Temasek Defence Systems Institute

Design of Single Wheel Tester

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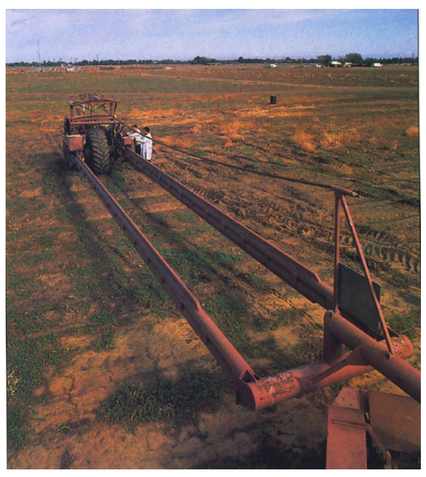
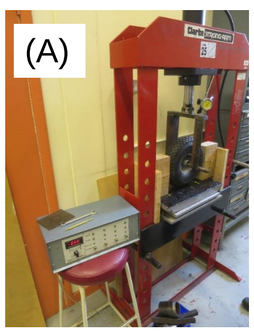
1. Introduction

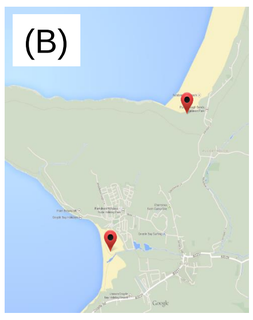
- Aim: To design and build a single wheel tester
- A single wheel tester is used to understand wheel-terrain interaction
- By using terramechanics, a portable single wheel tester can be designed and built to test tractive performance of wheels on site.



Single Wheel Traction Machine from University of California

2. Measurements





- Wheel deflection measurement done in EDC
- Cone index measurements carried out in Devon, U.K. using a cone penetrometer.
- Results input into mobility prediction equations for designing the single wheel tester

(A) : Wheel Deflection Measurement
(B) : Some of places in Devon, U.K.
(C) : CI readings by Author

3. Mobility Predictions

$$\mathrm{DBP} = \mathrm{H} - \mathrm{R_t}$$

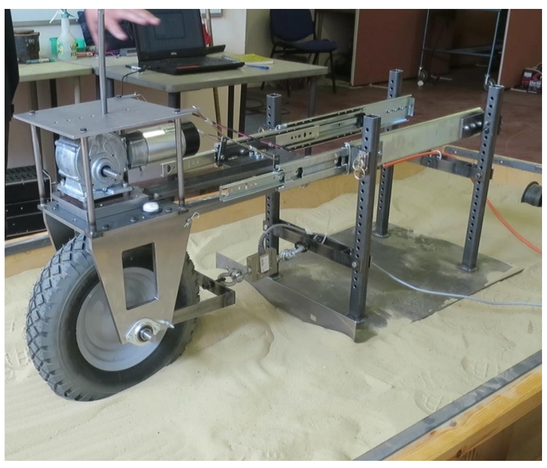
$$\Pi_{HS} = \frac{CIbd}{W}\sqrt{\frac{h-\delta}{d}}$$

$$\frac{D}{W} = 0.88(1 - e^{-0.1\Pi_{HS}})(1 - e^{-0.75\Pi_{HS}}) + 0.04$$

$$\frac{R}{W} = \frac{1}{\Pi_{HS}} + \frac{0.5s}{\sqrt{\Pi_{HS}}} + 0.04$$

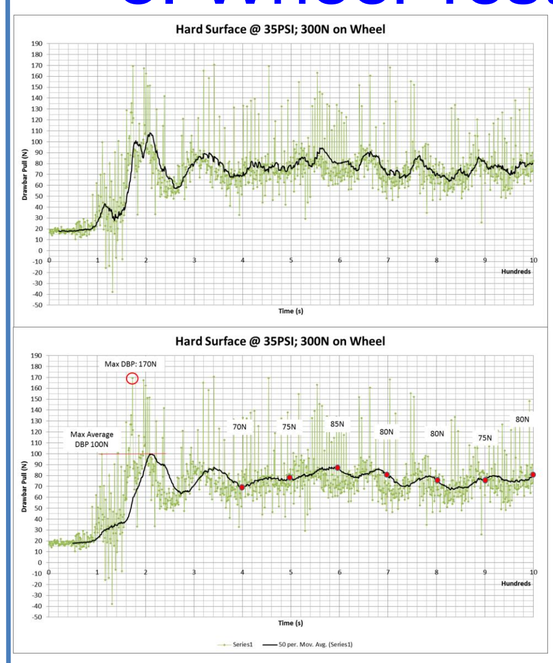
- Mobility numeric from Hegazy and Sandu shown
- Novel mobility numeric shown by Hegazy and Sandu to have good relation with experiments
- Initial prediction shown proposed single wheel tester is likely to get bogged down at low cone index sands

4. Wheel Testing in Sand Pit



- Wheel testing in sand pit not completed: single wheel tester is bogged down in sand pit
- This is likely due to the sledge being pushed down when wheel tester moved
- Modifications to the single wheel tester necessary
- Focus turned to wheel testing on hard ground

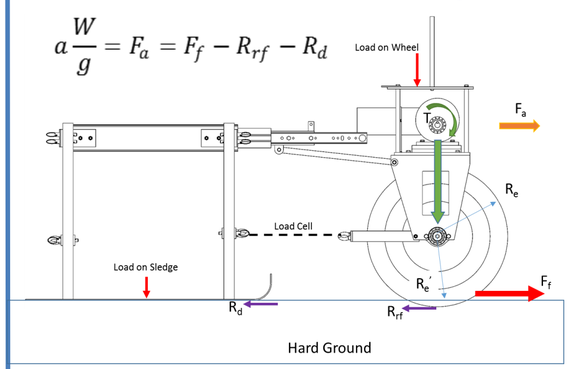
5. Wheel Testing on Hard Ground



- Single wheel tester tested on hard ground; weights are placed on it as drawbar pull measured.
- Noisy data obtained: moving averaging of data points is done using Excel®. Top graph uses period of 20 while bottom graph uses period of 50
- Trend is similar. Data are extracted from graphs for analysis

6. Discussion

$$a\frac{W}{g} = F_a = F_f - R_{rf} - R_d$$



- Wheel-Terrain Interaction represented and validated
- Single wheel tester will be immobilised when insufficient Fa is first calculated
- Data can be better correlated with velocity readings of wheel and single wheel tester
- Hardware filter could improve quality of data

Immobilised?	Loads Added		Maximum		DBP at each Second							Steady	Std	Weight		F_f	R_{rf}	R_d	F_a
	W (N)	S (N)	DBP (N)	A.DBP (N)	4th	5th	6th	7th	8th	9th	10th	State	Dev	Wheel	Sledge				
N	0	0	175	115	90	100	95	100	105	100	105	99.3	4.9	280	300	203.0	0.6	141.0	61.4
N	100	0	140	70	70	65	70	70	65	70	45	65.0	8.5	380	300	275.5	0.8	141.0	133.7
N	200	0	210	125	105	105	100	100	105	95	100	101.4	3.5	480	300	348.0	1.0	141.0	206.0
N	300	0	190	120	90	95	95	105	100	90	95	95.7	4.9	580	300	420.5	1.2	141.0	278.3
N	400	0	180	110	100	95	100	105	95	90	95	97.1	4.5	680	300	493.0	1.4	141.0	350.6
N	400	0	180	115	90	85	95	105	90	90	85	91.4	6.4	680	300	493.0	1.4	141.0	350.6
N	0	100	200	150	140	140	125	145	135	135	135	136.4	5.8	280	400	203.0	0.6	188.0	14.4
Y	0	200	225	150	140	155	155	135	145	145	145	145.7	6.8	280	500	203.0	0.6	235.0	-32.6
Y	0	200	215	160	160	165	160	145	155	155	160	157.1	5.9	280	500	203.0	0.6	235.0	-32.6
Y	50	200	260	185	170	180	170	175	175	185	185	177.1	5.9	330	500	239.3	0.7	235.0	3.6
N	100	200	275	210	185	170	175	190	180	170	175	177.9	7.0	380	500	275.5	0.8	235.0	39.7
N	100	200	260	195	220	205	205	190	200	190	200	201.4	9.5	380	500	275.5	0.8	235.0	39.7
Y	100	300	265	200	200	200	200	200	200	200	200	200.0	0.0	380	600	275.5	0.8	282.0	-7.3
N	200	300	300	205	220	200	185	240	205	190	215	207.5	16.4	480	600	348.0	1.0	282.0	65.0
Y	200	400	320	250	250	250	250	250	250	250	250	250.0	0.0	480	700	348.0	1.0	329.0	18.0
N	300	400	350	320	300	240	260	220	230	250	265	260.6	32.1	580	700	420.5	1.2	329.0	90.3

7. Conclusion

- Single wheel tester is able to represent the wheel-terrain interaction.
- Possible application (1): validate similitude studies of different wheel dimensions on different terrain.
- Possible application (2): In-situ testing is possible without costly protoyping
- Modifications have to be made to prevent bogging down in sand pit
- Velocity measurements have to be taken for better correlation with data from single wheel tester

Reference: Teo, Elton “Design of Single Wheel Tester” Cranfield University, MSc, 2014

NUS National University of Singapore