

MEMO	EV/M19.001
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Subject	Release-notes for CONTACT version 19.1

## Summary

These release-notes document the changes in CONTACT version 19.1 with respect to version 18.1.5.

- [Module 1](#) for wheel/rail contact is improved, and extended for roller rig configurations.
- Facilities are added for (rectangular) 2D Hertzian contact situations.
- The calculation of subsurface stresses is extended, and made available in the [CONTACT library version](#).

Note that features of the [commercial versions](#) are [marked in blue](#) in these release notes and the further documentation.

## 1 Calculation of roller rig configurations

In version 17.1, we introduced “module 1” for the analysis of contact geometry for wheel/rail situations. This functionality has been improved, and is extended to wheel/roller configurations.

Contact phenomena must be studied in suitably defined coordinates, with a local  $z$  ( $n$ ) direction aligned with the normal to the contact plane. This is a complicating factor for wheel-rail

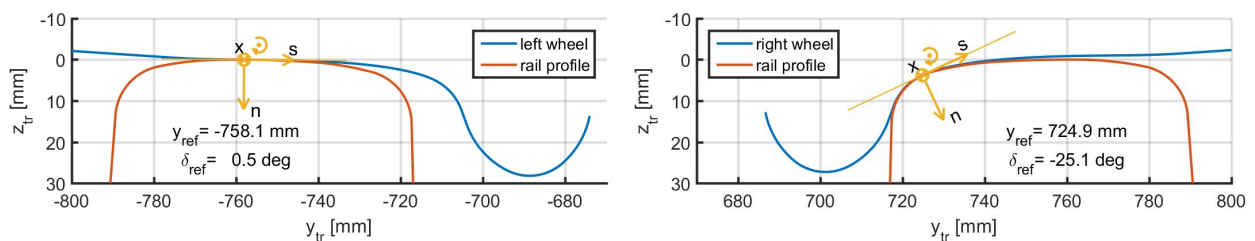


Figure 1: *Initial contact points for left and right wheels at wheelset lateral displacement  $y_{ws} = 6$  mm, yaw  $\psi_{ws} = 0^\circ$  (Manchester contact benchmark: User guide [1], §6.5).*

contact analysis, due to the contact angle  $\delta$  that arises when the contact moves from the wheel tread towards the flange, as illustrated in Figure 1.

CONTACT provides fully automated algorithms for this in module 1: location of contact patches, definition of local coordinate systems, analysis of the creepages and undeformed distance, and solution of the resulting contact problems. The robustness of these automated algorithms is improved in the new version.

- Splines are introduced to get more smooth profile interpolation.
- Additional checks and modifications are implemented for better profile handling.

The functionality is extended for roller rig configurations: the contact geometry and creep calculations.

- Two new options are provided for this in the  $C_1$ -digit (User guide [1]: §3.3.2):
  - 2 - wheelset on rollers, left wheel;
  - 3 - wheelset on rollers, right wheel.

A configuration with a single wheel on a roller can be described with both options.

Extensions have been made also for conformal contact analysis ( $D_1 = 3, 4, C_3 = 4$ ). These are provided as a beta-version to interested users.

## 2 Facilities for 2D Hertzian situations

Whereas railways typically use point contacts (modest ratio of semi-axes, e.g.  $a/b \in [0.3, 3]$ ) or contacts that are elongated in rolling direction ( $a \gg b$ ), wide contacts are needed to support heavy constructions ( $b \gg a$ ).

- A large contact area is needed to support the weight of the structure with acceptable contact pressures,
- The contact length  $2a$  is restricted by design considerations, esp. the desirable wheel radius  $R_{wx}$ .

The analysis of such configurations is facilitated by the introduction of “finite line contacts” in CONTACT. A rectangular contact area is assumed with pressures that are uniform on  $y \in [-b, b]$ , and zero outside this range.

- IPOTCN = -4: rectangular contact specified by curvature A1 and half width BB;
- IPOTCN = -5: rectangular contact with half length AA and half width BB.

The pressure distribution is then prescribed using options B = 2 or 3, using Hertzian formulas in each strip  $y = \text{const}$  ([1, §5.3.2]).

### 3 Improved subsurface stress calculation

In principle, the subsurface stresses can be calculated anywhere inside the contacting (elastic) half-spaces, independent of the potential contact area and its discretization. However, the computed stresses are affected adversely by the piecewise constant approximation that is used ( $C_3 = 2$ ) [2]. This can be resolved using bilinear loading elements, setting  $C_3 = 3$ , at the expense of longer computations. A practical alternative is to sample the subsurface stresses at the element centers only. This is the recommended approach for most applications [2].

### 4 Subsurface stresses in the CONTACT library

New subroutines are added to the CONTACT library for the calculation of subsurface stresses.

```
subs_addblock      - define a 3D grid for subsurface stress computation
subs_calculate     - perform actual subsurface stress calculation
subs_getblocksize - get the number of points used in one block
subs_getresults   - get detailed outputs of subsurface stress calculation
```

The calculation of subsurface stresses works with 3D “blocks” of  $n_x \cdot n_y \cdot n_z$  points. One or more of such blocks can be defined in the CONTACT library, before or after the solution of surface contact problems.

- An “on-line” way of working is to configure the subsurface problem (`subs_addblock`) together with the surface contact problem, then calling `cntc_calculate` and `subs_calculate` directly after another.
- An “off-line” way of working is to solve the surface problem first (`cntc_calculate`), then define (`subs_addblock`) and compute the blocks (`subs_calculate`) on the basis of the surface results, or even re-define (iterate) the subsurface problem, for instance to zoom in on a region where the largest values are found.

In module 1, blocks may be defined for each contact patch separately (`icp > 0`), or for the wheel/rail contact problem as a whole (`icp = -1`).

The outputs provided are the displacements, aggregate stresses (von Mises, Tresca), and the underlying components of the stress tensor, as detailed in the User guide [1], §8.4. Examples are provided in `matlab_mbench.m` (Matlab) and `test_mbench.f90` (Fortran).

### 5 Resolved problems

- The CONTACT GUI did not deal well with wheel/rail contact problems (module 1), due to issues with the location of include files. This has been resolved.

## 6 Compatibility w.r.t. previous versions

The selection of the SDEC approach is changed with respect to the previous version. User input files should be modified as follows:

- The value  $IPOTCN = -4$  for the SDEC approach should be replaced by  $IPOTCN = -6$ .

Changes to the CONTACT library are as follows:

- Several options are added to the include-file `caddon.flags.inc`, be sure to copy the new version.
- One additional parameter `nomrad` is added to subroutine `cntc_settrackdimensions`, in the 4<sup>th</sup> position of the `params`-array.

### Premium version & CONTACT library

The basic version of CONTACT is freely available in binary form, and can be downloaded from [www.kalkersoftware.org](http://www.kalkersoftware.org). “Module 1” for wheel/rail contact geometry processing is provided commercially through a [premium version](#) and through the [CONTACT library for MATLAB, Fortran and C](#). This functionality is marked [blue](#) in the release notes and in the User Guide. For information on licenses you may contact us at [support@kalkersoftware.org](mailto:support@kalkersoftware.org).

## References

- [1] E.A.H. Vollebregt. User guide for CONTACT, Rolling and sliding contact with friction. Technical Report TR09-03, version 19.1, VORtech, 2019. See [www.kalkersoftware.org](http://www.kalkersoftware.org).
- [2] C.D. van der Wekken and E.A.H. Vollebregt. Numerical calculation of the elastic field in a half-space using bilinear elements. *Mathematics and Mechanics of Solids*, 2019. submitted.