VI-4 INFLUENCE OF TRACK SHAPE RATIO ON TURNING CHARACTERISTICS OF A TRACKED VEHICLE RUNNING ON FRESH CONCRETE

Ehime University, Graduate School	Student Membership	Tran Dang Thai
Ehime University, Faculty of Engineering	Felllow Membership	Muro Tatsuro
Ehime University, Faculty of Engineering	Full Membership	Kawahara Soichiro
Hitachi Kenki Co., Ltd.	Full Membership	Hirakawa Manabu

1. Research objective: The aim of the research is to investigate on a method to adapt ordinary tracked vehicle to a very soft terrain by changing track shape ratio. This paper will present the result of the investigation of the effect of track shape ratio on the turnability of flexible tracked vehicle running on soft fresh concrete. The investigation is based on the result of both a numerical analysis and experiment.

2. Experiment: The experiment was carried out using the scale model of a bulldozer running on fresh concrete of slump of 5.5 cm with different traction force and with steering ratio of 1.6. The vehicle dimensions ant terrain-track system constants are shown in **Table 1**. Measured characteristics are sinkages, traction force, turning radius and slip ratios.

3. Numerical analysis: The numerical analysis used in this research is based on a numerical method to solve set of equation describing steady turning state of tracked vehicle [1) 2)]. The numerical analysis is carried out with different track shape ratio k defined as ratio of track theoretical contact length D and track width B ($k = D/B$). The cases of investigated track shape ratio are shown in **Table. 2**. The shape ratio was chosen so that mean theoretical contact pressure is unchanged. Apart from the changes on the track width B and contact length D, i.e. changes on track shape ratio k other dimension remained unchanged.

Vehicle weight (N) W			638
Height of hitch point (cm) H_{dp}			15
Dist. from grav.cent. to hitch point(cm) L_{dp}			30
Initial tract tension (N) Ho			196
Height of gravity center (cm) Hg			10
Contact length (cm) D			33
Track width (cm) B			20
Track gauge (cm) C			33
Grouser height (cm) H			1.7
Grouser pitch (cm)			2.55
Grouser thickness (cm)			0.3
Maximum track extension (cm)			1
Rad. of front idler (cm) R_f R_r			6.5
Radius of road rollers (cm) R_m			1.9
Number of road rollers			3
Road roller interval (cm)			6
k_1 (N/cm^{n1+2})	0.2276	m_{clon}(N/cm^2)	0.0157
n_1	1.2130	m_{flon}	1.0170
k_2 (N/cm^{n1+2})	8.5445	a_{lon}(cm)	0.1531
n_2	0.8010	m_{clat}(N/cm^2)	0.1236
c_0(cm$^{1+2c1-c2}$/N^{c1})	0.9262	m_{flat}	0.0170
c_1	0.9152	a_{lat}(cm)	0.1225
c_2	0.6006	--	--

Table 1 Vehicle specifications and terrain-track system constants

B (cm)	D (cm)	k	p mean (N/cm^2)
12.50	52.80	4.224	0.4831
13.75	48.00	3.491	0.4831
15.00	44.00	2.933	0.4831
16.00	41.25	2.578	0.4831
20.00	33.00	1.650	0.4831

Table 2 Track shape ratio cases

4. Influence of track shape ratio to turning characteristics: Fig. 1 shows the influence of the track shape ratio k on lateral trim angle θ_{lat} for different slip ratios of outer track i_o. The figure shows that with the decrement of the track shape ratio k, i. e. the increment of the track width B, the lateral trim angle θ_{lat} becomes smaller on the zone where the slip ratio of inner track in contact plane has positive values. In the zone where the slip ratio of inner track in contact plane has negative values this influence becomes reverse. It can be said that for both zones the vehicle becomes more stable in lateral direction with the decrement of the track shape ratio k. The figure also shows the comparison between measured and calculated values of lateral trim angle θ_{lat} for the case of track shape ratio of 1.650.

Fig. 2 shows the influence of the track shape ratio k on the effective tractive effort T_4. In general, the tractive effort T_4 increases with the decrement of the track shape ratio k, i.e. increment of the track width B in the region where the slip ratio of inner track in contact plane has negative values. Contrary, the tractive effort T_4 increases with the increment of the track shape ratio k in the region where the slip ratio of inner track in contact plane has positive values. The figure shows there exists maximum effective tractive effort T_4 for all the cases of the track shape ratio k. The figure also shows the comparison between measured and computed values of the effective tractive effort for the case of track shape ratio of 1.650.

Influence of track shape ratio on turning characteristics of a tracked vehicle running on fresh concrete, Tran Dang Thai, Tatsuro Muro, , Soichiro Kawahara (Ehime University) and Hirakawa Manabu (Hitachi kenki. Co. Ltd.)

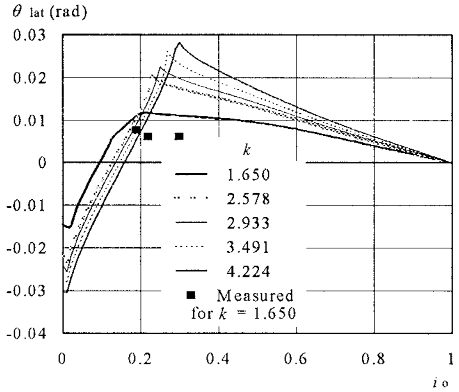

Fig. 1 Influence of track shape ratio k on lateral inclination angle θ_{lat} for different slip ratios of outer track i_o

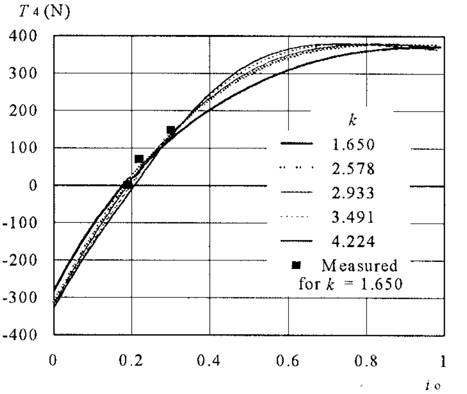

Fig. 2 Influence of track shape ratio k on effective tractive effort T_4 for different slip ratios of outer track i_o

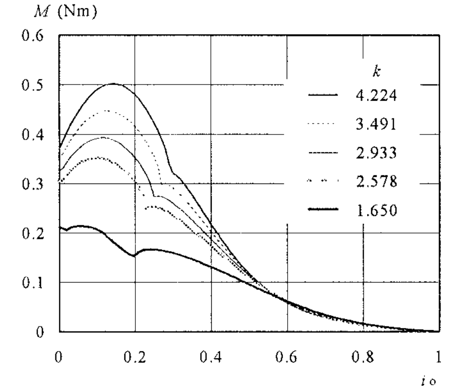

Fig. 3 Influence of track shape ratio k on turning moment M for different slip ratios of outer track i_o

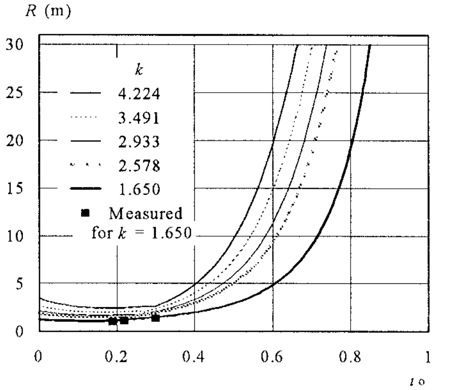

Fig. 4 Influence of track shape ratio k on turning radius R for different slip ratios of outer track i_o

Fig. 3 shows the influence of the track shape ratio k on the turning moment M for different slip ratios of outer track i_o. The turning moment M decreases with the decrement of the track shape ratio k, i. e. increment of the track width B. This phenomenon can be explained by decrease of arm length and lateral bulldozing resistance due to the decrease of the contact length when the track width increases. The maximum turning moment M can be observed for all the cases of the track shape ratio k. It is obvious that the track shape ratio k exerts considerable influence on the turning moment M in the region of smaller slip ratio of outer track i_o.

Fig. 4 shows the influence of the track shape ratio k on the turning radius R for different slip ratios of outer track i_o. The turning radius R decreases with the decrement of the track shape ratio k. From the figure, it can be observed that the track shape ratio k exerts considerable influence on the turning radius R especially in the larger range of the slip ratio of outer track i_o. The figure shows the minimum value of turning radius R can be observed for all the cases of shape track ratio k. The figure also shows the comparison between measured and calculated turning radius R for the case of the track shape ratio k of 1.650, i.e the track width B of 20 cm.

5. Conclusion: The effect of track shape ratio at the same mean theoretical contact pressure was investigated and the followings can be concluded for a given fresh concrete-model vehicle:

(1) The effective tractive effort increases with the increment of the track shape ratio for a zone of driving state of both tracks.

(2) The vehicle becomes more stable in lateral direction with the decrement of the track shape ratio.

(3) The track shape ratio has relatively great influence on turning radius and turning moment.

References: 1)T. Muro, T.D. Thai : Turning Characteristics of a Bulldozer under Traction on a Weak Sandy Terrain, Proceedings of 7th European ISTVS Conference, pp. 102-109, 1997.

2)T. Muro, T.D. Thai : Numerical Analysis to Predict Turning Characteristics of Rigid Tracked Vehicle under Traction on Loose Sandy Soil, TERRAMECHANICS, Vol. 18, The Japanese Society for Terramechanics, pp. 41-48, 1998.