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Increased Road Surface Unevenness after the Installation of an Electric Road System

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Summary

Incorporating Electric Road Systems into a road infrastructure will affect traditional construction, maintenance, and operation procedures. The aim of the study was to investigate the potential increase in road unevenness after the reinstatement of drainage and power supply tracks. Even if increased unevenness levels remain within prescribed standards, it is likely that discomfort levels will increase.

Driving over repetitive surface irregularities will influence the motorists perceived level of comfort. It is also likely that noise will be generated by each passing tyre. If unevenness adversely affects comfort levels, motorists will reduce speed until similar levels of comfort are achieved.

1 Research Questions

The aim of this study was to assess what effects an Electric Road System (ERS) will have on the road infrastructure. Focus was concentrated on issues relating to road construction, maintenance and operations.

2 Methodology

The first stage of the study involved identifying what issues could arise with the introduction of an ERS. Issues had to be specific to the road infrastructure and were relevant to the construction, operation, and maintenance of the road network.

The next stage involved subjectively quantifying the relevance of each issue for each of the various types of ERS. At this stage the relevance was quantified on a scale of three –

1) No relevance
2) Some relevance
3) Significant relevance

The final stage was to expand the issues and determine the specific effects each issue could have on the road infrastructure. The specific effects identified were used to develop questions that were used in interviews with leading ERS stakeholders.

One issue which was quantified as having a significant relevance was the reinstatement of the pavement construction. This issue is confined to ERS that are constructed on or within the road structure.

It is generally accepted that the reinstatement of a pavement structure should be laid flat and flush with the adjacent surfaces. No significant depression or crowning should be apparent. However, it is likely that variations will be acceptable to a Road Authority provided they are within specified tolerance levels. This will mean that a certain level of edge depression, surface depression, and surface crowning could be apparent after a track has been reinstated.

The structural integrity of the reinstatement is also of importance. It is difficult to compact a reinstatement to the same levels as the surrounding pavement structure. It is likely that a certain amount of post compaction will occur from traffic loading. Again, a certain amount of depression will be acceptable to the Road Authority providing that the amount is within specified tolerances.

To supply an ERS with power, electric supply cables will need to be installed across the carriageway. Tracks will need to be excavated at regular intervals along the length of the ERS installation. The distance between tracks will vary depending on the type of ERS system. In addition to the power supply, drainage ducts, required to drain surface water from the ERS units, will also need to be installed across the carriageway. These will also be required at regular intervals and at low points in the longitudinal profile.

If the excavation tracks are reinstated and maintained within the specified tolerances, it is likely that a certain level of surface irregularity will be present. This will be experienced as a type of local unevenness.

Previous research, ROADEX II project [1], has shown that a high percentage of road users experience unevenness either as a severe problem or very severe problem. This is especially the case for HGV drivers. Local unevenness can surprise the road user and lead to reduced ride comfort. In the worst cases accidents can occur. Combining local unevenness with poor friction levels can enhance the negative effect.

To try and quantify the extent of this issue, longitudinal IRI profiles with surface irregularities at 100 m intervals were simulated in a case study.

3 Results

In the following case study, the distance between the simulated irregularities was 100 m. As tolerance levels for track reinstatements are not likely to be greater than 10 mm, the height or depth of the irregularities varied between -10 mm and 10 mm in each simulation. The width of the irregularity was 500 mm. The form of the irregularities was either surface depressions or a surface crowning. Simulations were carried out for sections with existing IRI levels of 0, 0.6, 1.2263, 2.4526, 6.1316 and 12.2632. Consideration was not given to edge depression irregularities.

The results, summarised in Table 1, show the increase in IRI values that would occur for each profile simulation. As expected, the irregularities have a greater effect on even road surfaces.

Table 1. Differences in IRI levels (100 m average values, mm/m and %) as a factor of defect severity and original IRI level.

	Orig. IRI										
Defect height [mm]	**0**	**0.6**		**1.2263**		**2.4526**		**6.1316**		**12.2632**	
-10	0.23	0.20	33.7	0.17	14.1	0.15	6.0	0.10	1.6	0.07	0.5
-9	0.21	0.18	30.1	0.15	12.5	0.13	5.2	0.09	1.4	0.06	0.5
-8	0.18	0.16	26.4	0.13	10.8	0.11	4.4	0.07	1.2	0.05	0.4
-7	0.16	0.14	22.8	0.11	9.2	0.09	3.7	0.06	0.9	0.04	0.3
-6	0.14	0.12	19.3	0.09	7.6	0.07	3.0	0.05	0.7	0.03	0.2
-5	0.12	0.09	15.7	0.07	6.0	0.06	2.3	0.03	0.5	0.02	0.2
-4	0.09	0.07	12.2	0.05	4.4	0.04	1.6	0.02	0.4	0.01	0.1
-3	0.07	0.05	8.8	0.04	3.0	0.03	1.0	0.01	0.2	0.01	0.1
-2	0.05	0.03	5.5	0.02	1.6	0.01	0.5	0.01	0.1	0.00	0.0
-1	0.02	0.01	2.5	0.01	0.5	0.00	0.2	0.00	0.0	0.00	0.0
0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
1	0.02	0.01	2.3	0.00	0.4	0.00	0.1	0.00	0.0	0.00	0.0
2	0.05	0.03	5.2	0.02	1.3	0.01	0.4	0.00	0.0	0.00	0.0
3	0.07	0.05	8.4	0.03	2.6	0.02	0.8	0.01	0.1	0.00	0.0
4	0.09	0.07	11.8	0.05	4.0	0.03	1.3	0.01	0.2	0.00	0.0
5	0.12	0.09	15.2	0.07	5.5	0.05	1.9	0.02	0.4	0.01	0.1
6	0.14	0.11	18.8	0.09	7.1	0.06	2.6	0.03	0.5	0.01	0.1
7	0.16	0.13	22.3	0.11	8.7	0.08	3.3	0.04	0.7	0.02	0.2
8	0.18	0.16	25.9	0.13	10.3	0.10	4.0	0.05	0.9	0.03	0.2
9	0.21	0.18	29.5	0.15	11.9	0.12	4.7	0.07	1.1	0.03	0.3
10	0.23	0.20	33.1	0.17	13.6	0.14	5.5	0.08	1.3	0.04	0.4

In the following figure, Figure 1, a screenshot from Trafikverkets PMSv3 database is detailed. Road surface characteristics were extracted for a section of motorway, road E4, outside Linköping. This section is a good example of the type of road that would form part of a future ERS network.

The section, which had been resurfaced in 2015, had an average IRI value around 0.8 mm/m. The traffic volume, annual average daily flow (AADF), was 11665. This means that, according to Table 1, if a specified surface tolerance level of 10 mm (+ or -) is acceptable for track reinstatements, it is possible that the IRI value could increase by up to 30%.

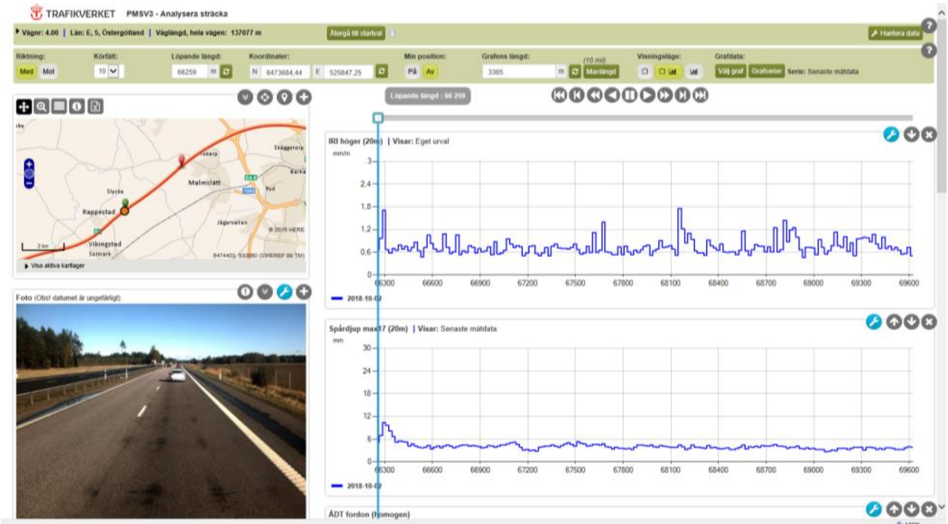

Figure 1. E4, Current IRI values.

According to current standards, *Underhållsstandard belagd väg, 2011 [2]*, the maximum IRI value for this type of road and traffic volume should not exceed 2.6 mm/m. In this case study, IRI values would increase to around 1.0 mm/m and would be well within the action level value prescribed in the standard. This should mean that vehicle speeds will not be affected by the increase in unevenness.

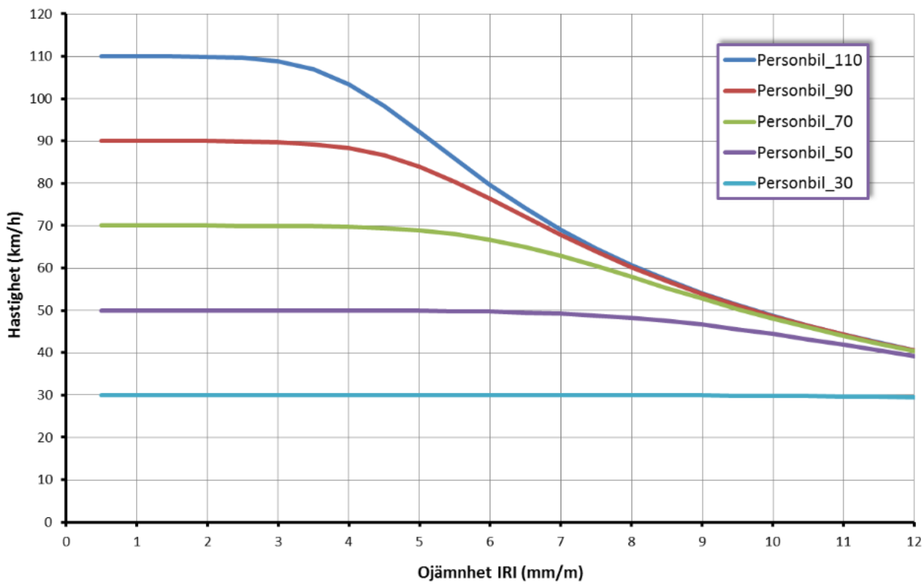

Figure 2. Relationship between vehicle speed and unevenness. Trafikverket, Effektsamband för transportsystem, 2017 [3].

However, although IRI levels are still within prescribed standard, it is possible that the level of discomfort experienced by motorists will increase. Driving over regularly spaced road surface depressions or crowns may influence the motorists perceived level of comfort. It is also possible that a sound will be produced by each passing tyre. At 110 km/h vehicle speeds, the local unevenness and sound will be experienced every 3.2 seconds.

If unevenness adversely affects comfort levels, motorists will usually reduce speed until similar levels of comfort are achieved.

Further studies should be undertaken to determine what effect this type of local unevenness will have on motorists perceived levels of comfort. If comfort levels are affected negatively, the effect this will have on vehicle speed reduction should also be investigated further.

Acknowledgments

References

[1] Saarenketo, Timo and Saari, Johanna, *User Perspective to ROADEX II Test Areas Road Network Service Level. Results of a Questionnaire Study on Road Network*, 2004 Condition and the Use of Roads. Roadex II

[2] Trafikverket, *Underhållsstandard belagd väg 2011*, 2012:074

[3] Trafikverket, *Effektsamband för transportsystem,* 2017.

Authors

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My main area of work focuses on the research and development of pavement technology viewed in a life cycle perspective. Focus is directed on issues relating to how cost-effectiveness can be increased while taking transport quality, traffic safety and the environment into consideration. My work is based upon the development and testing of both classic and new innovative road construction materials. In addition, I have worked with road performance assessment through analysis of road surface measurement data.

I am currently involved with a research and innovation platform for electric roads.