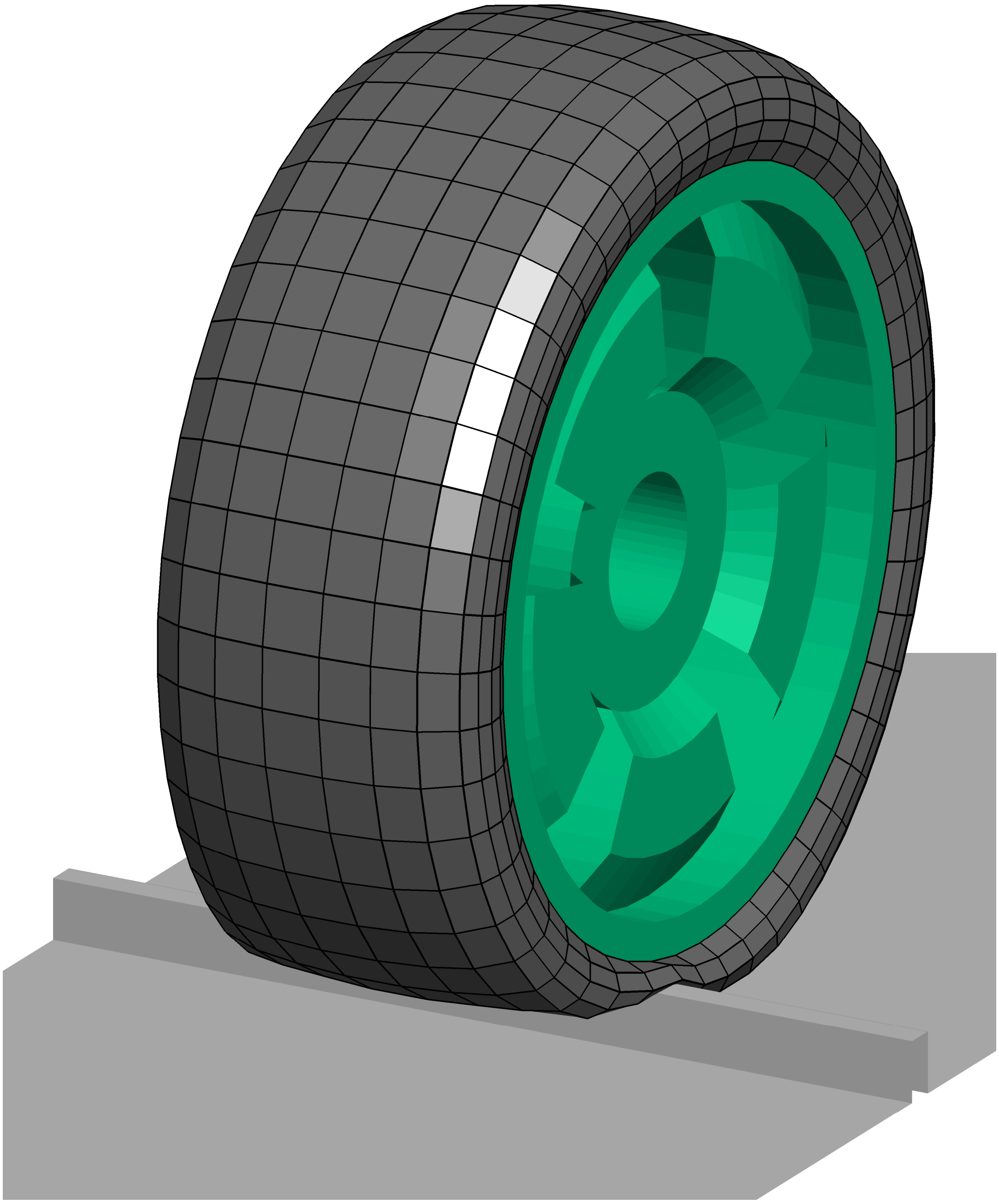

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Table of Contents

Introduction

The *Comfort and Durability Tire* is a tire model family to be used with the MBS software systems. It focuses on comfort and durability applications but also allows for handling analysis.

Remark: In the further text *Comfort and Durability Tire* will be referenced as *CDTire*.

Tire Model Background

CDTire is a tire model for passenger car and light truck tires that allows engineers to do full vehicle ride comfort and durability analysis in respective MBS software systems, taking into account tire belt dynamics and interaction with 3D road surfaces.

During the multi-body simulation CDTire computes the spindle forces and moments acting on each wheel in the model as well as the local contact forces while driving on a 3D road surface. CDTire accurately captures the vibrations in the frequency range for durability and comfort studies up to 150 Hz.

CDTire Model Family

CDTire offers 2 basic tire models

- **CDTire/Realtime**
- **CDTire/3D**

The following models are considered CDTire/Legacy and are not actively developed anymore:

- **CDTire 20**
- **CDTire 30, 2030**
- **CDTire 40, 2040**

However, existing model 30 parameter files can be easily adapted by CDTire/Realtime and model 40 files can be adapted by CDTire/3D.

The following paragraphs give some general background information to the sub-models. See the *Appendix* for a detailed description of the corresponding parameter files and their function.

CDTire/Realtime

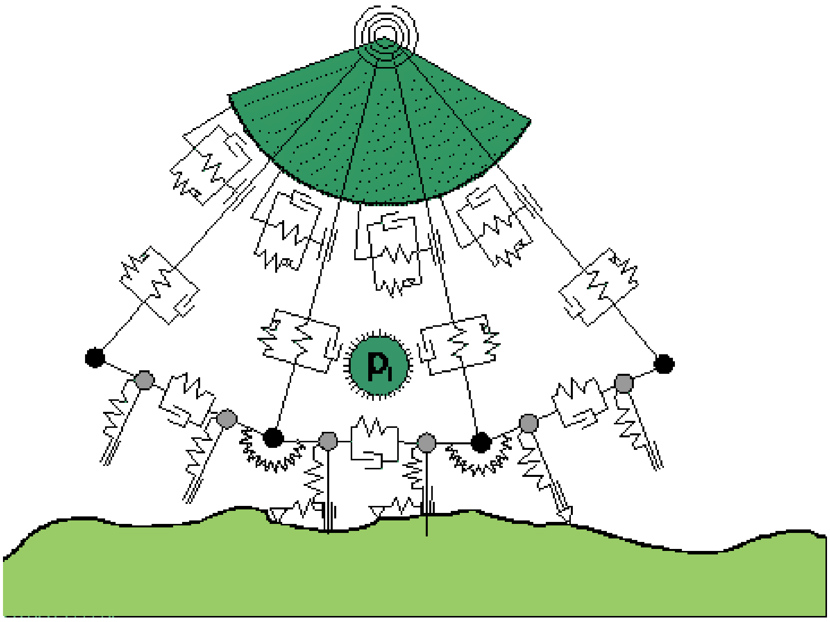


Fig. 1: CDTire/Realtime

Tire Model Structure:

- belt is flexible ring (default: 3x50 dof´s)
- sidewall is local viscoelastic foundation

Contact Formulation:

- brush type contact
- local static stick-slip ability

Performance:

- hard real time capable
- road surface wavelength $lambda_{road}$ can be arbitrary in tire in-plane direction
- restriction: only in-plane obstacle enveloping, as lateral extension of in-plane tire-road intersection is considered constant for each tire

CDTire/3D

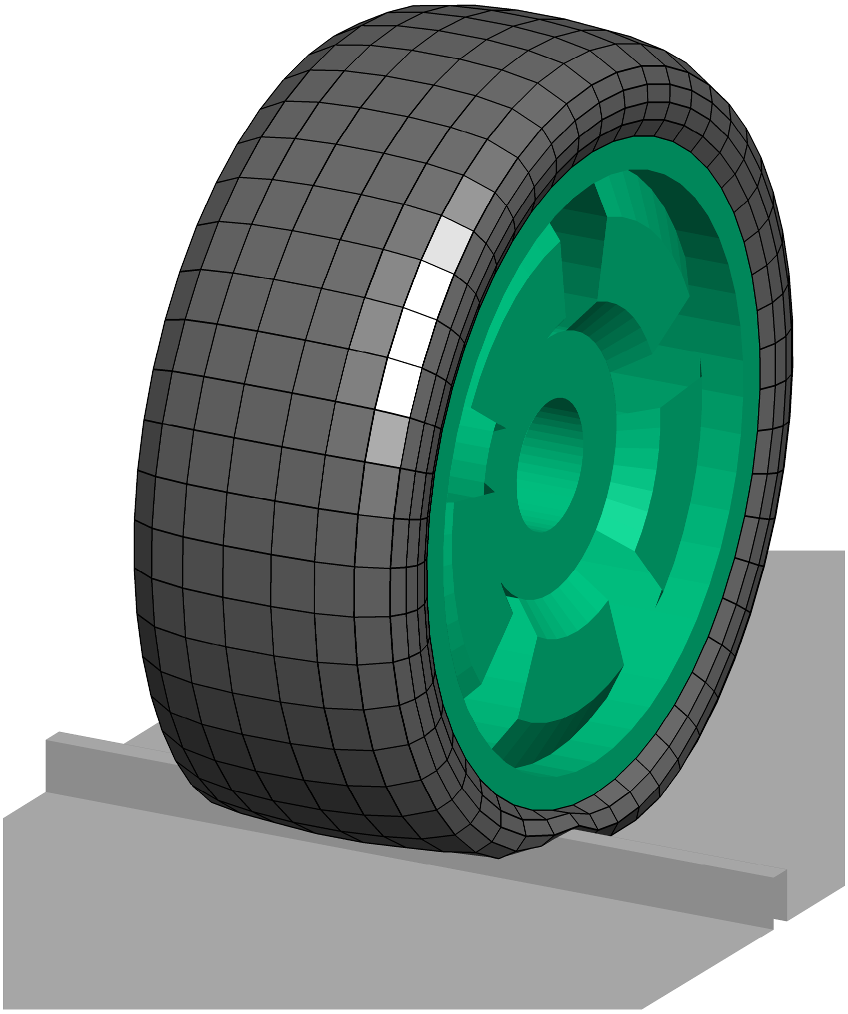


Fig. 2: CDTire/3D

Tire Model Structure:

- belt is flexible shell (default: 6x3x50 dof´s)
- both sidewalls are flexible shells (default: 8x3x50 dof´s)

Contact Formulation:

- brush type contact
- local static stick-slip ability

Performance:

- substantial effort
- $lambda_{road}$ can be arbitrary
- full obstacle enveloping

Road Surface Models

Technically, the Road Surface Model is a software library through which *CDTire* can interrogate road surfaces in order to sense contact. Three mechanisms for road surface definitions are supported with the Road Surface Model:

- CDTire internal road surface models (RSM 1000, 1002, 2000, 3000)
- User defined road surface model (RSM 1100)
- MBS dependent road surface models may be available, see the corresponding *CDTireMBSManual* for more information.

CDTire road surfaces models (RSMs)

See the chapter ***Model Usage*** for detailed information on the single models.

CDTire now also supports the OpenCRG road format as Road Surface Model 3000. This part of the software and the respective data is licensed under the Apache License, Version 2.0 (the "License"); you may not use this file except in compliance with the License. You may obtain a copy of the License at http://www.apache.org/licenses/LICENSE-2.0. Unless required by applicable law or agreed to in writing, software distributed under the License is distributed on an "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied. See the License for the specific language governing permissions and limitations under the License. More Information on OpenCRG open file formats and tools can be found at http://www.opencrg.org

Model Implementation

The implementation is done by using a dedicated element to include *CDTire* in your vehicle or testrig model.

Modeling with CDTire

The *CDTire* element is a dedicated element in the modeling process and supports various commercially available MBS software packages :

- LMS Virtual.Lab Motion
- MSC.ADAMS
- SIMPACK
- Altair MotionSolve
- MATLAB & Simulink

Please see the *CDTire* documentation of the specific guides on how to model with CDTire.

Model Usage

To include the CDTire in a MBS model also road data is required. This data can, in the simplest form, describe a plain surface without any obstacles or tracks. More complex data give an analytical description of a road surface with obstacles or tracks, digitized measured data, a combination of those or of a drum surface.

CDTire supports several road surface models:

Road Surface Model	Surface Type
1000	parametric road surface description
1002	rolling drum with or without a cleat
1100	User road model (ADAMS only)
2000	parametric and digitized road data
3000	OpenCRG road data (1.0.3)

Road Surface Model 1000

The Road Surface Model 1000 is adapted for an analytical description of the road surface. A number of different obstacle types and tracks are available to model the road. It will generate a surface Z(X,Y) with respect to the coordinate system representing the surface origin as defined in the MBS model.

A road definition file for the Road Surface Model 1000 is structured as follows:

- **Header**: This part specifies the additional translation and the used data type (obstacles, equidistant tracks or non-equidistant tracks).
- **Data Part**: For each obstacle or track the corresponding data is defined

Header (Road Surface Model 1000)

```
# HEADER ROAD MODEL 1000
# X0_ROAD   Y0_ROAD   Z0_ROAD   MU_ROAD
  200.0     200.0     100.0     0.9
# DATA TYPE: (2, 3 OR 4)
       1
```

The first line is a comment line starting with a hash (#). You may use it for specifying a short description or general comment to the road definition file. This line is required but all contents will be ignored by *CDTire*.

The second and the fourth lines are comment lines starting with a hash (#), too. Here you should enter "placeholders" for the data in the following lines. *CDTire* ignores these lines but the file will be easier to read for all users.

The third line contains the data defining the additional translation. The data type is defined by the entry in the fifth line.

Additional Translation

You may define a translation of the road coordinate system from the road origin (in the figure below denoted by the GFORCE marker p5).

Fig. 1: additional translation

The additional translation is defined in the third line:

```
Line 1: # HEADER ROAD MODEL 1000
Line 2: # X0_ROAD   Y0_ROAD   Z0_ROAD   MU_ROAD
Line 3:   200.0     200.0     100.0     0.9
```

with

X0_ROAD Translation in x-direction

Y0_ROAD Translation in y-direction

Z0_ROAD Translation in z-direction

MU_ROAD friction coefficient road

The parameters **X0_ROAD**, **Y0_ROAD** and **Z0_ROAD** determine the position of the subsequent definitions with respect to the coordinate system representing the surface origin as defined in the MBS model.

The friction coefficient of the road defines the friction of the defined plane except for all explicitly defined parts like tracks or obstacles, as these must specify their own friction coefficient.

Data Type

The data type defines the surface structure in general. It is given in the 5th line of the road definition file:

```
Line 1: # HEADER ROAD MODEL 1000
Line 2: # X0_ROAD    Y0_ROAD    Z0_ROAD    MU_ROAD
Line 3:   200.0      200.0      100.0       0.9
Line 4: # DATA TYPE: (2, 3 OR 4)
Line 5:   1
```

with

DATA TYPE 2 = equidistant track data

3 = non-equidistant track data

4 = matrix track data

The previously available **Data Type 1** road surface description is not supported anymore and will generate an error message.

Data Part (Road Surface Model 1000)

Depending on the data type defined in the header the data part contains one or more definitions of either obstacles or equidistant tracks or non-equidistant tracks. Mixing the data types is not possible.

Equidistant Track Data

This is the preferred data type to construct track surfaces Z(X) on equidistant data (**DATA TYPE** = 2).

Fig. 2: Road Surface Model 1000: equidistant track data

The direction of the track will be the x-direction of the coordinate system representing the surface origin as defined in the MBS model. Interpolation of the track data will be linear.

There can be several tracks defined in one file. Therefore the header of a road definition file for equidistant track data contains two additional lines:

```
# NTRACKS
  3
```

with

NTRACKS	total number of tracks

For each of the **NTRACKS** tracks a body definition follows. If these tracks overlap, *CDTire* will generate a runtime error once it tries to evaluate a multiply defined surface point. The body of a track consists of 2 + **NDATA** lines:

```
# NDATA   X0_TRACK   Y0_TRACK   HALF_WIDTH   DX     MU_TRACK
  4       0.0        0.0        300.0        10.0   1.0
  0.0
  10.0
  10.0
  0.0
```

with

NDATA	number of data points of the track
X0_TRACK	track origin x-coordinate with respect to the road data origin
Y0_TRACK	track origin y-coordinate with respect to the road data origin
HALF_WIDTH	half width of the track
DX	equidistant spacing Δx of the track data
MU_TRACK	friction coefficient of the track surface
Line 10 ... Line 9 + **NDATA**	these lines contain the z data of the single tracks (local hight)

The total width of the track is 2***HALF_WIDTH**, i.e. **HALF_WIDTH** is applied in the positive and the negative Y-direction, starting at **Y0_TRACK**.

Line 3 starts with the first data value. This value does not need to be zero, allowing for discontinuous surfaces. All further data must be on consecutive lines, one value each, as specified by NDATA.

See the chapter ***Example for Equidistant Track Data (Data Type 2)*** in the Appendix for a detailed example.

Non-equidistant Track Data

This data type (**DATA TYPE** = 3) is used to construct track surfaces with non-equidistant data (based on pairs of (X,Z) data). For certain types of street profiles the use of this data type would be much more efficient than equidistant data (e.g. a ramp). The direction of the track is the same as for the equidistant data. Again, several tracks can be defined in one file.

As for equidistant track data, the header is extended by the lines

```
# NTRACKS
  3
```

with

NTRACKS	total number of tracks

For each of the **NTRACKS** tracks a body definition follows. If these tracks overlap, *CDTire* will generate a runtime error once it tries to evaluate a multiply defined surface point. The body of a track consists of 2 + **NDATA** lines:

```
# NDATA  X0_TRACK  Y0_TRACK  HALF_WIDTH  MU_TRACK
  3      0.0       0.0       300.0       1.0
  0      0
  30000  1000
  50000  0
```

with

NDATA	number of data points of the track
X0_TRACK	track origin x-coordinate with respect to the road data origin
Y0_TRACK	track origin y-coordinate with respect to the road data origin
HALF_WIDTH	half width of the track
MU_TRACK	friction coefficient of the track surface
Line 10 ... Line 9 + **NDATA**	these lines contain the x and z data of the single tracks

See the chapter ***Example for Non-Equidistant Track Data (Data Type 3)*** in the Appendix for a detailed example.

Matrix Track Data (DATA TYPE 4)

This data type (**DATA TYPE** = 4) is used to construct track surfaces with matrix data. The direction of the track is the same as for the equidistant data. Again, several tracks can be defined in one file.

```
Line 6: # NTRACKS
Line 7:   3
```

with

NTRACKS	total number of tracks

For each of the **NTRACKS** tracks a body definition follows. If these tracks overlap, *CDTire* will generate a runtime error once it tries to evaluate a multiply defined surface point. The body of a track consists of 2 + **NDATA** lines:

```
# NX     NY     X0     Y0     DX     DY     MU     ZSCALE     Z0
  3      5     -10.0  -10.0   10.0   5.0    0.9    1.0        0.0
  6.0   6.0   6.0   6.0   6.0
  6.0   3.0   0.0   3.0   6.0
  6.0   6.0   6.0   6.0   6.0
```

with

NX	number of matrix rows of the track matrix
NY	number of matrix columns of the track matrix
X0	track origin x-coordinate with respect to the road data origin (upper left point)
Y0	track origin y-coordinate with respect to the road data origin (upper left point)
DX	(signed) spacing x direction (between rows)
DY	(signed) spacing y direction (between columns)
MU	friction coefficient of the track matrix
ZSCALE	Scaling of matrix values (z values)
Z0	Additive offset of matrix values (z values)

Road Surface Model 1002

The Road Surface Model 1002 describes a drum surface.

Three different types of obstacles, respectively tracks are available to model the drum surface.

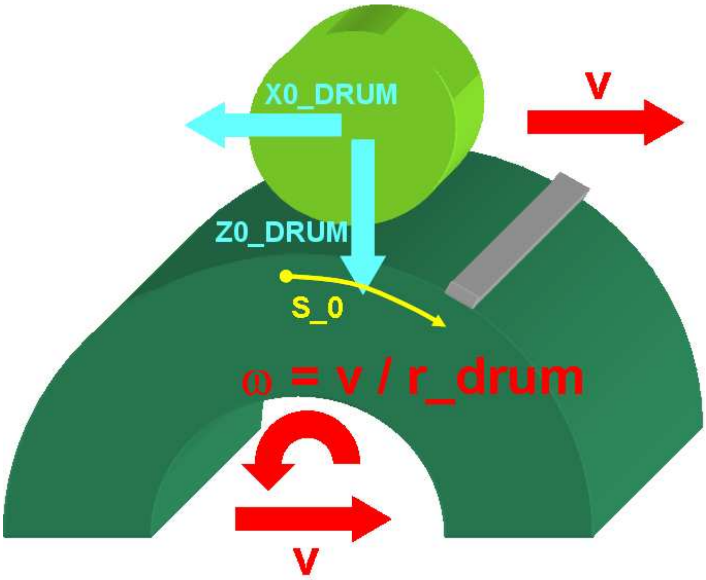


Fig. 3: Road Surface Model 1002: rolling drum

The road definition file for a rolling drum surface has the following structure:

```
# DESCRIPTION LINE
# RADIUS_DRUM      MU_DRUM     PERIODIC
  1000.0           1.0         1
# SURFACE TYPE
  2
# H      W       S_0       PHI        MU_CLEAT
  10.0   20.0   -2522.2    90.0         0.0
```

with

RADIUS_DRUM	drum radius
MU_DRUM	friction coefficient drum surface
PERIODIC	repeat cleat (1) or only once (0)
SURFACE TYPE	2 = with cleat
For SURFACE_TYPE = 2	Additional lines:
H	height of cleat
W	width of cleat
S_0	arc length of (0,RADIUS_DRUM) to cleat origin, for PERIODIC_FLAG = 1, this must be -RADIUS_DRUM*PI < S_0 < RADIUS_DRUM*PI
PHI	direction angle of cleat, measured from wheel plane

MU_CLEAT	Friction coefficient on cleat

All lines starting with a hash (#) are comment files used to define place-holders for the data in the following lines. Even if *CDTire* will ignore them these lines are required. Do not delete them!

If the rotation angle of the cleat is not specified, a perpendicular cleat is assumed.

Road Surface Model 2000

CDTire Setup for Road Surface Model 2000

CDTire needs to be set up for road surface type “2000” in order to make use of the Road Surface Model.

In order to run *CDTire* on road data, following set of files is required in the directory referred to in the CDTire setup:

- a global definition file that defines the boundaries of the track **MasterRectangle.h**
- a surface type classification file **SurfacType.h** that defines the friction coefficient for the different surface types as referred in the road data files
- a set of "macropatch" header files named **MP_0_0.h**, **MP_0_1.h** etc.
- (when applicable) a set of “macropatch” binary data files named **MP_0_0.d**, **MP_0_1.d** etc.
- (when applicable) a set of parametric road description files

Note : the mention "when applicable" relates to the fact that a track definition for CDTire may be defined either through digitized data only, parametric description files only, or a mix of both.

IMPORTANT : all the files mentioned above are ***strictly required***, and need to adhere to the specified naming and format conventions. The format of the needed header files is explained in the following sections.

The fundamental idea behind the *Road Format* concept is that any track will be described in a rectangular grid ; which has three levels of discretization :

- a "master rectangle" that envelopes the complete track
- a series of "macropatches" (typically size 10 x 10 m) defined inside this master rectangle
- a series of "micropatches" per macropatch (typical size 0.5 x 0.5 m)
- a rectangular mesh in each micropatch (grid size typically 5 x 5 mm), where per grid point in the mesh the track Z-coordinate has been measured and stored

MasterRectangle.h

The structure of the file **`MasterRectangle.h`** is:

`version indicator`	actual value : v002 (string)
`comment`	string(s) of arbitrary length beginning with #
`platform-flag`	specifies platform where binary data have been written (integer) 1→Unix, 2→Windows NT, 3→SGI IRIX
`. . .`	
`Xoff Yoff Zoff`	real altitude and offset of left lower corner of the Master Rectangle (double)
`indicator`	to read the Macro-patches column-wise (1 char: c)
`rows <space> columns`	number of rows and columns of Macro-patches (long)
`width <space> height`	width and height of a Macro patch (double)
`units`	string max 17 characters – reserved for future use

Example for MasterRectangle.h

```
v002
# Master rectangle definition for Track A
2
-100.000 –100.000 15.000
c
7 1
10000.000 10000.000
mm
```

MacroPatch header files

The structure of the macropatch files **MP_0_0.h**, **MP_0_1.h** , ...is:

File entry	Meaning
Macropatch column_nr row_n	
{	
version indicator	actual value : v002 (string)
comment	string(s) of arbitrary length beginning with #
platform-flag	specifies platform where binary data have been written (integer) 1→Unix, 2→Windows NT, 3→SGI IRIX
Zoff	z-Position of left lower corner relative to origin of Master-rectangle (double)
columns <space> rows	number of columns and rows of micro-patches (long)
width <space> height	width and height in mm of a micro-patch (double)
indicator	to read the micro-patches column-wise (1 char: c)
}	
Micropatch 0 0	header of micro patch section 0 0
<header info>	header info of micro patch section 0 0
Micropatch 0 1	header of micro patch section 0 1
<header info>	header info of micro patch section 0 1
Micropatch 0 2	header of micro patch section 0 2
<header info>	header info of micro patch section 0 2
. . .	

The format of the micro patch sections in the macro patch header files depends on the type of road description:

- off-road

File entry	Meaning
`Micropatch micro_column_nr micro_row_n`	micro patch header
`datatype`	0 -> off road (integer)

- digitized

File entry	Meaning
`Micropatch micro_column_nr micro_row_n`	micro patch header
`datatype`	1 -> digitized (integer)
`trackclassification`	refers to a classification number in surface classification file (integer)
`width <space> height`	width and height in mm of an element (double)
`lines_h <space> lines_v`	number of grid lines horizontally and vertically (integer)
. . .	
`byte number`	byte number of the first micro-patch identifier index in the data file (unsigned integer)
`indicator`	to read the micro-patches column-wise (1 char: c)
. . .	
`tiretype_proposed`	20 | 30 | 40 (integer)
`flag`	reserved for future use (integer)

- parameterized

File entry	Meaning
`Micropatch micro_column_nr micro_row_n`	micro patch header
`datatype`	2 -> parameterized (integer)
`trackclassification`	refers to a classification number in

File entry	Meaning
	surface classification file (integer)
filename	Filename withozt pathname for data specification (string)
tiretype_proposed	20 | 30 | 40 (integer)
flag	reserved for future use (integer)

Example for a MacroPatch header file

The following example contains the 3 types of micropatches. This file shows only the first and second column.

```
Macropatch 0 0
{
 v002
# Example
 2
 -10.0000
 20 20
 500.000 500.000
 c
}
Micropatch 0 0
1
1
5.000 5.000
101 101
0
c
20
2030
Micropatch 0 1
1
1
5.000 5.000
101 101
40812
c
20
2030
Micropatch 0 2
1
1
5.000 5.000
101 101
81624
c
20
2030
```

```
Micropatch 0 3
1
1
5.000 5.000
101 101
122436
c
20
2030
Micropatch 0 4
1
1
5.000 5.000
101 101
163248
c
20
2030
Micropatch 0 5
1
1
5.000 5.000
101 101
204060
c
20
2030
. . .
Micropatch 0 9
2
1
ParametricFile.h
20
2030
Micropatch 0 10
2
1
ParametricFile.h
20
2030
Micropatch 0 11
2
1
ParametricFile.h
20
2030
Micropatch 0 12
2
1
ParametricFile.h
20
2030
. . .
Micropatch 1 7
1
```

```
1
5.000 5.000
101 101
652992
c
20
2030
Micropatch 1 8
1
1
5.000 5.000
101 101
693804
c
20
2030
Micropatch 1 9
0
Micropatch 1 10
0
Micropatch 1 11
0
Micropatch 1 12
0
Micropatch 1 13
0
Micropatch 1 14
0
Micropatch 1 15
0
Micropatch 1 16
0
Micropatch 1 17
0
Micropatch 1 18
0
Micropatch 1 19
0
```

Parametric description files

See paragraph ***Plug-in library mechanism*** for the description.

Surface type classification file

This file contains an ascii table defining the friction coefficient that corresponds to the surface types as specified in each micro patch header file.

Example for a surface type classification file

```
17           →   Maximum class number defined in the file
0<tab>1.00   →   Surface class  <tab>  friction coefficient
5<tab>1.01   →   Surface class  <tab>  friction coefficient
12<tab>1.05  →   …
13<tab>1.1   →   …
17<tab>1.15  →   …
```

Customizing CDTire

Even though *CDTire* tries to present a setup in a plug-and-play fashion, there are several considerations for a successful simulation that can not be tuned automatically. These include structural discretization, integrator tuning, adaptivity and inflation pressure.

For more information on

- Structural discretization and inflation pressure refer to the chapters in the Appendix:
    - ***Tire Parameter Files for CDTire/Realtime*** and
    - ***Tire Parameter Files for CDTire/3D***

Appendix

Tire Parameters

The following paragraphs explain the parameter files for the tire models *CDTir/Realtime* and *CDTire/3D* in detail. For each tire model a listing of the corresponding parameter file and explanations to the single parameters are given.

Tire Parameter File - CDTire/Realtime

The following listing shows the input file for a tire with the dimension 195/65 R 15 as used in the tire model *CDTire 30/HPS*:

```
[CDT30-HPS MODEL PARAMETERS]
PREF = 0.21
PIN = 0.21
NMP = 50
MASS_BELT = 0.005
R_BELT = 307.0
R_RIM  = 203.0
W_BELT = 190.0
FTX = 75.0
FTY = 38.0
FRY = 60.0
DTX = 0.08
DTY = 0.08
DRY = 0.08
Y_BENDING_STIFF = 3.0E6
Y_BENDING_DAMP = 1.0E-5
CIRC_STIFF = 1.0E6
CIRC_DAMP = 1.0E-6
RAD_NL_MOD = 0.3
KSRED = -70.0
TREAD_NSEN_X = 5
TREAD_HEIGHT = 10
TREAD_SCAN_HEIGHT = 150
TREAD_MAX_COMPRESS = 0.9
TREAD_RAD_D = 5.0E-4
TREAD_KM = 0.9
TREAD_EG = 120
```

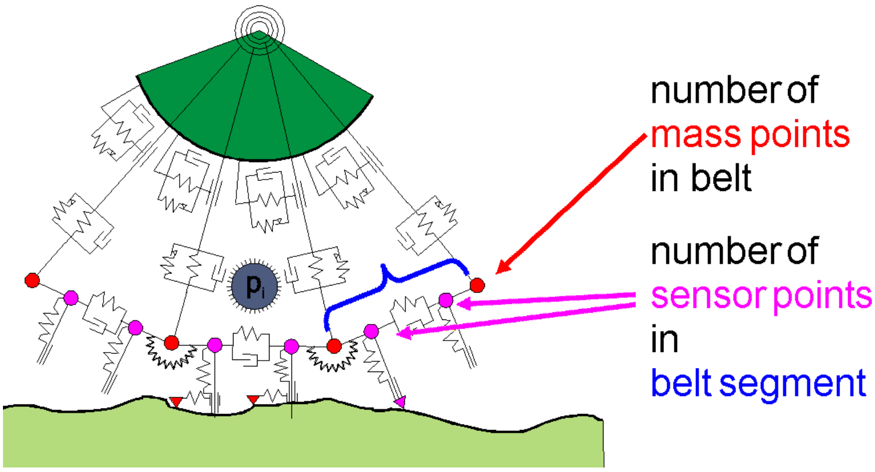
```
TREAD_GG = 40.0
MU = [1.0, 1.0, 1.0]
V_MU = [0.0, 1.0E3, 10.0E3]
R_EFF = 317.0
CR1_STAT = 235.0

[CDT30-HPS SOLVER PARAMETERS]
TOL = 1.001E-3
DTM = 2.001E-4
DT_START_EXPL = 2e-005
NMAX_IMPL_ITER = 4
PRE_STEP_TIME = 0.05
TYPE = 2
ALPHA_EXPLICIT = 0
BETA_EXPLICIT =  0.16666666666667
GAMMA_EXPLICIT = 0.5
ALPHA_IMPLICIT = 0
BETA_IMPLICIT =  0.25
GAMMA_IMPLICIT = 0.5
UPDATE_FOR_MASTERCORRECTOR = 0
IMPL_STEP_CTRL_ENABLE = 1
IMPL_STEP_CTRL_EPS = 200
IMPL_STEP_CTRL_NSUBSTEPS = 3
IMPL_JAC_EVAL_AT_ITER = 0
```

Remark: You may edit some parameters to suit your requirements. These parameters are colored blue in the listing above and an according remark is given in the following table.
The parameters colored in orange are optional and (if used) change model behavior or introduce new functionality.

With 2 mandatory sections:

- [CDT30-HPS MODEL PARAMETERS]
- [CDT30-HPS SOLVER PARAMETERS]

Name	Explanation	Default	Unit
	CDT30-HPS MODEL PARAMETERS		
NMP	Number of mass points in belt you may need to edit this value: the distance between two mass points (2 pi RGRT/NMP) must be around half of the fundamental wavelength of the surface, e.g. for a 20x20mm obstacle, this is 20 mm.	50	-
TREAD_NSEN_X	Number of sensor points in belt segment (Optional: NSEN)  you may edit this value to account for the higher wave-lengths of the surface	5	-
R_RIM	Radius of the rim (CDT30: RFEL)	203	mm
R_BELT	Radius of the belt (inflated) (CDT30: RGRT)	307	mm
W_BELT	Effective width of the belt (Optional: BGRT)	190	mm
MASS_BELT	Mass of belt and tread (CDT30: MGRT)	5.0E-3	t
CIRC_STIFF	Tensile stiffness of belt in circum-ferential direction (Optional: EF)	1.0E6	N
Y_BENDING_STIFF	Bending stiffness of the belt (around y-axis) (Optional: EIY)	3.0E6	Nmm²
FTX	Natural frequency: Translation x	75	Hz

Name	Explanation	Default	Unit
	(mode R_1)		
FTY	Natural frequency: Translation y (mode L_0)	38	Hz
FRY	Natural frequency: rotation around y (mode C_0)	60	Hz
DTX	Damping coefficient of mode R_1	0.08	-
DTY	Damping coefficient of mode L_0	0.08	-
DRY	Damping coefficient of mode C_0	0.08	-
RAD_NL_MOD	Stiffness influence factor radial (Optional: KARED)	0.3	-
KSRED	Stiffness influence factor lateral	-70	-
PIN	Internal pressure for analysis	2.1E-1	MPa
TREAD_EG	Young's modulus of the tread rubber times tread width per circumferential unit length (Optional: EG)	120	N/mm^2
TREAD_KM	Shear stiffness reduction coefficient (Optional: KM)	0.9	1
TREAD_HEIGHT	Height of tread (Optional: HL)	10.0	mm
TREAD_GG	Shear modulus of the tread rubber times tread width per circumferential unit length (Optional: BL)	40.0	N/mm^2
MU	Relative friction coefficient e.g. [1.0, 1.0, 1.0] (Optional: MGLT)	table	-
V_MU	Sliding velocity e.g. [0.0, 1000, 10000] (Optional: VGLT)	table	mm/s
	The friction coefficient MU is defined as a function of sliding velocity V_MU		
Y_BENDING_DAMP	Damping factor of EIY (CDT30: hard-coded 1.0E-5)	1.0E-5	-

Name	Explanation	Default	Unit
	(Optional: D_ALPHA)		
CIRC_DAMP	Damping factor of EF (CDT30: hard-coded 1.0E-6) (Optional: D_TAN)	1.0E-6	-
TREAD_SCAN _HEIGHT	Height in mm above surface where contact sensors are active	150.0	mm
TREAD_MAX _COMPRESS	Maximum compression of tread before warning is issued	0.95	-
TREAD_RAD_D	Damping factor of EG (CDT30: hard-coded 5.0E-4) (Optional: D_RAD_TREAD)	5.0E-4	-
R_EFF	Unloaded static radius (Optional R_STAT)	317	mm
CR1_STAT	Linear vertical stiffness	200	N/mm
	CDT30-HPS SOLVER PARAMETERS		
TOL	Vertical stiffness unloaded radius	1.0E-3	-
DTM	Stiffness influence factor radial	2.0E-4	s
DT_START _EXPL	Stiffness influence factor lateral	2.0E-5	s
NMAX_IMPL _ITER	Maximum number of iteration for the implicit integrator	4	-
PRE_STEP _TIME	Duration of pre-step in beginning of simulation	0.05	s
TYPE	Explicit 1, Implicit 2	2	-
ALPHA _EXPLICIT	Explicit Newmark alpha integrator value	0	-
BETA _EXPLICIT	Explicit Newmark beta integrator value	0.166667	-
GAMMA _EXPLICIT	Explicit Newmark gamma integrator value	0.5	-
ALPHA _IMPLICIT	Implicit Newmark alpha integrator value	0	-
BETA _IMPLICIT	Implicit Newmark beta integrator value	0.25	-

Name	Explanation	Default	Unit
GAMMA _IMPLICIT	Implicit Newmark gamma integrator value	0.5	-
UPDATE_FOR _MASTERCORR ECTOR	Toggle corrector iterations to be taken into account (0 off, 1 on)	0	-
IMPL_STEP _CTRL _ENABLE	Toggle internal step size control (0 off, 1 on)	1	-
IMPL_STEP _CTRL_EPS	Percentage of error tolerance TOL used to activate step size control	200	-
IMPL_STEP_CTR L_NSUBSTEPS	Subdivion of steps if step size reduction is activated	3	-
IMPL_JAC _EVAL_AT _ITER	Toggle update of jacobian calcula-tion during iteration (0 off, 1 on)	0	-

Tire Parameter File for CDTire/3D

The following listing shows the input file for a tire with the dimension 245/40 R 18 as used in the tire model *CDTire/3D*:

```
[CDT50-N MODEL PARAMETERS]
PIN = 0.27
NCS = 50
NR = 16
NRSW = 4
NRSENSTART = 4
SW_MODE=40
CONTOUR_SHELL_Y = [-111.2,-112.35,-115,-120.6,-109.2,-78.9,-
46.3,-13.2,13.2,46.3,78.9,109.2,120.6,115,112.35,111.2]
CONTOUR_SHELL_Z =
[248.1,262.45,278.25,292.2,304.4,306.1,306.2,306.8,306.8,306.2,
306.1,304.4,292.2,278.25,262.45,248.1]
MASS_BELT = 0.006
MASS_SIDEWALL = 0.005
MASS_BEAD = 0.001
MASS_W = [1.5,1,0.5,0.5,0.8,1,1,1,1,1,1,0.8,0.5,0.5,1,1.5]
RUBBER_CIRC_EH = 40
RUBBER_LAT_EH = 40
RUBBER_DIAG_EH = 25
RUBBER_SHEAR_GH = 0
RUBBER_CIRC_DAMP = 0.0003
RUBBER_LAT_DAMP = 0.0003
RUBBER_DIAG_DAMP = 0.0007
RUBBER_SHEAR_DAMP = 1e-005
RUBBER_CIRC_EH_W = [3,2,0.8,0.8,1,1,1,1,1,1,1,1,0.8,0.8,2,3]
RUBBER_LAT_EH_W = [2.5,2,0.5,0.8,1,1,1,1,1,1,1,0.8,0.5,2,2.5]
RUBBER_SHEAR_EH_W = [3,2,1,0.5,1,1,1,1,1,1,1,1,0.5,1,2,3]
RUBBER_DIAG_EH_W = [3,2,0.8,0.8,1,1,1,1,1.1,1,1,0.8,0.8,2,3]
NUMB_STEEL_CORDLAYERS = 2
STEEL_CORDLAYER_ANGLE = [24,-24]
STEEL_CORDLAYER_STIFF = [2000,2000]
STEEL_CORDLAYER_DAMP = [1e-005,1e-005]
STEEL_CORDLAYER_L0_REDFACTOR = [1,1]
CARCASS_CORDLAYER_STIFF = 900
CARCASS_CORDLAYER_DAMP = 1e-005
CARCASS_CORDLAYER_STIFF_W = [1,1,1,1,1,1,1,1,1,1,1,1,1,1,1]
CARCASS_CORDLAYER_L0_REDFACTOR = 0.98
BANDAGE_CORDLAYER_STIFF = 400
BANDAGE_CORDLAYER_DAMP = 1e-005
BANDAGE_CORDLAYER_STIFF_W = [0,0,0,0,1,1,1,1,1,1,1,0,0,0,0]
BANDAGE_CORDLAYER_L0_REDFACTOR =
[1,1,1,1,1,1,0.94,0.94,0.94,0.94,1,1,1,1,1,1]
Y_BENDING_STIFF = 5000
Y_BENDING_DAMP = 0.0001
Y_BENDING_STIFF_W =
[0.5,0.3,0.125,0.2,0.5,1,1,1,1,1,0.5,0.2,0.125,0.3,0.5]
X_BENDING_STIFF = 500
```

```
X_BENDING_DAMP = 0.0001
X_BENDING_STIFF_W =
[2,0.5,0.4,0.8,1,1,1,1,1,1,1,1,0.8,0.4,0.5,2]
XY_DIAG_BENDING_STIFF = 0
XY_DIAG_BENDING_DAMP = 0.0001
XY_DIAG_BENDING_STIFF_W = [1,1,1,1,1,1,1,1,1,1,1,1,1,1,1]
TREAD_NSEN_X = 5
TREAD_NSEN_Y = 3
TREAD_HEIGHT = 10
TREAD_E/H = 0.26
TREAD_Gx/H = 0.1
TREAD_Gy/H = 0.1
TREAD_RAD_D = 0.0005
TREAD_KM = 1
TREAD_MAX_COMPRESS = 0.95
TREAD_SCAN_HEIGHT = 150
MU = [1.05,1.05,0.9]
V_MU = [0,1000,10000]
LDE_FLAG = 0
LDE_CNL = 50
LDE_CLIN = 100
LDE_RNL = 12
LDE_RLIN = 5
LDE_Y_COORD = [-140.0,-120,-100.0,-80.0,80.0,100,120,140.0]
LDE_W = [0.0,1.0,1.0,1.0,1.0,1.0,1.0,0.0]
R_EFF = 320.0
CR1_STAT = 250.0

[CDT40-N MODEL PARAMETERS]
PREF = 0.27
FTX = 76.0
FTY = 41.0
FRY = 80.0
DTX = 0.08
DTY = 0.08
DRY = 0.08
SWBEND = 40.0

[CDT50-N SOLVER PARAMETERS]
TOL = 1.001E-3
DTM = 2.001E-4
DT_START_EXPL = 2e-005
PRE_STEP_TIME = 0.05
TYPE = 1
ALPHA_EXPLICIT = 0
BETA_EXPLICIT =  0.16666666666667
GAMMA_EXPLICIT = 0.5
UPDATE_FOR_MASTERCORRECTOR = 0
```

Remark: You may edit some parameters to suit your requirements. These parameters are colored blue in the listing above and an according remark is given in the following table.

The parameters colored in orange are optional and (if used) change model behavior or introduce new functionality.

```
with 2 mandatory sections:
   - [CDT50-N MODEL PARAMETERS]
   - [CDT50-N SOLVER PARAMETERS]
and 1 optional section (needed when SW_MODE=40):
   - [CDT40-N MODEL PARAMETERS]
```

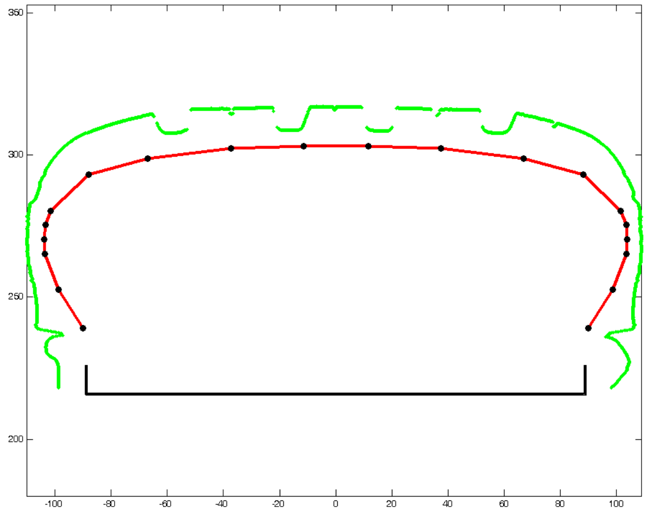
The parameters contain many one dimensional arrays. One has to be careful about the lengths of these arrays. There are two types of entities utilizing arrays:

- ring entities (table length is NR)
- segment entities (table length is NR-1).

Ring entities are all entities that are associated with mass, geometry or circumferential properties, e.g. MASS_W, CONTOUR_SHELL_Y or RUBBER_CIRC_EH_W. Segment entities are all entities associated with lateral or diagonal properties, e.g. RUBBER_LAT_EH_W or RUBBER_DIAG_EH_W.

Additionally, many entities consist of a material property and an associated weight, e.g. X_BENDING_STIFF and X_BENDING_STIFF_W. The local property then is a multiplication of the material property with its associated weight. In that way, it is possible to easily modify one local property or all properties simultaneously.

Name	**Explanation**	**Default**	**Unit**
	CDT50-N MODEL PARAMETERS		
PIN	Inflation pressure	0.27	MPa
NCS	Number of cross section	50	-
NR	Number of rings	16	-
NRSW	Number of rings in either sidewall	4	-
NRSENSTART	Index of ring from outside where contact calculation starts	NRSW+1	-
SW_MODE	Materialized sidewall (50) or massless sidewall (40)	50	-
CONTOUR_SHELL_Y	Lateral cross section coordinate of non-inflated configuration	Table	mm
CONTOUR_SHELL_Z	Radial cross section coordinate of non-inflated configuration	Table	mm

Name	**Explanation**	**Default**	**Unit**
			
MASS_BELT	Mass of belt rings	0.006	t
MASS_ SIDEWALL	Mass of sidewall rings without bead	0.005	t
MASS_BEAD	Mass of bead ring	0.001	t
MASS_W	Weighting factors of mass distribution (table of length NR)	table	-
RUBBER _CIRC_EH	Rubber stiffness in circumferential direction (Young E * thickness H)	40	N/mm
RUBBER _LAT_EH	Rubber stiffness in lateral direction (Young E * thickness H)	40	N/mm
RUBBER _DIAG_EH	Rubber stiffness in diagonal direction (Young E * thickness H)	25	N/mm
RUBBER _SHEAR_GH	Remaining rubber shear stiffness (Shearmodulus G * thickness H)	0	N/mm
RUBBER _XXX_DAMP	Corresponding (CIRC, LAT,DIAG, SHEAR) damping factors	0.0003 0.0007	-
RUBBER _XXX_W	Corresponding (CIRC, LAT,DIAG, SHEAR) weighting factors	table	-
NUMB_STEEL _CORDLAYERS	Number of steel cord layers	2	-
STEEL_CORD LAYER_ANGLE	Angle of steel cord layers against circumferential direction	table	deg
STEEL_CORD LAYER_STIFF	Cordlayer stiffness in cord angle direction (Young E * thickness H)	table	N/mm
STEEL_CORD LAYER_DAMP	Cordlayer damping factor in cord angle direction	table	-

Name	Explanation	Default	Unit
STEEL_CORDLAYER_L0_REDFACTOR	Cordlayer zero length relative to non-inflated configuration	table	-
CARCASS_CORDLAYER_STIFF	Carcass stiffness in cord angle direction (Young E * thickness H)	900	N/mm
CARCASS_CORDLAYER_DAMP	Carcass damping factor in cord angle direction	1.0E-5	-
CARCASS_CORDLAYER_STIFF_W	Carcass stiffness weighting factors	table	-
CARCASS_CORDLAYER_L0_REDFACTOR	Carcass zero length relative to non-inflated configuration	table	-
BANDAGE_CORDLAYER_STIFF	Bandage stiffness in cord angle direction (Young E * thickness H)	400	N/mm
BANDAGE_CORDLAYER_DAMP	Bandage damping factor in cord angle direction	1.0E-5	-
BANDAGE_CORDLAYER_STIFF_W	Bandage stiffness weighting factors	table	-
BANDAGE_CORDLAYER_L0_REDFACTOR	Bandage zero length relative to non-inflated configuration	table	-
Y_BENDING_STIFF	Bending stiffness in circumferential direction (Young E * thickness H^3)	5000	Nmm
Y_BENDING_DAMP	Bending damping factor in circumferential direction	1.0E-4	-
Y_BENDING_STIFF_W	Bending stiffness weighting factors in circumferential direction	table	-
X_BENDING_STIFF	Bending stiffness in lateral direction (Young E * thickness H^3)	500	Nmm
X_BENDING_DAMP	Bending damping factor in lateral direction	1.0E-4	-
X_BENDING_STIFF_W	Bending stiffness weighting factors in lateral direction	table	-
XY_DIAG_BENDING_STIFF	Bending stiffness in diagonal direction (Young E * thickness H^3)	1000	Nmm
XY_DIAG_BENDING_DAMP	Bending damping factor in diagonal direction	1.0E-4	-
XY_DIAG_BENDING_STIFF_W	Bending stiffness weighting factors in diagonal direction	table	-
TREAD_NSEN_X	Number of sensors per element in circumferential direction	5	-

Name	Explanation	Default	Unit
TREAD _NSEN_Y	Number of sensors per element in lateral direction	3	-
TREAD_HEIGHT	Height of tread	table	mm
TREAD_CSG	Tread shear stiffness reduction coefficient due to compression	0	1
TREAD_CSMUE	Friction reduction coefficient due to compression	0	1
TREAD_E/H	Radial tread stiffness (Young E / thickness H)	0.3	N/mm^3
TREAD_Gx/H	Tread shear stiffness in circumferen-tial direction (Shear G / thickness H)	0.1	N/mm^3
TREAD_Gy/H	Tread shear stiffness in lateral direction (Shear G / thickness H)	0.1	N/mm^3
TREAD_RAD_D	Radial tread damping factor	5.0E-4	1
TREAD_MAX _COMPRESS	Maximum compression of tread before warning is issued	0.95	1
TREAD_SCAN _HEIGHT	Height in mm above surface where contact sensors are active	150	mm
MU	Relative friction coefficient e.g. [1.0, 1.0, 1.0]	table	-
V_MU	Sliding velocity e.g. [0.0, 1000, 10000]	table	mm/s
LDE_FLAG	Toggle Large Deformation Element	0	-
LDE_CNL	Radial LDE progression stiffness	1.0E-9	N/mm^2
LDE_CLIN	Radial LDE final stiffness	0	N/mm^2
LDE_RNL	Radial LDE progression radius	1.0E-9	mm
LDE_RLIN	Radial LDE final radius	0	mm
LDE_Y_COORD	Lateral coordinate of LDE weighting	table	mm
LDE_W	LDE weighting	table	-
R_EFF	Unloaded static radius	320	mm
CR1_STAT	Linear vertical stiffness	200	N/mm

	CDT40-N SOLVER PARAMETERS		
FTX	Natural frequency: Translation x	89.5	Hz

Name	Explanation	Default	Unit
	(mode R_1)		
FTY	Natural frequency: Translation y (mode L_0)	45.7	Hz
FRY	Natural frequency: rotation around y (mode C_0)	65.4	Hz
SWBEND	Percent of radial stiffness due to bending, also toggles to discrete membrane sidewall method	0	%
DTX	Damping coefficient of mode R_1	0.05	-
DTY	Damping coefficient of mode L_0	0.05	-
DRY	Damping coefficient of mode C_0	0.05	-
	CDT50-N SOLVER PARAMETERS		
TOL	Vertical stiffness unloaded radius	1.0E-3	-
DTM	Stiffness influence factor radial	2.0E-4	s
DT_START _EXPL	Stiffness influence factor lateral	2.0E-5	s
PRE_STEP _TIME	Duration of pre-step in beginning of simulation	0.05	s
TYPE	Explicit 1	1	-
ALPHA _EXPLICIT	Explicit Newmark alpha integrator value	0	-
BETA _EXPLICIT	Explicit Newmark beta integrator value	0.166667	-
GAMMA _EXPLICIT	Explicit Newmark gamma integrator value	0.5	-
UPDATE_FOR _MASTERCORREC TOR	Toggle corrector iterations to be taken into account (0 off, 1 on)	0	-

Road Parameters

The following paragraphs show detailed examples for

- equidistant track data and
- non-equidistant track data.

Each example contains a road definition file and a figure displaying the defined road surface.

Example for Equidistant Track Data (Data Type 2)

```
# EXAMPLE EQUIDISTANT TRACK DATA
# X0_ROAD    Y0_ROAD    Z0_ROAD    MU_ROAD
  200.0      200.0      50.0       1.0
# DATA TYPE : EQUIDISTANT TRACK DATA
  2
# NTRACKS
  2
# NDATA  X0_TRACK  Y0_TRACK  HALF_WIDTH  DX    MU_TRACK
  21     -300      -150      150         25    1.0
    0.0000
   -9.5492
  -34.5492
  -65.4508
  -90.4508
 -100.0000
  -90.4508
  -65.4508
  -34.5492
   -9.5492
    0.0000
   -9.5492
  -34.5492
  -65.4508
  -90.4508
 -100.0000
  -90.4508
  -65.4508
  -34.5492
   -9.5492
    0.0000
# NDATA  X0_TRACK  Y0_TRACK  HALF_WIDTH  DX    MU_TRACK
  4      -100      350       150         200   1.0
    50.0000
   100.0000
   100.0000
```

```
    50.0000
END
```

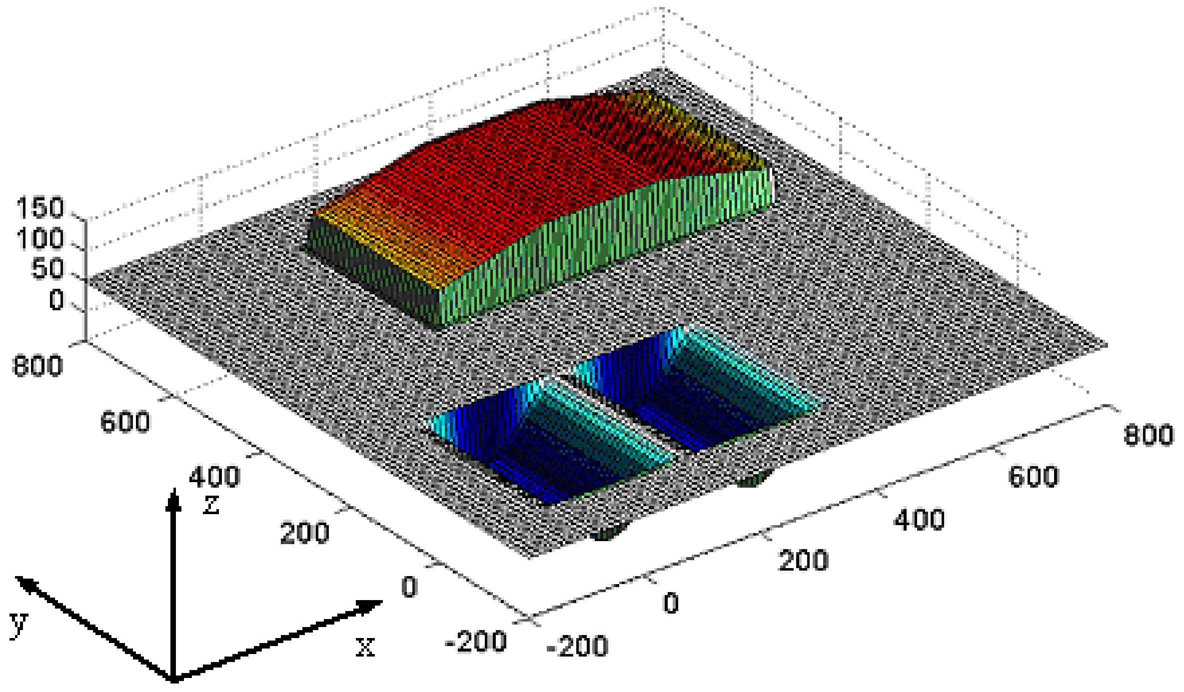


Fig. 4: Road Surface Model 1000: equidistant track

Example for Non-Equidistant Track Data (Data Type 3)

```
# EXAMPLE NON-EQUIDISTANT TRACK DATA
# X0_ROAD    Y0_ROAD    Z0_ROAD    MU_ROAD
  200.0      200.0      50.0       1.0
# DATA TYPE : NON-EQUIDISTANT TRACK DATA
  3
# NTRACKS
  1
# NDATA  X0_TRACK  Y0_TRACK  HALF_WIDTH   MU_TRACK
  24     -300       100      400     1.0
     0.0000    0.0000
    25.0000   -9.5492
    50.0000  -34.5492
    75.0000  -65.4508
   100.0000  -90.4508
   125.0000 -100.0000
   225.0000 -100.0000
   250.0000  -90.4508
   275.0000  -65.4508
   300.0000  -34.5492
   325.0000   -9.5492
   350.0000    0.0000
   450.0000    0.0000
   475.0000    9.5492
   500.0000   34.5492
   525.0000   65.4508
   550.0000   90.4508
   575.0000  100.0000
   675.0000  100.0000
   700.0000   90.4508
   725.0000   65.4508
   750.0000   34.5492
   775.0000    9.5492
   800.0000    0.0000
END
```

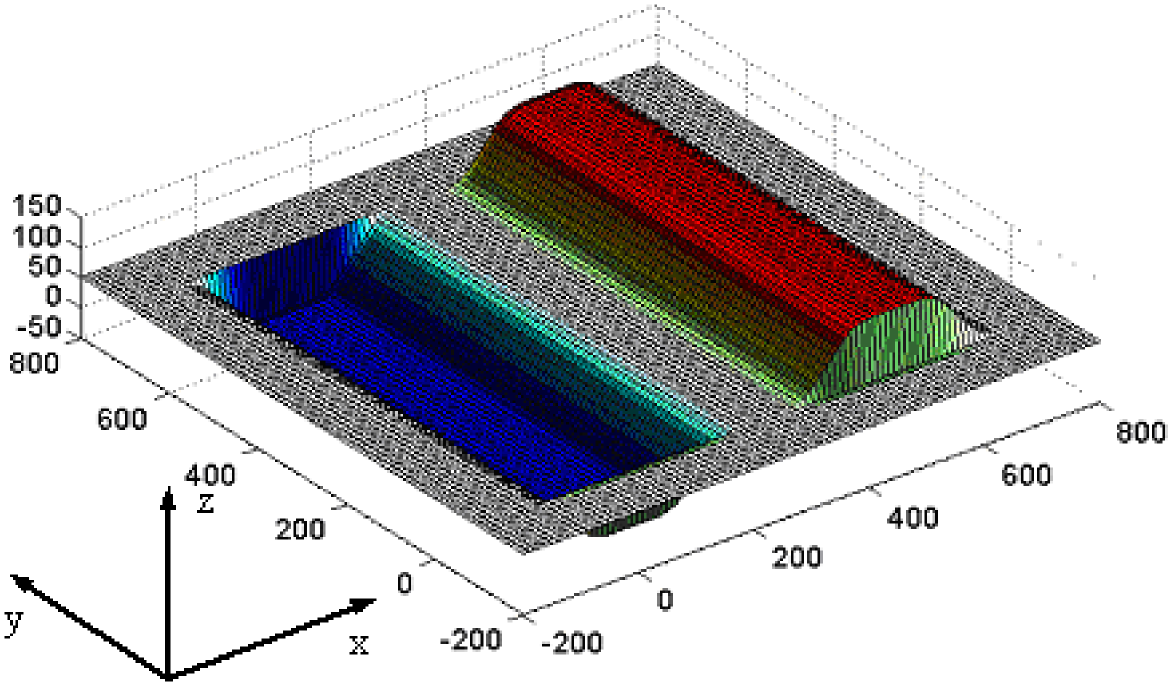


Fig. 5: Road Surface Model 1000: non-equidistant track

Warnings and Errors

CDTire

ERROR NUMBER	VLM/ADAMS	ERROR MESSAGE and SOLUTION
MESS5067	X/X	CDT License not available for tire ID Call support
MESS1002	X/X	GFORCE ID NUMBER NOT ALLOWED set to 1000
MESS1003	X/X	GFORCE TYP NUMBER NOT ALLOWED set to 1000
MESS1004	--/X	TIRE NUMBER NOT ALLOWED Tire identifier must be increasing consecutivly
MESS1005	X/X	MAX. TIRE NUMBER NOT ALLOWED too many tires for license
MESS1006	X/X	DOCUMENTATION TOGGLE NOT ALLOWED must be either 0 or 1
MESS1007	X/X	NUMBER CORR. ITERATIONS NOT ALLOWED must be between 0 and 9
MESS1008	X/X	TIRE MODEL NOT ALLOWED must be either 20, 30, 40, 2030, 2040
MESS1009	X/X	TIRE TYPE NUMBER NOT ALLOWED must be between 1 and 99
MESS1010	X/X	ROAD MODEL NUMBER NOT ALLOWED must be either 1000, 1002, 1100 or 2000
MESS1011	X/X	ERROR WHILE CALLING TIRE INTERFACE call support
MESS1012	X/X	DOCUMENTATION FILE CAN NOT BE OPENED check CDTire Main Path and Log File Name
MESS1013	--/X	INITIALIZATION MUST BE WITH TIRE NR=1 first tire identifier must be 1
MESS1016	X/X	LTIME < HTIME (1) call support

ERROR NUMBER	VLM/ADAMS	ERROR MESSAGE and SOLUTION
MESS1021	X/X	UNIT VECTOR UNDEFINED call support

CDTire Model Interface

ERROR NUMBER	ERROR MESSAGE and SOLUTION
2002	CDT : PARAMETER FILE <name>' NOT FOUND ! ==> STOP Check CDTire Main Path, Tire File Root Name, Tire Model and Tire Type
2003	ICDT20 : ERROR IN PARAMETER FILE <name> END-OF-FILE WHILE READING PARAMETER <parameter> ! ==> STOP Check specified parameter file
2004	ICDT20 : ERROR IN PARAMETER FILE <name> ERROR WHILE READING PARAMETER <parameter> ! ==> STOP Check specified parameter file
2031	ICDT20 : PIN <= 0 ! ==> STOP Inflation pressure must be positive
2061	CDT20 : BELTDEFORMATION TOO LARGE ! ==> STOP Check initial deflection (surface height)
2063	CDT20 : BELT DEFORMATION TOO LARGE ! ==> STOP Check initial deflection (surface height)
2065	CDT : BELT TORSION TOO LARGE ! ==> STOP Check drive line
3003	ICDT30 : ERROR IN PARAMETER FILE <name> END-OF-FILE WHILE READING PARAMETER <parameter> ! ==> STOP Check parameter file
3004	ICDT30 : ERROR IN PARAMETER FILE <name> ERROR WHILE READING PARAMETER <parameter> ! ==> STOP Check parameter file
3009	ICDT30 : NMP < 50 ! ==> STOP NMP must be at least 50

ERROR NUMBER	**ERROR MESSAGE and SOLUTION**
3010	ICDT30 : NMP > NM30 ! ==> STOP Call support
3011	ICDT30 : NSEN < 1 ! ==> STOP NSEN must be at least 1
3012	ICDT30 : NSEN > NS30 ! ==> STOP Call support
3013	ICDT30 : NFMIN < 1 ! ==> STOP NFMIN must be at least 1
3014	ICDT30 : NFMAX < 1 ! ==> STOP NFMAX must be at least 1
3015	ICDT30 : NFMIN > NF30 ! ==> STOP Call support
3016	ICDT30 : NFMAX > NF30 ! ==> STOP Call support
3017	ICDT30 : NFMIN > NFMAX ! ==> STOP NFMIN <= NFMAX must hold
3033	ICDT30 : PIN <=0 ! ==> STOP Inflation pressure must be positive
3046	CDT30 : BELT SEGMENT LENGTH ZERO ! ==> STOP Check initial deflection (surface height)
3047	CDT30 : BELT DEFORMATION TOO LARGE ! ==> STOP Check initial deflection (surface height)
3048	CDT30 : BELT DEFORMATION TOO LARGE ! ==> STOP Check initial deflection (surface height)
3102	CDT40 : PARAMETER FILE <name> NOT FOUND ! ==> STOP Check CDTire Main Path, Tire File Root Name, Tire Model and Tire Type

ERROR NUMBER	**ERROR MESSAGE and SOLUTION**
3103	ICDT40 : ERROR IN PARAMETER FILE <name> END-OF-FILE WHILE READINGPARAMETER <parameter> ! ==> STOP Check parameter file
3104	ICDT40 : ERROR IN PARAMETER FILE <name> ERROR WHILE READINGPARAMETER <parameter> ! ==> STOP Check parameter file
3109	ICDT40 : NMP < 144 ! ==> STOP NMP must be al least 144
3110	ICDT40 : NMP > NM31 ! ==> STOP Call support
3111	ICDT40 : NMP NICHT DURCH 4 TEILBAR ! ==> STOP NMP must be factor of 4
3112	ICDT40 : NSP < 1 ! ==> STOP NSP must be at least 1
3113	ICDT40 : NSP > NL31 ! ==> STOP Call support
3114	ICDT40 : NSEN < 1 ! ==> STOP NSEN must be at least 1
3115	ICDT40 : NSEN > NS31 ! ==> STOP Call support
3116	ICDT40 : NFMIN < 1 ! ==> STOP NFMIN must be at least 1
3117	ICDT40 : NFMAX < 1 ! ==> STOP NFMAX must be at least 1
3118	ICDT40 : NFMIN > NF31 ! ==> STOP Call support
3119	ICDT40 : NFMAX > NF31 ! ==> STOP Call support

ERROR NUMBER	ERROR MESSAGE and SOLUTION
3120	ICDT40 : NFMIN > NFMAX ! ==> STOP NFMIN <= NFMAX must hold
3138	ICDT40 : PIN <= 0 ! ==> STOP Inflation pressure must be positive
3152	CDT40 : KA/PIN TOO SMALL OR TOO LARGE ! ==> STOP Call support
3153	CDT40 : ITERATION OF SIDEWALL CURVATURE DOES NOT KONVERGE ! ==> STOP Call support
3154	CDT40 : BELT CORD LENGTH ZERO ! ==> STOP Check initial deflection (surface height)
3155	CDT40 : BELT SEGMENT LENGTH ZERO ! ==> STOP Check initial deflection (surface height)
3156	CDT40 : BELT SEGMENT WIDTH ZERO ! ==> STOP Check initial deflection (surface height)
3157	CDT40 : BELT DEFORMATION TOO LARGE ! ==> STOP Check initial deflection (surface height)
3158	CDT40 : BELT DEFORMATION TOO LARGE ! ==> STOP Check initial deflection (surface height)
5038	CDT CONTROL FILE: PATHNAME TOO LONG ! ==> STOP Limit is 256 characters
5039	CDT CONTROL FILE: FILE <name> NOT FOUND ! ==> STOP Check CDTire Main Path and CDT Control File
5040	CDT : ERROR IN PARAMETER FILE <name> END-OF-FILE WHILE READING PARAMETERLINE Check parameter file
5041	CDT : ERROR IN PARAMETER FILE <name> ERROR WHILE READING PARAMETERLINE

ERROR NUMBER	**ERROR MESSAGE and SOLUTION**
	Check parameter file
5043	CDT CONTROL FILE : DSSCAN <= 0 ! ==> STOP DSSCAN must be positive
5044	CDT CONTROL FILE : 0 <= DPHISCAN <= 90 ! ==> STOP DPHISCAN must be positive and less then 90
5045	CDT CONTROL FILE : KAPMAX <= 0 ! ==> STOP KAPMAX must be positive
5046	CDT CONTROL FILE : TOL <= 0 ! ==> STOP TOL must be positive
5047	CDT CONTROL FILE : DTM20 <= 0 ! ==> STOP DTM20 must be positive
5048	CDT CONTROL FILE : DTM30 <= 0 ! ==> STOP DTM30 must be positive
5049	CDT CONTROL FILE : DTM40 <= 0 ! ==> STOP DTM40 must be positive
5053	CDT CONTROL FILE : TSTART < 0 ! ==> STOP TSTART must be positive
5054	CDT CONTROL FILE : TSWITCH <= 0 ! ==> STOP TSWITCH must be positive
5055	CDT CONTROL FILE : TSECURE < 0 ! ==> STOP TSECURE must be positive
5063	CDT : PATHNAME TOO LONG ! ==> STOP Check CDTire Main Path
5067	CDT : MORE THAN 500 TIME STEP ATTEMPTS Call support
5068	CDT CONTROL FILE : NWARN < 100 ! ==> STOP

ERROR NUMBER	ERROR MESSAGE and SOLUTION
	NWARN must be at least 100
5069	CDT CONTROL FILE : MONITOR_FILE != 0 OR 1 ! ==> STOP MONITOR_FILE must be 0 or 1

Road Interface

ERROR NUMBER	ERROR MESSAGE and SOLUTION
902	ZBODEN : PATHNAME TOO LANG ! ==> STOP Limit is 256 characters
903	ZBODEN : ROAD FILE ... NOT FOUND ! ==> STOP Check CDTire Main Path and Road Surface File
0	ZB : NHIN Call support
1	ZB : IZBDAT Call support
2	ZB : IFILE NOT FOUND Check CDTire Main Path and Road Surface File
3	ZB : OFILE CANT BE OPENED Check CDTire Main Path and Road Log File
4	ZB : IFILE CANT BE OPENED Check CDTire Main Path and Road Surface File
5	ZB : OBSTACLE AMBIGUOUS Check surface definition, obstacles or tracks are intersecting
6	ZB : TYPE NOT IMPLEMENTED Only use obstacle types 1 to 7
7	ZB : ERROR END-OF-FILE Anzahl der Zeilen in der Bodeneingabedatei prüfen
8	ZB : ERROR COMMENT Call support
9	ZB : ERROR DATASIZE Call support
11	ZB : NZBSPU .GT. NSPARR Call support

ERROR NUMBER	ERROR MESSAGE and SOLUTION
12	ZB : NZBDAT .GT. NSPARR Call support
13	ZB : XK1 = XK0 Track with zero length, check surface definition
14	ZB : YK1 = YK0 Track with zero width, check surface definition
16	ZB : DATA NOT MONOTON Check X-data of track definition
100	ZB : ZH TOO SMALL Obstacle height <= 10.0E-12, check surface definition
101	ZB : ZH LARGER THAN R Cap height must be smaller than R
9001	NORM : VECTOR IS ZERO ! ==> STOP Call support