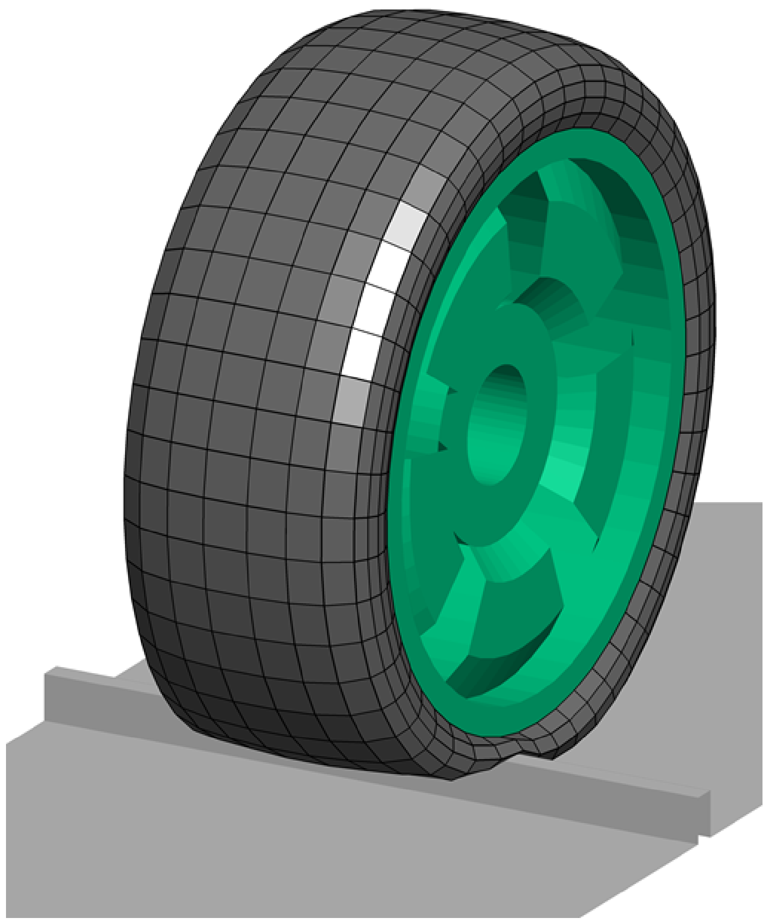
Fraunhofer CDTire

User Manual for CDTire

Version 2023.1.1



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Introduction

The *Comfort and Durability Tire* (*CDTire*) is a tire model family to be used with MBS software systems like *Adams®*. 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*.

1.1 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 frequency range for durability and comfort studies up to 150 Hz.

1.1.1 CDTire Model Family

CDTire offers 3 basic tire models:

- **CDTire/3D**
- **CDTire/Realtime**
- **CDTire/MF++**

The following models are considered CDTire/Legacy and are not actively developed any-more:

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

However, existing model 30 and model 40 parameter files can be used as they are automatically converted to CDTire/Realltime and CDTire/3D, respectively. The following paragraphs give some general background information to the sub-models. See *CDTire User Manual* for a detailed description of the corresponding parameter files and their function.

CDTire/3D

The structural tire model CDTire/3D has been developed at Fraunhofer ITWM [1]. It is used in the automotive industry for comfort, durability, and advanced vehicle dynamics (handling) scenarios. The model is based on a spatial finite difference (FD) formulation of the tire, which is modeled from different shell elements (figure 1).

The functional plies of the tire such as the carcasses, belt plies, and bandages are accumulated into these shell properties during the generation of the tire model. The properties of these plies are adjustable and accessible through the material parameters and geometry using parameterization. The modeling of the individual plies also includes a non-linear component within the elastic material description of the fiber reinforced plies. This is necessary due to a different behavior in tension and compression. The dissipative part of the material description combines visco-elastic properties and considers internal friction. The tread of the tire is formulated as a brush-like contact. This type of modeling allows stick-slip effects in the tire to be well represented. The model is also characterized by a strict separation between material and geometric properties. The geometric formulation of the material behavior also allows large deformations to be modeled. The air pressure is applied to the inner liner of the tire.

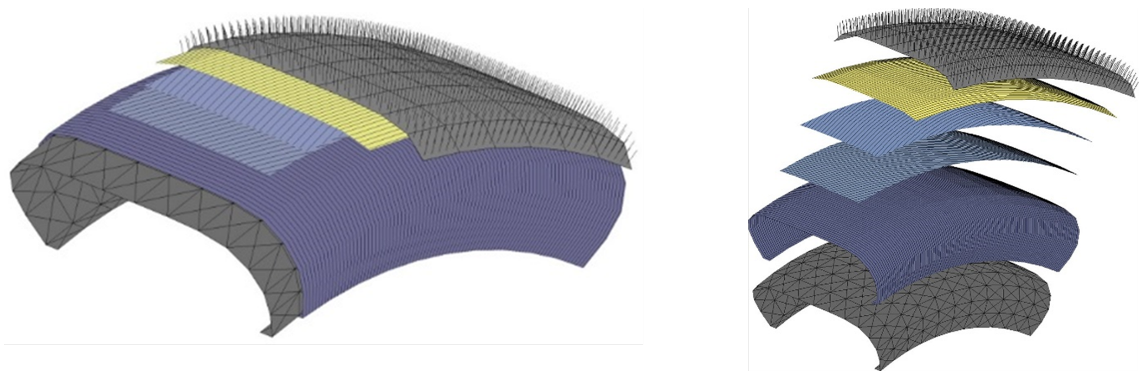

Figure 1.1: Structure of CDTire/3D

Tire Model Structure:

- belt is a 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
- can be arbitrary
- full obstacle enveloping

CDTire/Realtime

CDTire/Realtime model is derived from a CDTire/3D. The belt is modelled as a flexible beam. As in CDTire/3D, the structural properties of the different plies are combined into global bending and deformation properties (stiffness, damping). The sidewall is modelled using discrete force elements (stiffnesses and damping) with no internal degrees of freedom. Just like CDTire/3D, the model has a brush-like contact formulation. Locally, the model of a bristle is even identical. The stick-slip effects already mentioned can also be captured locally in the areas of the contact zone.

The offline version of this tire model has been used in comfort and durability applications for many years. In recent years, the model has been improved and also qualified for complex vehicle dynamics applications, with simulation quality very close to that of the parent model CDTire/3D. However, the real-time model CDTire/Realtime does not have the same predictive capabilities with respect to internal pressure changes or size changes of tires and rims as CDTire/3D.
For use within hard real-time applications, a dedicated implicit solver of type "NEWMARK" was developed and implemented. The solution is done - as usual for implicit solvers - by using a JACOBI matrix in combination with NEWTON's method. The main computational cost of such a scheme lies in the generation of the JACOBI matrix and in the linear algebra associated with solving the linear problem at each iteration.
To avoid this, Fraunhofer ITWM has developed a special method for setting up the projector for the Newton iteration, which is very well adapted to the physics of the equation. This advancement makes it possible to accelerate the Newton iteration immensely and to guarantee hard real-time computational performance.

Tire Model Structure:

- belt is modelled as a 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 λ_{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/MF++

CDTire/MF++ is a temperature enhanced Magic Formula for coupling to CDTire/Thermal in advanced handling applications.

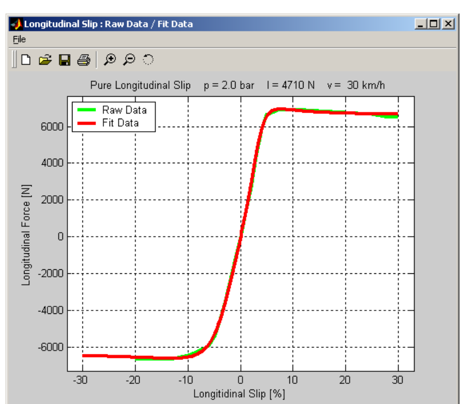

Figure 1.2: CDTire/MF++

Tire Model Structure:

- MF 5.2 / PAC2002
- Coupled with CDTire/Thermal

Contact Formulation:

- Estimation of contact patch shape, location and stick/slip zones
- Temperature dependent friction and grip levels

Performance:

- hard real time capable

1.1.2 CDTire ADD-ONs

The following CDTire modules are additional add-ons and are not included in the delivery and the license of standard CDTire for the Adams (MSC Software) product suite. To get access to these options an additional license is needed.

CDTire/Thermal

- detailed thermo-dynamical model to predict temperature creation and propagation in a tire
- fully 3D finite volume based description
- scalable resolution in all dimensions
- auto-meshing functionality
- runs with real time factor below 0.1
- easy to parameterize
- can be coupled with CDTire/3D, CDTire/MF++

CDTire with resizing capability

If the Resizing capability is licensed, the customer can add an additional resizing section into the parameter file by using the following keyword [$TIRE\_AND\_RIM\_RESIZING$]. This section allows for resizing of a given tire size to a target tire size. The base tire needs to be specified (e.g. 205\55 R 16.0). Also the reference rim (e.g. 16.0 x 6.0) needs to be specified (reference dimensions). The desired tire size (e.g. 195\65 R 16.0) and rim size (e.g. 16.0 x 5.5) dimensions need to be specified as target dimensions. Assuming the material properties remain the same, CDTire now automatically resizes the tire to fit the new dimensions.

Example:
[$TIRE\_AND\_RIM\_RESIZING$]
$TIRE\_REF = 205/50R16$ #Reference tire specification*
$RIM\_REF = 16x6$ #Reference rim specification*
$TIRE\_NEW = 225/45R17$ #Target tire specification*
$RIM\_NEW = 17x7$ #Target rim specification*

1.2 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, 1008, 2000, 3000)
- User defined road surface model (RSM 1100)
- MBS dependent road surface models may be available, see the corresponding *CDTireMBSManual* for more information.

1.2.1 CDTire Road Surface Models (RSMs)

See the chapter 3 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 distribu-ted on an "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either ex-press or implied. See the License for the specific language governing permissions and limita-tions under the License. More Information on OpenCRG® open file formats and tools can be found at http://www.opencrg.org.

1.2.2 MBS Road Surface Models (RSMs)

Some MBS systems allow CDTire to utilize their own road surface models. See the respective *CDTire MBS Guide* for detailed information on the these models and how to use them.

2 Model Implementation

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

2.1 Modelling with CDTire

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

- Altair MotionSolve
- Dassault Systemes SIMPACK
- IPG CarMaker
- LMS Samtech Samcef Mecano
- MATLAB / Simulink
- Mechanical Simulation CarSim
- MSC ADAMS
- Siemens Simcenter Amesim
- Siemens Simcenter 3D Motion
- VI-grade VI-CarRealTime

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

3 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 gives 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
1008	3D Surface
1100	User road model (ADAMS only)
2000	Parametric and Digitized Road Data
3000	OpenCRG®(1.1.1) Road Data

3.1 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 (P5).

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.

3.1.1 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)
    2
```

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 (X0) from the road origin marker (P5) of the MBS model.

Figure 3.1: 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
Line 4:	#	DATA TYPE: (2, 3 OR 4)			
Line 5:		2			

with:

X0_ROAD	Translation in x-direction
Y0_ROAD	Translation in y-direction
Z0_ROAD	Translation in z-direction
MU_ROAD	Road friction coefficient

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:		2			

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.

3.1.2 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 (DATA TYPE 2)

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

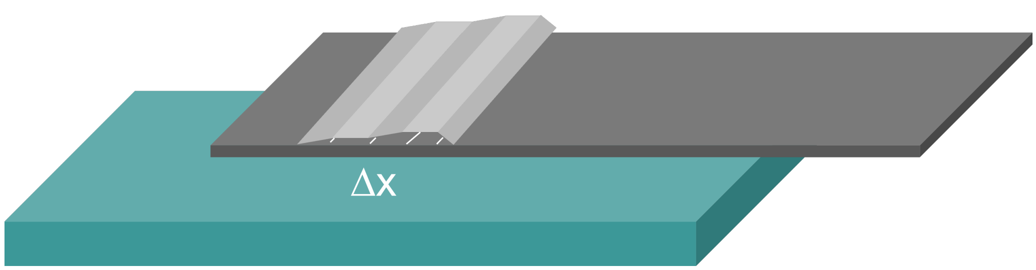

Figure 3.2: Road Surface Model 1000: Equidistant Track Data

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:

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:

#	NDATA	X0_TRACK	Y0_TRACK	HALF_WIDTH	DX	MU_TRACK
	4.0	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 w.r.t. the road data origin
Y0_TRACK	Track origin y-coordinate w.r.t. the road data origin
HALF_WIDTH	Half width of the track
DX	Equidistant spacing delta x on the track data
MU_TRACK	Friction coefficient of the track surface
Line 10... Line 9 + **NDATA**	These lines contain the zu data of the single tracks (local heights)

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 (DATA TYPE 3)

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

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:

#	**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 w.r.t. the road data origin
Y0_TRACK	Track origin y-coordinate w.r.t. 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 zu data of the single tracks (local heights)

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 di-rection of the track is the same as for the equidistant data. Again, several tracks can be defi-ned 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 w.r.t. the road data origin (upper left point)
Y0	Track origin y-coordinate w.r.t. 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)

3.2 Road Surface Model 1002

The Road Surface Model 1002 adapts an analytical description of a drum surface. A number of different obstacle types and tracks are available to model the drum. It will generate a surface dR(phi,Y) with respect to the coordinate system representing the surface origin as defined in the MBS model (P5).

A road definition file for the Road Surface Model 1002 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

3.2.1 Header (Road Surface Model 1002)

Line 1:	#	DESCRIPTION LINE		
Line 2:	#	RADIUS_DRUM	MU_DRUM	PERIODIC
Line 3:		1000.0	1.0	1
Line 4:	#	SURFACE TYPE		
Line 5:		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 drum definition file. This line is required but all con-tents will be ignored by *CDTire*.

The second and fourth lines are comment lines starting with a hash (#), too. Here you should enter "place-holders" 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 drum surface without any obstacles or data. It consists of the radius of the drum (in [mm]) and the friction coefficient (in [1]). A third para-meter is the periodic flag, and if set obstacles appear with every revolution of the drum surface. If not set, the obstacle will appear only once (depending on S_0 settings). The fifth line contains the type of obstacle data.

Line 1:	#	DESCRIPTION LINE		
Line 2:	#	**RADIUS_DRUM**	**MU_DRUM**	**PERIODIC**
Line 3:		1000.0	1.0	1
Line 4:	#	**SURFACE TYPE**		
Line 5:		1		

with:

RADIUS_DRUM	Drum radius in [mm], positive for outer drum, negative for inner drum
MU_DRUM	Friction coefficient drum surface outside obstacle data
PERIODIC	Repeat cleat (1) or only once (0)
SURFACE TYPE	2 = with rectangular cleat
	3 = with chamfered cleat
	4 = matrix data

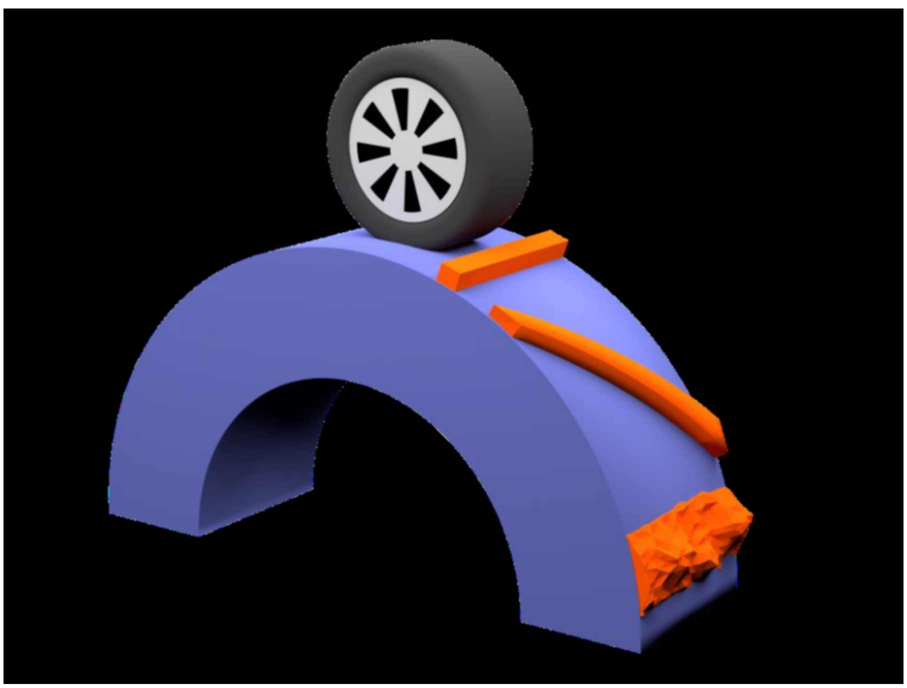

Figure 3.3: Road Surface Model 1002: Rolling Drum

3.2.2 Header (Road Surface Model 1002)

With R4.2.7, there are 3 surface types to construct drum surfaces with.

Rectangular cleat (SURFACE TYPE 2)

The road definition file for a drum surface with any rectangular cleat (SURFACE TYPE 2) has the following structure (with infinite lateral dimension):

#	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	0.8

with:

H	Height [mm] of cleat
W	Width [mm] of cleat (length of cleat is infinite)
S_0	Arc length[mm] from top of 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, transversal cleat is 90°
MU_CLEAT	Friction coefficient on cleat

Ramped / trapezoid cleat (SURFACE TYPE 3)

The road definition file for a drum surface with any ramped or trapezoid cleat (SURFACE TYPE 3) has the following structure (with infinite lateral dimension):

#	DESCRIPTION LINE		
#	RADIUS_DRUM	MU_DRUM	PERIODIC
	1000.0	1.0	1
#	**SURFACE TYPE**		
	3		

#	**H**	**W1**	**W2**	**W3**	**S_0**	**PHI**	**MU_CLEAT**
	10.0	20.0	40.0	20.0	-2522.2	90.0	0.8

with:

H	Height [mm] of cleat
W1	Width (arclength) [mm] of leading ramp
W2	Width (arclength) [mm] of constant height H
W3	Width (arclength) [mm] of trailing ramp
S_0	Arc length[mm] from top of 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

Matrix data (SURFACE TYPE 4)

The road definition file for a drum surface with any equidistant grid or matrix data dR(phi,y) (SURFACE TYPE 4) has the following structure:

#	DESCRIPTION LINE		
#	RADIUS_DRUM	MU_DRUM	PERIODIC
	1000.0	1.0	1
#	**SURFACE TYPE**		
	4		

#	NPHI	NY	PHI0	DPHISEG	Y0	DY	MU	SCALE	RADIUSOFFSET
	4	2.0	0.0	3.48	-200.0	400	0.8	1.0	0.0

10.0	10.0
20.0	20.0
20.0	20.0
10.0	10.0

with:

NPHI	Number of circumferential data points
NY	Number of lateral (axial) data points
PHI0	Starting angle [deg] of data segment, -180 < PHI0 < 180
DPHISEG	Angular segment range [deg] of data, 360° for full drum
Y0	Starting lateral coordinate [mm] of data
DY	Lateral discretization spacing [mm] of data
MU	Friction coefficient on data
SCALE	Scaling coefficient for radial data
RADIUSOFFSET	Offset value [mm]
DATA	NPHI rows, NY columns

Above example makes up a trapeze. All lines starting with a hash (#) are comment files used to define placeholders for the data in the following lines. Even if *CDTire* will skip over them, these lines are required. Do not delete them!

3.3 Road Surface Model 1008

This road surface model is the CDTire implementation of the 3D method of MSC Adams .rdf data files. Some MBS systems can also visualize this road format in their respective Pre-/Postprocessor. This documentation lists only the required data format to work with CDTire - for visualization support of MBS systems, please refer to the respective MBS documentation.

Data structure and format

The data file is based on section / keyword format. A valid section line contains the name of the section is square brackets. A valid keyword line contains the name of the keyword, followed by the '=' character, followed by the value. A valid CDTire RSM1008 file is shown here:

```
[MODEL]
METHOD = '3D'


[UNITS]
LENGTH = 'MM'


[OFFSET]
X = 100.0
Y = 200.0
Z = -10.0


[NODES]
NUMBER_OF_NODES = 4
{node   x_value   y_value   z_value}
1       -10.0     -200.0    10.0
2       10.0      -200.0    10.0
3       10.0      200.0     10.0
4       -10.0     200.0     10.0


[ELEMENTS]
NUMBER_OF_ELEMENTS = 2
{node_1   node_2   node_3   u}
1         2        3        0.8
1         3        4        0.8
```

The following format details may only be valid for the CDTire implementation of .rdf files:

- Section names, keyword names and strings are case insensitive. All of "METHOD", "method", "Method" are the same valid keyword.
- Supported units are "MM" (millimeter), "CM" (centimeter), and "M" (meter)

- In node and element section, a comment line containing a left brace (curly) bracket indicates that the next line starts with the respective data matrix (nodes or elements). The successive NUMBER_OF_xxx lines must contain valid line data for each line.

3.4 Road Surface Model 2000

3.4.1 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.
- A (when applicable) a set of “macropatch” binary data files named MP_0_0.d, MP_0_1.d etc.
- A (when applicable) a set of parametric road description files

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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

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 (dou-ble)
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 path header
data type	0 -> off road (integer)

- Digitized:

File entry	Meaning
Micropatch micro_column_nr micro_row_n	Micro path header
data type	0 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 columnwise (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 path header
data type	2 -> parameterized (integer)
trackclassification	Refers to a classification number in surface classification file (integer)
filename	Filename without 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	
}	
Macropatch	0 0
1	
1	
5.000	5.000
101	101
0	
c	
20	
2030	
Macropatch	0 1
1	
1	
5.000	5.000
101	101
40812	
c	
20	
2030	
Macropatch	0 2
1	
1	
5.000	5.000
101	101
81624	
c	
20	
2030	
Macropatch	0 3
1	
1	
5.000	5.000
101	101
122436	
c	
20	
2030	
Macropatch	0 4
1	
1	
5.000	5.000

101	101
163248	
c	
20	
2030	
Macropatch	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	

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	→	...

3.5 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 cannot be tuned automatically. These include structural discretization, integrator tuning and inflation pressure.

For more information on

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

4 Appendix

The following paragraphs explain the parameter files for the tire models *CDTire/MF++*, *CDTire/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.

5

Tire Parameter File - CDTire/MF++

The following listing shows the input file for a tire as used in the tire model *CDTire/MF++*:

[CDT10 PARAMETERS]

[UNIT]	
LENGTH =	'meter'
FORCE =	'newton'
ANGLE =	'radians'
MASS =	'kg'
TIME =	'second'
[MODEL]	
LONGVL = 16.6	$Measurement speed
THERMAL_MODEL_FLAG = 0	
VELOCITY_TRESHOLD = 0.5	$Lower cut off velocity
[DIMENSION]	
UNLOADED_RADIUS = 0.312	$Free tyre radius
WIDTH = 0.195	$Nominal section width of tyre
ASPECT_RATIO = 0.65	$Nominal aspect ratio
RIM_RADIUS = 0.19	$Nominal rim radius
RIM_WIDTH = 0.1524	$Rim width
[VERTICAL]	
VERTICAL_STIFFNESS = 2e+005	$Tyre vertical stiffness
VERTICAL_DAMPING = 0	$Tyre vertical damping
BREFF = 6.1	$Low load stiffness e.r.r.
DREFF = 0.45	$Peak value of e.r.r.
FREFF = 0.01	$High load stiffness e.r.r.
FNOMIN = 4000	$Nominal wheel load

[PARAMETER]
VERTICAL_STIFFNESS = 2e+005 $Tyre vertical stiffness

[LONG_SLIP_RANGE]
KPUMIN = -1.5 $Minimum valid wheel slip
KPUMAX = 1.5 $Maximum valid wheel slip

[SLIP_ANGLE_RANGE]
ALPMIN = -1.5708 $Minimum valid slip angle
ALPMAX = 1.5708 $Maximum valid slip angle

[INCLINATION_ANGLE_RANGE]
CAMMIN = -0.26181 $Minimum valid camber angle
CAMMAX = 0.26181 $Maximum valid camber angle

[VERTICAL_FORCE_RANGE]
FZMIN = 200 $Minimum allowed wheel load
FZMAX = 9000 $Maximum allowed wheel load

[SCALING_COEFFICIENTS]
LFZO = 1 $Scale factor of nominal (rated) load
LCX = 1 $Scale factor of Fx shape factor
LMUX = 1 $Scale factor of Fx peak friction coefficient
LEX = 1 $Scale factor of Fx curvature factor
LKX = 1 $Scale factor of Fx slip stiffness
LHX = 1 $Scale factor of Fx horizontal shift
LVX = 1 $Scale factor of Fx vertical shift
LGAX = 1 $Scale factor of camber for Fx
LCY = 1 $Scale factor of Fy shape factor
LMUY = 1 $Scale factor of Fy peak friction coefficient
LEY = 1 $Scale factor of Fy curvature factor
LKY = 1 $Scale factor of Fy cornering stiffness
LHY = 1 $Scale factor of Fy horizontal shift
LVY = 1 $Scale factor of Fy vertical shift
LGAY = 1 $Scale factor of camber for Fy
LTR = 1 $Scale factor of Peak of pneumatic trail
LRES = 1 $Scale factor for offset of residual torque
LGAZ = 1 $Scale factor of camber for Mz
LXAL = 1 $Scale factor of alpha influence on Fx
LYKA = 1 $Scale factor of alpha influence on Fx
LVYKA = 1 $Scale factor of kappa induced Fy

Continued on the next page...

[SCALING_COEFFICIENTS]

LS = 1	$Scale factor of Moment arm of Fx
LSGKP = 1	$Scale factor of Relaxation length of Fx
LSGAL = 1	$Scale factor of Relaxation length of Fy
LGYR = 1	$Scale factor of gyroscopic torque
LMX = 1	$Scale factor of overturning couple
LVMX = 1	$Scale factor of Mx vertical shift
LMY = 1	$Scale factor of rolling resistance torque

[LONGITUDNAL_COEFFICIENTS]

PCX1 = 1.839	$Shape factor Cfx for longitudinal force
PDX1 = 1.1387	$Longitudinal friction Mux at Fznom
PDX2 = -0.11999	$Variation of friction Mux with load
PDX3 = -2.2142e-005	$Variation of friction Mux with camber
PEX1 = 0.62727	$Longitudinal curvature Efx at Fznom
PEX2 = -0.12336	$Variation of curvature Efx with load
PEX3 = -0.03448	$Variation of curvature Efx with load squared
PEX4 = -1.5066e-005	$Factor in curvature Efx while driving
PKX1 = 18.886	$Longitudinal slip stiffness Kfx/Fz at Fznom
PKX2 = -3.988	$Variation of slip stiffness Kfx/Fz with load
PKX3 = 0.21542	$Exponent in slip stiffness Kfx/Fz with load
PHX1 = -0.00033912	$Horizontal shift Shx at Fznom
PHX2 = -8.5877e-006	$Variation of shift Shx with load
PVX1 = -4.638e-006	$Vertical shift Svx/Fz at Fznom
PVX2 = 1.9874e-005	$Variation of shift Svx/Fz with load
RBX1 = 5.9945	$Slope factor for combined slip Fx reduction
RBX2 = -8.2609	$Variation of slope Fx reduction with kappa
RCX1 = 1.07816	$Shape factor for combined slip Fx reduction
REX1 = 1.644	$Curvature factor of combined Fx
REX2 = -0.0064359	$Curvature factor of combined Fx with load
RHX1 = 0.008847	$Shift factor for combined slip Fx reduction
PTX1 = 1.85	$Relaxation length SigKap0/Fz at Fznom
PTX2 = 0.000109	$Variation of SigKap0/Fz with load
PTX3 = 0.101	$Variation of SigKap0/Fz with exponent of load

[OVERTURNING_COEFFICIENTS]	
QSX1 = 0	$Lateral force induced overturning moment
QSX2 = 0	$Camber induced overturning couple
QSX3 = 0	$Fy induced overturning couple
[LATERAL_COEFFICIENTS]	
PCY1 = 1.3223	$Shape factor Cfy for lateral forces
PDY1 = 1.0141	$Lateral friction Muy
PDY2 = -0.12274	$Variation of friction Muy with load
PDY3 = -1.0426	$Variation of friction Muy with squared camber
PEY1 = -0.63772	$Lateral curvature Efy at Fznom
PEY2 = -0.050782	$Variation of curvature Efy with load
PEY3 = -0.27333	$Zero order camber dependency of curvature Efy
PEY4 = -8.3143	$Variation of curvature Efy with camber
PKY1 = -19.797	$Maximum value of stiffness Kfy/Fznom
PKY2 = 1.7999	$Load at which Kfy reaches maximum value
PKY3 = 0.0095418	$Variation of Kfy/Fznom with camber
PHY1 = 0.0011453	$Horizontal shift Shy at Fznom
PHY2 = -6.6688e-005	$Variation of shift Shy with load
PHY3 = 0.044112	$Variation of shift Shy with camber
PVY1 = 0.031305	$Vertical shift in Svy/Fz at Fznom
PVY2 = -0.0085749	$Variation of shift Svy/Fz with load
PVY3 = -0.092912	$Variation of shift Svy/Fz with camber
PVY4 = -0.27907	$Variation of shift Svy/Fz with camber + load
RBY1 = 6.2238	$Slope factor for combined Fy reduction
RBY2 = 3.0734	$Variation of slope Fy reduction with alpha
RBY3 = 0.016076	$Shift term for alpha in slope Fy reduction
RCY1 = 1.0051	$Shape factor for combined Fy reduction
REY1 = 0.019749	$Curvature factor of combined Fy
REY2 = -0.0020691	$Curvature factor of combined Fy with load
RHY1 = -0.0010319	$Shift factor for combined Fy reduction
RHY2 = 7.4123e-006	$Shift factor for combined Fy red. w. load
RVY1 = 0.02962	$Kappa induced side force Svyk/Muy*Fz at Fznom
RVY2 = -0.011053	$Variation of Svyk/Muy*Fz with load
RVY3 = -0.0009317	$Variation of Svyk/Muy*Fz with camber
RVY4 = 11.842	$Variation of Svyk/Muy*Fz with alpha
RVY5 = 1.9	$Variation of Svyk/Muy*Fz with kappa
RVY6 = 0	$Variation of Svyk/Muy*Fz with atan(kappa)
PTY1 = 1.9	$Peak value of relaxation length SigAlp0/R0
PTY2 = 2.25	$Value of Fz/Fznom where SigAlp0 is extreme
[ROLLING_COEFFICIENTS]	
QSY1 = 0.01	$Rolling resistance torque coefficient

Continued on the next page...

[ROLLING_COEFFICIENTS]

QSY2 = 0	$Rolling resistance torque depending on Fx
QSY3 = 0	$Rolling resistance torque depending on speed
QSY4 = 0	$Rolling resistance torque depending on speed

[ALIGNING_COEFFICIENTS]

QBZ1 = 7.5088	$Trail slope factor for trail Bpt at Fznom
QBZ2 = -1.9428	$Variation of slope Bpt with load
QBZ3 = 0.61681	$Variation of slope Bpt with load squared
QBZ4 = 0.12231	$Variation of slope Bpt with camber
QBZ5 = 0.50016	$Variation of slope Bpt with absolute camber
QBZ9 = 5.5144	$Slope factor Br of residual torque Mzr
QBZ10 = 0	$Slope factor Br of residual torque Mzr
QCZ1 = 1.2237	$Shape factor Cpt for pneumatic trail
QDZ1 = 0.062582	$Peak trail
QDZ2 = 0.00052585	$Variation of peak Dpt" with load
QDZ3 = -0.60661	$Variation of peak Dpt" with camber
QDZ4 = 8.634	$Variation of peak Dpt" with camber squared
QDZ6 = -0.0048467	$Peak residual torque
QDZ7 = 0.0034983	$Variation of peak factor Dmr" with load
QDZ8 = -0.11032	$Variation of peak factor Dmr" with camber
QDZ9 = 0.021277	$Variation of peak factor Dmr" w. camber+load
QEZ1 = -5.3971	$Trail curvature Ept at Fznom
QEZ2 = 1.1207	$Variation of curvature Ept with load
QEZ3 = 0	$Variation of curvature Ept with load squared
QEZ4 = 0.14942	$Variation of curvature Ept w. sign of Alpha-t
QEZ5 = -1.1429	$Variation of Ept with camber and sign Alpha-t
QHZ1 = -0.00069905	$Trail horizontal shift Sht at Fznom
QHZ2 = 0.0055192	$Variation of shift Sht with load
QHZ3 = 0.065953	$Variation of shift Sht with camber
QHZ4 = 0.11393	$Variation of shift Sht with camber and load
SSZ1 = 0.022576	$Nominal value of s/R0: effect of Fx on Mz
SSZ2 = 0.024754	$Variation of distance s/R0 with Fy/Fznom
SSZ3 = 0.0014697	$Variation of distance s/R0 with camber
SSZ4 = 0.0014801	$Variation of distance s/R0 with load+camber
QTZ1 = 0.2	$Gyration torque constant
MBELT = 4.9	$Belt mass of the wheel

Parameter	**Default Value** Explanation	**Unit**	**Class**
	[CDT10 STATIC PARAMETERS]		
LOGGING_LEVEL	**0**	-	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
	Set to 1 for verbose mode		
INFLATION_PRESSURE_REF	**0.25** Reference inflation pressure (can be overruled by advanced settings)	MPa	MBS STATIC
INCLINATION_ANGLE_REF	**0** Reference inclination angle (can be overruled by advanced settings)	rad	MBS STATIC
FZW_REF	**5000** Reference vertical (normal) load (can be overruled by advanced settings)	N	MBS STATIC
VERTICAL_STIFFNESS_UNLOADED_HEIGHT	**325** Minimal unloaded height (surface normal) for reference IP/IA	mm	MBS STATIC
VERTICAL_STIFFNESS	**250** Linear vertical stiffness for reference IP/IA	N/mm	MBS STATIC
VERTICAL_STIFFNESS_QUADFACTOR	**0.5** Quadratic vertical stiffness for reference IP/IA	N/mm^2	MBS STATIC
LONGITUDINAL_SLIP_ACTIVATE	**0** (De-)activates longitudinal slip during statics	-	MBS STATIC
LONGITUDINAL_SLIP_KAPPA_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	-	MBS STATIC
LONGITUDINAL_SLIP_STIFFNESS	**$2e^{+5}$** Slip stiffness for reference IP/IA/FZW	N/1	MBS STATIC
LONGITUDINAL_STIFFNESS_ACTIVATE	**0** (De-)activates longitudinal stiffness during statics	-	MBS STATIC
LONGITUDINAL_STIFFNESS	**400** Static stiffness for reference IP/IA/FZW	N/mm	MBS STATIC
LATERAL_SLIP_ACTIVATE	**0** (De-)activates lateral slip during statics	-	MBS STATIC
LATERAL_SLIP_CORNERING_SLIPANGLE_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	rad	MBS STATIC
LATERAL_SLIP_CORNERING_STIFFNESS	**$1e^{+5}$**	N/rad	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
	Slip stiffness for reference IP/IA/FZW		
LATERAL_SLIP_ALIGNING_TORQUE_SLIPANGLE_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	rad	MBS STATIC
LATERAL_SLIP_ALIGNING_TORQUE_STIFFNESS	**5000** Slip stiffness for reference IP/IA/FZW	Nmm/rad	MBS STATIC
LATERAL_STIFFNESS_ACTIVATE	**0** (De-)activates lateral stiffness during statics	-	MBS STATIC
LATERAL_STIFFNESS	**200** Static stiffness for reference IP/IA/FZW	N/mm	MBS STATIC
VERTICAL_STIFFNESS_INFLATION_PRESSURE_REF	**0.25** Optional reference inflation pressure for VERTICAL_STIFFNESS derivatives dIP	MPa	MBS STATIC
VERTICAL_STIFFNESS_INCLINATION_ANGLE_REF	**0** Optional reference inclination angle for VERTICAL_STIFFNESS derivatives dIA	rad	MBS STATIC
VERTICAL_STIFFNESS_UNLOADED_HEIGHT_dIP_dIA	**[0,0]** First derivatives at reference IP/IA	[mm^3/N, mm/rad]	MBS STATIC
VERTICAL_STIFFNESS_dIP_dIA	**[0,0]** First derivatives at reference IP/IA	[mm, N/(mm rad)]	MBS STATIC
VERTICAL_STIFFNESS_QUADFACTOR_dIP_dIA	**[0,0]** First derivatives at reference IP/IA	[1, $N/(mm^2$ rad)]	MBS STATIC
VERTICAL_STIFFNESS_UNLOADED_HEIGHT dIP2_dIPdIA_dIA2_HALF	**[0,0,0]** One half of second derivatives at reference IP/IA	[mm^5/N^2, $mm^3/(N$ rad), mm/rad^2]	MBS STATIC
VERTICAL_STIFFNESS dIP2_dIPdIA_dIA2_HALF	**[0,0,0]** One half of second derivatives at reference IP/IA	[mm^3/N, mm/rad, $N/(mm\ rad^2)$]	MBS STATIC
VERTICAL_STIFFNESS_QUADFACTOR dIP2_dIPdIA_dIA2_HALF	**[0,0,0]** One half of second derivatives at reference IP/IA	[mm^2/N, 1/rad, $N/(mm^2\ rad^2)$]	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
LONGITUDINAL_SLIP _INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC
	Optional reference inflation pressure for LONGITUDINAL_SLIP derivatives dIP		
LONGITUDINAL_SLIP _INCLINATION_ANGLE_REF	**0**	MPa	MBS STATIC
	Optional reference inclination angle for LONGITUDINAL_SLIP derivatives dIA		
LONGITUDINAL_SLIP _FZW_REF	**5000**	MPa	MBS STATIC
	Optional reference vertical (normal) load for LONGITUDINAL_SLIP derivatives dFZW		
LONGITUDINAL_SLIP _KAPPA_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2/N, 1/rad, 1/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LONGITUDINAL_SLIP _STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^2, N/rad, 1]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LONGITUDINAL_ STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm, N/(mm rad), 1/mm]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC
	Optional reference inflation pressure for LATERAL_SLIP derivatives dIP		
LATERAL_SLIP _INFLATION_PRESSURE_REF	**0**	rad	MBS STATIC
	Optional reference inflation pressure for LATERAL_SLIP derivatives dIA		
LATERAL_SLIP _FZW_REF	**5000**	N	MBS STATIC
	Optional reference inflation pressure for LATERAL_SLIP derivatives dFZW		
LATERAL_SLIP _CORNERING_SLIPANGLE_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2 rad/N, 1, rad/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		

Parameter	Default Value Explanation	Unit	Class
LATERAL_SLIP _CORNERING_STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^2/rad, N/rad^2, 1/rad]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _ALIGNING_TORQUE_SLIPANGLE_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2 rad/N, 1, rad/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _ALIGNING_TORQUE_STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^3/rad, Nmm/rad^2, mm/rad]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_STIFFNESS _dIP_dIA_dFZW	**[0,0,0]**	[mm, Nmm/rad, 1/mm]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
WHEELCENTER_STIFFNESS _ACTIVATE	**0**	-	MBS STATIC
	(De-)activates wheel center stiffnesses during statics		
WHEELCENTER_STIFFNESS _INPLANE_TRANSLATIONAL	**400**	N/mm	MBS STATIC
	Derived (can be overuled if specified) stiffness		
WHEELCENTER_STIFFNESS _OUTPLANE_TRANSLATIONAL	**200**	N/mm	MBS STATIC
	Derived (can be overuled if specified) stiffness		
WHEELCENTER_STIFFNESS _OUTPLANE_ROTATIONAL	**2e**$^{+7}$	Nmm/rad	MBS STATIC
	Derived (can be overuled if specified) stiffness		
WHEELCENTER_STIFFNESS _INPLANE_ROTATIONAL	**5e**$^{+7}$	Nmm/rad	MBS STATIC
	Derived (can be overuled if specified) stiffness		

6 Tire Parameter File - CDTire/Realtime

The following listing shows the input file structure for the tire model *CDTire/Realtime*. For a comprehensive list of the respective parameters of each block, look into the appended table and the example parameter files from the installation.

The unit system is fixed to [N, mm, s, t] (Newton, millimeter second, ton). The parameters are keyword based and reside in respective sections. The two mandatory sections are:

- [CDT30-HPS MODEL PARAMETERS] contains all geometric, discretization, material and other physical modelling parameters
- [CDT30-HPS SOLVER PARAMETERS] contains all numerical parameters of the internal integrator

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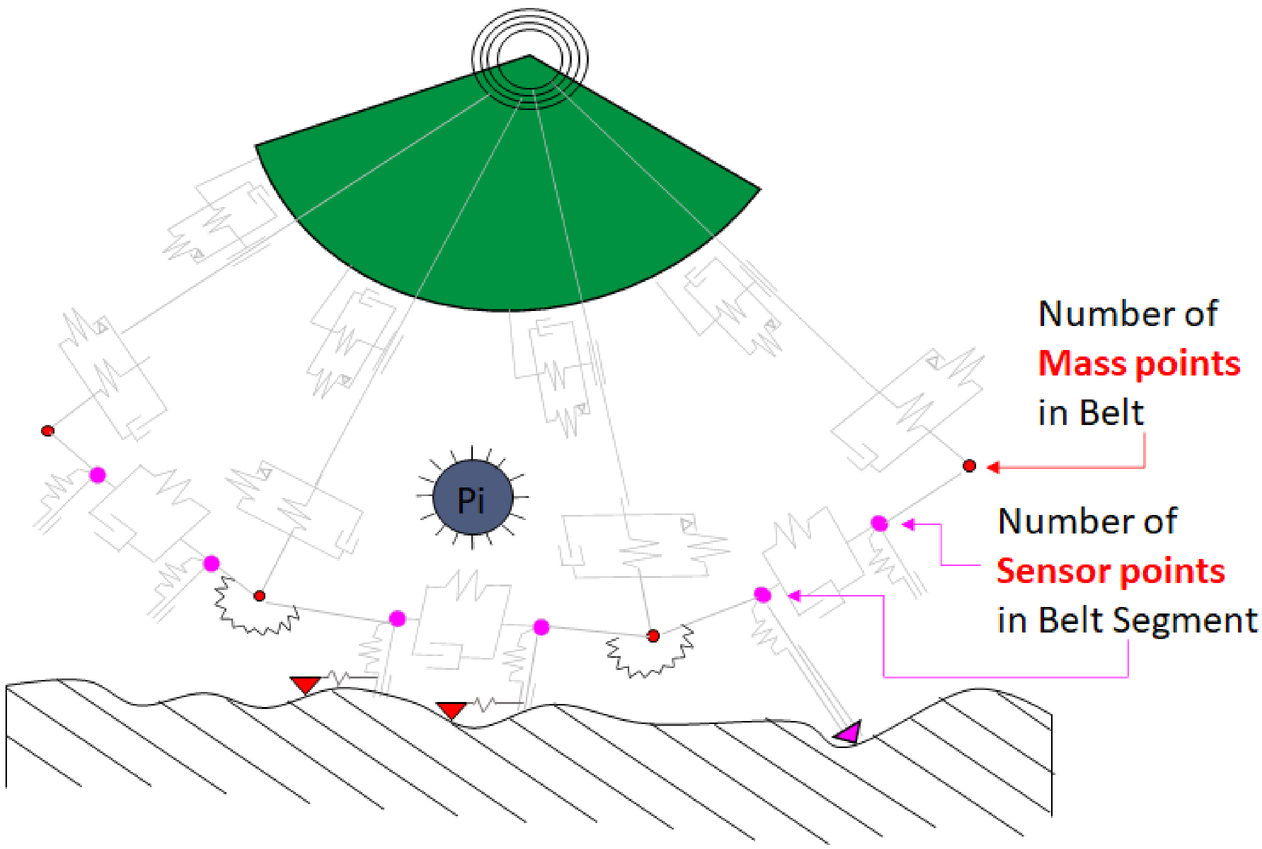
Remark: You may edit some parameters to suit your requirements. These parameters are colored blue in the listing above and an according remark is given in the following table. The parameters colored in orange are optional and (if used) change model behavior or introduce new functionality.

Parameter	Default Value Explanation	Unit	Class
[CDT30-HPS MODEL PARAMETERS]			
CDTIRE_VERSION_USED	**2021.1.0** Version of CDTire used to perform the simulation	-	VERSION
PIN	**0.25** Actual inflation pressure (maybe overruled by interface mechanism)	MPa	PRESSURE
PREF	**0.25** Reference inflation pressure	MPa	PRESSURE
PIN_FLAG	**0** Toggle pressure-dependency of sidewall	-	PRESSURE
NMP	**50**	-	PRESSURE

Parameter	Default Value Explanation	Unit	Class
	Number of mass points in belt. In case of an adjustment of this value: the distance between two mass points (2 pi R_BELT/NMP) must be around half of the fundamental wavelength of the surface, e.g. for a 20x20 obstacle it is 20mm		



Parameter	Default Value Explanation	Unit	Class
	GEOMETRY		
R_BELT	**300** Radius of the belt (inflated)	mm	GEOMETRY
R_RIM	**200** Radius of the rim	mm	GEOMETRY
W_BELT	**150** Effective width of the belt	mm	GEOMETRY
	MASS		
MASS_BELT	**0.00500** Mass of belt and tread	t	MASS
MASS_SIDEWALL	**0.00125**	t	MASS

Parameter	Default Value Explanation	Unit	Class
	Mass of one sidewall		
MASS_ADD_TO_RIM	**0.001** Used for MBD_MASS_ADD_TO_RIM and MBD_MASS_SUB_FROM_WHEEL calculation; does not affect tire simulation; This parameters give an advice how to update mass and inertia of the rim body	t	MASS
IXX_ADD_TO_RIM	**100** Same for MBD_IXX__xxx calculation	tmm^2	MASS
IYY_ADD_TO_RIM	**200** Same for MBD_IYY__xxx calculation	tmm^2	MASS
IZZ_ADD_TO_RIM	**100** Same for MBD_IZZ__xxx calculation	tmm^2	MASS
	SIDEWALL		
FTX	**75** Natural frequency: Translation in x/z-direction (mode R1)	Hz	SIDEWALL
FTY	**75** Natural frequency: Translation in y-direction (mode L_0))	Hz	SIDEWALL
FRY	**75** Natural frequency: rotation around y axis (mode C_0)	Hz	SIDEWALL
DTX	**0.08** Damping coefficient (mode R_0)	-	SIDEWALL
DTY	**0.08** Damping coefficient (mode L_0)	-	SIDEWALL
DRY	**0.08** Damping coefficient (mode C_0)	-	SIDEWALL
RAD_NL_MOD	**0.08** Stiffness influence factor radial	-	SIDEWALL
RAD_PRESTRAIN_RED_FACTOR	**0.2** Prestrain impact factor	-	SIDEWALL
	ADVANCED		
CRY_RED_FLAG	**1** Activates reduction of circumferential rotational sidewall stiffness for large deflections	Hz	ADVANCED
CRY_RED_DEF	**0**	Hz	ADVANCED

Parameter	Default Value Explanation	Unit	Class
	Deflection at which reduction of circumferential rotational sidewall stiffness starts		
CRY_RED_RES	**1** Residual stiffness factor of circumferential rotational sidewall stiffness at full deflection	Hz	ADVANCED
CRX_RED_FLAG	**1** Activates reduction of lateral rotational sidewall stiffness for large deflections	-	ADVANCED
CRX_RED_DEF	**1** Deflection at which reduction of lateral rotational sidewall stiffness starts	mm	ADVANCED
CRX_RED_RES	**1** Residual stiffness factor of lateral rotational sidewall stiffness at full deflection	-	ADVANCED
ADVANCED	**[20,3,40,1]** Scale rubber shear damping as function of absolute rotational velocity via [ω_0, s_0, ω_1, s_1], linear interpolation and constant extrapolation	[rad/s, -,rad/s, -]	ADVANCED
MU_CORRECT_CAMBER_ EFFECT_SCALE	**5** Scale factor for the friction of the physical camber effect present in the tire	-	ADVANCED
CORRECT_WEIGHT_TO_ NOMINAL_FLAG	**0** Mimic nominal tire weight	-	ADVANCED
LATSCH_SYSTEM_FLAG	**3** Selection of the LATSCH coordinate system	-	ADVANCED
	BELT		
CIRC_STIFF	**3.0e^{+6}** Tensile stiffness of belt in circumferential direction	N	BELT
CIRC_STIFF_COMPRES SION_FACTOR	**0** Optional tensile stiffness factor under compression condition of tensile belt stiffness CIRC_STIFF	-	BELT
CIRC_DAMP	**1.0e^{-5}** Damping factor of belt tensile stiffness	1/s	BELT
RAD_PRESTRAIN_RED_ FACTOR	**1** Optional scaling of inflation pre-strain distribution in radial direction of sidewall model	-	BELT

Parameter	Default Value Explanation	Unit	Class
Y_BENDING_STIFF	**3.0e^{+6}** Bending stiffness of the belt (around lateral axis)	Nmm^2	BELT
Y_BENDING_DAMP	**1.0e^{-5}** Damping factor of belt bending stiffness	1/s	BELT
MX_CORRECTION_SCALE	**1** Switch for the improvment of overturning torque (Tx) response of the model, 0=off, 1 = on.	-	BELT
MX_CORRECTION_SCALE_ADVANCED	**[0 1.3 4000 1.3 9000 0.6]** Optional load dependet scale for the improvment of overturning torque (Tx), scale factor is decreasing typically with increasing load. Specify as [f1,s1,...,fN,sN] , where f1, ... fN are the preloads and s1,...,sN are the respective scaling factors.Interpolation is linear and extrapolation is constant.	-	BELT
	TREAD		
TREAD_NSEN_X	**5** Number of circumferential sensor points in belt segment	-	TREAD
TREAD_HEIGHT	**10** Height of tread	mm	TREAD
TREAD_SCAN_HEIGHT	**150** Height above ideal contact point on surface within where contact sensors are active	mm	TREAD
TREAD_MAX_COMPRESS	**0.95** Maximum relative compression of tread before a warning is issued	-	TREAD
TREAD_RAD_D	**0.0005** Damping factor of radial tread stiffness	1/s	TREAD
TREAD_RAD_D_DEGRESSION_FACTOR	**1** Radial tread damping residual factor (active above degression velocity)	-	TREAD
TREAD_RAD_D_DEGRESSION_VEL	**0** Radial tread damping degression velocity	mm/s	TREAD
TREAD_TAN_D	**0** Tangential tread damping factor	1/s	TREAD
TREAD_TAN_D_DEGRESSION_FACTOR	**1**	-	TREAD

Parameter	Default Value Explanation	Unit	Class
	Tangential tread damping residual factor (active above degression velocity)		
TREAD_TAN_D_DEGRESSION_VEL	**0** Tangential tread damping degression velocity	mm/s	TREAD
TREAD_EG	**120** Young's modulus of the tread rubber times tread width per circumferential unit length	Nmm^2	TREAD
TREAD_GG_X	**40** Shear modulus of the tread rubber times tread width per circumferential unit length in circumferential direction	Nmm^2	TREAD
TREAD_GG_Y	**40** Shear modulus of the tread rubber times tread width per circumferential unit length in lateral direction	Nmm^2	TREAD
KSRED_FACTOR	**-80** Stiffness influence factor lateral	-	TREAD
KSRED_ADVANCED	**[-100,1]** Optional lookup table for scaling of KSRED as function of preload via [F_0, S_0, ..., F_N, S_N] with linear interpolation and constant extrapolation	[N, -, ...]	TREAD
PNEUMATIC_TRAIL_SCALE	**2** Optional scaling of the pneumatic trail	-	TREAD
PNEUMATIC_TRAIL_SCALE_ADVANCED	**[-100,1]** Optional lookup table for scaling of PNEUMATIC_TRAIL_SCALE as function of preload via [F_0, S_0, ..., F_N, S_N] with linear interpolation and constant extrapolation	[N, -, ...]	TREAD
	FRICTION		
MU	[$\overrightarrow{\textbf{Vector}}$] Relative friction coefficient: e.g. [1.2, 1.2, 1.0]	-	FRICTION
V_MU	[$\overrightarrow{\textbf{Vector}}$] Corresponding sliding velocity for MU e.g. [0.0, 1000, 10000]	mm/s	FRICTION
MU_GLOBAL_SCALEFACTOR	**1** Optional global scaling factor of friction	-	FRICTION
MU_X_SCALEFACTOR	**1** Optional longitudinal scaling factor of friction	-	FRICTION
MU_PRELOAD_DEPENDENCY	**[3000,0.2, 0.7,1.3]**	[N, -, -, -]	FRICTION

Parameter	Default Value Explanation	Unit	Class
	Optional preload dependent scaling of friction M from [F_{REF}, S, M_{MIN}, M_{MAX}] via M = 1 – S * (F / F_REF - 1)		
MU_ADVANCED	**[20,3,40,1]** Optional scaling of friction coefficient as function of rotational velocity via [ω_0, μ_0, ω_1, μ_1], linear interpolation and constant extrapolation	[rad/s, -,rad/s, -]	FRICTION
	LDE		
LDE_FLAG	**0** Activates LDE (Large Deformation Element) calculation for tire ground out (bottoming): 0 = OFF, 1 = LDE Type 1, 2 = LDE Type 2 (currently not supported for CDT30-HPS)	-	LDE
LDE_CNL	**20** LDE_FLAG=1 ; Radial stiffness of non-linear part per circumferential unit length	Nmm^2	LDE
LDE_CLIN	**80** LDE_FLAG=1 ; Radial stiffness of linear part per circumferential unit length	Nmm^2	LDE
LDE_RNL	**20** LDE_FLAG=1 ; Radius from rim at which non-linear part becomes active (must be > LDE_RLIN)	mm	LDE
LDE_RLIN	**10** LDE_FLAG=1 ; Radius from rim at which linear part becomes active	mm	LDE
	STATIC		
R_EFF	**300** Effective rolling radius used for postprocessing	mm	STATIC
R_STAT	**300** Radius of undeformed tire under inflation	mm	STATIC
CR1_STAT	**250** Global linear radial tire stiffness used for static	N/mm	STATIC
	[CDT30-HPS SOLVER PARAMETERS]		
TOL	**$1.0E^{-4}$** Error tolerance of internal integrator	-	SOLVER
TOL_EXCEPTION	**0.01**	-	SOLVER

Parameter	Default Value Explanation	Unit	Class
	Error tolerance of internal integrator in case of failed convergence		
DTM	**5.0E^{-5}** Maximum step size of internal integrator	s	SOLVER
DTMIN	**1.0E^{-10}** Minimum step size of internal integrator	s	SOLVER
DT_START_EXPL	**5.0E^{-5}** Initial step size of internal explicit integrator	s	SOLVER
PRE_STEP_TIME	**0.05** Duration of inflation pre-step before beginning of simulation	s	SOLVER
PRE_STEP_DEFLTIME	**0.05** Duration of deflection pre-step before beginning of simulation (adjusted automatically)	s	SOLVER
PRE_STEP_SAFETY_MARGIN	**10** Minimal clearance (from rim point) for legal initial deflection	mm	SOLVER
PRE_STEP_LDE_MARGIN	**10** Minimal clearance (from rim point) for legal initial deflection	mm	SOLVER
FORCE_NOSUCCESS	**1.0e^{+10}** Returned force value in case of no convergence	N	SOLVER
TYPE	**1** 1 = Explicit, 2 = Implicit	-	SOLVER
ALPHA_EXPLICIT	**0** Explicit NEWMARK alpha integrator value	-	SOLVER
BETA_EXPLICIT	**0.166667** Explicit NEWMARK beta integrator value	-	SOLVER
GAMMA_EXPLICIT	**30.5** Explicit NEWMARK gamma integrator value	-	SOLVER
ALPHA_IMPLICIT	**0** Implicit NEWMARK alpha integrator value	-	SOLVER
BETA_ IMPLICIT	**0.25** Implicit NEWMARK beta integrator value	-	SOLVER
GAMMA_ IMPLICIT	**0.5** Implicit NEWMARK gamma integrator value	-	SOLVER
NMAX_IMPL_ITER	**3** Maximum number of iteration for the implicit integrator	-	SOLVER
IMPL_STEP_CTRL_ENABLE	**1** Toggle internal step size control of implicit integrator: 0 = OFF, 1 = ON	-	SOLVER
IMPL_STEP_CTRL_EPS	**200**	-	SOLVER

Parameter	Default Value Explanation	Unit	Class
	Percentage of error tolerance TOL used to activate step size control		
IMPL_STEP_CTRL_NSUBSTEPS	**3**	-	SOLVER
	Subdivision of steps if step size reduction is activated for implicit integrator		
IMPL_JAC_EVAL_AT_ITER	**0**	-	SOLVER
	Toggle update of JACOBIAN calculation during iteration for implicit integrator: 0 = OFF, 1 = ON		
UPDATE_FOR_MASTER CORRECTOR	**0**	-	SOLVER
	Toggle corrector or Newton iterations to be taken into account: 0 = OFF, 1= ON		
	[CDT30-HPS STATIC PARAMETERS]		
LOGGING_LEVEL	**0**	-	MBS STATIC
	Set to 1 for verbose mode		
INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC
	Reference inflation pressure (can be overruled by advanced settings)		
INCLINATION_ANGLE_REF	**0**	rad	MBS STATIC
	Reference inclination angle (can be overruled by advanced settings)		
FZW_REF	**5000**	N	MBS STATIC
	Reference vertical (normal) load (can be overruled by advanced settings)		
VERTICAL_STIFFNESS_UNLOADED_HEIGHT	**325**	mm	MBS STATIC
	Minimal unloaded height (surface normal) for reference IP/IA		
VERTICAL_STIFFNESS	**250**	N/mm	MBS STATIC
	Linear vertical stiffness for reference IP/IA		
VERTICAL_STIFFNESS_QUADFACTOR	**0.5**	N/mm^2	MBS STATIC
	Quadratic vertical stiffness for reference IP/IA		
LONGITUDINAL_SLIP_ACTIVATE	**0**	-	MBS STATIC
	(De-)activates longitudinal slip during statics		
LONGITUDINAL_SLIP_KAPPA_SHIFT	**0**	-	MBS STATIC
	Shift (offset) for reference IP/IA/FZW		

Parameter	Default Value Explanation	Unit	Class
LONGITUDINAL_SLIP_STIFFNESS	**2e^{+5}** Slip stiffness for reference IP/IA/FZW	N/1	MBS STATIC
LONGITUDINAL_STIFFNESS_ACTIVATE	**0** (De-)activates longitudinal stiffness during statics	-	MBS STATIC
LONGITUDINAL_STIFFNESS	**400** Static stiffness for reference IP/IA/FZW	N/mm	MBS STATIC
LATERAL_SLIP_ACTIVATE	**0** (De-)activates lateral slip during statics	-	MBS STATIC
LATERAL_SLIP_CORNERING_SLIPANGLE_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	rad	MBS STATIC
LATERAL_SLIP_CORNERING_STIFFNESS	**1e^{+5}** Slip stiffness for reference IP/IA/FZW	N/rad	MBS STATIC
LATERAL_SLIP_ALIGNING_TORQUE_SLIPANGLE_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	rad	MBS STATIC
LATERAL_SLIP_ALIGNING_TORQUE_STIFFNESS	**5000** Slip stiffness for reference IP/IA/FZW	Nmm/rad	MBS STATIC
LATERAL_STIFFNESS_ACTIVATE	**0** (De-)activates lateral stiffness during statics	-	MBS STATIC
LATERAL_STIFFNESS	**200** Static stiffness for reference IP/IA/FZW	N/mm	MBS STATIC
VERTICAL_STIFFNESS_INFLATION_PRESSURE_REF	**0.25** Optional reference inflation pressure for VERTICAL_STIFFNESS derivatives dIP	MPa	MBS STATIC
VERTICAL_STIFFNESS_INCLINATION_ANGLE_REF	**0** Optional reference inclination angle for VERTICAL_STIFFNESS derivatives dIA	rad	MBS STATIC
VERTICAL_STIFFNESS_UNLOADED_HEIGHT_dIP_dIA	**[0,0]** First derivatives at reference IP/IA	[mm^3/N, mm/rad]	MBS STATIC
VERTICAL_STIFFNESS_dIP_dIA	**[0,0]**	[mm, N/(mm rad)]	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
	First derivatives at reference IP/IA		
VERTICAL_STIFFNESS _QUADFACTOR_dIP_dIA	**[0,0]**	[1, N/(mm^2 rad)]	MBS STATIC
	First derivatives at reference IP/IA		
VERTICAL_STIFFNESS _UNLOADED_HEIGHT dIP2_dIPdIA_dIA2_HALF	**[0,0,0]**	[mm^5/N^2, mm^3/(N rad), mm/rad^2]	MBS STATIC
	One half of second derivatives at reference IP/IA		
VERTICAL_STIFFNESS dIP2_dIPdIA_dIA2_HALF	**[0,0,0]**	[mm^3/N, mm/rad, N/(mm rad^2)]	MBS STATIC
	One half of second derivatives at reference IP/IA		
VERTICAL_STIFFNESS _QUADFACTOR dIP2_dIPdIA_dIA2_HALF	**[0,0,0]**	[mm^2/N, 1/rad, N/(mm^2 rad^2)]	MBS STATIC
	One half of second derivatives at reference IP/IA		
LONGITUDINAL_SLIP _INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC
	Optional reference inflation pressure for LONGITUDINAL_SLIP derivatives dIP		
LONGITUDINAL_SLIP _INCLINATION_ANGLE_REF	**0**	MPa	MBS STATIC
	Optional reference inclination angle for LONGITUDINAL_SLIP derivatives dIA		
LONGITUDINAL_SLIP _FZW_REF	**5000**	MPa	MBS STATIC
	Optional reference vertical (normal) load for LONGITUDINAL_SLIP derivatives dFZW		
LONGITUDINAL_SLIP _KAPPA_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2/N, 1/rad, 1/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LONGITUDINAL_SLIP _STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^2, N/rad, 1]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LONGITUDINAL_ STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm, N/(mm rad), 1/mm]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
	Optional reference inflation pressure for LATERAL_SLIP derivatives dIP		
LATERAL_SLIP _INFLATION_PRESSURE_REF	**0**	rad	MBS STATIC
	Optional reference inflation pressure for LATERAL_SLIP derivatives dIA		
LATERAL_SLIP _FZW_REF	**5000**	N	MBS STATIC
	Optional reference inflation pressure for LATERAL_SLIP derivatives dFZW		
LATERAL_SLIP _CORNERING_SLIPANGLE_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2 rad/N, 1, rad/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _CORNERING_STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^2/rad, N/rad^2, 1/rad]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _ALIGNING_TORQUE_SLIPANGLE_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2 rad/N, 1, rad/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _ALIGNING_TORQUE_STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^3/rad, Nmm/rad^2, mm/rad]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_STIFFNESS _dIP_dIA_dFZW	**[0,0,0]**	[mm, Nmm/rad, 1/mm]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
WHEELCENTER_STIFFNESS _ACTIVATE	**0**	-	MBS STATIC
	(De-)activates wheel center stiffnesses during statics		
WHEELCENTER_STIFFNESS _INPLANE_TRANSLATIONAL	**400**	N/mm	MBS STATIC
	Derived (can be overuled if specified) stiffness		
WHEELCENTER_STIFFNESS _OUTPLANE_TRANSLATIONAL	**200**	N/mm	MBS STATIC
	Derived (can be overuled if specified) stiffness		
WHEELCENTER_STIFFNESS _OUTPLANE_ROTATIONAL	**$2e^{+7}$**	Nmm/rad	MBS STATIC
	Derived (can be overuled if specified) stiffness		

Parameter	Default Value Explanation	Unit	Class
WHEELCENTER_STIFFNESS _INPLANE_ROTATIONAL	**5e**$^{+7}$	Nmm/rad	MBS STATIC
	Derived (can be overuled if specified) stiffness		

7

Tire Parameter File - CDTire/3D

The following listing shows the input file structure of the tire model *CDTire/3D*. For a comprehensive list of the respective parameters of each block, look into the appended table and the example parameter files from the installation.

The unit system is fixed to *N* (newton), *mm* (millimeter), *s* (second) and *t* (tons). The parameters are keyword based and reside in respective sections. The two mandatory sections are:

- [CDT50-N MODEL PARAMETERS] contains all geometric, discretization, material and other physical modelling parameters (except *SW_MODE=40* and cavity parameters)
- [CDT50-N SOLVER PARAMETERS] contains all numerical parameters of the internal integrator.

and seven optional sections:

- [CAVITY MODEL PARAMETERS] contains all CAVITY_MODEL_FLAG = 1 parameters for compressible Euler flow model
- [CDT40-N MODEL PARAMETERS] contains all SW_MODE = 40 parameters for analytical sidewall model
- [TIRE_AND_RIM_RESIZING] contains reference and target tire and rim specification for automatic resizing
- [FLEXRIM_S MODEL PARAMETERS] contains information for the interface to a static flexible rim.
- [CDT50-N ADVANCED OUTPUT PARAMETERS] contains advanced output options for post processing via CDTireViewer
- [WHEEL NOMINAL DATA] contains nominal tire radius, tire mass, aspect ratio, nominal width, tire inertia (I_{xx}, I_{yy} and I_{zz}) as well as nominal rim width and rim radius.
- [CDT50-N STATIC PARAMETERS] contains parameters of the static model used in MBS systems.

The parameters may contain one or two-dimensional arrays. A special emphasis in on the length of these arrays. There are three different types of entities utilizing arrays, that are explained in the following section:

Ring Entities (table length is *NR (= number of rings, see table below)*)
Ring entities are all entities that are associated with mass, geometry or circumferential pro-perties, e.g. MASS_W, CONTOUR_SHELL_Y or RUBBER_CIRC_EH_W.

Segment Entities (table length is NR-1)
Segment entities are all entities associated with lateral or diagonal properties, e.g. RUBBER_LAT_EH_W or

RUBBER_DIAG_EH_W.

Contact Entities

Contact entities can have two different sizes: Associated mass points (table length *NR-2*(NRSENSTART-1)* with linear interpolation for the sensors) or directly number of sensors (table length (*NR-2*(NRSENSTART-1)-1)*TREAD_NSEN_Y*). If *NRSENSTART* is not set, it defaults to NRSW+1.

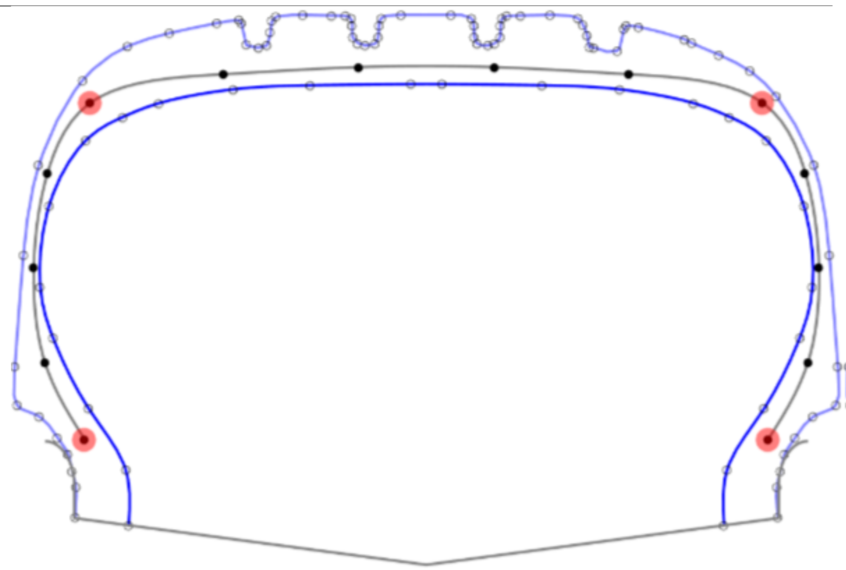
Additionally, many entities consist of a material property and an associated weight, e.g. *X_BENDING_STIFF and X_BENDING_STIFF_W*. The local property then is a multiplication of the material property with its associated weight. In that way, it is possible to easily modify one local property or all properties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

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.

Parameter	Default Value Explanation	Unit	Class
	[CDT50-N MODEL PARAMETERS]		
CDTIRE_VERSION_USED	**2023.1.0** Version of CDTire used to perform the simulation	-	VERSION
TIRE_TYPE	**10 (default)** Optional selection of the tire type of the given CDTire-Model: 10 –> Passenger Car Tires (default) 20 –> Light Truck Tires 30 –> Truck Tires (on Drop Center Rim) 31 –> Truck Tires 40 –> Agricultural Tires 50 –> Airplane Tires 60 –> Motorcycle Tires	-	DISCRETIZATION
PIN	**0.25** Actual inflation pressure (maybe overruled by interface mechanism)	MPa	INFLATION
ROLE	**-1** ROLE of the tire: LEFT –> -1 (default) RIGHT –> 1 ANY –> 0	-	DISCRETIZATION
SYMMETRIZE	**0** Switch, to either enforce a symmetric tire (SYMMETRIZE=1) or asymmetric tire (SYMMETRIZE=0)	-	DISCRETIZATION
NCS	**50**	-	DISCRETIZATION

Parameter	**Default Value** Explanation	**Unit**	**Class**
	Number of cross sections around the circumference		
NR	**14** Number of rings	-	DISCRETIZATION
NRSW	**4** Number of rings in either sidewall (including bead node)	-	DISCRETIZATION
NRSENSTART	**NRSW+1** Index of ring from where contact calculation starts. Only set to NRSW +1 if not specified. Typically equal to NRSW or NRSW -1 for applications with higher deflection.	-	DISCRETIZATION
SW_MODE	**50** Materialized sidewall (50) or analytical sidewall (40)	-	DISCRETIZATION
CONTOUR_SHELL_Y	[$\overrightarrow{\mathbf{Vector}}$] Lateral cross section coordinate of reference configuration, ring entity	mm	DISCRETIZATION
CONTOUR_SHELL_Z	[$\overrightarrow{\mathbf{Vector}}$] Radial cross section coordinate of reference configuration, ring entity	mm	DISCRETIZATION

Example of a discretized tire cross-section with inner and outer contour using 14 rings (NR) and 4 rings (NRSW) in the side-wall. The contact formulation start one ring after the sidewall, marked with a red mass point on either side.



MASS & INERTIA

MASS_SIDEWALL	**0.003** Mass of one sidewall (including bead)	mm	MASS & INERTIA
MASS_BELT	**0.006** Mass of the belt	t	MASS & INERTIA
MASS_BEAD	**0.001** Mass of one bead	t	MASS & INERTIA
MASS_W	[$\overrightarrow{\mathbf{Vector}}$]	t	MASS & INERTIA

Parameter	Default Value / Explanation	Unit	Class
	Weighting factors of mass distribution (vector of length of NR), ring entity		
MASS_ADD_TO_RIM	**0.001** Used for MBD_MASS_ADD_TO_RIM and MBD_MASS_SUB_FROM_WHEEL calculation; does not af-fect tire simulation	t	MASS & INERTIA
IXX_ADD_TO_RIM	**100** Same for MBD_IXX_xxx calculation	tmm^2	MASS & INERTIA
IYY_ADD_TO_RIM	**200** Same for MBD_IYY_xxx calculation	tmm^2	MASS & INERTIA
ZZ_ADD_TO_RIM	**100** Same for MBD_IZZ_xxx calculation	tmm^2	MASS & INERTIA
	RUBBER		
RUBBER_CIRC_EH	**40** Rubber stiffness in circumferential direction (think Young E * thickness H)	N/mm	RUBBER
RUBBER_LAT_EH	**40** Rubber stiffness in lateral direction (think Young E * thick-ness H)	N/mm	RUBBER
RUBBER_DIAG_EH	**10** Rubber stiffness in diagonal direction (think Young E * thick-ness H)	N/mm	RUBBER
RUBBER_SHEAR_GH	**10** Rubber shear stiffness (think shear modulus G * thick-ness H)	N/mm	RUBBER
RUBBER_XXX_DAMP	**0.0003** Corresponding damping factors, XXX either replaced by CIRC, LAT, DIAG or SHEAR	1/s	RUBBER
RUBBER_XXX_EH_W	[$\overrightarrow{\textbf{Vector}}$] Corresponding weighting factors, ring or segment entity, XXX either replaced by CIRC, LAT, DIAG or SHEAR	-	RUBBER
	CARCASS		
CARCASS_CORDLAYER_STIFF	**300** Carcass stiffness in cord angle direction (think YOUNGS Modulus E * thickness H)	N/mm	CARCASS
CARCASS_CORDLAYER_DAMP	$\mathbf{5e}^{-6}$ Carcass damping factor in cord angle direction	N/mm	CARCASS
CARCASS_CORDLAYER_ STIFF_W	[$\overrightarrow{\textbf{Vector}}$]	-	CARCASS

Parameter	Default Value Explanation	Unit	Class
	Carcass stiffness weighting factors, segment entity		
CARCASS_CORDLAYER_L0_ REDFACTOR	[$\overrightarrow{\mathbf{Vector}}$]	-	CARCASS
	Carcass zero length factor relative to reference configuration, segment entity		
CARCASS_CORDLAYER_STIFF _COMPRESSION_FACTOR	**0**	-	CARCASS
	Carcass stiffness factor under compression condition, direct multiplication		
	BANDAGE		
BANDAGE_CORDLAYER_STIFF	**1000**	N/mm	BANDAGE
	Bandage stiffness in cord angle direction (think Young E * thickness H)		
BANDAGE_CORDLAYER_DAMP	$\mathbf{5e}^{-6}$	N/mm	BANDAGE
	Bandage damping factor in cord angle direction		
BANDAGE_CORDLAYER_ STIFF_W	[$\overrightarrow{\mathbf{Vector}}$]	-	BANDAGE
	Bandage stiffness weight factors, ring entity		
BANDAGE_CORDLAYER_L0_ REDFACTOR	[$\overrightarrow{\mathbf{Vector}}$]	-	BANDAGE
	Bandage zero length factor relative to reference configuration, ring entity		
BANDAGE_CORDLAYER_STIFF _COMPRESSION_FACTOR	**0**	-	BANDAGE
	Bandage stiffness factor under compression condition, direct multiplication		
	STEEL CORD		
NUMB_STEEL_CORDLAYERS	**2**	-	STEEL CORD
	Number of steel cord layers		
STEEL_CORDLAYER_ANGLE	**[25,-25]**	deg	STEEL CORD
	Angle of steel cord layers against circumferential Direction, vector with as many columns as NUMB_STEEL_CORDLAYERS		
STEEL_CORDLAYER_STIFF	**[5000,5000]**	N/mm	STEEL CORD
	Cordlayer stiffness in cord angle direction (think Young E * thickness H), vector with as many columns as NUMB_STEEL_CORDLAYERS		
STEEL_CORDLAYER_DAMP	[$\mathbf{5e}^{-6}$, $\mathbf{5e}^{-6}$]	1/s	STEEL CORD

Parameter	Default Value Explanation	Unit	Class
	Cordlayer damping factor in cord angle direction, vector with as many columns as NUMB_STEEL_CORDLAYERS		
STEEL_CORDLAYER_STIFF_COMPRESSION_FACTOR	**0.2**	-	STEEL CORD
	Cordlayer stiffness factor under compression condition, direct multiplication		
STEEL_CORDLAYER_L0_REDFACTOR	[0.998,0.998]	-	STEEL CORD
	Cordlayer zero length factor relative to reference Configuration, vector with as many columns as NUMB_STEEL_CORDLAYERS		
NUMB_DISCRETE_STRIPES_IN_STEEL_CORDLAYER	**2**	-	STEEL CORD
	Number of discrete stripes in steel cord layer		
	CROSSPLY		
NUMB_CARCASS_CROSSPLY_CORDLAYERS	**0**	-	CROSSPLY
	Number of carcass cross ply layers, (optional), per default deactivated to enhance computational performance if no crossply layer has been modeled.		
CARCASS_CROSSPLY_CORDLAYERS_STIFF_COMPRESSION_FACTOR	**0.2**	-	CROSSPLY
	Global crossply stiffness factor under compression condition, direct multiplication. Active for every crossply layer if not set non individual corssply compression factor is set.		
CARCASS_CROSSPLY_CORDLAYERS_ANGLE___1	**88**	deg	CROSSPLY
	Crossply cord angle from circumferential direction for cross ply layer. Must be given explicitly for each layer _1 to _N		
CARCASS_CROSSPLY_CORDLAYERS_STIFF___1	**500**	N/mm	CROSSPLY
	Crossply stiffness in cord angle direction (think Young E * thickness H). Must be given explicitly for each layer _1 to _N		
CARCASS_CROSSPLY_CORDLAYERS_DAMP___1	$\mathbf{5e^{-6}}$	1/s	CROSSPLY

Parameter	Default Value Explanation	Unit	Class
	Crossply damping factor in cord angle direction. Must be given explicitly for each layer _1 to _N		
CARCASS_CROSSPLY_ CORDLAYERS_STIFF_W___1	[$\overrightarrow{\mathbf{Vector}}$]	-	CROSSPLY
	Local crossply stiffness factor in cord angle direction (think Young E * thickness H). Must be given explicitly for each layer _1 to _N		
CARCASS_CROSSPLY_ CORDLAYERS_L0_ REDFACTOR___1	[$\overrightarrow{\mathbf{Vector}}$]	-	CROSSPLY
	Local crossply zero length factor relative to reference configuration. Must be given explicitly for each layer _1 to _N		
CARCASS_CROSSPLY_ CORDLAYERS_STIFF_ COMPRESSION_FACTOR___1	**0.2**	-	CROSSPLY
	Crossply stiffness factor under compression condition, direct multiplication.		
	BENDING		
X_BENDING_STIFF	**6000**	Nmm	BENDING
	Bending stiffness in lateral direction (think YOUNGS Modulus E * thickness $H^3/12$)		
X_BENDING_DAMP	**0.0005**	1/s	BENDING
	Bending damping factor in lateral direction		
X_BENDING_STIFF_W	[$\overrightarrow{\mathbf{Vector}}$]	-	BENDING
	Bending stiffness weighting factors in lateral direction, ring entity		
X_BENDING_ALPHANL	**0**	rad	BENDING
	Angle where non-linear progression starts (it ends at angle 0)		
X_BENDING_EXPNL	**1**	-	BENDING
	Exponent of non-linear progression (c * (x-x0)^{Y}_BENDING_EXPNL))		
X_BENDING_PREANGLE	[$\overrightarrow{\mathbf{Vector}}$]	rad	BENDING
	Local zero angle relative to reference configuration		
X_BENDING_STIFF_UNILAT_ ADDFACTOR	[$\overrightarrow{\mathbf{Vector}}$]	-	BENDING
	Additional local stiffness factor		
Y_BENDING_STIFF	**8000**	Nmm	BENDING

Parameter	Default Value / Explanation	Unit	Class
	Bending stiffness in circumferential direction (think YOUNGS Modulus E * thickness $H^3/12$)		
Y_BENDING_DAMP	**0.0005**	1/s	BENDING
	Bending damping factor in circumferential direction		
Y_BENDING_STIFF_W	[$\overrightarrow{\textbf{Vector}}$]	-	BENDING
	Bending stiffness weighting factors in circumferential direction, segment entity		
Y_BENDING_ALPHANL	**0**	rad	BENDING
	Angle where non-linear progression starts (it ends at angle 0)		
Y_BENDING_EXPNL	**1**	-	BENDING
	Exponent of non-linear progression (c * $(x-x0)^Y$_BENDING_EXPNL))		
XY_DIAG_BENDING_STIFF	**10000**	Nmm	BENDING
	Bending stiffness in diagonal direction (think YOUNGS Modulus E * thickness $H^{3/12}$)		
XY_DIAG_BENDING_DAMP	**0.0005**	1/s	BENDING
	Bending damping factor in diagonal direction		
XY_DIAG_BENDING_STIFF_W	[$\overrightarrow{\textbf{Vector}}$]	-	BENDING
	Bending stiffness weighting factors in diagonal direction, segment entity		
XY_DIAG_BENDING_ALPHANL	**0**	rad	BENDING
	Angle where non-linear progression starts (it ends at angle 0)		
XY_DIAG_BENDING_EXPNL	**1**	-	BENDING
	Exponent of non-linear progression (c * $(x-x_0)^Y$_BENDING_EXPNL))		
	TREAD		
TREAD_NSEN_X	**7**	-	TREAD
	Number of sensors per element in circumferential direction		
TREAD_NSEN_Y	**5**	-	TREAD
	Number of sensors per element in lateral direction		
TREAD_HEIGHT_ALL	[$\overrightarrow{\textbf{Vector}}$]	mm	TREAD
	Height of tread sensors of full cross section		
SENSOR_LENGTH	[$\overrightarrow{\textbf{Vector}}$]	mm	TREAD
	Length of the single sensors arrows in the tread region contact zone. This parameter is just and information.		
TREAD_SCAN_HEIGHT	**200**	mm	TREAD

Parameter	Default Value Explanation	Unit	Class
	Height above ideal contact point on surface within where contact sensors are active		
TREAD_RAD_NL_TYPE	1 Type of progression of radial tread stiffness: 0 = linear, 1 = Shape function type I (NEO-HOOKE-like), 2 = Shape function type II, 3 = Shape function type III	-	TREAD
TREAD_MAX_COMPRESS	**0.95** Maximum relative compression of tread (capped and warning is issued)	-	TREAD
TREAD_RAD_NL_GAIN_MAX	**1** Cut-off factor for non-linear progression	-	TREAD
TREAD_RAD_D	**0.0001** Radial tread damping factor	1/s	TREAD
TREAD_RAD_D_ DEGRESSION_FACTOR	**1** Radial tread damping residual factor (active above degression velocity	-	TREAD
TREAD_RAD_D_ DEGRESSION_VEL	**0** Radial tread damping degression velocity	mm/s	TREAD
TREAD_TAN_D	**0** Tangential tread damping factor	1/s	TREAD
TREAD_TAN_D_ DEGRESSION_FACTOR	**1** Tangential tread damping residual factor (active above degression velocity)	-	TREAD
TREAD_TAN_D_ DEGRESSION_VEL	**0** Tangential tread damping degression velocity	mm/s	TREAD
TREAD_E/H	**0.3** Radial tread stiffness (think YOUNGS Modulus E / thickness H)	N/mm^3	TREAD
TREAD_Gx/H	**0.1** Tread shear stiffness in circumferential direction (think shear modulus G / thickness H)	N/mm^3	TREAD
TREAD_Gy/H	**0.1** Tread shear stiffness in lateral direction (think shear modulus G / thickness H)	N/mm^3	TREAD
TREAD_E/H_W	$[\overrightarrow{\textbf{Vector}}]$ Local tread rubber stiffness modification, direct multiplication, (optional)	-	TREAD
TREAD_Gx/H_W	$[\overrightarrow{\textbf{Vector}}]$	-	TREAD

Parameter	Default Value Explanation	Unit	Class
	Local tread rubber stiffness modification, direct multiplication, (optional)		
TREAD_Gy/H_W	[$\overrightarrow{\textbf{Vector}}$] Local tread rubber stiffness modification, direct multiplication, (optional)	-	TREAD
TREAD_HEIGHT_REF	$\mathbf{H}_{MAX}$ Optional scaling of tread stiffness properties with H_{REF} / H_i	mm	TREAD
FRICTION			
MU	[$\overrightarrow{\textbf{Vector}}$] Relative friction coefficient e.g. [1.2, 1.2, 1.0]	-	FRICTION
V_MUV_MU	[$\overrightarrow{\textbf{Vector}}$] Corresponding sliding velocity for MU e.g. [0.0, 1000, 10000]	mm/s	FRICTION
MU_GLOBAL_SCALEFACTOR	**1** Optional global scaling factor of friction	-	FRICTION
MU_X_SCALEFACTOR	**1** Optional longitudinal scaling factor of friction	-	FRICTION
MU_LOCAL_W	[$\overrightarrow{\textbf{Vector}}$] Optional local scaling of friction of a single brush element (to adapt for different tread rubber materials)	-	FRICTION
MU_NSTRESS_DEPENDENCY	**[0.35,0.3, 0.7,1.3]** Optional normal stress dependent scaling of friction M from [n_{REF}, S, M_{MIN}, M_{MAX}] via M = 1 – S * (n / n_{REF} - 1) n_{REF} → reference normal contact stress [MPa] S → slope of modification M_{MIN} → M_{MIN}, M_{MAX} M_{MAX} → minimum, maximum friction coefficient threshold	[MPa, -, -, -]	FRICTION
ADVANCED			
LOSSENERGY_FLAG	**0** Toggle energy loss post-processing	-	ADVANCED
THERMAL_MODEL_FLAG	**0** Toggle CDTire/Thermal usage: 0 = OFF, 1 = ON	-	ADVANCED
CAVITY_MODEL_FLAG	**0** Select cavity simulation model: 0 = contant pressure, 1 = euler flow, 2 = ideal gas	-	ADVANCED
FLEXRIM_S_MODEL_FLAG	**0**	-	ADVANCED

Parameter	Default Value Explanation	Unit	Class
	Flag for the activation of a compliance model to interface a flexible rim (static): 0 = OFF , 1 = ON		
FLEXRIM_M_MODEL_FLAG	**0** Flag for the activation to a flexible rim (modal) in decidated MBS solvers: 0 = OFF , 1 = ON, Requires CDTireVersion > R 2023.0.0	-	ADVANCED
CORRECT_WEIGHT_TO_NOMINAL_FLAG	**0** Flag to mimic nominal tire weight	-	ADVANCED
ADVANCED	**[20,3,40,1]** Scale rubber shear damping as function of absolute rotatio-nal velocity via [ω_0, s_0, ω_1, s_1], linear interpolation and constant extrapolation	[rad/s, -, rad/s, -]	ADVANCED
MASS_UPDATE_NOCAVITY	**0** Add mass to belt to adjust part of missing cavity gas mass, in case of CAVITY_MODEL_FLAG=2 .	t	ADVANCED
PCF	**1** Pressure correction factor (multiplication)	-	ADVANCED
SENSOR_NORMAL_FLAG	**0** Adjustment of the orientation of the tread sensors in the shoulder-segment of the tire normal to that ring-section only (only recomemanded for truck tires).	-	ADVANCED
CONSTRUCT_ALL_SENSORS_FLAG	1 Can be set so that all contact sensors (regardless of contact or not) are calculated.As this is computationally expensive, it is recommended to activate this only in case the animation results are of interest. The parameter can be set in parameter file as well as control file.	-	ADVANCED
	LDE		
LDE_FLAG	**0** Select large deformation element to investigate tire ground out: 0 = OFF, 1 = LDE Type 1 , 2 = LDE Type 2	-	LDE
LDE_Y_COORD	[$\overrightarrow{\textbf{Vector}}$] Lateral coordinate of LDE weighting, same length as LDE_W,	mm	LDE
LDE_W	**[0,1,1,0,0,1,1,0]** LDE weighting spline, has a much entries a LDE_Y_COORD	-	LDE

Parameter	Default Value Explanation	Unit	Class
LDE_CNL	**0.1** LDE_FLAG=1 ; Radial LDE progression stiffness	Nmm^{-3}	LDE
LDE_CLIN	**0.6** LDE_FLAG=1 ; Radial LDE final stiffness	Nmm^{-3}	LDE
LDE_RNL	**10** LDE_FLAG=1 ; Radius (from 'bead' node locations) where LDE starts	mm	LDE
LDE_RLIN	**5** LDE_FLAG=1 ; Radius (from last rim point) where LDE fully active	mm	LDE
LDE_RIM_FLANGE_RADIUS	**0** LDE_FLAG=2 ; absolute radius of the rim flange	mm	LDE
LDE_C	**0.3** LDE_FLAG=2 ; Radial LDE stiffness	Nmm^{-3}	LDE
LDE_D	**5e^{-6}** LDE_FLAG=2 ; LDE Damping factor	1/s	LDE
LDE_C_SHAPE_FACTOR	**1** LDE_FLAG=2 ; Exponent of LDE_C	-	LDE
LDE_C_GAIN_MAX	**1** LDE_FLAG=2 ; Stiffness factor cut-off	-	LDE
LDE_HEIGHT	**30** LDE_FLAG=2 ; height of the rubber in the contact zone between rim flange and the shell midplane contour.	mm	LDE
LDE_SCAN_RADIUS	**30** Enable LDE search (from rim point) = typically equal to LDE_RNL + 20 mm	mm	LDE
LDE_ACTIVE_RADIUS	**10** Signal LDE is active (from rim point) = typically equal to LDE_RNL	mm	LDE
LDE_FRICTION_FLAG	**0** LDE_FLAG=2 ;Switch for modeling of rate-independent dissipation during LDE, 0 = off, 1 = on: The parameter .._FRICTION_FLAG=1 activates the inner friction modeled parallel to the respective viscous-elastic property.	-	LDE
LDE_ FRICTIONELEMENT _STIFF_FACTOR	**0** LDE_FLAG=2 ;The _FRICTIONELEMENT _STIFF_FACTOR set the added parallel stiffness as a factor (relative to 1) of its respective viscous-elastic property. All values must be scalar.	-	LDE

Parameter	Default Value Explanation	Unit	Class
LDE_ FRICTIONELEMENT _MAXDEFL	**0** LDE_FLAG=2 ;The _FRICTIONELEMENT _MAXDEFL specifies the respective activation deformation (in [1] for LDE as factor relative to LDE_HEIGHT. All values must be scalar.	-	LDE
	DESIGN		
STEEL_CORDLAYER_STIFF _GLOBAL_SCALEFACTOR	**1.0** Optional scaling for STEEL_CORDLAYER_STIFF. Intended to be used with the Control-File. Obsolete for CDT50 Parameter File.	-	DESIGN
TREAD_E/H_GLOBAL _SCALEFACTOR	**1.0** Optional scaling for TREAD_E/H via Control-File. Obsolete for CDT50 Parameter File.	-	DESIGN
TREAD_Gx/H_GLOBAL _SCALEFACTOR	**1.0** Optional scaling for TREAD_Gx/H via Control-File. Obsolete for CDT50 Parameter File.	-	DESIGN
TREAD_Gy/H_GLOBAL _SCALEFACTOR	**1.0** Optional scaling for TREAD_Gy/H via Control-File. Obsolete for CDT50 Parameter File.	-	DESIGN
RUBBER_STIFF_GLOBAL _SCALEFACTOR	**1.0** Optional, simultaneous scaling for the RUBBER base material (applies on RUBBER_CIRC_EH, RUBBER_LAT_EH, RUBBER_SHEAR_GH and RUBBER_DIAG_EH) via Control-File. Obsolete for CDT50 Parameter File. Attention:This modification is not reflected equivalently into the bending properties of the tire.	-	DESIGN
	NONUNIFORMITY PARAMETERS		
NONUNIFORMITY_FLAG	**0**	-	NONUNIFORMITY

Parameter	Default Value Explanation	Unit	Class
	Switch for geometric circumferential non-uniformity, requires the following three parameters, 0 = off, 1 = on. All three parameters must be present, if the FLAG is set. As this make a Fourier series, any (circumferential) geometric non-uniformity can be modeled		
NONUNIFORMITY_K	**[1,2]** Specification of the cirumferential wave order(s) (non-negative), can be scalar or a vector, must be an INT	-	NONUNIFORMITY
NONUNIFORMITY_PHASE	**[0,1]** Specification of the cirumferential wave order phase(s) (non-negative), can be scalar or a vector	rad	NONUNIFORMITY
NONUNIFORMITY_AMP	**[0.5,0.25]** Specification of the cirumferential wave order amplitude(s) (non-negative), can be scalar or a vector	mm	NONUNIFORMITY
INNER FRICTION PARAMETERS			
X_BENDING_FRICTION_FLAG	**0** Switch for modelling of rate-independent dissipation in the X_BENDING, 0 = off, 1 = on: The parameter .._FRICTION_FLAG=1 activates the inner friction modeled parallel to the respective viscous-elastic property.	-	INNER FRICTION
X_BENDING_FRICTIONELEMENT _STIFF_FACTOR	**1.5** The _FRICTIONELEMENT_STIFF_FACTOR set the added parallel stiffness as a factor (relative to 1) of its respective viscous-elastic property.	-	INNER FRICTION
X_BENDING_FRICTIONELEMENT _MAXDEFL	**0.01** The _FRICTIONELEMENT_MAXDEFL specifies the respective activation deformation (in [rad] for X_BENDING.	rad	INNER FRICTION
Y_BENDING_FRICTION_FLAG	**0** Switch for modeling of rate-independent dissipation in the Y_BENDING, 0 = off, 1 = on: The parameter .._FRICTION_FLAG=1 activates the inner friction modeled parallel to the respective viscous-elastic property.All values must be scalar.	-	INNER FRICTION
Y_BENDING_FRICTIONELEMENT _STIFF_FACTOR	**1.5**	-	INNER FRICTION

Parameter	Default Value Explanation	Unit	Class
	The _FRICTIONELEMENT_STIFF_FACTOR set the added parallel stiffness as a factor (relative to 1) of its respective viscous-elastic property.All values must be scalar.		
Y_BENDING_FRICTIONELEMENT _MAXDEFL	**0.01**	rad	INNER FRICTION
	The _FRICTIONELEMENT_MAXDEFL specifies the respective activation deformation (in [rad] for Y_BENDING.All values must be scalar.		
RUBBER_DIAG_FRICTION_FLAG	**0**	-	INNER FRICTION
	Switch for modeling of rate-independent dissipation in the rubber, 0 = off, 1 = on: The parameter .._FRICTION_FLAG=1 activates the inner friction modeled parallel to the respective viscous-elastic property.		
RUBBER_DIAG_ FRICTIONELEMENT _STIFF_FACTOR	**2**	-	INNER FRICTION
	The _FRICTIONELEMENT_STIFF_FACTOR set the added parallel stiffness as a factor (relative to 1) of its respective viscous-elastic property. All values must be scalar.		
RUBBER_DIAG_ FRICTIONELEMENT _MAXDEFL	**0.01**	rad	INNER FRICTION
	The _FRICTIONELEMENT_MAXDEFL specifies the respective activation deformation (in [rad] for Rubber as factor relative to 1. All values must be scalar.		
TREAD_NFRICTION_Z	**0**	-	INNER FRICTION
	Switch for modeling of rate-independent dissipation in the tread, 0 = off, 1 = on: The parameter .._FRICTION_FLAG=1 activates the inner friction modeled parallel to the respective viscous-elastic property.		
TREAD_FRICTIONELEMENT _STIFF_FACTOR_Z	**[0.5]**	-	INNER FRICTION
	Added parallel stiffness as factor in tread normal deformation in [1] relative to the respective elastic property. All values must be scalars or vectors, set by <n>.		
TREAD_ FRICTIONELEMENT _MAXDEFL	**[0.5]**	-	INNER FRICTION

Parameter	Default Value Explanation	Unit	Class
	The _FRICTIONELEMENT_MAXDEFL specifies the respective activation deformation (in [1] for Rubber as factor relative to tread height. All values must be scalars or vectors, set by <n>.		
	STATIC		
R_EFF	**320** Effective rolling radius used for postprocessing	mm	STATIC
R_STAT	**320** Radius of undeformed tire under inflation	mm	STATIC
CR1_STAT	**250** Global linear radial tire stiffness used for static	N/mm	STATIC
	[CAVITY MODEL PARAMETERS]		
RADIUS_EFFECTIVE	**260** Radius of gas column; (only active if CAVITY_MODEL_FLAG =1)	mm	CAVITY
SOUND_VELOCITY	**340000** soundvelocity of the media inside the tire, default value for air; need to be adjusted for other media (only active if CAVITY_MODEL_FLAG =1)	mm/s	CAVITY
CFL_FACTOR	**0.3** Courant number from COURANT-FIEDRICHS-LEWY condition ; (only active if CAVITY_MODEL_FLAG =1)	-	CAVITY
DX_RESAMPLE_FACTOR	**5** Number of cavity degree of freedoms per segment, (only active if CAVITY_MODEL_FLAG =1)	-	CAVITY
A_RIM	**0** Cross section area of rim cavity not covered by tire nodes i.e. the area below the first node of CDTire the rim surface; (only active if CAVITY_MODEL_FLAG =1)	mm^2	CAVITY
ACF_TIRE	**1** Scaling of the dynamic pressure effect of the cavity mode acting on the inner liner of the tire (only active if CAVITY_MODEL_FLAG =1)	-	CAVITY
ACF_RIM	**1** Scaling of the dynamic pressure effect of the cavity mode acting on the rim surface of the wheel; (only active if CAVITY_MODEL_FLAG =1)	-	CAVITY

Parameter	Default Value Explanation	Unit	Class
[CDT40-N MODEL PARAMETERS]			
PREF	**0.25** Reference inflation pressure	MPa	CDT40
PIN_FLAG	**0** Toggle pressure-dependency of sidewall	-	CDT40
MASS_ADD_TO_BELT	**0.0001** Because in the case off analytical sidewall the dynamic mass of the sidewall is eliminated the MASS_ADD_TO_BELT parameter can be used to take a part of the sidewall mass to the rim in order to get the same model properties than in full CDTire/3D (optional) parameter to accommodate the massless sidewall modeling	t	CDT40
MASS_ADD_TO_RIM	**0.0001** Used for MBD_MASS_ADD_TO_RIM and MBD_MASS_SUB_FROM_WHEEL calculation; does not affect tire simulation	tmm^2	CDT40
IXX_ADD_TO_RIM	**100** Same for MBD_IXX_xxx calculation	tmm^2	CDT40
IYY_ADD_TO_RIM	**200** Same for MBD_IYY_xxx calculation	tmm^2	CDT40
IZZ_ADD_TO_RIM	**100** Same for MBD_IZZ_xxx calculation	tmm^2	CDT40
BEAD_OFFSET_Y	**0** Same for MBD_IZZ_xxx calculation	mm	CDT40
BEAD_OFFSET_Z	**20** Same for MBD_IZZ_xxx calculation	mm	CDT40
INPUT_MODE	**0** Optionally switches sidewall model (0,1,2,3)	-	CDT40
FTX	**89.5** Natural frequency: Translation in x/z direction (mode R_1)	Hz	CDT40
FTY	**45.7** Natural frequency: Translation in y direction (mode L_0)	Hz	CDT40
FRY	**65.4** Natural frequency: rotation around y axis (mode C_0)	Hz	CDT40
DTX	**0.05** Damping coefficient (mode R_1)	-	CDT40
DTY	**0.05** Damping coefficient (mode L_0)	-	CDT40
DRY	**0.05**	-	CDT40

Parameter	Default Value Explanation	Unit	Class
	Damping coefficient (mode $C_0 4$)		
SW_ANGLE	**28** Reference sidewall angle for INPUT_MODE =1,2,3	deg	CDT40
CRX	**$5.5e^6$** Lateral rotational foundational sidewall stiffness for INPUT_MODE =2	Nmm	CDT40
CRY	**$7.0e^6$** Circumferential rotational foundational sidewall stiffness for INPUT_MODE=2	Nmm	CDT40
CRX_S	**$3.2e^6$** Lateral rotational structural sidewall stiffness for INPUT_MODE=3	Nmm	CDT40
CRY_S	**$4.5e^6$** Circumferential rotational structural sidewall stiffness for INPUT_MODE=3	Nmm	CDT40
SWBEND	**20** Percent radial stiffness due to bending	%	CDT40
CRY_RED_DEF	**0** Deflection value at which reduction of circumferential rotational sidewall stiffness starts	mm	CDT40
CRY_RED_RES	**1** Residual stiffness factor of circumferential rotational sidewall stiffness at full deflection	-	CDT40
CRX_RED_DEF	**0** Deflection value at which reduction of lateral rotational sidewall stiffness starts	mm	CDT40
CRX_RED_RES	**1** Residual stiffness factor of lateral rotational sidewall stiffness CRY at full deflection	-	CDT40
LDE_AUTO_ADAPT	**0** Automatically adapts the LDE_Y_COORD for the analytical sidewall model	-	CDT40
LDE_SCALE_FACTOR	**1** Scales the LDE_W in case of analytical sidewall model	-	CDT40
ADVANCED	**[20,3,40,1]** Scale rubber shear damping as function of rotational velocity via [ω_0, s_0, ω_1, s_1], linear interpolation and constant extrapolation (same functionality as ADVANCED while SW_Mode = 50)	[rad/s, -,rad/s, -]	CDT40

[CDT50-N SOLVER PARAMETERS]

Parameter	Default Value Explanation	Unit	Class
TOL	**1.0E^{-4}** Error tolerance of internal integrator	-	SOLVER
TTOL_EXCEPTION	**0.01** Error tolerance of internal integrator in case of failed convergence	-	SOLVER
TDTM	**5.0E^{-5}** Maximum step size of internal integrator	s	SOLVER
TDTMIN	**1.0E^{-10}** Minimum step size of internal integrator	s	SOLVER
TDT_START_EXPL	**5.0E^{-5}** Initial step size of internal explicit integrator	s	SOLVER
TPRE_STEP_TIME	**0.05** Duration of inflation pre-step before beginning of simulation	s	SOLVER
TPRE_STEP_DEFLTIME	**0.2** Duration of deflection pre-step before beginning of simulation (adjusted automatically)	s	SOLVER
TPRE_STEP_SAFETY_MARGIN	**10** Height above ideal contact point for initial inflation phase	mm	SOLVER
TPRE_STEP_LDE_MARGIN	**10** Minimal clearance (from rim point) for legal initial deflection	mm	SOLVER
TFORCE_NOSUCCESS	**1.0E^{+10}** Returned force value in case of no convergence	N	SOLVER
TYPE	**1** 1 = Explicit; 2 = Implicit	-	SOLVER
ALPHA_EXPLICIT	**0** Explicit Newmark alpha integrator value	-	SOLVER
BETA_EXPLICIT	**0.166667** Explicit Newmark beta integrator value	-	SOLVER
GAMMA_EXPLICIT	**0.5** Explicit Newmark gamma integrator value	-	SOLVER
UPDATE_FOR_MASTER CORRECTOR	**0** Toggle corrector or Newton iterations to be taken into account: 0 = OFF; 1 = ON	-	SOLVER
[TIRE AND RIM RESIZING]			
TIRE_REFT	**205/50R16** Reference tire specification	-	RESIZING

Parameter	Default Value Explanation	Unit	Class
RIM_REF	**16x6** Reference rim specification	-	RESIZING
TIRE_NEW	**225/45R17** Target tire specification	-	RESIZING
RIM_NEW	**17x7** Target rim specification	-	RESIZING
USE_RESIZING_FROM_VERSION	**e.g. 2021.2.0** Switch to enable resizing from a previous CDTire version. If not set the resizing mechanism associated with the current CDTire binary will be used.	-	RESIZING
[FLEXRIM_S MODEL PARAMETER]			
RIMFILENAME	**Flextim.dat** Name of the file containing the compliance. Please contact Fraunhofer ITWM for further information on how to use this functionality.	-	FLEXRIM
MODE	**0** required, but no functionality	-	FLEXRIM
ACTIVE_FLAG	**1** Swtich for activation of the flexible rim (redundant)	-	FLEXRIM
SIDE	**-1** ROLE of the rim: LEFT –> -1, RIGHT –> 1, ANY –> 0, same as the ROLE Parameter of the tire.	-	FLEXRIM
ORIENTATION	**-1** Selection of the orientation of the rim e.g. face outside or face inside.	-	FLEXRIM
ITER_KMAX	**40** Solver Parameter: Maximum number of iterations.	-	FLEXRIM
ITER_KMIN	**4** Solver Parameter: Minimum number of iterations.	-	FLEXRIM
ITER_GAIN	**0.2** Solver Parameter: Relaxation factor	-	FLEXRIM
ITER_TOL	**1** Solver Parameter: abort criterion	-	FLEXRIM
[CDT50-N ADVANCED OUTPUT PARAMETERS]			
T_START	**0** Start of output simulation time	s	OUTPUT
T_END	**100** End of output simulation time	s	OUTPUT
DT_OUT	**0.001**	s	OUTPUT

Parameter	Default Value Explanation	Unit	Class
	Output step size		
OUTPUT_TIRESTATES	**0** Flag to output the tire states (0 = off, 1 = on)	-	OUTPUT
OUTPUT_ROAD CONTACTFORCES	**0** Flag to output the road contact forces (0 = off, 1 = on)	-	OUTPUT
TAKE_LOGFILENAME_AS_ PREFIX	- Naming convention of resulting output file	-	OUTPUT
[CDT50-N STATIC PARAMETERS]			
LOGGING_LEVEL	**0** Set to 1 for verbose mode	-	MBS STATIC
INFLATION_PRESSURE_REF	**0.25** Reference inflation pressure (can be overruled by advanced settings)	MPa	MBS STATIC
INCLINATION_ANGLE_REF	**0** Reference inclination angle (can be overruled by advanced settings)	rad	MBS STATIC
FZW_REF	**5000** Reference vertical (normal) load (can be overruled by advanced settings)	N	MBS STATIC
VERTICAL_STIFFNESS_ UNLOADED_HEIGHT	**325** Minimal unloaded height (surface normal) for reference IP/IA	mm	MBS STATIC
VERTICAL_STIFFNESS	**250** Linear vertical stiffness for reference IP/IA	N/mm	MBS STATIC
VERTICAL_STIFFNESS_ QUADFACTOR	**0.5** Quadratic vertical stiffness for reference IP/IA	N/mm^2	MBS STATIC
LONGITUDINAL_SLIP_ ACTIVATE	**0** (De-)activates longitudinal slip during statics	-	MBS STATIC
LONGITUDINAL_SLIP_ KAPPA_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	-	MBS STATIC
LONGITUDINAL_SLIP_ STIFFNESS	$\mathbf{2e^{+5}}$ Slip stiffness for reference IP/IA/FZW	N/1	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
LONGITUDINAL _STIFFNESS_ACTIVATE	**0** (De-)activates longitudinal stiffness during statics	-	MBS STATIC
LONGITUDINAL _STIFFNESS	**400** Static stiffness for reference IP/IA/FZW	N/mm	MBS STATIC
LATERAL_SLIP_ ACTIVATE	**0** (De-)activates lateral slip during statics	-	MBS STATIC
LATERAL_SLIP_CORNERING _SLIPANGLE_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	rad	MBS STATIC
LATERAL_SLIP_CORNERING _STIFFNESS	**$1e^{+5}$** Slip stiffness for reference IP/IA/FZW	N/rad	MBS STATIC
LATERAL_SLIP_ALIGNING _TORQUE_SLIPANGLE_SHIFT	**0** Shift (offset) for reference IP/IA/FZW	rad	MBS STATIC
LATERAL_SLIP_ALIGNING _TORQUE_STIFFNESS	**5000** Slip stiffness for reference IP/IA/FZW	Nmm/rad	MBS STATIC
LATERAL_STIFFNESS_ ACTIVATE	**0** (De-)activates lateral stiffness during statics	-	MBS STATIC
LATERAL_STIFFNESS	**200** Static stiffness for reference IP/IA/FZW	N/mm	MBS STATIC
VERTICAL_STIFFNESS _INFLATION_PRESSURE_REF	**0.25** Optional reference inflation pressure for VERTICAL_STIFFNESS derivatives dIP	MPa	MBS STATIC
VERTICAL_STIFFNESS _INCLINATION_ANGLE_REF	**0** Optional reference inclination angle for VERTICAL_STIFFNESS derivatives dIA	rad	MBS STATIC
VERTICAL_STIFFNESS _UNLOADED_HEIGHT_dIP_dIA	**[0,0]** First derivatives at reference IP/IA	[mm^3/N, mm/rad]	MBS STATIC
VERTICAL_STIFFNESS _dIP_dIA	**[0,0]** First derivatives at reference IP/IA	[mm, N/(mm rad)]	MBS STATIC
VERTICAL_STIFFNESS _QUADFACTOR_dIP_dIA	**[0,0]**	[1, N/(mm^2 rad)]	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
	First derivatives at reference IP/IA		
VERTICAL_STIFFNESS _UNLOADED_HEIGHT dIP2_dIPdIA_dIA2_HALF	**[0,0,0]**	[mm^5/N^2, $mm^3/(N\ rad)$, mm/rad^2]	MBS STATIC
	One half of second derivatives at reference IP/IA		
VERTICAL_STIFFNESS dIP2_dIPdIA_dIA2_HALF	**[0,0,0]**	[mm^3/N, mm/rad, $N/(mm\ rad^2)$]	MBS STATIC
	One half of second derivatives at reference IP/IA		
VERTICAL_STIFFNESS _QUADFACTOR dIP2_dIPdIA_dIA2_HALF	**[0,0,0]**	[mm^2/N, 1/rad, $N/(mm^2\ rad^2)$]	MBS STATIC
	One half of second derivatives at reference IP/IA		
LONGITUDINAL_SLIP _INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC
	Optional reference inflation pressure for LONGITUDINAL_SLIP derivatives dIP		
LONGITUDINAL_SLIP _INCLINATION_ANGLE_REF	**0**	MPa	MBS STATIC
	Optional reference inclination angle for LONGITUDINAL_SLIP derivatives dIA		
LONGITUDINAL_SLIP _FZW_REF	**5000**	MPa	MBS STATIC
	Optional reference vertical (normal) load for LONGITUDINAL_SLIP derivatives dFZW		
LONGITUDINAL_SLIP _KAPPA_SHIFT dIP_dIA_dFZW	**[0,0,0]**	[mm^2/N, 1/rad, 1/N]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LONGITUDINAL_SLIP _STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm^2, N/rad, 1]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LONGITUDINAL_ STIFFNESS dIP_dIA_dFZW	**[0,0,0]**	[mm, N/(mm rad), 1/mm]	MBS STATIC
	First derivatives at reference IP/IA/FZW		
LATERAL_SLIP _INFLATION_PRESSURE_REF	**0.25**	MPa	MBS STATIC
	Optional reference inflation pressure for LATERAL_SLIP derivatives dIP		

Parameter	Default Value Explanation	Unit	Class
LATERAL_SLIP _INFLATION_PRESSURE_REF	**0** Optional reference inflation pressure for LATERAL_SLIP derivatives dIA	rad	MBS STATIC
LATERAL_SLIP _FZW_REF	**5000** Optional reference inflation pressure for LATERAL_SLIP derivatives dFZW	N	MBS STATIC
LATERAL_SLIP _CORNERING_SLIPANGLE_SHIFT dIP_dIA_dFZW	**[0,0,0]** First derivatives at reference IP/IA/FZW	[mm^2 rad/N, 1, rad/N]	MBS STATIC
LATERAL_SLIP _CORNERING_STIFFNESS dIP_dIA_dFZW	**[0,0,0]** First derivatives at reference IP/IA/FZW	[mm^2/rad, N/rad^2, 1/rad]	MBS STATIC
LATERAL_SLIP _ALIGNING_TORQUE_SLIPANGLE_SHIFT dIP_dIA_dFZW	**[0,0,0]** First derivatives at reference IP/IA/FZW	[mm^2 rad/N, 1, rad/N]	MBS STATIC
LATERAL_SLIP _ALIGNING_TORQUE_STIFFNESS dIP_dIA_dFZW	**[0,0,0]** First derivatives at reference IP/IA/FZW	[mm^3/rad, Nmm/rad^2, mm/rad]	MBS STATIC
LATERAL_STIFFNESS _dIP_dIA_dFZW	**[0,0,0]** First derivatives at reference IP/IA/FZW	[mm, Nmm/rad, 1/mm]	MBS STATIC
WHEELCENTER_STIFFNESS _ACTIVATE	**0** (De-)activates wheel center stiffnesses during statics	-	MBS STATIC
WHEELCENTER_STIFFNESS _INPLANE_TRANSLATIONAL	**400** Derived (can be overuled if specified) stiffness	N/mm	MBS STATIC
WHEELCENTER_STIFFNESS _OUTPLANE_TRANSLATIONAL	**200** Derived (can be overuled if specified) stiffness	N/mm	MBS STATIC
WHEELCENTER_STIFFNESS _OUTPLANE_ROTATIONAL	**$2e^{+7}$** Derived (can be overuled if specified) stiffness	Nmm/rad	MBS STATIC
WHEELCENTER_STIFFNESS _INPLANE_ROTATIONAL	**$5e^{+7}$**	Nmm/rad	MBS STATIC

Parameter	Default Value Explanation	Unit	Class
	Derived (can be overuled if specified) stiffness		

7.1 Control-File Options

Selected CDTire/3D parameters can also be modified using the control-file. The control-file option does overrule the parameter file values. This option is especially of interest when dealing with crypted parameter files. The following list shows all parameters that can be modified using the control file. Beside this all solver parameter can be modified as well.

- ROLE
- SYMMETRIZE
- NCS
- NRSENSTART
- SW_MODE
- RUBBER_LAT_DAMP
- RUBBER_CIRC_DAMP
- RUBBER_SHEAR_DAMP
- RUBBER_DIAG_DAMP
- STEEL_CORDLAYER_STIFF_GLOBAL_SCALEFACTOR (DEFAULT = 1.0)
- X_BENDING_DAMP
- Y_BENDING_DAMP
- XY_DIAG_BENDING_DAMP

- TREAD_HEIGHT_REF
- TREAD_SCAN_HEIGHT
- TREAD_RAD_D
- TREAD_TAN_D
- TREAD_E/H_GLOBAL_SCALEFACTOR (DEFAULT = 1.0)
- TREAD_Gx/H_GLOBAL_SCALEFACTOR (DEFAULT = 1.0)
- TREAD_Gy/H_GLOBAL_SCALEFACTOR (DEFAULT = 1.0)
- RUBBER_STIFF_GLOBAL_SCALEFACTOR (DEFAULT = 1.0)
- MU_GLOBAL_SCALEFACTOR
- MU_X_SCALEFACTOR
- ADVANCED
- MASS_UPDATE_NOCAVITY
- CORRECT_WEIGHT_TO_NOMINAL_FLAG
- LDE_FLAG
- LDE_Y_COORD
- LDE_W
- LDE_RIM_FLANGE_RADIUS
- LDE_HEIGHT
- LDE_C

- LDE_C_SHAPE_FACTOR
- LDE_C_GAIN_MAX
- LDE_CNL
- LDE_CLIN
- LDE_RNL
- LDE_RLIN
- LDE_SCAN_RADIUS
- LDE_ACTIVE_RADIUS
- CAVITY_MODEL_FLAG
- FLEXRIM_S_MODEL_FLAG
- R_EFF
- R_STAT
- CR1_STAT

8

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.

8.1 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
```

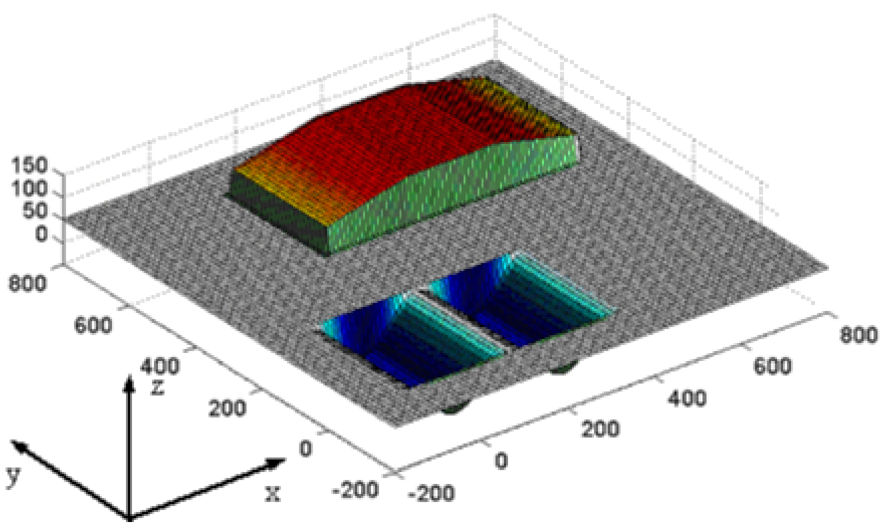


Figure 8.1: Road Surface Model 1000: equidistant track

8.2 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					

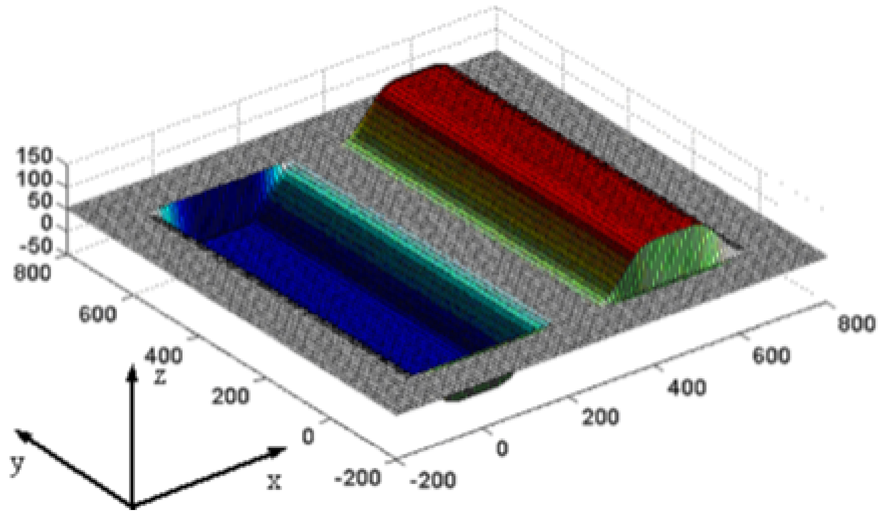


Figure 8.2: Road Surface Model 1000: non-equidistant track

8.3 Warning and Errors

For errors and warnings, please see the CDTire log files and/or the log files of the respective MBS solver run.

8.4 Extended Support

- For technical questions please contact cdtire@itwm.fraunhofer.de
- For question referring to licensing setup and license extrension please contact license.cdtire@itwm.fraunhofer.de