**Model：Time and Construct Cost Model**

**Assumptions**

**Model establishing**

The throughput and construct cost of a toll plaza are two contradictory indexes. Usually, the more throughput is wanted, the more construct cost is paid. In order to seek an optimal scheme to balance them both, we plan to establish an objective function in which the throughput is related to money consumption. So we introduce a variable called unit waiting time cost, C\_h (USD/h/veh). It signifies that if a vehicle queues for one hour at a toll plaza, it will cause C\_h dollors loss. Briefly speaking, the overall cost of a toll plaza is defined as an aggregate of time cost and construct cost.

With regard to a toll plaza, suppose the average congestion time is h\_g (h) and the average enter flow when congesting is Q\_g (veh/hs), then the total waiting time is,

公式1

Where, Q\_max is maximal throughput of this toll plaza.

If the designed service time of the toll plaza is *y* years, then then time cost during y years is,

公式2

Because we only think about the design of the departure zone when calculating the construct cost, the cost of approach zone and tollbooths is not included. But such omission does not influence our conclusion. Construction can be calculated by a linear function concerning area, that is,

C\_c=S\_r\*C\_r+S\_l\*C\_l

Where,

S\_r The area of the road

C\_r The cost of the road per unit area

S\_l The area of the occupied land

C\_r The cost of the occupied land per unit area

Our goal is to minimize the total cost C\_s

C\_s=C\_t+C\_c

This chapter mainly discusses the effects of throughput and construct cost on the toll plaza design, i.e., accident prevention is not included as a major research object. Instead, some basic security indicators are constraints when seeking the minimum C\_s.

In the next step, we are establishing more explicit relationships between size, shape as well as merging pattern, and cost along with throughput.

From our perspective, connecting all the considerations with cost directly or indirectly and make cost our major objective function is an explicit and effective plan. Thus, all our models are established out of this thought.

In detail, we can determine an average waiting time by calculating the throughput of the toll plaza. In this way, we may then quantify the average waiting time as money consumption with an introduction of a uniform “waiting time cost”. Our goal is to look for the minimum cost (including time and construct cost) in the case of satisfying basic security conditions. In other words, the overall cost is our objective function and security factors are constraints towards the objective function. We can get better solutions by minimizing the overall cost.