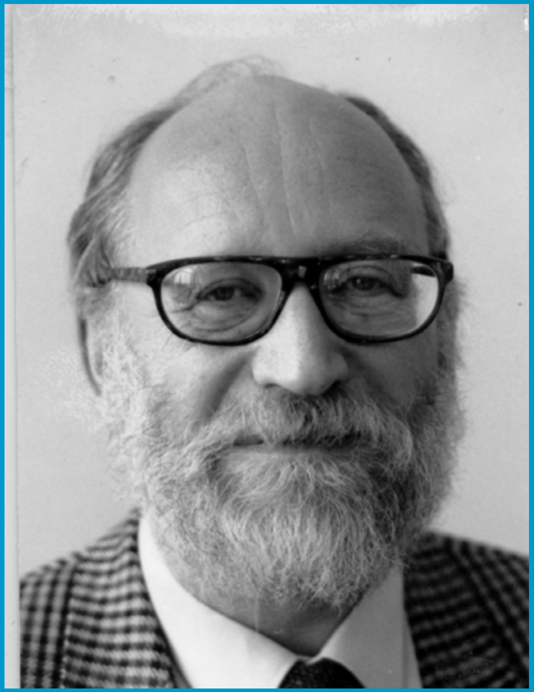
Joost J. Kalker
(1933-2006)
A Life in Rolling Contact



Arend L. Schwab
Laboratory for Engineering Mechanics
Faculty of Mechanical Engineering
Delft University of Technology
The Netherlands

ASME 2007 IDETC, Sep 4-7, 2007, Las Vegas, USA

TU Delft
Delft University of Technology

Acknowledgement

C. M. Kalker-Kalkman, TUDelft

K. L. Johnson, Cambridge UK

G. J. Olsder, TUDelft

K. Knothe, TUBerlin, Germany

J. P. Meijaard, Nottingham UK

TUDelft

Born

The Hague, July 25, 1933

Jewish Family; Father: GP, Mother: Dentist

TU Delft

Born

The Hague, July 25, 1933

Jewish Family; Father: GP, Mother: Dentist

TUDelft

II World War 1940-1945

After the Holocaust, 1945

TU Delft

Youth

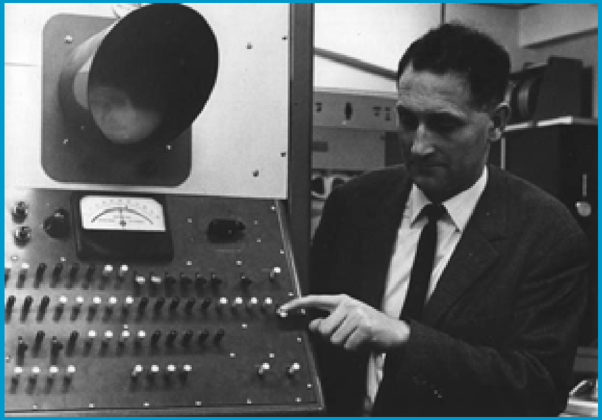
1945-1951: Gymnasium (secondary school)

1951: enters TUDelft in the new department of Applied Mathematics

TUDelft

TUDelft studies 1951-1958

Cokkie Kalkman



Prof van der Poel

Prof Timman

(Prof) de Pater

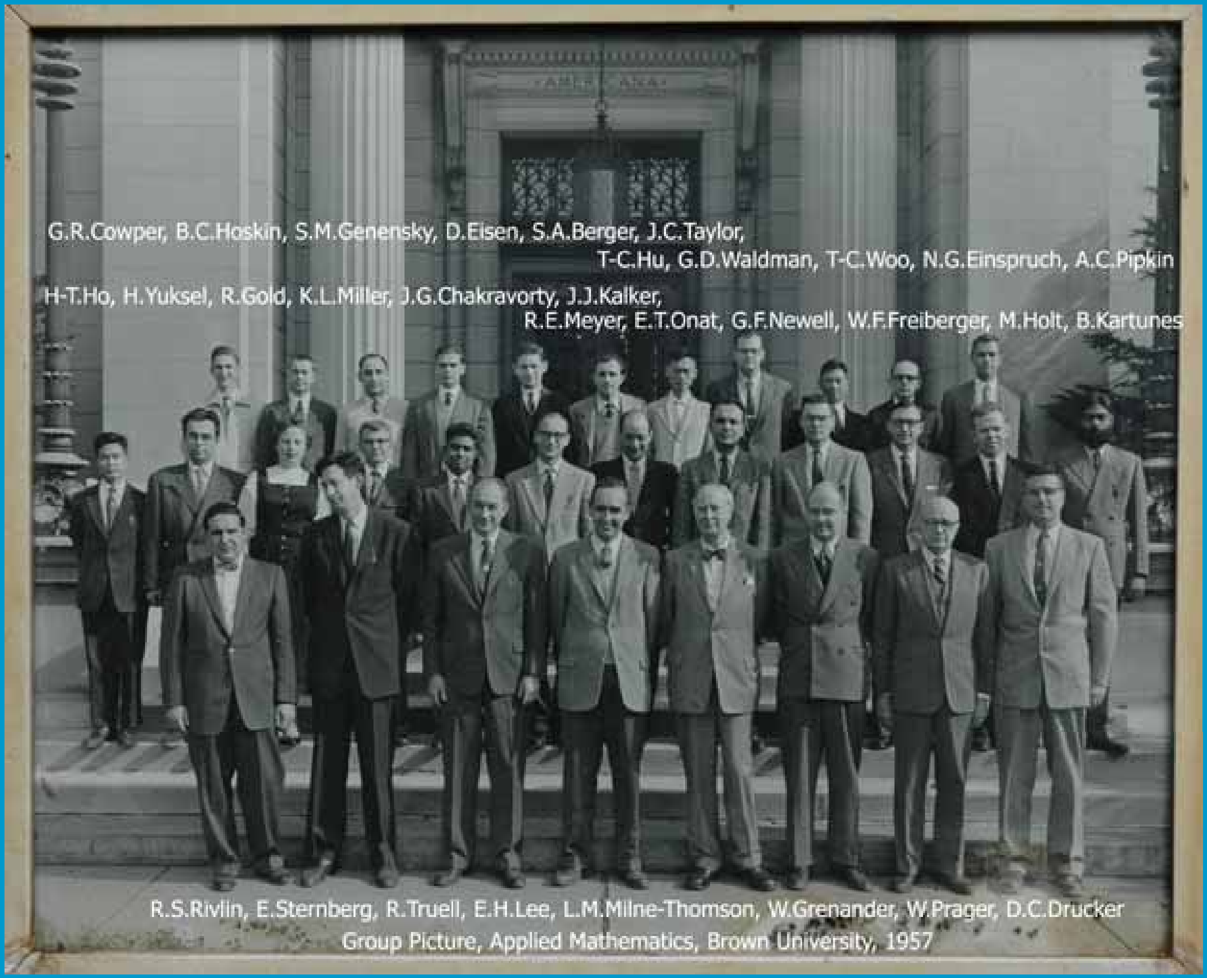
TUDelft

TUDelft studies 1951-1958

1956-1957:
Research Associate at Brown University (Fulbright Grant)

Applied Math group of Prager and Sternberg

TUDelft studies 1951-1958



1956-1957:
Research Associate at Brown University (Fulbright Grant)

Applied Math group of Prager and Sternberg

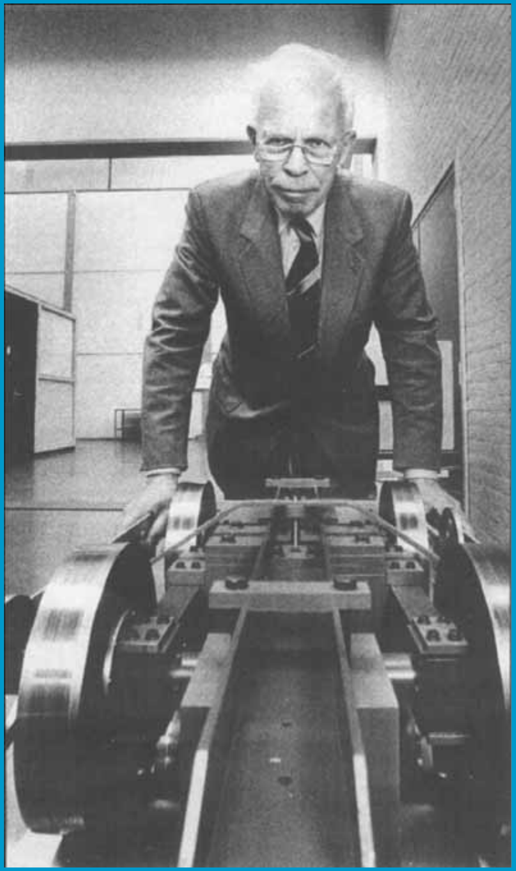
TUDelft studies 1951-1958

1956-1957:
Research Associate
at Brown University
(Fulbright Grant)

Topic: programming an IBM 704 for minimal weight design of steel frames

TUDelft

TUDelft studies 1951-1958

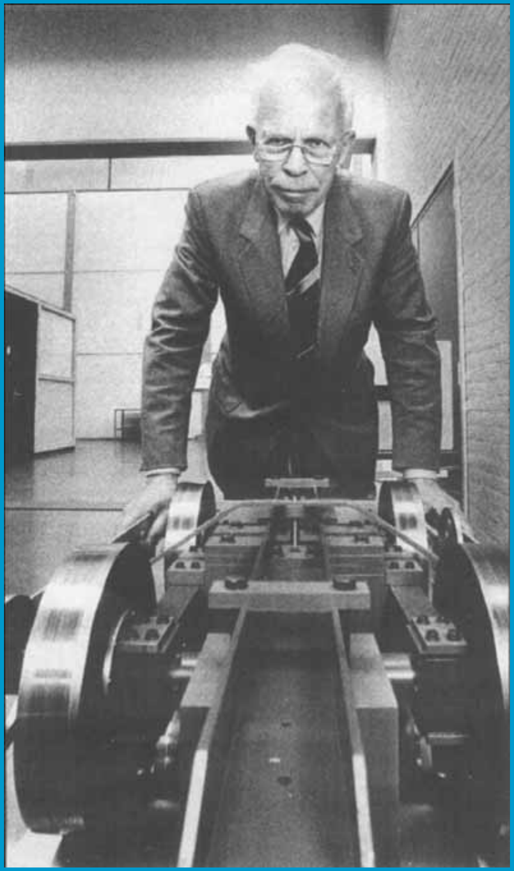


Prof de Pater

1958 MSc thesis (Summa Cum Laude):

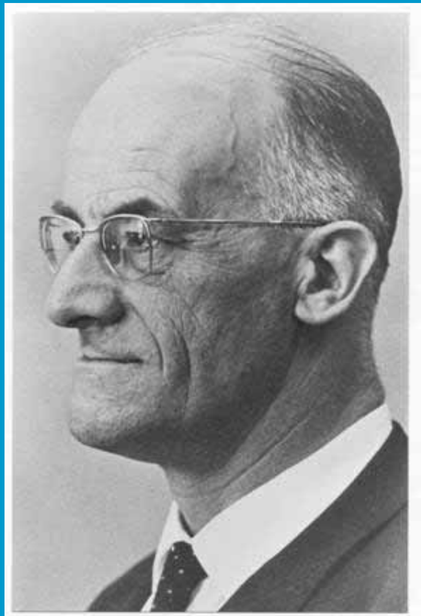
`The forces transmitted by two elastic bodies'

TUDelft position



Prof de Pater

1960: Assistant Professor working with Timman and de Pater who is now (1958) full Professor in the group of Prof W. T. Koiter



Warner Tjardus Koiter

TUDelft

PhD Dissertation 1967

ON THE ROLLING CONTACT OF TWO ELASTIC BODIES
IN THE PRESENCE OF DRY FRICTION

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR IN DE TECHNISCHE WETENSCHAPPEN AAN DE TECHNISCHE HOGESCHOOL TE DELFT OP GEZAG VAN DE RECTOR MAGNIFICUS IR. H. J. DE WIJS, HOOGLERAAR IN DE AFDELING DER MIJNBOUWKUNDE, TE VERDEDIGEN OP WOENSDAG 5 JULI 1967 DES NAMIDDAGS TE 2 UUR

DOOR

JOOST JACQUES KALKER
WISKUNDIG INGENIEUR
GEBOREN TE 'S-GRAVENHAGE

Advised by de Pater and Timman

Magnus Opus

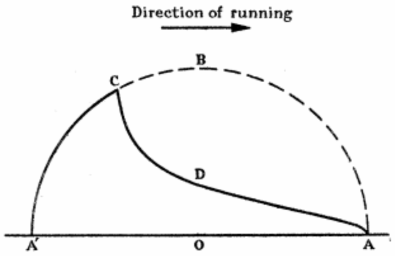
Starting: Carter, Fromm and Love.

On the Action of a Locomotive Driving Wheel.

By F. W. Carter, M.A., Sc.D., M.Inst.C.E., M.I.E.E.

(Communicated by Prof. A. E. H. Love, F.R.S.—Received April 15, 1926.)

We next consider the normal operation of the wheel. Assuming it to be running in the positive direction of the x-axis, let A′OA in the figure represent the contact surface, A being the point of first contact, and A′ the point of leaving. Let ABA′ be the curve of limiting tangential traction T_1P'/P. The actual curve of tangential traction will follow some line ADCA′, starting at A and never exceeding the limiting curve. Over the portion ADC of the curve, the surfaces



in contact are locked together, and the surface-strain is accordingly constant ;

TU Delft

PhD Dissertation 1967

$$
\left.\begin{aligned}
&I(x,y) = \iint_E J(x',y')K(x',y')H(x-x',y-y')\,dx'dy', \\
&\text{then, if } (x,y) \text{ lies in } E = \{x,y:\ x^2/a^2+y^2/b^2 \le 1\}, \\
&I(x,y) = \sum_{m=0}^{M} \sum_{n=0}^{M-m} a_{mn} x^m y^n,
\end{aligned}\right\} \quad (2.21b)
$$

that is, $I(x,y)$ is a polynomial in x,y of the same degree as $K(x,y)$.

The lemma was established by GALIN [1], ch. 2, sec. 8, in the special case that $k=\ell=0$, by means of LAME's functions. Its significance for the solution of the integral equations (2.18) and (2.19) is the following. We see that all functions of $(x-x')$ and $(y-y')$ that occur in the integrands of (2.18) and (2.19) are of the form $H(x-x',y-y')$. If we suppose that the tractions X,Y,Z are of the form $J(x,y)K(x,y)$, then it follows that the displacement differences u,v,w inside the elliptical area are polynomials in x and y of the same degree as that of $K(x,y)$. But that means that there are as many parameters in the displacement differences as there are in the tractions. There is a strong presumption x), borne out by our numerical work, that the displacement fields are independent of each other. It follows that we may invert the argument, and say that when u, v and w are given as polynomials inside E, the tractions X,Y,Z must be of the form $J(x,y)K(x,y)$. Clearly, the connection between the constants d_{pq} and a_{mn} is linear, owing to the linearity of the equations. Summarizing, we see that the lemma presumably implies that

$$
\left.\begin{aligned}
&(u,v,w) = \sum_{m=0}^{M} \sum_{n=0}^{M-m} (a_{mn}, b_{mn}, c_{mn})\, x^m y^n \text{ inside } E \\
&\Leftrightarrow (X,Y,Z) = J(x,y)G \sum_{p=0}^{M} \sum_{q=0}^{M-p} (d_{pq}, e_{pq}, f_{pq})\, x^p y^q,
\end{aligned}\right\} \quad (2.22)
$$

where the constants (a_{mn}, b_{mn}, c_{mn}) are connected with (d_{pq}, e_{pq}, f_{pq})

---

x) KIRCHHOFF's uniqueness theorem does not hold when the stresses go to infinity, as they do here.

by linear equations.

We now turn to the

Proof of the Lemma.

Consider a typical term of the polynomial $K(x,y)$, viz. $x^p y^q$. Then the lemma is proved, if we can show that

$$\iint_E J(x',y')x'^p y'^q H(x-x',y-y')\,dx'dy' = P_{p+q}(x,y), \quad (2.23)$$

where $P_m(x,y)$ denotes an arbitrary polynomial in x,y of degree m. We introduce polar coordinates R, ψ about the point (x,y):

$$x'-x = R\cos\psi,\quad y'-y = R\sin\psi,\quad dx'dy' = R\,dR\,d\psi, \quad (2.24)$$

and we introduce a new notation: $F_m(\psi)$ is an unspecified function of ψ, independent of R, x, and y, for which

$$F_m(\psi+\pi) = (-1)^m F_m(\psi). \quad (2.25)$$

For example, $\sin\psi = F_1(\psi)$, $\cos\psi = F_1(\psi)$. Multiplication of functions $F_m(\psi)$ is governed by the law that $F_m(\psi)F_n(\psi) = F_{m+n}(\psi)$. Now,

$$H(x-x',y-y') = (x-x')^k (y-y')^{2\ell-k}/R^{2\ell+1}, \text{ so,}$$

$$H(x-x',y-y') = \frac{1}{R} F_o(\psi). \quad (2.26)$$

We must write the factor $1-(x'/a)^2-(y'/b)^2$ in polar coordinates:

$$1-(x'/a)^2-(y'/b)^2 = 1 - \frac{(R\cos\psi+x)^2}{a^2} - \frac{(R\sin\psi+y)^2}{b^2} =$$

$$= \left(1-\frac{x^2}{a^2}-\frac{y^2}{b^2}\right) - 2R\left(\frac{x\cos\psi}{a^2}+\frac{y\sin\psi}{b^2}\right) - R^2\left(\frac{\cos^2\psi}{a^2}+\frac{\sin^2\psi}{b^2}\right) =$$

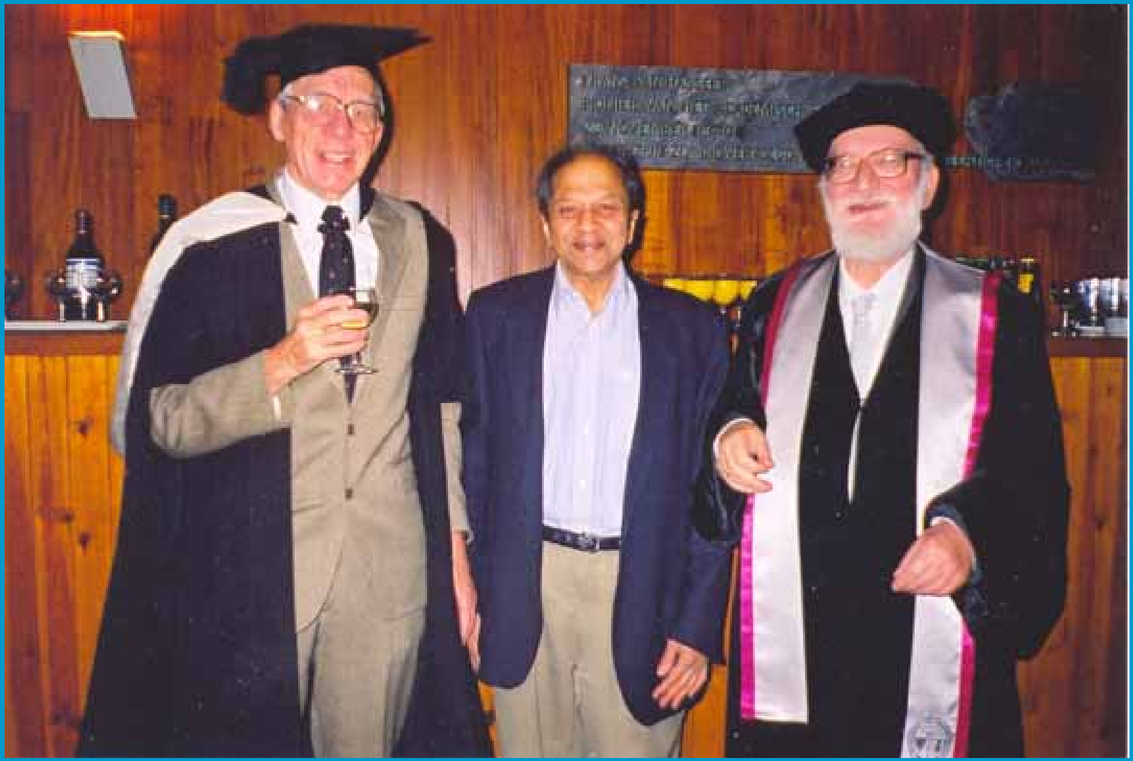
$$= -A\{R^2+2DR-C\} = -A\{(R+D)^2-C-D^2\} = A\{B^2-(R+D)^2\},$$

with

$$
\left.\begin{aligned}
&A = \frac{\cos^2\psi}{a^2} + \frac{\sin^2\psi}{b^2} = F_o(\psi) > 0, \\
&C = \frac{1}{A}\{1-x^2/a^2-y^2/b^2\}, \\
&D = \frac{1}{A}\left(\frac{x\cos\psi}{a^2}+\frac{y\sin\psi}{b^2}\right), \\
&B = B(\psi) = \sqrt{B^2} = \sqrt{\frac{1}{A}\left(1-\frac{x^2}{a^2}-\frac{y^2}{b^2}\right) + \frac{1}{A^2}\left(\frac{x\cos\psi}{a^2}+\frac{y\sin\psi}{b^2}\right)^2} =
\end{aligned}\right\} \quad (2.27)
$$

TUDelft position

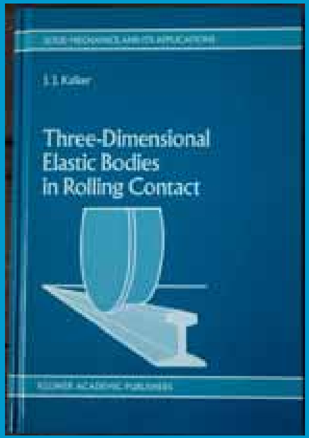
1979: Full Professor on a personal chair in Applied Mathematics



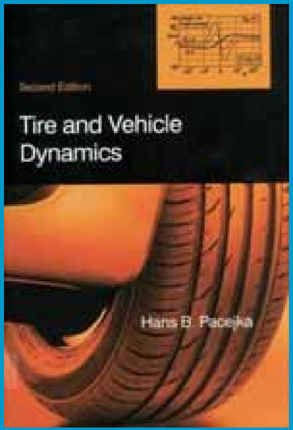
K. L. Johnson A. R. Savkoor J. J. Kalker

TUDelft

The role of Prof de Pater



A. D. de Pater
(1920-2001)



Wheel-Rail
Joost Kalker PhD 1967

Tire-Road
Hans Pacejka PhD 1966

TUDelft

The role of Prof de Pater

IAVSD 1991

The role of Prof de Pater

IAVSD 1991

Work continues

A living legend: the `Kalker Coefficients’

```
C ***********************************************************************
      Subroutine Contac (Inp)
C Performs calculations for one case. Calls Dis, RzNorm, RzTang, GenCr if
C this is requested, and if R=0,1 computes tractions Ps and Contact area Igs.
      Implicit None
      Include 'matrsize.new'
C Variables of the commons
      Integer Ic(16), MaxGS, MaxIn, MaxNR, MaxOut, Dczep, Kigowr, Vtnfs,
     , Mx,My, NPot, Row1st(NPO), RowLst(NPO), IBase,IPlan, Nn, Col(NPO),
     , Mx2, My2, Row(NPO), Igs(NPO), iKombi, iNorm, iTang
      Double Precision Eps, Dx,Dy,DxDy, X(Npo), Xo, Y(Npo), Yo, B(NPO),
     , ExRhs(NPO,3), H(NPO,3), Xb(Mxb,3), Ak, Cr(-2*NPO:2*NPO,3,3),
     , CrF(-2*NPO:2*NPO,3,3), CrS(-2*NPO:2*NPO,3,3), Chi, FKin, Fn,
     , FStat, Fux, Fuy, Fun, Fx,
     , Fy, Pen, Ph, S, Ux, Uy, Couple, dU(NPO,3), Elen, Fric, Ps(NPO,3),
     , Pv(NPO,3), Sens(5,3), WAbs(NPO)
C Local variables :
      Integer It, Inp
      Logical zKombi

      Common /Contrl/ Ic,MaxGS,MaxIn,MaxNR,MaxOut,Dczep,Kigowr,Vtnfs,Eps
      Common /DisCns/ Mx, My, NPot, Row1st, RowLst,
     , Dx, Dy, DxDy, X, Xo, Y, Yo
      Common /Geomet/ iBase, iPlan, Nn, B, ExRhs, H, Xb
      Common /Influe/ Col, Mx2, My2, Row, Ak, Cr, CrF, CrS
      Common /KinCns/ Chi, FKin, Fn, FStat, Fun, Fux, Fuy, Fx, Fy,
     ,      Pen, Ph, S, Ux, Uy
      Common /OutCmm/ Igs, iKombi, iNorm, iTang,
     ,        Couple, dU, Elen, Fric, Ps, Pv, Sens, WAbs

      External UnPack

      Call UnPack (Vtnfs, Dczep, Kigowr, Ic)
      zKombi = Ic(Kombi).Eq.1 .And. Ic(Force).Eq.0 .And. Ic(Tang).Ne.0
      If (Ic(Dis) .Gt. 0) Then
C!    make new discretisation
```

1982: Computer code ‘CONTACT’

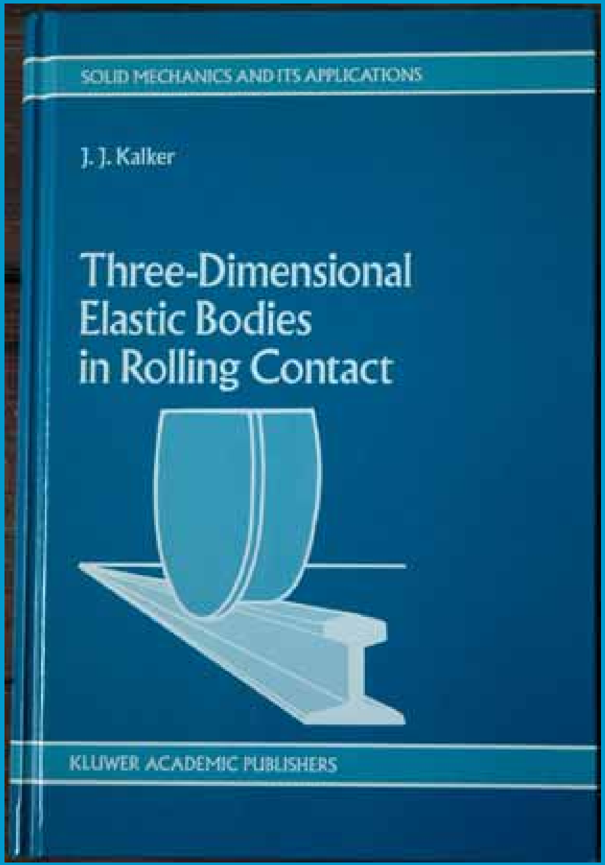
Work continues

Simplified theory

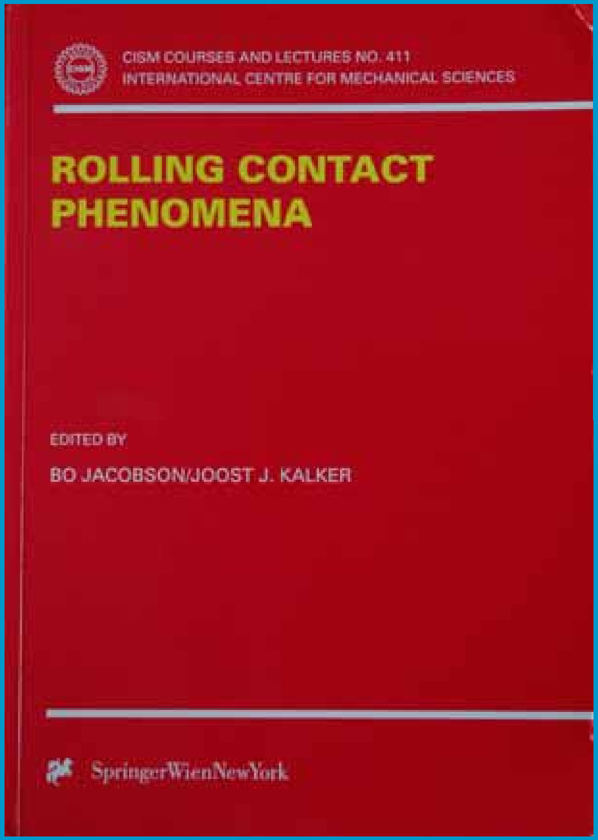
```
C FASTSIMF VERSION 1980.02.01 (FORTRAN), SIMPLIFIED THEORY OF ROLLING.
* 14-NOV-02 schwab created.
      IMPLICIT NONE
      LOGICAL KLEIN,NK
      DOUBLE PRECISION UX,UY,FX,FY,TX,TY,TZ,TOL,NUX,NUY,FI,C1,C2,C3,
     &  PI,B,C,Y,YMI,DY
      INTEGER RN,MX,MY,CSE,S,J
C INPUT OF CREEP QUANTITIES
      PI=3.141592653D0
      CSE=1
      READ(5,*) RN
  500 CONTINUE
      IF(RN) 100,101,102
  100 CONTINUE
      READ(5,*) MX,MY,TOL,C1,C2,C3,B
  102 READ(5,*) NUX,NUY,FI
      UX=C1*NUX
      UY=C2*NUY
      FX=C3*B*FI
      FY=C3*FI
C
C THE CALCULATION
C
C SET THE TANGENTIAL FORCES EQUAL TO ZERO
      TX=0.0D0
      TY=0.0D0
      S=1.0D0
   10 CONTINUE
      IF(ABS(UX).GT.ABS(FX).OR.ABS(UY).GT.ABS(FY)) GOTO 105
      GOTO 110
  105 KLEIN=.FALSE.
      DY=2.0D0/MY
      S=-1.0D0
      YMI=-1.0D0
      GOTO 115
  110 KLEIN=.TRUE.
      C=UX/FX*S
      J=IDINT((1.0D0-C)*MY/2.0D0)+1
```

Computer code ‘FASTSIM’

The Book



1990



1999

Advisor

- Max Viergever (1980): ‘Mechanics of the inner ear; a mathematical approach’
- Francois van Geer (1987): ‘Application of Kalman filtering in the analysis and design of groundwater monitoring networks’
- Juergen Jaeger (1992): ‘Elastic impact with friction’
- Gerard Braat (1993): ‘Theory and experiments on layered, visco-elastic cylinders in rolling contact’
- Francois Periard (1998): ’ Wheel-rail noise generation: curve squealing by trams’
- Zili Li (2002): ‘Wheel-rail rolling contact and its application to wear simulation’

TU Delft

International Contacts & Travel

1991, TGV Lyon

1990, Cokkie & Joost in China

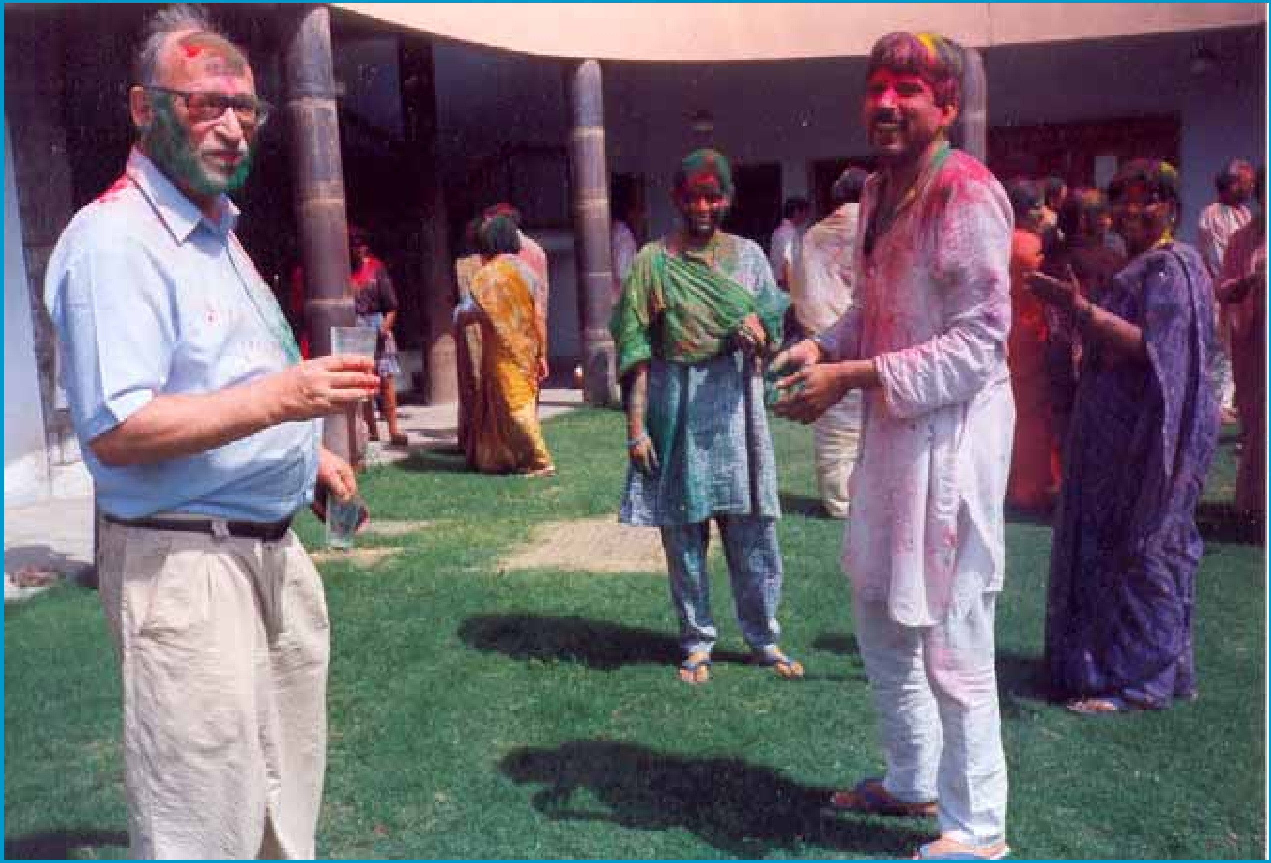
International Contacts & Travel

1990, Cokkie & Joost in the Shinkansen

1990, Cokkie & Joost in Japan

TUDelft

International Contacts & Travel



1996, Joost in India

TUDelft

Garden Parties & Cooking

TUDelft

Family Life

1981, Pauline Kalker, Titia Kalker, Cokkie & Joost

2004, Joost, Felix Kalker, Cokkie

Family Life

July 2005

Family Life


Olaf Duin
Titia Kalker
Cokkie Kalker
Herman Helle
Pauline Kalker
Felix Kalker
Floor Kalker
Joost Kalker
Simon Kalker
July 2005

Joost J. Kalker
(1933-2006)
A Life in Rolling Contact