Simulation Analysis of Double Road Train Adaptability of Highway in China

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Abstract

Three different type of double road trains are selected as simulation model, which is commonly used in developed countries and regions in order to improve the efficiency of road transport and the development of China’s logistics industry. The passing ability simulation model of double road train is established based on Auto Turn, and China's current longest tractor-semitrailer is used as a comparison. Simulation models of highway ramp, first class highway and second class highway are established according to the requirement of JTG D20-2006 ‘Design Specification for Highway Alignment’. Adaptability of double road train and highway structure parameter is researched by analyzing different types of double road train turn left, turn right and turn around on the road. The type of double road train which can meet China’s standards is recommended. The result can promote the application of double road train and give some advice for improving passing ability.

Keywords: Double road train; Passing ability; Highway; AutoTurn; Simulation analysis.

1. Introduction

Recently, both the quality and proportion of road fright has largely increased, resulting in the demand of a more effective deliver method to relieve the pressure. In the last decade, Longer Combination Vehicles has been focused on in most developed countries, acting as a breakthrough in transport method with high unit deliver capacity. LCV
has become the leading role in middle-and-long range cargo transport with less times, less fuel consuming, lower emission and less damage to roads and bridges [1,2].

Recently, Chinese government intends to carry out double-road trains running test. Revision of relevant regulations and policies and research projects are starting. Research for double semitrailer road train are analysed in order to analysis passing capacity in China. Simulation models are established of 3 different type’s double semitrailer road train to simulate the passing ability, which are widely used in developed countries. China's current longest tractor-semitrailer is used as a comparison. Then modify the structure and parameters of double semitrailer road trains to simulate the passing ability test and try to find the relationship between them.

2. Establishment of Simulation Models

2.1. Establishment of Vehicle Simulation Models

Three different type of double road trains are selected as simulation model, which is commonly used in developing countries and regions [3-5]. Simulation models of A-Train, B-Double and C-Train are established by using Auto TURN as shown in Fig. 1, and China’s current longest tractor-semitrailer is used as a comparison. Vehicle speed is 5 km/h and different demission parameters are set as shown in Fig. 2, while the others parameters remain default setting.

![Fig. 1. (a) A-Train; (b) B-Double; (c) C-Train; (d) Tractor-semitrailer.](image)

2.2. Establishment of Highway Simulation Models

Simulation models of highway ramp, first class highway and second class highway are established according to the requirement of JTG D20-2006 Design Specification for Highway Alignment.

Simulation model of highway ramp is established, ramps which turn left and turn right is shown in Fig. 2 and Fig. 3. The minimum circular curve radius of ramp is 50m, width of lane is 3.5m, and width of right side hard shoulder is 1.5m.

Intersection simulation model of first class highway is established as shown in Fig. 4. It is a two way with four lane road. The width of lane is 3.75m and the width of right side hard shoulder is 2.5m, the inner radius of pavement edge is 15m, the width of semi-circular intermediate zone of road is 2.0m.

Intersection simulation model of second class highway is established as shown in Fig. 5. It is a two way road. The width of lane is 3.75m and the width of right side hard shoulder is 0.75m, the inner radius of pavement edge is 15m.
3. Simulation of Highway Ramp

3.1. Turn Left Simulation

Result of double road train turns left on highway ramp simulation is shown in Fig. 6. The unit in Fig 6–Fig. 13. is meter the same as follows.

The maximum swept path width of A-Train, B-Double and C-Train is 4.31m, 4.39 m and 4.29m in double road train turns left on highway ramp simulation. When simulation vehicles are traveling along the left lane, outermost right side of the train exceed right lane 1.25m, 1.28m and 1.12m respectively, but not beyond the scope of shoulder on right side. The maximum swept path width of tractor-semitrailer is 3.57m, which is smaller than double road train. Swept path width of double road train is bigger than currently longest tractor-semitrailer.
3.2. **Turn Right Simulation**

Result of double road train turns right on highway ramp simulation is shown in Fig. 7.

The maximum swept path width of A-Train, B-Double and C-Train is 4.34m, 4.42m and 4.33m in double road train turns right on highway ramp simulation. When simulation vehicles are traveling along the right lane, outermost right side of the train exceed right lane 0.90m, 1.13m and 0.95m respectively, but not beyond the scope of shoulder on right side. The maximum swept path width of tractor-semitrailer is 3.57m, which is smaller than double road train. Swept path width of double road train is bigger than currently longest tractor-semitrailer.

In summary, vehicles are traveling along the right lane in this simulation which is slightly different with actual operation of vehicle. The driver will be more flexible under actual operation, but it can basically reflect the operation of vehicle. The outermost right side of the train is not beyond the scope of shoulder on right side in simulation, however, it may cause damage to the roadside railing in actual. Double road train should travel on a larger curvature ramp to avoid affecting the other vehicles.

4. **Simulation of First Class Highway Intersection**

4.1. **Turn Left on First Class Highway Intersection**

Result of double road train turns left on first class highway intersection simulation is shown in Fig. 8.

The maximum swept path width of A-Train, B-Double and C-Train is 6.09m, 6.42m and 6.26m in double road train turns left on first class highway intersection simulation. Outermost right side of the train exceed adjacent lane 2.37m, 2.55m and 2.32m respectively, but not beyond the scope of right lane. The maximum swept path width of tractor-semitrailer is 4.77m and it exceed adjacent lane 0.67m, which is smaller than double road train. Swept path width and invaded adjacent lane width of double road train is bigger than currently longest tractor-semitrailer. Double road train can turn left on first class highway intersection and it will affect the other vehicles driving.
4.2. Turn Right on First Class Highway Intersection

Result of double road train turns right on first class highway intersection simulation is shown in Fig. 9.

Fig. 9. Turn right simulation on first class highway intersection

The maximum swept path width of A-Train, B-Double and C-Train is 8.20m, 8.54 m and 7.81m in double road train turns left on first class highway intersection simulation. Outermost right side of the train exceed adjacent lane 3.86m, 4.14m and 3.71m respectively, but not beyond the scope of right lane. B-Double occupies too much lane and it occupies intermediate zone. The maximum swept path width of tractor-semitrailer is 5.70m and it exceed adjacent lane 1.67m, which is smaller than double road train. Swept path width and invaded adjacent lane width of double road train is bigger than currently longest tractor-semitrailer. Double road train can turn right on first class highway intersection but it affects the other vehicles driving.

4.3. Turn Around on First Class Highway Intersection

Result of double road train turn around on first class highway intersection simulation is shown in Fig. 10.

The maximum swept path width of A-Train, B-Double and C-Train is 12.85m, 13.16m and 11.19m in double road train turn around on first class highway intersection simulation. A-Double exceeds shoulder 0.33m. The maximum swept path width of tractor-semitrailer is 9.64m, which is smaller than double road train. Swept path width and invaded adjacent lane width of double road train is bigger than currently longest tractor-semitrailer. Double road train can turn around on first class highway intersection but it will affect the other vehicles driving.

In summary, when double road train turn on first class intersection, swept path width is bigger and will occupy adjacent lane. When the traffic is small, it can cross the intersection.
5. Simulation of Second Class Highway Intersection

5.1. Turn Left on Second Class Highway Intersection

Result of double road train turns left on second class highway intersection simulation is shown in Fig. 11.
The maximum swept path width of A-Train, B-Double and C-Train is 6.97m, 7.25m and 7.00m in double road train turns left on second class highway intersection simulation. Outermost right side of the train exceed adjacent lane 3.02m, 3.25m and 2.95m respectively, and beyond the scope of right lane and shoulder. The maximum swept path width of tractor-semitrailer is 5.14m and it exceed adjacent lane 1.09m, which is smaller than double road train. Swept path width and invaded adjacent lane width of double road train is bigger than currently longest tractor-semitrailer. Double road train will not recommend to turn left on first class highway intersection, it affects the other vehicles driving seriously.

5.2. Turn Right on Second Class Highway Intersection

Result of double road train turns right on second class highway intersection simulation is shown in Fig. 12.

![Fig. 12. Turn right simulation on second class highway intersection](image)

The maximum swept path width of A-Train, B-Double and C-Train is 7.67m, 8.42m and 7.50m in double road train turns right on second class highway intersection simulation. Outermost left side of the train exceed adjacent lane 3.69m, 3.97m and 3.58m respectively and beyond left shoulder 0.12m, 0.36m and 0.20m. The maximum swept path width of tractor-semitrailer is 5.69m and it exceed adjacent lane 1.52m, which is smaller than double road train. Swept path width and invaded adjacent lane width of double road train is bigger than currently longest tractor-semitrailer. Double road train will not recommend to turn right on first class highway intersection, it affects the other vehicles driving seriously.

5.3. Turn Around on Second Class Highway Intersection

Result of double road train turn around on second class highway intersection simulation is shown in Fig. 13.
The maximum swept path width of A-Train, B-Double and C-Train is 12.35m, 14.54m and 12.19m in double road train turn around on second class highway intersection simulation. All the vehicles exceeds shoulder and adjacent lane seriously. Double road train can’t turn around on second class highway intersection.

In summary, when double road train turn on second class intersection, swept path width is bigger and will occupy adjacent lane, it can’t turn cross the intersection.

6. Conclusion

Double road train travels along one side of road in simulation, it will not affect the adjacent lane vehicle. When double road train travels turn on highway ramp and first class highway intersection, outermost right side of the train exceed adjacent lane, but it has little impact on traffic. Double road train can turn across highway ramp and first class highway intersection. When double road train travels turn on second class highway intersection, outermost right side of the train exceed adjacent lane and shoulder, it impacts traffic seriously. So it can’t turn cross second class highway intersection.

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