Crossing of Bridge Junctions & Railway Tracks - Effect on Vehicle Motion

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Gorski Consulting has conducted a variety of testing to document the effect of various road characteristics on the motion of a vehicle. Data from that testing has been presented in a number of articles uploaded to the Gorski Consulting website.

In the present article we focus on a special character of a road that exists regardless of where one might travel. Bridge junctions and railway tracks are discontinuities in the normally smooth road surface that could be an influence in the cause of a loss-of-control collisions. In normal circumstances the bumps that are felt when passing over these features are often nothing more than a nuisance. However in special circumstances, such as icy or snow-covered road surfaces, or even in wet surface conditions the large tire force that is normally available on dry road surfaces becomes reduced and thus those disturbances experienced when passing over bridge junctions and railway tracks may be sufficient to cause a vehicle loss-of-control.

Figure 1:

To get a handle on the likelihood that a specific bridge junction or railway crossing could cause the loss-of-control of a vehicle one must get a sense of what motions can typically be expected when a vehicle travels over these features and then select those few that produce an exceptionally extreme reaction of a vehicle. Gorski Consulting has gathered such data and this will be reported in the present article.

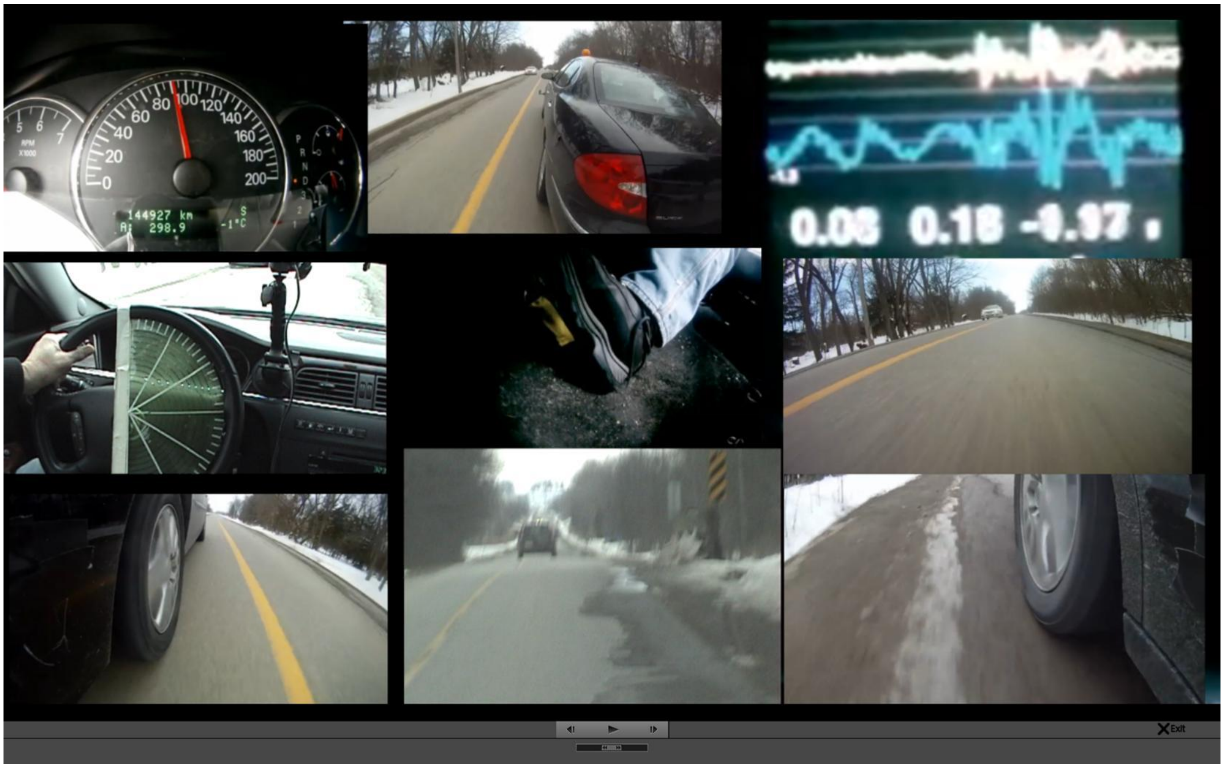

Figure 2: Example of multiple video cameras and iPhone accelerometer and gyro, used by Gorski Consulting to document roadway characteristics.

As discussed in previous articles, the parameters that we have chosen to report are the rates of lateral and longitudinal rotation expressed in terms of radians per second. One radian is equal to about 57.3 degrees. To be clear, the lateral rotation is what occurs when the vehicle is rotated side-to-side, so it is expressing the degree to which the vehicle rocks to the left and right about its centre of gravity. Similarly the longitudinal rotation is what occurs when the front or rear end dips or rises about the vehicle's centre of gravity.

The tri-axial gyro of the iPhone 4S used in this testing also senses the vehicle's rotation about it vertical axis (yaw). We have chosen not to report this third parameter because we reasoned that, in the normal motions performed by our test vehicle, there is unlikely to be enough yawing motion that can be ascribed to the bumpy nature of the road surface. Had we conducted more severe motions where the centripetal/centrifugal balance was more tested then we might expect some yawing that might be worth exploring. This decision may be revisited at a later date.

To keep with a standard methodology we have also chosen a time frame of 2 seconds after the initial encounter with the bridge junction or railway track to document the vehicle motion. This is an arbitrary decision that, in situations where out test vehicle travels at highway speed, a substantial distance could be travelled while the encounter of the obstruction might inhabit only a short time of that 2 second interval. Obviously, at slower speeds, the alternative is true. Thus it is possible that, for higher test speeds the effect of the bridge junction or railway track could be underestimated compared to that of a slower vehicle speed.

Figure 4 shows the results of our testing. In order to appreciate the meaning of the data we offer the following explanation based on our previous testing.

In previous testing we documented the effect of our vehicle's travel over a longer segment of roadway, or about 30 seconds of continuous data. This testing indicated that a good-quality road surface caused lateral and longitudinal rotations in the range of 0.0100 radians per seconds. Roads of average quality caused rotations in the range of 0.0200 to 0.0300 radians per second. Poor road surfaces caused rotations above 0.0500 radians per second.

We also conducted testing at the location of four, in-complete road repairs where there was a substantial depression in the temporary patch of the pavement. That data is shown in Figure 3 below. The extreme longitudinal rotations noted in the last three tests were obtained at the site of a depression on Vancouver Street, in London, Ontario.

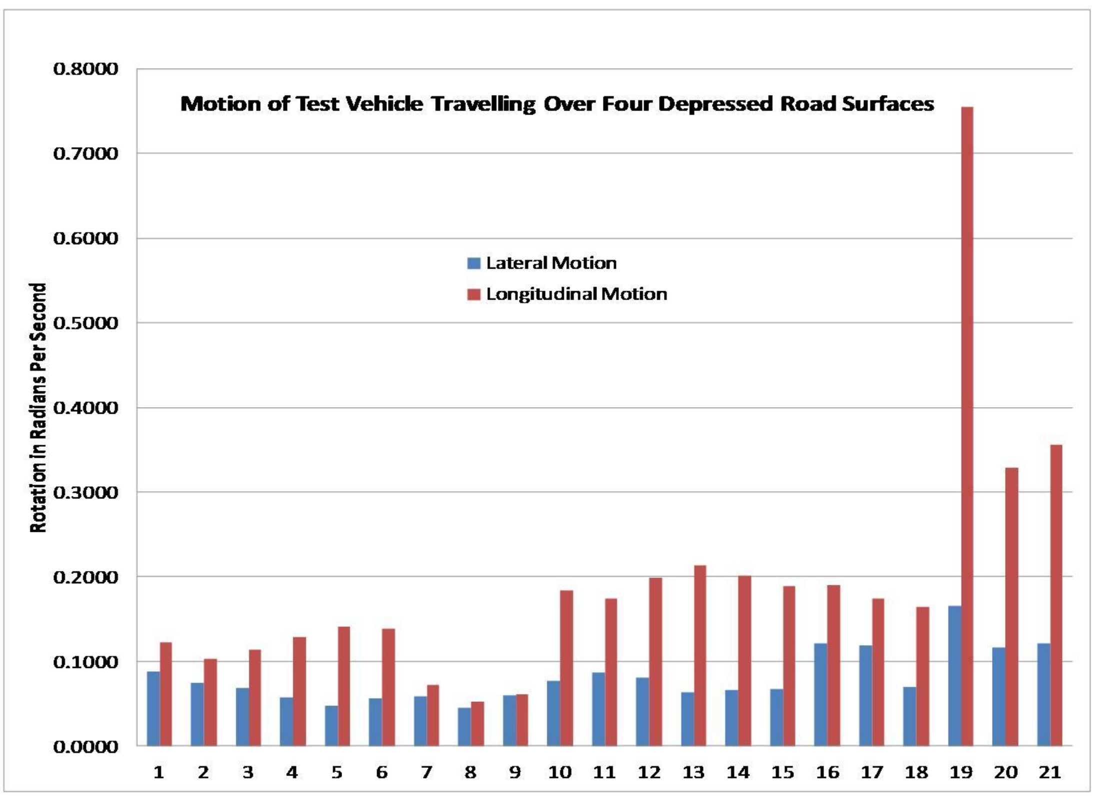

Figure 3: Results from testing on incomplete road repairs.

Figure 4:

Bridge Junction & Railway Track Effects On Vehicle Motion For Two-Second Reaction Intervals

Location	Date	Bridge Junction or Railway Crossing	Test Vehicle Speed (km/h)	Lateral Motion Stan Deviation (Radians/Second)	Longitudinal Motion Stan Deviation (Radians/Second)
Adelaide St N, SB, London at N Branch Thames River Bridge	Mar 3-14	North Bridge Junction	55.0	0.0191	0.0844
Adelaide St N, SB, London at N Branch Thames River Bridge	Mar 3-14	South Bridge Junction	56.0	0.0392	0.0793
Adelaide St N, SB, London at CPR Tracks S of Pall Mall	Mar 3-14	Railway Tracks	49.0	0.0328	0.1200
Adelaide St N, SB, London at S Branch Thames River Bridge	Mar 3-14	North Bridge Junction	58.0	0.0270	0.0759
Adelaide St N, SB, London at S Branch Thames River Bridge	Mar 3-14	South Bridge Junction	58.0	0.0336	0.0793
Dundas St, EB, at Kelloggs Manufacturing Plant	Mar 12-14	Railway Tracks	41.0	0.0338	0.1219
Dundas St, EB, at Hale Street	Mar 12-14	Railway Tracks	23.0	0.0484	0.0368
Dundas St, EB, at Hale Street	Mar 31-14	Railway Tracks	37.0	0.0676	0.0951
Horton St, EB, London at Lond Pt Stanley RR at Maitland St	Mar 3-14	Railway Tracks	53.0	0.0296	0.0917
Hwy 80, NB CPR Tracks North of Glencoe	Feb 14-14	Railway Tracks	90.0	0.0283	0.0658
Hwy 80, WB, at Sydenham River Bridge	Feb 14-14	Both Bridge Junctions	90.0	0.0291	0.0333
Hwy 402, WB, East of Longwoods Road	Feb 14-14	East Bridge Junction	106.0	0.0225	0.0324
Hwy 402, WB, East of Longwoods Road	Feb 14-14	West Bridge Junction	106.0	0.0331	0.0233
Hwy 402, WB, Overpass of Longwoods Road	Feb 14-14	East Bridge Junction	77.0	0.0287	0.0427
Hwy 402, WB, Overpass of Longwoods Road	Feb 14-14	West Bridge Junction	68.0	0.0257	0.0315
Longwoods Road, WB at Newbiggen Creek	Feb 14-14	Both Bridge Junctions	90.0	0.0304	0.0381
Oxford St, EB, London at N Branch Thames River Bridge E of Wharcliffe Rd	Mar 31-14	West Bridge Junction	58.0	0.0363	0.0735
Oxford St, EB, London at N Branch Thames River Bridge E of Wharcliffe Rd	Mar 31-14	East Bridge Junction	55.0	0.0320	0.0707
Plover Mills Rd, EB, Thames River Bridge West of Nissouri Rd	Mar 14-14	West Bridge Junction	88.0	0.0230	0.0304
Plover Mills Rd, EB, Thames River Bridge West of Nissouri Rd	Mar 14-14	East Bridge Junction	82.0	0.0251	0.0270
Plover Mills Rd, EB, West of Wellburn Rd	Mar 14-14	Railway Tracks	81.0	0.0555	0.1012
Veterans Memorial Parkway, SB	Feb 14-14	North Bridge Junction	80.0	0.0245	0.0272
Veterans Memorial Parkway, SB	Feb 14-14	South Bridge Junction	80.0	0.0290	0.0383
Wharncliffe Rd, NB, London at Thames River Bridge Near Riverside Drive	Mar 31-14	South Bridge Junction	57.0	0.0307	0.1095
Wharncliffe Rd, NB, London at Thames River Bridge Near Riverside Drive	Mar 31-14	North Bridge Junction	61.0	0.0708	0.3760

Discussion

While crossing a bridge junction or railway tracks our test vehicle's motion was substantially different from one site to another. The primary effect was a high longitudinal rotation. In other words, our vehicle's front/rear ends were lifted or dropped toward/away from the pavement during, and just after, making these crossings.

There were many sites where the effect on the test vehicle was minimal. The lateral rotation was often in the range of 0.0200 to 0.0300 radians per second which is not much different than if the vehicle travelled over a typical road without a bridge junction or railway track. A number of the sites also contained longitudinal rotations of a similar, small, magnitude.

However, several sites caused high longitudinal rotations of our vehicle. Four sites caused longitudinal rotations that were above 0.1000 radians per second and those are listed below:

Location	Test Date	Type of Obstruction	Vehicle Speed (km/h)	Lateral Rotation	Longitudinal Rotation
Adelaide St SB at CPR railway tracks S of Pallmall St	Mar 3-14	Railway Tracks	49	0.0328	0.1200
Dundas St EB at Kelloggs Plant	Mar 12-14	Railway Tracks	41	0.0338	0.1219
Plover Mills Rd, EB, West of Wellburn Rd	Mar 14-14	Railway Tracks	81	0.0555	0.1012
Wharncliffe Rd, NB, at Thames River Bridge	Mar 31-14	Bridge Junction	57	0.0307	0.1095

Even though these motions are substantial and an uncomfortable experience to a driver, our test vehicle was maintained in control. One might argue that this is a good indication that the motions are insignificant to the safety of the public. We do not share that view.

The fact that a thousand such repetitions resulted in no problems might only relate to a daily traffic volume for that road which could easily be 1000 vehicles or more. If one driver were to lose control of a vehicle per week due to the road then that would be unacceptable, yet, for a road with a traffic volume of 1000 vehicles (for that direction of travel) it would require us to perform 7000 repetitions before we could detect the problem. Furthermore, because our test vehicle is of a typical design it would not detect the problems that special vehicles, such as taller SUVs or motorcycles might encounter. Therefore testing like this cannot fully uncover a problem that might exist.

While road authorities often depend on statistics from traffic accidents those too have their limitations in uncovering a potential roadway safety problem. The vast majority of incidents where a driver might lose control of their vehicle while making a crossing over a bridge junction, railway track or an incomplete road repair would involve a single vehicle and the driver would not be compelled to report the incident. Nor would it become a reportable incident that would be documented by police and therefore enter into a database that a road authority could evaluate.

A testament to this opinion is the site on Vancouver Street in London, Ontario where there has been a deep depression the road surface since early February, 2014. Our examination of that site shows that numerous drivers have struck the undersides of their vehicles with the edges of the depression. Those incidents that we have documented with videotape show that drivers might slow down briefly, or even stop, to evaluate what just took place, but then they simply drive away and the incident is not reported.

We have documented exceptional road conditions such as those on Sunningdale Road in north-east London where, during winter conditions, the road surface develops major rises and collapses. We have also documented the few exception bridge junctions and railway crossings that cause excessive vehicle motion. However, by far, the most extreme conditions we have documented are the incomplete road repairs that create isolated, depressed patches where road work has been patched by a temporary layer of asphalt. Indeed, when we look at the chart reproduced in this article, the longitudinal motions of our test vehicle caused by travelling over such patches are mostly above 0.1000 radians per second. But a single depression, that on Vancouver Street in London, Ontario produced longitudinal motions that were 8 times larger than even those worst motions caused by travelling over the worst bridge junctions or railway tracks.