

Evaluation Method of Maglev for Introducing Urban Transport in Japan

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Abstract

Maglev has many merits in introducing urban transport in Japan, for examples, low noise, comfortable riding, high performances of acceleration and etc. However, in comparison with other conventional urban transports, it is difficult to clarify and determine merits quantitatively because there are many competitive items.

Therefore, in this paper, we express simulation and evaluation method for comparing with several urban transportation systems through calculating running data and evaluation items.

Through this method, we can extract merits of Maglev quantitatively for introducing in Japan.

Key Words: urban Maglev, evaluation method, simulation

1 Overview of simulation

For evaluationg proposal transportation systems, it is better to run on the estimated line and to compare with other systems in same running conditions. However, these comparisons are almost impossible because of high cost. Therefore, running simulation based on several real data and evaluation through unified calculations are necessary for introducing new systems.

For these reasons, we developed new simulation method for calculationg several evaluation items.

This simulator realizes that several transportation systems can run on the road map set for appropriate route(curve radius, gradient, location of stations) in accordance with each performance.

Basically, each transportation system runs for satisfying the equation of motion (1) on the map in simulation and we can calculate running energy consumption on this case by equation (2).

$$(F+Fr.m).g=m.\alpha \quad (1)$$

F : Thrust force(kg), Fr : Running Curve Resistance(kg/t), g : Acceleration of gravity, m : Car weight(+passengers)(t),
 α : Acc.Deceleration(m/s²)

$$W=(1/2).m.v^2.\{1+(\mu/100).(v/100)\}.k/\delta t \quad \dots(2)$$

W : Power consumption(W) v : Speed(m/s),
 μ : Wearing rate of wheel(%), v : Reflection rate of wear (%), k : Efficiency, t : Sampling time(s)

Moreover, we define equation (3) as the reduction amount of CO₂ based on the regenerative energy. This means that if new system naturally electric driven is introduced, automobile transport will decrease and as the result CO₂ will decrease nothing but this.

$$CO_2\text{reduction}(t/\text{year})=(\text{Regenerative power :kW})\cdot\varepsilon /3,600 \quad (3)$$

ε : CO₂ Exhaust coefficient (kg/kWh)

By these equations, running simulations using by setting route, stations and car performance can be carried out and be calculated average speed, running energy consumption and CO₂ reduction amount.

2 Execution of simulation

2.1 Setting route and transportation systems

In this study, we suppose to introduce new transportation system in urban space.

This simulation has the characteristics in setting route on the map. So, we set supposed route on the map (scale:1/8000) in west area of Tokyo. This route has total 9.5km length and minimum curve radius is 40m and gradient is flat. Moreover, we choose 3 transportation systems for urban use, HSST as Maglev, LIM system with primary side on ground (LIM on G) and AGT(Automated Guideway Transit).

Table 1 shows major specifications of each transport system.

Table1 Major specifications of each system

Specifications	HSST	LIM on G	AGT
Power feeding	Trolley	None	Third rail
Passenger capacity	100	100	100
Empty car weight (t)	18	10	30
Minimum curve (m)	20	20	20
Maximum Speed(km/h)	100	50	60
Regenerative rate (%)	30	20	10
Acc (km/h/s)	4.5	4.5	4.5
Dcc (km/h/s)	4.5	4.5	4.5
Wearing rate (%)	0	5	15
Wear reflecting rate (%)	0	5	15

Maximum speeds are designed by the domestic law (AGT) and performances of linear motors(HSST, LIM on G) respectively.

As to the acc/deceleration, AGT driven by rubber tires is decided by practical data and the other two systems driven by linear motors are set the same with AGT because of non-adhesion driven.

Regenerative rates are decided based on the practical data for examples, AGT and HSST are

estimated by the practical running and LIM on G is estimated by the experimental data.

As for wearing rate of wheel and wear reflecting rate, AGT is only considered by the practical data.

Figure 1 shows the characteristics of speed and thrust forces and figure 2 shows the running resistance of each system. Moreover, the relation of curve radius with speed is shown in figure 3.

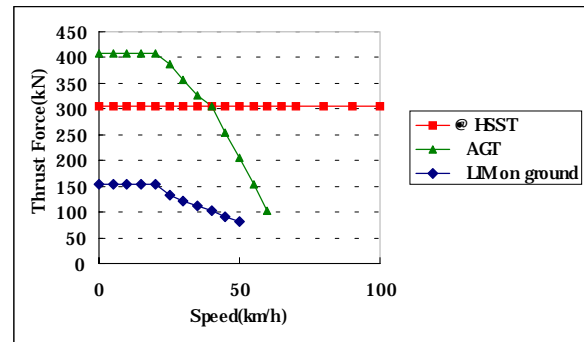


Fig.1 Characteristics of thrust force and speed

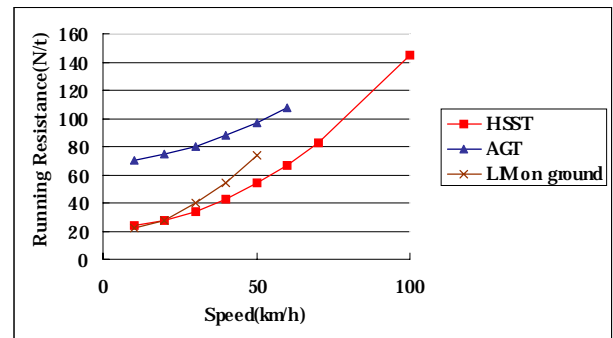


Fig.2 Running resistance of each system

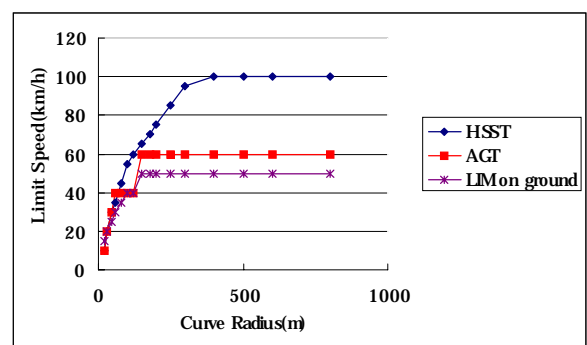


Fig.3 The relation of curve radius with speed

The characteristics of thrust force and speed are set by the practical data.

As to the running resistances, equations of (4),(5) and (6) are estimated under the practical data.

$$R_{HSST} = 22.8 + 0.0225v + 0.0119v^2 \quad (4)$$

$$R_{LIMG} = 19.3 + 0.0164v + 0.0216v^2 \quad (5)$$

$$R_{AGT} = 67.0 + 0.22v + 0.00759v^2 \quad (6)$$

R:Running resistance (N/t).v:Speed(km/h)

As AGT is driven by rubber tires, running resistance is larger than other linear motor drive systems.

The limit speed at curve radius on each system is decided by practical data(AGT) and experimental data(HSST and LIM on G). As the reference, the relation of curve radius and speed on HSST is decided to satisfy equation (7).

$$v < 5.5 \sqrt{R} \quad (7)$$

v:Speed(km/h).R:Curve radius(m)

2.2 Simulation results

Above mentioned method, simulation is carried out based on route data and transportation data.

Photo 1 shows the example of output results.

Each transportation system runs on the estimated route and we can see the real speed of train and energy consumption at this time simultaneously on the right side of the computer screen.

Besides, the example of simulation result output after running on the map is shown figure 4.



Photo 1 Example of output screen on computer



Fig.5 Example of output results

In this example, urban Maglev system of HSST reduces running time for 17% in comparison with AGT because of high speed and low running resistance. However, energy consumption is a little larger than AGT for 6% nevertheless high regenerative power. This depends on the high performance of HSST for high speed and thrust.

3. Conclusion

The above mentioned, through proposed simulation, we can evaluate several items for examples, running time and energy consumption, quantitatively on the supposed route. By this, we can find and prove the merits quantitatively for introducing urban Maglev in Japan. Especially, we need the clear reasons for choosing new transportation systems in Japan because there are several transportation systems in several areas. Therefore, these quantitative evaluation data can make good help to realize urban Maglev system. In fact, HSST will start revenue service at the north-east side of Nagoya in 2005. This result shows the usefulness of this simulation.