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Tunnels

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The object type Tunnel opening was introduced with Version 7.0. With this object type it becomes very easy to model the radiation from a tunnel opening and at the same time cut the emission from road/railway segments inside the tunnel.

The emission from the opening is automatically calculated from the emission of the road/railway. The energy is spread over 4 point sources according to the theory described in NORD2000, see Fig 1. The propagation of the noise radiated from those 4 points is in road noise projects according to RTN96 calculated with ISO 9613-2 whereas General Prediction Method (GPM1982) is used for rail noise modelled with NMT96. In road and rail noise projects calculated with NORD2000 this standard is also used to estimate the contribution from the 4 point sources.

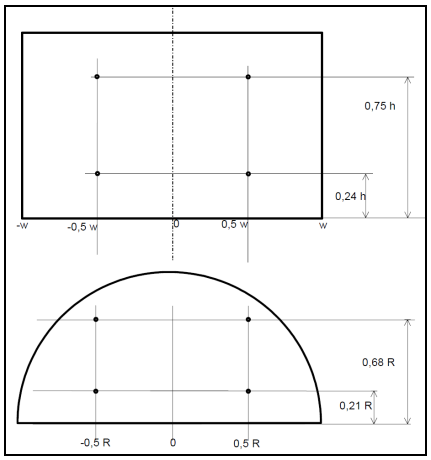

Fig 1 *Point source distribution in tunnel openings according to NORD2000*

The tunnel opening is basically defined by two points only, start and end point. The line between those two points **must** cross the master alignment of the road/railway, otherwise the program cannot pick up the emission (and eventually the elevation, see below) from the source. But apart from that the two points can be insert rather carelessly since the location and geometry of the tunnel is adjusted afterwards in the dialog window shown in Fig 2 (it can be recommended to work with settings 'Show object dialog when finishing the object' under the Option menu in GeoDatabase).

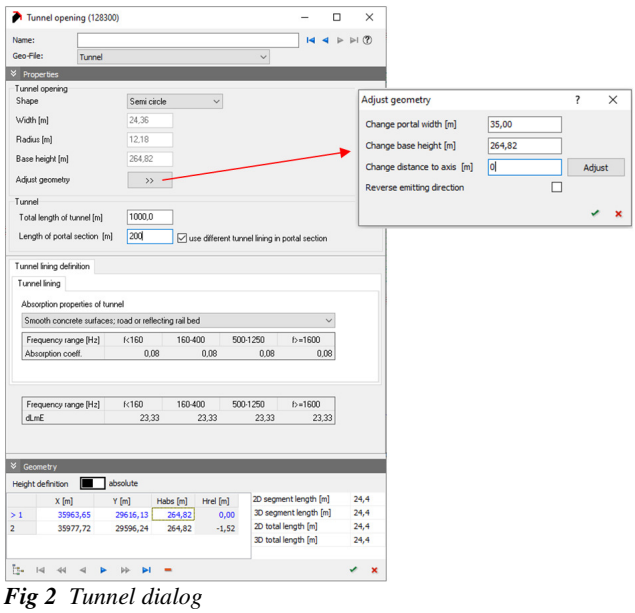

Fig 2 *Tunnel dialog*

Select between semi-circle or rectangular shape of the opening. Click Adjust Geometry and change the width to the relevant size. If you selected semi-circle shape the radius is calculated automatically. If you took rectangular shape you must add the height. The value for 'base height' is the elevation of the tunnel foot. 'Change distance to axis': this parameter is the distance from centre point of tunnel foot to the master alignment of the road/railroad. In case the road/railway is located symmetrically in the tunnel this distance should be set equal to 0. Leaving the Adjust geometry window by hitting the Adjust button will make the program save the portal width and distance you keyed in AND at the same time the program will insert a new base height found by interpolation from the elevation of the two nearest road/railroad points. If you happen to know the exact elevation of the tunnel foot, you must open the Adjust geometry window again and key in these coordinates AND this time close the Adjust geometry window by hitting the green tick mark. If you close the window with the Adjust button, the program will again insert the interpolated elevation.

Looking in the input direction the tunnel is to the right and the direction of radiation therefore to the left. This can be reversed in the Adjust geometry window.

A two lane road might need two separate tunnels. However, even if the distance between the two emission lines might be considerable (like on the sketch Fig 3), the two tunnels need to be created so they cross the master alignment; afterwards they must be moved by adjusting 'Change distance to axis'. One distance must be positive and the other negative. Positive displacement will move the tunnel to the left when looking into the tunnel.

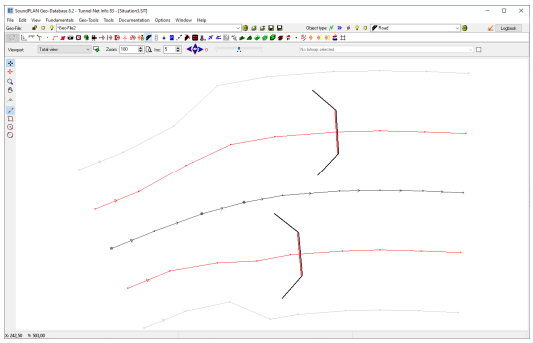

Fig 3 *A two lane road might need two tunnels*

The emission from the road/railway is cut at the tunnel mouth; the rest of the road/railtrack (inside the tunnel) will not emit noise. If the other end of the tunnel is inside the project area, a second tunnel must be defined there, reversed relative to the first one.

The emission from the tunnel opening increases with the tunnel length; but naturally the portal section contributes more to the emission than the inner sections. To increase the tunnel length beyond 300 m will make no significant difference.

A portal section with different absorbing properties than the rest of the tunnel can be defined, see Fig 4.

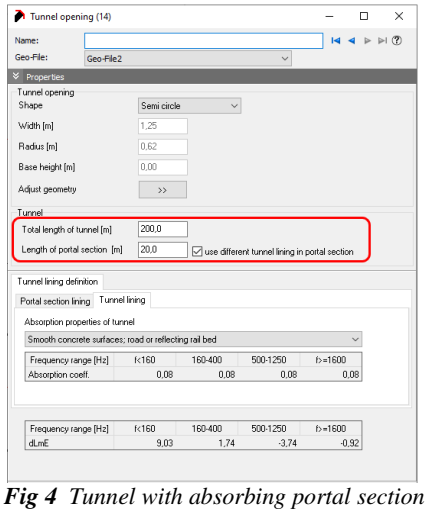

Fig 4 *Tunnel with absorbing portal section*

The directivity of the radiation from the 4 point sources assumes the tunnel is 'deep'. It makes no sense to use the tunnel object types in case the tunnel 'depth' is less than 5 times the width. The zero direction of the directivity is always perpendicular to the tunnel opening (which is not necessarily parallel to the road/railroad).

Tunnels might cause the level to go up by some 1 – 2 dB in an area up to 300 m in front of the tunnel opening (worst case, no absorbing lining). This can be seen from the upper map in Fig 5. This map shows the (arithmetic) difference in noise level with and without a tunnel located very near (5 cm) from the end of a road. The increase takes place mainly under an angle of approx. 60° relative to the normal of the tunnel; near the road the level is dominated by the contribution from the road itself causing the difference with and without tunnel to become very little in this area. Parallel to the opening there are not that many reflections from the tunnel walls causing low directivity in this direction.

This later tendency can also be seen from the lower map. The lower map is also a difference map, but here the level with and without tunnel was subtracted energetically from each other in order to reflect the directivity of the 4 point sources. As expected, the radiation is highest along the normal to the opening and decreases gradually towards +/– 90°. The low frequencies are even (to some extend) radiated 'backwards', see Fig 6, which accounts for a low level there.

(Note: in areas near the road and far away from the tunnel the contribution from the 4 point sources are left out due to the Tolerance in the run set up. For this reason, the contour lines bend towards the opening).

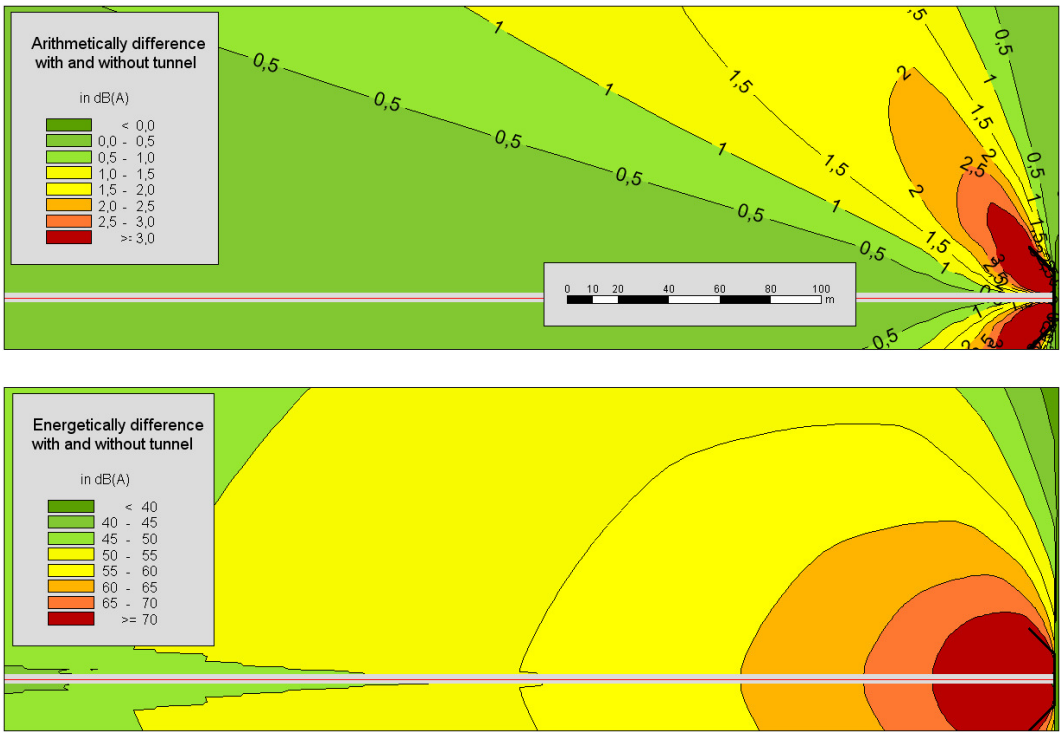

Fig 5 *Contribution and directivity from the tunnel*

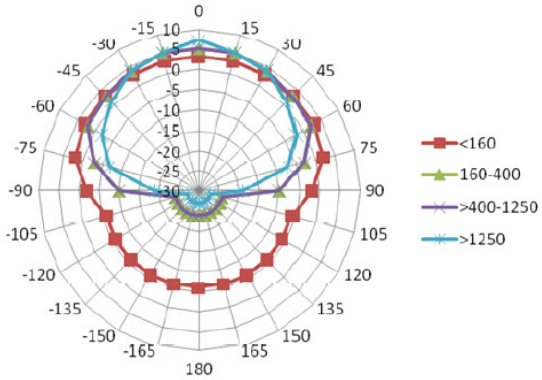

Fig 6 *Directivity from the tunnel*