



A catalogue of vibration reducing measures for railways

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Summary

It is very common for people living close to railways to suffer from vibration nuisance in their homes. Since there is not one specified and approved way to predict the effect of vibration reducing measures, every consultant more or less uses his own system. The goal of this research is to create a catalogue as an unambiguous system to consider the effect of vibration reducing measures. This catalogue can be used in all future railway projects, which makes it easier to compare the effect of different measures within a project or between projects. An international literature study has been conducted to collect as much information as possible about train induced ground borne vibrations. This information is incorporated in the catalogue. A computer program (MatCat) is created that includes the catalogue. MatCat contains a large database of vibration reducing measures. The measures are divided into categories (source, path receiver) and can be compared based on different properties (frequency range, reduction factor, TRL, costs and working principals). The literature on which the measures are based is available in the catalogue.

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1. Introduction

The Netherlands has the busiest railway system in the European Union [1]. Estimates show that in the Netherlands 845,000 homes are built in a distance of 300 m of a railroad [2]. It is very common for people living this close to railways to suffer from vibration nuisance in their homes.

Changes to the railway tracks or changes in the type and amount of trains using the railway mean that the vibration levels caused by the trains in this new situation have to be determined. When the vibration levels are too high, reducing measures have to be taken into consideration.

Measures to reduce unwanted vibrations in buildings caused by trains are costly and differentiated. Since there is not one specified and approved way to predict the effect of vibration reducing measures, every consultant more or less uses his own system. As a consequence the results can be very different and the results of different studies are hard to combine.ProRail (organization managing the railway network in the Netherlands) is looking for ways to create an unambiguous system to consider the effect of reducing measures. Past research [3] suggests that a catalogue is needed to create such a system. That is why ProRail has commissioned Grontmij and DPA Cauberg-Huygen to develop a catalogue of vibration reducing measures for railways. The goal is to create a catalogue that is used in all future railway projects, which makes it easier to compare the effect of different measures within a project or between projects. It is also improving the procedure in the consideration of the effectiveness of the measures. Which measure can be taken within the amount of money that is available? This paper shows the process of development of the catalogue and describes the first edition of the catalogue. Furthermore, suggestions are made for future studies to improve the efficiency of the catalogue.

2. Literature study

A literature study has been conducted to collect as much information as possible about train induced ground borne vibrations. All available information in the current market, from research institutes, governments and European research projects such as CargoVibes [4] and RIVAS [5] has been reviewed and incorporated in the catalogue. COB (Dutch knowledge center for underground construction and use of underground space) has put together a commission that assessed the catalogue in terms of completeness and depth.

3. Results

The conducted research resulted in a database with over 50 different vibration reducing measures. This database is included in the computer program MatCat.

3.1. MatCat

In the main menu of MatCat the user can choose between searching the measure database and searching through the literature database. In the literature database, all the literature can be found on which the measure database is based. A screenshot of the main menu is shown in figure 1.





To easily browse the measure database in MatCat the vibration reducing measures are divided into four categories. These categories are based on the standard source-path-receiver concept. The database consists of the following four categories:

- Source
 - ° Railway material
 - ° Track
- Transmission path
- Receiver

The search result can be narrowed down further by selecting in which frequency range the measure should be most effective and what the maximum reduction factor can be.

Generally, feelable vibrations are noticeable in the frequency range between 1 Hz and 80-100 Hz. Measures that are primarily effective in frequencies above 100 Hz are not listed in the database

The reduction factor describes the reducing effect of the measure in dB. These reduction factors are taken from the studied literature. Consideration should be taken into account when using these reduction factors. The reduction factor depends on the situation in which it is used. This is not yet taken into account in MatCat.

When you select the properties in the main menu and press search a new window will open. In this window you can browse through the vibration reducing measures within the given properties. An example of one measure is shown in figure 2.

Nummer en Naam Maatregel:	Nr: 217 Naam: Under Sleeper Pads
Туре:	Baan
Datum Creatie:	26-2-2015
Frequentie tussen:	30 en 100 Hz
Reductiefactor:	tot 20 dB
TRL Waarde:	9
Kosten kengetal:	€ 750, tot € 900, per meter
Werkingprincipe:	Enkelvoudig massa-veer systeem
Afbeelding:	\images\Maatregel 217.jpg
	$\begin{array}{c c} & 1 & 1 & 1 \\ \hline & 1 & 0 & 0 \\ \hline & 0 & 0 & 0 \\ \hline & 0 & 0 & 0 \\ \hline & 0 & 0 & 0 & 0 \\ \hline & 0 &$
	Klik op afbeelding voor vergroting
	Maatregel 217 - Under sleeper Pads (Rivas)

Figure 2. vibration reducing measurement page in MatCat

In this window further information is shown for each measure. Further information can be found regarding Technology Readiness Level, cost and working principals of the vibration reducing measure.

The Technology Readiness Level estimates the maturity of measure. Some measures are still in their development stage and cannot be implemented immediately. When a measure is

ready to be used it is placed in the highest Technology Readiness Level.

Another important factor that has to be taken into account in order to choose the correct vibration reducing measure is cost. The cost prefix gives an estimate of the costs of a certain measure.

The working principals (e.g. mass-spring system, reflecting wall in ground, etc.) are shortly described and when applicable, measures are further explained with pictures.

When you click on a measure a new window will open with further information of that measure. In this window, the working principals are explained more extensively. Furthermore, conditions that need to be met for the application and implementation of the vibration reducing measure are described in this window. Case studies of the specific measure are presented. Also, a link is available to the corresponding literature. Where possible, manufacturers and suppliers of the vibration reducing measures are named in the catalogue.

4. Conclusion

Future information is needed for the completion of the catalogue.

Since sustainability is also an important factor to take into account when choosing a vibration reducing measure a life Cycle Assessment (LCA) should be done on each measure to determine its impact on the environment.

Furthermore, the development of a standard comparison model is needed to compare measures objectively. Currently, the effectiveness of the vibration reducing measures are denoted differently, depending on literature. To develop a standard comparison model, one standard situation should be defined in which all measures are calculated. The outcome of this model should be one spectral reduction factor (V_{max}) which can be included in the catalogue.

A clear method is needed to determine if a vibration reducing measure is cost effective. This method should describe the applicability of a measure and should take into account the number of homes that are effected by vibration nuisance, the amount of vibration reduction that is needed per home and the amount of money it costs to reduce the vibration levels to an acceptable level.

Further research should also be conducted on the negative side effects of vibration reducing measures. Some measures use a mass-spring system to reduce vibrations. These systems can increase the vibrations around the resonance frequency which can increase complaints regarding noise and vibrations.

References

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