APPENDIX C

GEOTRACK INPUT AND OUTPUT

Tie length .... 2200 mm
Number of segments per tie 10
Number of segments between rails ... 6
Tie spacing .... 650.2 mm
Tie width .... 259.1 mm
Tie area .... 5.981e+004 mm^2
Tie weight .... 285 kg
Tie EI .... 1.235e+004 kN.m^2
Rail spacing .... 1140 mm
Rail area .... 7703 mm^2
Rail weight .... 60.02 kg/m
Rail EI .... 6558 kN.m^2
Rail fastener stiffness .... 1.2e+006 kN/m

Number of axle loads 1
Axle loads are on tie number(s) 1 0 0 0
Wheel load per axle (Tonnes. 17 0 0 0
Number of soil layers 5

Layer	Modulus (Mpa)	Vrat	Depth (mm)	Gamma (kN/m^3)	Knot	Ktype
1	344.83	0.30	549.91	19.49	3.00	0
2	36.00	0.40	500.13	20.50	0.70	0
3	34.65	0.40	199.90	20.50	0.70	0
4	62.68	0.40	1300.0	20.50	0.70	0
5	62.68	0.40	0.00	20.50	0.70	0

Different Depths at Which Moduli are Computed

Z(1) = 50.04 mm
Z(2) = 554.99 mm
Z(3) = 1055.12 mm
Z(4) = 1255.02 mm
Z(5) = 2555.25 mm

CALC. STEP NO. 1

DEFLECTIONS AND REACTIONS
NEGATIVE DEFLECTION IS DOWNWARD
NEGATIVE REACTION IS TENSION

---- SINGLE AXLE ----

TIE NO.	DEFLECTION RAIL mm	REACTION RAIL SEAT kN	DEFLECTION TIE mm
1	-2.367996	88.1	-2.294615
2	-1.860706	35.9	-1.830836
3	-1.205842	5.4	-1.201321
4	-0.771222	0.9	-0.770511
5	-0.508306	-1.3	-0.509423
6	-0.315113	-1.4	-0.316256

PEAK RAIL BENDING MOMENT= 2.40e+001 kN.m

TRACK MODULUS U = 5.673 KIPS/IN./IN. = 39.106 MN/M/M

SOIL VERTICAL DISPLACEMENTS AND INCREMENTAL STRESSES

T = TIE NUMBER (1=CENTER TIE)
SEG = SEGMENT NUMBER
Z = DEPTH POINT NUMBER
XX = DIRECTION PARALLEL TO TIES
YY = DIRECTION PARALLEL TO RAILS
ZZ = VERTICAL DIRECTION
Units are mm and kPa
COMPRESSION IS NEGATIVE FOR STRESSES
DOWNWARD IS POSITIVE FOR DEFLECTIONS

Z(1) = 50.04 mm
Z(2) = 554.99 mm
Z(3) = 1055.12 mm
Z(4) = 1255.02 mm
Z(5) = 2555.25 mm

T	SEG	Z	W	THETA	S-XX	S-YY	S-ZZ	S-XY	S-XZ	S-YZ
1	1	1	2.0447	-1009.66	-251.72	-262.76	-495.17	0.00	-28.28	0.00
1	1	2	1.7942	-77.93	-17.24	-13.10	-47.59	0.00	-10.34	0.00
1	1	3	1.3799	-57.93	-13.10	-10.34	-34.48	0.00	-8.28	0.00
1	1	4	1.2509	-43.45	-8.28	-4.83	-30.34	0.00	-8.97	0.00
1	1	5	0.8521	-17.93	-2.07	-0.69	-15.17	0.00	-4.14	0.00
1	2	1	2.1864	-825.52	-258.62	-239.31	-326.90	0.00	6.90	0.00
1	2	2	1.9667	-89.66	-19.31	-14.48	-55.86	0.00	-6.21	0.00
				*						
				*						
				*						
1	5	4	1.4480	-55.17	-8.97	-6.21	-40.69	0.00	-0.69	0.00
1	5	5	0.9238	-20.00	-1.38	-0.69	-18.62	0.00	-0.69	0.00

T	SEG	Z	W	THETA	S-XX	S-YY	S-ZZ	S-XY	S-XZ	S-YZ
2	1	1	1.6759	-546.90	-144.83	-134.48	-266.90	-21.38	-13.79	4.83
2	1	2	1.5415	-61.38	-13.79	-14.48	-33.79	2.76	-6.90	6.90
2	1	3	1.2545	-48.28	-11.03	-10.34	-26.90	2.07	-6.90	6.21
2	1	4	1.1554	-37.93	-6.90	-6.21	-24.83	2.07	-6.90	6.21
2	1	5	0.8194	-16.55	-1.38	-0.69	-13.79	0.69	-3.45	2.76
2	2	1	1.7673	-375.17	-135.86	-104.83	-134.48	-17.24	6.90	6.21
2	2	2	1.6675	-68.97	-15.17	-15.86	-37.93	2.07	-3.45	7.59
2	2	3	1.3347	-54.48	-11.72	-11.72	-31.03	1.38	-5.52	6.90
				*						
				*						
				*						
5	5	4	0.5565	-7.59	-0.69	-4.83	-1.38	0.00	0.00	4.14
5	5	5	0.5303	-7.59	0.00	-3.45	-4.14	0.00	0.00	4.14

T	SEG	Z	W	THETA	S-XX	S-YY	S-ZZ	S-XY	S-XZ	S-YZ
6	1	1	0.3154	7.59	0.00	8.97	-1.38	-2.07	0.69	-0.69
6	1	2	0.3180	0.00	0.00	-0.69	0.69	0.00	0.00	0.69
6	1	3	0.3340	-1.38	0.00	-1.38	0.00	0.00	0.00	1.38
6	1	4	0.3385	-2.76	0.00	-2.07	0.00	0.69	0.00	1.38
6	1	5	0.3426	-4.14	0.00	-2.07	-1.38	0.69	-0.69	2.07
6	2	1	0.3157	14.48	1.38	11.03	1.38	-1.38	0.69	-0.69
6	2	2	0.3200	0.00	0.00	-0.69	1.38	0.00	0.00	0.69
6	2	3	0.3383	-1.38	0.00	-1.38	0.69	0.00	0.00	1.38
				*						
				*						
				*						
6	5	4	0.3512	-2.76	0.00	-2.76	0.00	0.00	0.00	1.38
6	5	5	0.3561	-4.14	0.00	-2.07	-2.07	0.00	0.00	2.76

			GEOSTAT.	INIT.	INIT.			EQUIVALENT TRIAXIAL STATES					
TIE	SEG	POINT	DEPTH	KNOT	VERT.STR.	P	Q	SOCT	TOCT	SIG 1	SIG 3	MAX P	MAX Q
			(mm)	(kPa) ->									
1	1	1	50.80	3.00	6.14	12.34	-6.14	350.97	108.76	504.76	274.07	389.38	115.38
1	1	2	556.26	0.70	16.00	13.59	2.41	38.83	18.69	65.24	25.66	45.45	19.79
1	1	3	1054.10	0.70	26.28	22.34	3.93	40.34	14.90	61.38	29.79	45.59	15.79
1	1	4	1254.76	0.70	30.34	25.79	4.55	38.90	16.90	62.76	26.97	44.83	17.93
1	1	5	2555.25	0.70	57.03	48.48	8.55	51.52	14.90	72.62	41.03	56.83	15.79
1	2	1	50.80	3.00	6.41	12.83	-6.41	290.07	31.86	335.10	267.52	301.31	33.79
1	2	2	556.26	0.70	16.28	13.86	2.41	42.83	21.10	72.62	27.93	50.28	22.34
1	2	3	1054.10	0.70	26.55	22.55	4.00	42.90	16.90	66.76	30.90	48.83	17.93
1	2	4	1254.76	0.70	30.62	26.00	4.62	40.55	17.79	65.79	28.00	46.90	18.90
1	2	5	2555.25	0.70	57.31	48.69	8.62	52.00	14.90	73.10	41.52	57.31	15.79
1	3	1	50.80	3.00	10.83	21.66	-10.83	289.66	21.10	319.45	274.76	297.10	22.34
1	3	2	556.26	0.70	20.69	17.59	3.10	48.69	21.79	79.52	33.24	56.34	23.10
				*									
				*									
				*									
6	5	3	1054.10	0.70	26.34	22.34	3.93	21.45	0.00	21.45	21.45	21.45	0.00
6	5	4	1254.76	0.70	30.41	25.86	4.55	25.24	0.00	25.24	25.24	25.24	0.00
6	5	5	2555.25	0.70	57.10	48.55	8.55	47.10	7.93	58.34	41.45	49.93	8.41

APPENDIX D

DYNAMIC MODELLING

Dynamics is the part of mechanics which deals with the study of both motion of material bodies and the forces that bring about the motion. Dynamic modelling is the mathematical representation of such behaviour. In this appendix a simple system in motion is described and its mathematical equation is given.

In Figure D1 a body of mass, m, is fixed to a spring with stiffness, k, and damper with damping coefficient, ρ. The system possesses only one degree of freedom since its motion is described by a single coordinate, x. If the body is acted upon by a restoring force k per unit displacement from the equilibrium position and by a damping force ρ per unit velocity, the force equilibrium according to Newton's second law of motion is given by the following equation.

$$m \frac{d^2x}{dt^2} = -kx - \rho \frac{dx}{dt} \qquad \text{(D1)}$$

The equation is called the equation of motion of the system and is mathematically defined as a homogeneous second-order differential equation. It can be seen that the restoring force and the damping force is negative since its direction is opposite to that of the displacement and velocity respectively.

In some cases the body may be subjected to a disturbing force due to the movement, y, of the spring and damper support. In this instance the equation of motion becomes

$$m \frac{d^2 x}{dt^2} = - k(x - y) - \rho\left(\frac{dx}{dt} - \frac{dy}{dt}\right) \tag{D2}$$

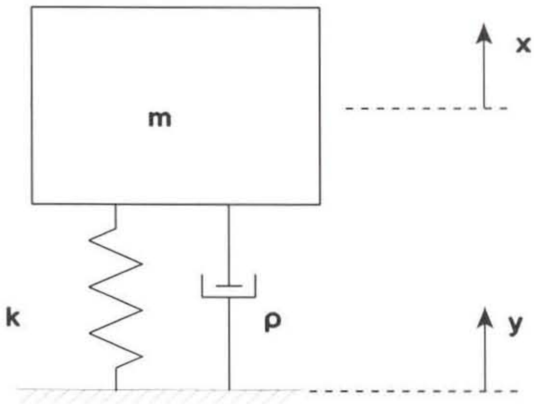

Figure D1: One degree-of-freedom model.