

How a Freeway Breaks Down

AS A RESULT OF AN ACCIDENT

Let us consider a segment of Highway 101 in San Rafael southbound around 2nd Street and I-580 on ramp with three mixed flow lanes and an auxiliary lane.

According to CALTRANS traffic count for the year 2000 on Monday through Thursday, this segment has a high a.m. peak period demand as follows:

| A.M. Peak Periods | Passenger cars per hour |
|-----------------------|-------------------------|
| 7:00 a.m.-8:00 a.m. | 7,300 |
| 8:00 a.m.-9:00 a.m. | 6,700 |
| 9:00 a.m.-10:00 a.m. | 4,850 |
| 10:00 a.m.-11:00 a.m. | 4,320 |

What will occur if an accident blocks one lane for 15 minutes at the beginning of the peak period?

Each lane has a capacity of 1,500 to 2,000 passenger cars per hour depending on the amount of weaving that the vehicles are engaged in. In a situation with a high volume on ramp or off ramp or a lane drop, any of which might cause a lot of weaving (changing lanes/entering/exiting), the capacity drops to about 1,500 vehicles per hour per lane. In a stable situation, a volume with no weaving (traffic changing lanes) from on ramps or off ramps and low speed flows up to 2,000 vehicles per hour can be processed by a single lane of traffic. Therefore, just before the accident, we had: 3 mixed flow lanes x 2,000 passenger cars per hour capacity = 6,000 passenger cars per hour plus 1,000 passenger cars for auxiliary lane. Thus total capacity was 7,000 passenger cars. Maximum peak demand was 7,300 passenger cars per hour; therefore we had a queue (backup) of 300 cars develop.

If an accident takes place in the auxiliary lane due to weaving actions, our capacity drops from 2,000 per lane to 1,500; therefore, there are only 3 lanes x 1,500 passenger cars per hour = 4,500 passenger cars per hour capacity, which quickly creates queued stop-and-go traffic due to the 7,300 passenger cars per hour demand. During the first 15 minutes, 7,300 passenger cars divided by 4 (quarter of an hour) = 1,825 passenger cars arrive. But we can only process 3 lanes x 1,500 passenger cars per hour divided by 4 (quarter of an hour) = 1,125 passenger cars per hour. Therefore we have 1,825 cars arrive and only 1,125 can be processed, so we have a queue of 700 cars develop in the first 15 minutes.

After the blockage (accident) is removed, capacity improves to 3 lanes x 1,500 passenger cars per hour, plus an auxiliary lane of 1,000 = 5,500 passenger cars per hour. In the ensuing 45 minutes, 5,475 (7,300 passenger cars per hour x $\frac{3}{4}$ hour) arrive, but only 3 lanes x 1,500 cars per hour, plus an auxiliary lane 1,000, x $\frac{3}{4}$ hour = 4,125 passenger cars can be processed. Therefore,

the queue continues to grow from 700 to 2,050 [700 (original queue) + 1,350 (additional queue 5,475 – 4,125)].

During the second hour, 6,700 vehicles arrive with 2,050 in queue. Only 7,000 are served. Therefore, the queue will go from 2,050 to 1,750 vehicles (6,700+2,050-7,000).

During the third hour and after that, 4,850 vehicles per hour arrive and the remaining queue of 1,750, for a total of 6,600 vehicles. 7,000 vehicles can be processed; therefore, we now have enough capacity to serve all of the demand.

Summarizing - a queue at the beginning of the traffic peak period caused by a fifteen minute lane blockage took over 3 hours after the cause was eliminated to go back to a normal functioning freeway at this segment. The maximum queue length of 2,050 cars at 25 feet per car spread over three lanes is 3.2 miles of additional backup.

In other words, without creating additional capacity, we will continue being extremely vulnerable on the one and only freeway that serves all of us.

How A Freeway Breaks Down

