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On the extensive use of close-track noise barriers in a Norwegian railroad project

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1. THE PROJECT AREA

The railroad connection between the Norwegian towns of Stavanger and Sandnes is part of the Sørland railway line between Stavanger and Kristiansand. Stavanger is situated in the southwest of Norway and is the 4th largest city in Norway with ca. 120 000 inhabitants. Sandnes is the 8th largest city with ca. 65 000 inhabitants. Together the cities form the 3rd largest urban area in the country. Stavanger the densest populated city in Norway with ca. 1750 inhabitants pr. km^2. [1]

The Sørland railway line was build in 1874-78. The last major upgrade was made in 1955-56. The railway section between Stavanger and Sandnes runs close to the coastline through what is today one of the densest populated areas in the country. Many of the houses along the track have splendid sea views over the Gansfjord.

Figure 1a: The Stavanger area on the railway map of Norway. **1b** Arial photo over part of the project area

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In 2006 ca. 2 500 000 passengers are transported between Stavanger and Sandnes. To increase the capacity of the 14,5 km railroad section between the two cities a double track connection was needed. Norconsult carried out the final design for the National Railway Administration (Jernbaneverket).

2. NOISE REGULATIONS

Because of the significant changes to the railway the double track project was considered a "new railway" according to the Norwegian noise regulations. The following requirements were therefore imposed on dwellings exposed by noise from the project:

- *Outdoor noise: The outdoor noise level shall not exceed $L_{A,eq,24t}$ = 55 dBA on at least one private outdoor seating area (balcony/veranda/terrace) with good sun conditions. This can be increased to max. 60 dBA when measures needed are disproportionate (economically or esthetically).*
- *Indoor noise: The indoor noise level shall not exceed $L_{A,eq,24t}$ = 30 dBA. This can be increased to max. 35 dBA when measures needed are disproportionate.*

3. NOISE SITUATION

Many of the houses closest to the railway have outdoor noise levels of $L_{A,eq,24t}$ = 60-70 dBA with the existing single track railway. Noise levels with the future double track railway are expected 1-2 dB lower despite of increased traffic. This is the result of better track conditions and better trains. Still the outdoor noise levels at the houses closest to the railway exceed the imposed limit by typically 5-15 dB.

4. NOISE ABATEMENT MEASURES

The project made use of the following noise abatement measures to satisfy the imposed noise limits:

- Noise barriers along the tracks in densely populated areas
- Local noise barriers to screen individual private outdoor seating areas
- Façade upgrades to reduce indoor noise

Originally the use of traditional noise barriers with a height of 2-2,5 m over railway track were proposed. These caused strong protest by many of the house owners, who risked losing their sea views. As a solution the use of low close-track noise barriers was proposed.

5. LOW CLOSE-TRACK BARRIERS

A. How these work

At normal speeds (50-150 km/h) the main source noise from modern passenger trains comes from the contact between the wheels of the train and the tracks. This noise is typically radiated from the wheels, the tracks and the sleepers. All these sources are located between 0-0,5 m from the ground. A low noise barrier close to the track can therefore give significant reduction of the total noise level from the railway.

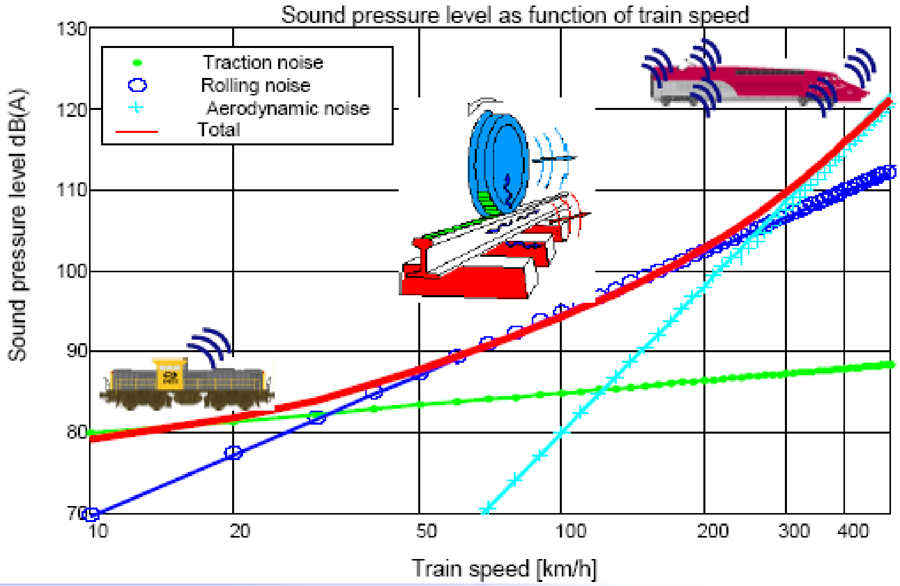


Figure 2: Noise sources as a function of train speed (source: TNO)

For freight trains other sources, located higher up on the train will contribute to the overall noise level also at higher speeds. However, no freight trains use the railway section in this project.

By placing a close-track barrier only 10-15 cm from the wagon skirt and adding an absorptive layer to the barrier the sound has to be reflected several times between the barrier and the wagon before it can spread to the surroundings. Close-track barriers can give a reduction of noise levels comparable to or even better than traditional noise barriers placed typically 4-4,5 m from the track center.

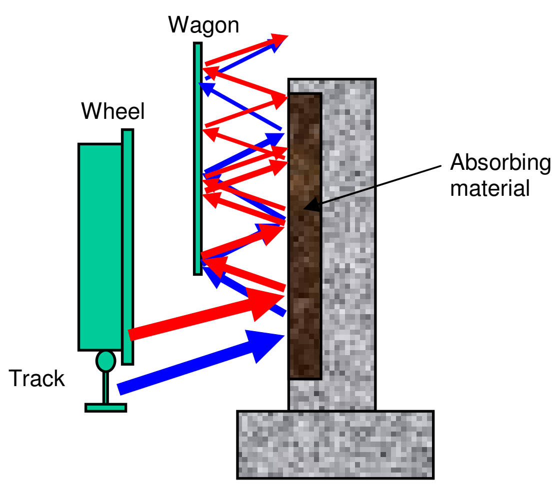


Figure 3: How close-track barriers work

In order to give effective screening these close-track barriers need to be placed along every track of the railway, giving 2 rows of barriers for a double track railroad, compared to a single traditional barrier. Close-track barriers can therefore give the same noise reduction for both tracks, wheras a traditional barrier loses much of its effect for the 2nd track (furthest away). Figure 4 shows both situations.

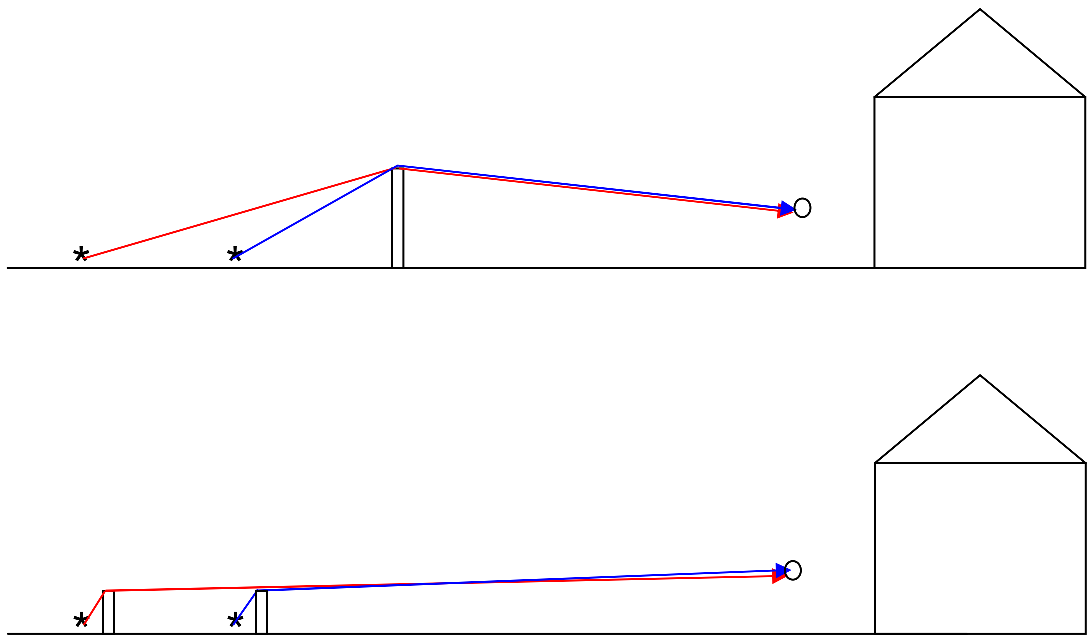


Figure 4: Screening effect of traditional (upper) vs. close-track barriers on a double track railway

B. Expected noise reduction

Several pilot projects with low close-track barriers were realized in Sweden and different concepts were tried (Sound Track, Z-Bloc). In Norway a pilot project was realized just outside the Central station in Oslo [2]. Measured sound reduction by the various barriers in these pilot projects was typically 7-11 dB (measured 2 m over terrain, 10m from track center). In our projects it was assumed that a barrier with optimized design would give a reduction of 8-10 dB.

C. Arguments against

The National Rail Administration had doubts about using low close-track barriers in the beginning. The main areas of concern were:

- Uncertain safety consequences in case of e.g. evacuation, derailment and dislocation of barrier elements
- Possible need for removing the barriers in case of certain types of major maintenance works on the tracks (typically every 20-30 years)
- Risk of snow building up along the inside of the barriers and uncertain consequences for snow removal
- Uncertain life cycle costs

Several safety studies showed that safety issues were acceptable and well within the design criteria [4][5]. To further improve safety in case of evacuation the minimum width of the top of the elements was set to 0,30 m, to allow a person to walk safely on top of the barrier. Also the barriers were fitted with steps for every 30 m.

Experience from pilot projects in Sweden showed no problems with the building up of snow.

Life cycle costs showed little difference between the use of 2 rows of close-track barriers versus a single traditional wooden barrier (h = 2,0-2,5 m).

Finally the National Rail Administration approved of the use of close-track barriers.

D. The final design

Norwegian railroad regulations give strict guidelines that state a minimum distance of 1,70 m from the track center to the top of the close-track barrier. The maximum possible height of an element is 0,73 m over the top of the track. These distances correspond to the dimensions of a “high platform” in railway stations.

Design criteria for the barriers were given to potential manufacturers, who made their final designs in a bidding round to the National Rail Administration. Figure 5 shows the winning design (assumed protected by the manufacturer). The barrier elements are produced in reinforced concrete. The absorptive elements on the inside consist of a 50 mm rock wool, covered with a perforated steel plate. This ensures high absorption rates for the dominating frequencies for passenger trains. The width at the top is 300 mm, according to safety demands. The width at the base is 500 mm, limited by the space for 2 rows of barriers between the two tracks. The elements are placed on a leveled and compressed layer of fine gravel (4-20 mm), with no further fixation.

In total ca. 7 000 m of close track barriers will be fitted along the 14,5 km railway section. In addition ca. 3 000 m traditional barriers will be fitted in areas where blocking views is not an issue, along with ca. 70 local sound barriers and façade improvements on ca. 120 houses. Most house owners along the railway section seem very satisfied with the chosen solutions. Their sea views are mostly unaffected, whereas their noise levels will be significantly reduced. All noise limits imposed on the project are likely to be satisfied.

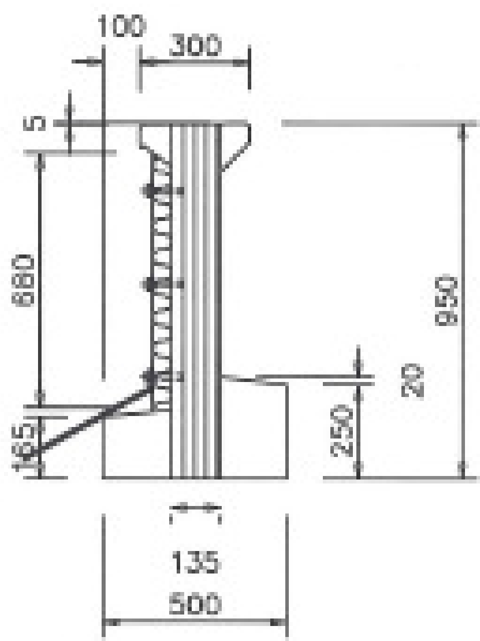
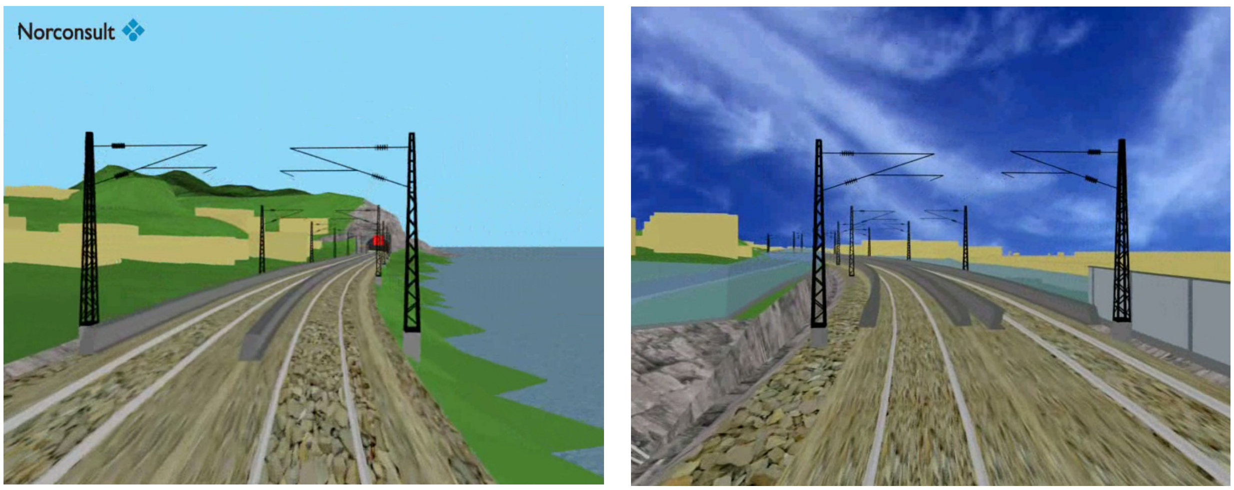


Figure 5: The final design from the chosen manufacturer (dimensions in mm)

E. Measurements

At the moment of writing this article the double track project is at its final building stages and the close-track barriers are being fitted along the tracks. In this period there is no train traffic and no measurements have been possible as yet. Hopefully some preliminary measurements can be presented at the conference.

6. SOME PICTURES



Low barriers on the left of both tracks

Barriers on both left an right side (traditional barrier on the right side near camera)

Figure 6: From our 3D simulations

Figure 7: The first barrier elements being fitted in Stavanger

REFERENCES

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3. Sveriges Provnings- och Forskningsanstalt, Measurements on the Sound Track barrier system in Sweden
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