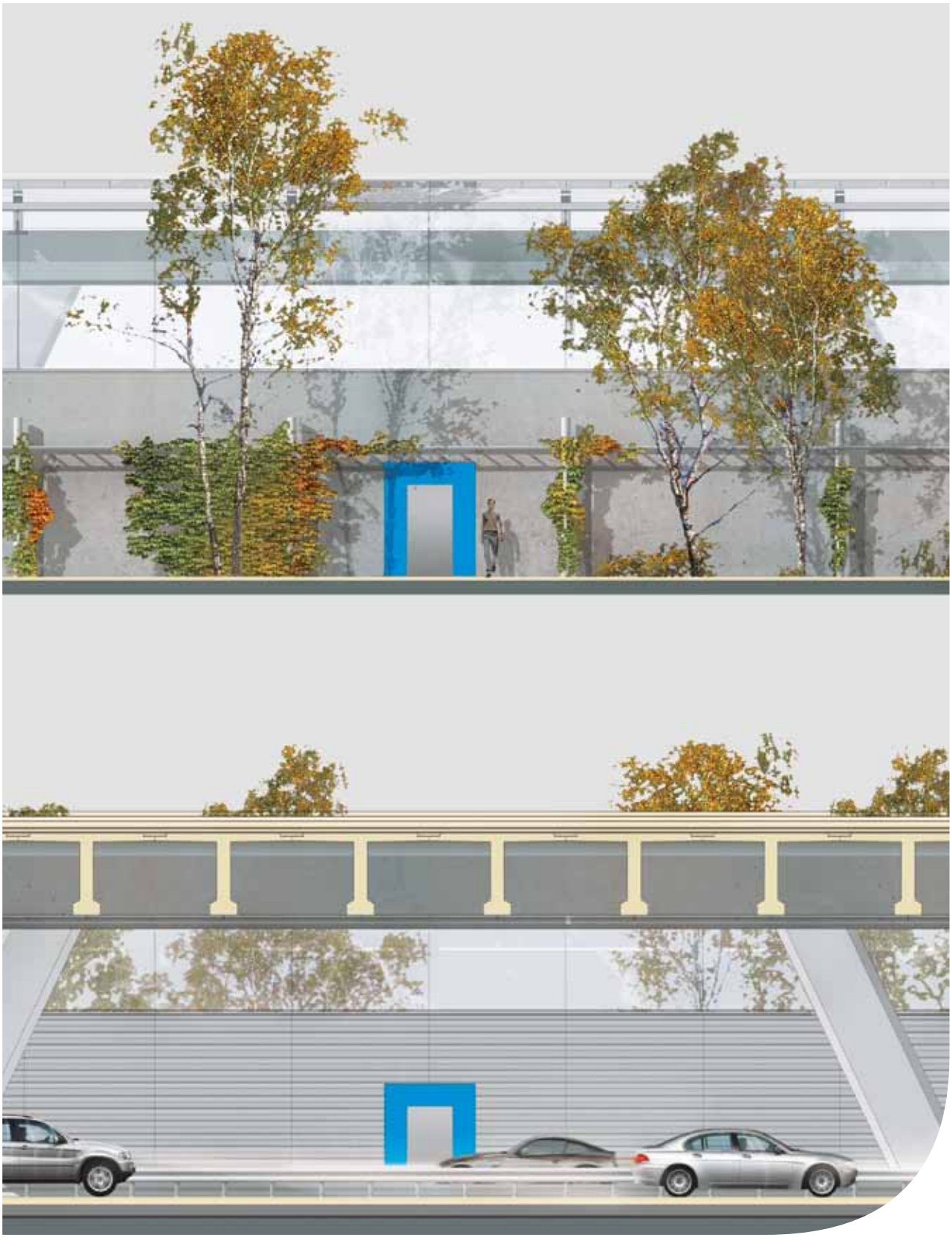
System development

"Lightweight noise enclosures"

SSF Ingenieure



Preliminary remarks

Road traffic is one of the major sources of noise in Germany. Noise protection is, hence, of utmost importance, especially when it comes to construction approval and costs. Essential changes to or new constructions of traffic routes are always connected with the citizens' wish to minimize noise by mainly active noise protection measures in order to obey limit values stipulated in the German Noise Protection Act (16. BImSchV).

Ever larger traffic routes in the context of road and motorway upgrades lead to ever higher noise barriers and embankment-wall combinations. Especially in densely settled conurbation areas, the difficulty is presented that traffic routes move closer and closer to buildings. For example during the 8-lane extension of motorways, the installations reach (theoretical) heights of up to 12 meters; costs increase disproportionally. Because of their separating effect within settled area and disturbance of the landscape, noise protection installations are no longer justifiable in public. That is why especially in urban agglomerations, noise enclosures seem to be very appropriate solutions. A conventional tunnel as solid, mostly double-cell frame structure – frequently with 24h artificial lighting – is still the most cost-saving tunnel or enclosure variant in terms of construction, operation and maintenance. This was also confirmed in the "Study for development of noise enclosures" from June 3rd, 2008, realized by the South Bavarian Motorway Authority in cooperation with SSF Ingenieure GmbH, ordered by the Central Department for Bridge and Tunnel Construction. It showed that special solutions of enclosures implemented until then brought no significant savings compared to conventional tunnels neither to initial investments nor to maintenance and operation. As long as they are technically feasible and capable of receiving permission, noise barrier walls or wall-embankment constructions are the most economic option.

Visualisation: Lang Hugger Rampp GmbH Architekten

System development

In the context of a system development a so called "Lightweight noise enclosure" was proposed which is assumed to bring savings during construction and operation compared to conventional tunnel solutions because of its unique concept.

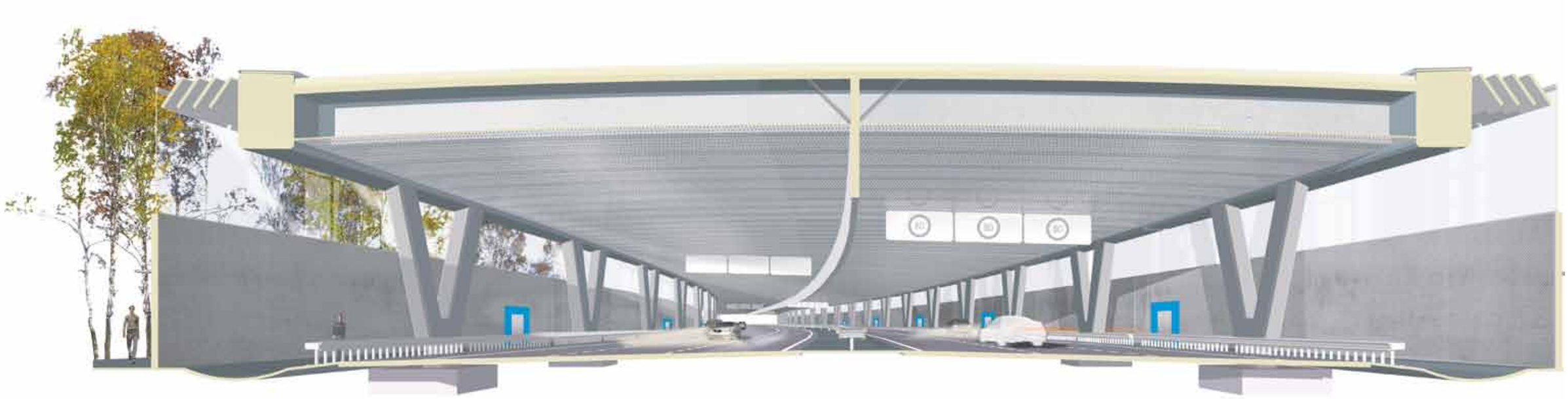
Concept, Design

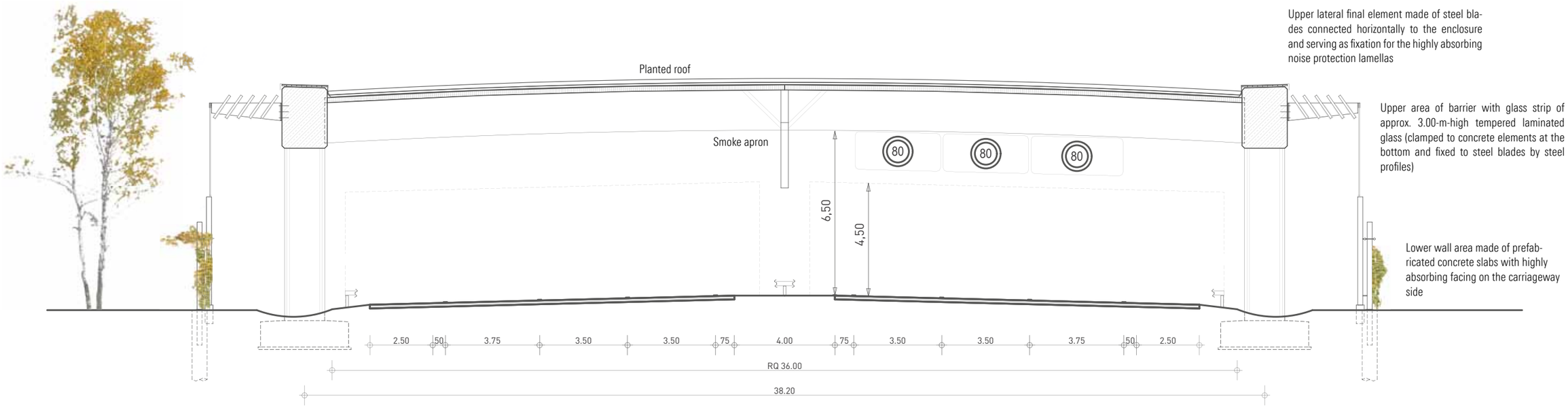
The fundamental concept of the development is based on a light, nonconfining enclosure without separating middle wall and traffic led uninterruptedly trough it; in case of motorways this includes also the hard-shoulders. Moreover, it is of priority that at small distances escape into the open is given, thus, providing highest possible safety in case of fire.

The noise enclosure with a clearance of 6.50 m is built with a framing system made of prefabricated pre-stressed concrete headers (made at the pre-stressing mill) above the carriageway which are connected rigidly to the side columns. Reinforced longitudinal girders are planned as coupling elements at the framing corners. The headers are completed with cast-in-situ concrete to form a closed ceiling slab. On the outside the ceiling is formed as structural roof and planted. The columns are inclined in longitudinal direction. Two columns form a V-shaped pair. A support at the central reservation is relinquished contrary to previous noise enclosure concepts in order to approach the characteristic of an open section with large openings and to minimize influences on the traffic during construction and not to disturb the view of traffic participants. The construction is concluded by separately founded noise barrier walls with highly absorbing surface, completed with a 3-m-high glass strip.

Between the solid roof and these distanced noise barriers, ventilation lamellas with sound-absorbing surface are assembled as upper lateral finishing. In addition to ventilation of the barrier,

Visualisation feasibility study





Upper lateral final element made of steel blades connected horizontally to the enclosure and serving as fixation for the highly absorbing noise protection lamellas

Upper area of barrier with glass strip of approx. 3.00-m-high tempered laminated glass (clamped to concrete elements at the bottom and fixed to steel blades by steel profiles)

Lower wall area made of prefabricated concrete slabs with highly absorbing facing on the carriageway side

Regular cross-section

these lamellas, equipped with highly noise absorbing facing, allow supplementary lighting of the installation and natural irrigation of the grass verge. Continuous ventilation slots in the roof arranged parallel to the street allow in a very easy constructional way efficient ventilation and smoke exhaust. Another positive effect of this construction is the additional natural light incidence into the structure.

The verges as well as the ditches next to the motorway are not disturbed by the enclosure. If the space between ditch and noise barrier is sufficiently large a narrow green strip can be planted. The distance of the detached bright walls planted with tendrils emphasizes the visual spaciousness of the barrier. The glass strip provides natural light and artificial lighting can be minimized.

Sound emissions are isolated by the glass strip and are absorbed by the noise protection walls. A fire protection and acoustic ceilings improves the sound-absorbing effect.
The road surface is recommended as asphalt cover with relatively low tyre noise. The presented measures are expected to bring a high degree of sound reduction next to and above the noise sources so that further noise reducing measures, such as porous asphalt, are unnecessary

Noise level reduction
With noise immission located at 25 m from the carriageway, at a height of 4 m, the reduction factor should be at 20 to 25 dB(a) which has already been verified in noise enclosures with lateral ventilation slots of similar construction type.

Operational equipment and requirements according to RABT
(German directive for equipment and operation of road tunnels)

Traffic space
The regular cross-section typical for routes is led without hindrance through noise enclosures. The clearance is about 6.50 m in order to plan traffic and variable traffic signs above the carriageway and to assure a sufficient amount of daylight within the installation.

picture credits: Lang Hugger Rampp GmbH Architekten

Lighting
The lighting of the access route and of the route in the tunnel results from RABT. For short noise enclosures a lighting of the access route is not necessary, the route within the tunnel is illuminated by lateral light incidence. At night, a minimum lighting of 0.5 cd/m² is required. The lateral light incidence replaces the lighting of access routes in case of relatively small enclosures. In case of noise enclosures covering multiple-lane roads, the lateral light is replenished by regular route lighting. But compared to laterally closed enclosures, a lot of savings can be made as even with low light incident from outside, the lighting of the access areas can be reduced.

Ventilation
Ventilation of a tunnel has to be determined depending on different traffic situations and the admitted limit values of pollutants and particles.

For the present system development it can be assumed that because of the continuous upper openings parallel to the road, ventilation is not required for regular operation in case of short to average-length enclosures. The natural air exhaust on both sides through the large opening – so called piston effect in case of separated tunnel shafts – prevents immission concentration.
In case of fire, the ventilation concept depends in general from the length of the tunnel. Tunnels up to 400-m-long get by with natural ventilation even in case of fire (see RABT). According to RABT, for all tunnels longer than 400 m a risk assessment has to be carried out.

A computer simulation of fire incidents was accomplished by Sofistik AG. A three-dimensional air-flow simulation was modelled by the company EAS GmbH in Karlsruhe, Germany, for a regular cross-section of a six-lane motorway, in order to reliably predict fire propagation, smoke generation and ventilation.

These simulations showed that additional ventilation systems are not required if in the area of the central reservation a stationary smoke apron is mounted to the ceiling. This suspended apron prevents the propagation of flue gases to the oncoming carriageway

and minimizes their concentration to an acceptable quantity. The implementation of this approximately 2.6 m high apron, e.g. as suspended membrane with prefabricated elements or in modular construction method, has to be verified for each individual project.

Safety installations for traffic

- Continuous hard shoulders
- Special cross-sections with lay-bys are not necessary
- Arrangement of escape doors reasonable to the required extent
- Emergency stations are only partially required
- Tunnel radio installations are only partially required
- Utilization of video systems has to be assessed from case to case on the basis of RABT
- Loudspeakers only partially necessary (acc. to RABT, tunnel installations with video surveillance are to be equipped with loudspeakers in the tunnel and at the tunnel portals)
- Manual fire alarms are to be installed in noise enclosures under 400 m length
- Automatic fire alarms are required in tunnels of 400 m or longer and tunnels with mechanical ventilation
- Hand-held fire extinguishers are to be placed in niches if there are no emergency call cabins.
- Supply of quenching water is, in general, not necessary in the same way as it is stipulated for tunnels as fire-fighting is also possible through the escape doors at 50-m-distances; but is recommended to be on the safe side.
- The use of orientation lighting and escape route marking acc. to RABT is recommended.

Overview operational equipment
Regulations for a 2-km-long tunnel and recommendations for system development „Light noise enclosure" following table 12, RABT:

••	required
•	required to a small extent
•○	required to a small extent or not required
○○	not required

Equipment, Safety installations		**Conventional Tunnel**	**Noise enclosures**
Lighting	Counter-beam lighting/ Interior lighting, lighting control installation	••	•
Ventilation		••	○○
Traffic installation	Basic equipment such as traffic sings and variable traffic signs	••	••
Centralized facilities	Operation rooms	••	•
	Energy supply (UPS-system)	••	•
	Drainage with slot-gutters	••	○○
	Control devices	••	•
Constructional installations	Hard-shoulders	•○	existing
	Lay-bys	••	○○
	Turning-areas	••	○○
	Emergency exits	••	••
	Emergency paths	••	•
	Height control	••	○○
	Barriers at tunnel entry/exit	••	••
Communication installations	Emergency stations	••	•
	Video surveillance with individual control	••	••
	Tunnel radio (for police and rescue units)	••	•○
	Loudspeakers	••	••
Fire call devices	Manuel fire alarm devices in emergency stations	••	•
	Automatic fire alarm devices	••	••
	Hand-held fire extinguishers (next to emergency doors)	••	••
	Quenching water supply, hydrants	••	•
	Mechanical longitudinal ventilation/ smoke exhaust	••	•○
Orientation,marking	Orientation lighting Escape route marking	••	••
	Flash lights at emergency doors with video activation	••	•
	Visual guiding devices LED for regular operation	•	○
	Visual guiding devices LED for self-rescue, incident	••	••

Summary
The system development "Lightweight noise enclosure" is an economic construction whose operation of traffic-technical and safety-technical equipment is rather reasonable.
Compared to common tunnel constructions, the user feels no distraction to the road cross-section. The motorway/street continues without caesura or constriction within the enclosure in spacious room and daylight.

Because of its light, modular appearance, the Lightweight noise enclosure is not seen from the outside as massive screen.

Ventilation slots provide airing and the possibility of smoke exhaust without supplementary technical installations. Noise barriers detached from the system bring high variability in their implementation. Lateral glazed strips minimize artificial lighting necessities and communicate transparency.
A planted roof seems pleasant and natural in built area. Compared to sealed roof surfaces, it offers ecological advantages and can, furthermore, be equipped with solar panels.

The concept strives at the highest possible acceptance with residents and traffic participants by, at the same time, aiming at economic aspects for construction and operation.

The "Lightweight noise enclosure" is developed according to the regulations of RABT. A case study for a large motorway noise enclosure has already been analyzed for fire incidents and resulted in a positive safety assessment.

Visualisation preliminary study

Visualisation: bit-better Visualisierung

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