TECHNICAL CONDITIONS

MIGRATION STRUCTURES FOR WILDLIFE
Part 1: Project engineering, construction, operation, maintenance and repair of ecoducts

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1 Introductory chapter

1.1 Subject of the Technical Conditions (TC)

The subject of the technical conditions (TCs) is the solution to the problem of wildlife migration routes crossing with roads (motorway, expressway, other category of road) by means of ecoducts, i.e. bridge structures located above the road in question. These TCs define the design of ecoducts in individual degrees of project documentation, ecoduct categorisation according to the significance of the migration routes and the species of migrating animal and propose technical parameters, vegetation modifications, maintenance and greenery treatment for ecoducts.

1.2 Purpose of the TCs

The purpose of the TCs is to establish the work process and extent during ecoduct design in the preparation of the individual levels of project documentation and define the basic technical and ecological parameters of the object designed.

1.3 Use of the TCs

These TCs are intended for project engineers and ecologists compiling project documentation (PD) concerning the environment (SEA and EIA process) and define their duties during the preparation of individual stages of PD.

1.4 Processing of the TCs

The TCs were compiled on the basis of an order from the Slovak Road Administration (Slovenská správa ciest – SSC) by the company PFstatik, s.r.o., Pohramičňíkov 43, 851 10 Bratislava, designer in charge: Ing. Peter Federič, (tel. 02/6720 0051, e-mail: pfstatik@pfstatik.sk). The environmental part was compiled by Mgr. Tomáš Šembera and Ing. Ivan Šembera, CSc., EKOJET, s.r.o., Staré Grunty 9A, 841 04 Bratislava, (tel. 02/4569 0568, e-mail: info@ekojet.sk).

1.5 Distribution of the TCs

Upon being approved, the electronic form of the TCs will be published on the Slovak Road Administration’s website: www.ssc.sk (technical regulations) and on the website of the Ministry of Transport, Construction and Regional Development of the Slovak Republic: www.mindop.sk (traffic, road transport, road infrastructure, legislation, technical regulations).

1.6 Legal effect of the TCs

The TCs shall enter into legal effect on the date specified on the title page.

1.7 Replacement of prior regulations

These TCs are not replacing any other regulations.

1.8 Related and cited statutory regulations

Statutory regulations of the Slovak Republic

- Act No 543/2002 Coll. on nature and landscape preservation, as amended;
- Slovak Ministry of the Environment Regulation No 24/2003 Coll.;
- Act No 50/1976 Coll. on zone planning and construction order (the Construction Act) as amended;
- Act No 135/1961 Coll. on land routes (the Road Act), as amended by the most recent legislation;
- Federal Ministry of Transport Regulation No 35/1984 Coll., implementing the act on land routes (the Road Act), as amended;
- Act No 8/2009 Coll. on transit on land routes as amended by the most recent legislation;
- Regulation No 9/2009 Coll. implementing the act on road transit and on the amendment and supplementation of certain laws, as amended;
Migration structures for wildlife
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- Act No 90/1998 Coll. on construction products (promulgated in its full wording by Act No 69/2009 Coll.);
- Regulation No 558/2009 Coll., establishing an index of construction products which must be labelled, conformity certification systems and details on the use of conformity marks;
- Act No 24/2006 Coll. on the assessment of effects on the environment and the supplementation of certain acts;

International conventions
- Convention on Wetlands (the Ramsar Convention);
- Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) and agreements adopted within the scope of it (Agreement on the Conservation of African-Eurasian Migratory Waterbirds [AEWA], Agreement on the Conservation of Bats in Europe [EUROBATS]);
- Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention);
- Biodiversity Convention;
- Convention concerning the Protection of the World Cultural and Natural Heritage;
- Framework Convention on the Protection and Sustainable Development of the Carpathians (the Carpathian Convention);
- European Landscape Convention;

European Union directives

1.9 Related and cited standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STN EN 1990</td>
<td>Eurocode. Principles of construction projection (73 0031)</td>
</tr>
<tr>
<td>STN EN 1992-2</td>
<td>Eurocode 2. Concrete structure design. Part 2: Concrete bridges. Design and engineering (73 6206)</td>
</tr>
<tr>
<td>STN 73 6101</td>
<td>Road and motorway design</td>
</tr>
<tr>
<td>STN 73 6200</td>
<td>Terminology for bridges</td>
</tr>
<tr>
<td>STN 73 6201</td>
<td>Bridge design</td>
</tr>
<tr>
<td>STN 73 7507</td>
<td>Tunnel projecting on land roads</td>
</tr>
<tr>
<td>STN 83 7015</td>
<td>Vegetation technology in landscaping. Soil work.</td>
</tr>
<tr>
<td>STN 83 7016</td>
<td>Vegetation technology in landscaping. Plants and plant care.</td>
</tr>
<tr>
<td>STN 83 7017</td>
<td>Vegetation technology in landscaping. Turf and seeding.</td>
</tr>
<tr>
<td>STN 83 7018</td>
<td>Vegetation technology in landscaping. Biological methods of site stabilisation. Stabilisation by seeding and planting, stabilisation by means of</td>
</tr>
</tbody>
</table>
living plant material, dead material and building elements, combined construction methods.

STN 83 7010 Nature protection. Tree care and tree protection.

1.10 Related and cited technical regulations
TC SSC 02/2003 Drainage for bridges on land roads, Slovak Road Administration: 2003;
TC 05/2004 Anti-corrosion protection for steel bridge structures, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2004;
TC 03/2006 Road construction documentation + Annexes (1-14). Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2005;
TC 08/2006 Use, quality and system of evaluation of noise protection walls, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2006;
TC 12/2006 Special surface treatment for concrete bridges beneath the insulation layer. Anchoring impregnation coating and sealing layer, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2006;
Amendment 01/2006 Technical conditions TC 09B/2005 Road inspections, maintenance and repairs. Bridges, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2006;
TC 04/2007 Catalogue of damage to bridge structures on motorways, expressways and class I, II and III roads, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2007;
TC 06/2008 Handbook on monitoring the effect of roads on the environment, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2008;
TC 04/2010 Vegetation modifications for land roads + Annex (1-3), Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2010;
TC 06/2010 Safety arresting devices on land routes. Concrete barrier, Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2010;
TC 07/2010 Basic motorway map. Execution, maintenance and restoration + Annexe (1-8), Ministry of Transport, Post and Telecommunications of the Slovak Republic: 2010;

2 Terms and abbreviations used in these TCs
The following abbreviations are used in this text:
CORINE Land Cover of Slovakia
EIA Environmental Impact Assessment
PLA Protected landscape area
SSDP Slovak Spatial Development Policy
NP National park
PD Project documentation
SEA Strategic Environmental Impact Assessment
SNP State nature protection
ZPD Zone planning documentation
TSES Territorial system of ecological stability
HTU Higher territorial unit
LPT Legally protected territory

Terms used in these TCs:
ecoduct length - distance which wildlife must cover when crossing from one side of the road to the other

ecoduct - migration structure over a road serving as a crossing for animals on a migration route which prevents any kind of vehicle movement, with the exception of vehicles for vegetation care

ecologist - compiler of the environmental part of the PD

core territory - territory in which the species of wildlife in question appear

animal migration - long distance movements of animals away from their original home area

migration route - route regularly used for migration by wildlife

migration corridor - 500 m wide belt connecting two points in the corridor network

migration structure - forms a barrier-free crossing for animals over or under an existing (or planned) road

disrupted zone - area in the surroundings of a road which is affected by noise, emissions, illumination and visual disruption

corridor axis - line passing through the centre of the corridor which constitutes the ideal trajectory of movement of the migrating individual

project engineer - compiler of the technical part of the PD (roads, bridges)

average ecoduct width - the width of the migration route measured on the surface of the terrain in a parallel direction with the axes of the bridged road in the centre of the bridge (free width between fencing on the ecoduct)

nodal point - junction of two or more corridors
3 Migration routes and ensuring the passability of migration routes

3.1 Objective of the migration structure draft
The objective of the migration structure draft is to design functional migration structures which reduce the road’s separating effect and ensure uninterrupted animal movement above or below the road which intersects the migration route. The migration structure draft project must meet the technical, ecological and economic criteria and at the same time must be optimally used by migrating animals, according to the possibilities. The structure’s equipment, dimensions and connection to the ecosystem and terrain in the vicinity of the migration structure must be optimised. In order to achieve these goals, it is necessary to establish equal ecological, technical and economic criteria – optimum cooperation between the ecologist and project engineer. This evaluation must be conducted in a super-regional, regional and local context in the scope of the individual stages of preparation of the migration passability documentation.

3.1.1 Evaluation of the passability of roads for animals
The evaluation of the passability of roads is contained in documentation of the SEA and EIA processes. Its objective is the concrete definition of real and potential migration corridors for large and medium-sized mammals including ensuring connection to the network of the Slovak Republic’s neighbouring states on the basis of current scientific knowledge on the expansion and nature of migration of the animals being evaluated.

The evaluation of passability contains and defines:
- zoological research on local routes, determination of species diversity and population,
- animal categorisation,
- definition of the core territories and potential main migration directions,
- evaluation of the landscape elements aiding migration from a long-term sustainability standpoint,
- evaluation of landscape elements limiting migration, both current and potential (landscape barriers),
- evaluation of local documents on the territory of the corridor’s concrete route,
- current data on traffic intensity.

3.1.2 Animal categorisation
Tables 1 and 2 contain a categorisation of animals. The categorisation primarily takes into account the ethological parameters of the migration behaviour of the species of mammals in question, determined using analyses of domestic and foreign habitats based on telemetric studies and monitoring of individuals using photo traps. For model species of carnivores (lynx, wolf, bear), available data on the appearance and behaviour (ethology) of said animals from the Slovak State Nature Protection are analysed.

3.1.3 Definition of the core territories and main migration directions
A core territory is the territory of appearance of the species of animals in question and their real or potential interconnection through main migration directions. Core territories are defined according to the database of currently observed species of animals from the National Park Administration, PLA, game organisations, NATURA 2000, Slovak land cover databases (CORINE Land Cover 2006 and similar).

The main migration corridors in Slovakia have not yet been defined. The following may serve as supporting documents for defining corridors:
- The documentation ‘Slovak Spatial Development Policy 2001, Natural and Social-Economic Barriers and Development Possibilities of Residential Structures’;
- Regional territorial systems on ecological stability compiled as part of the zoning planning documentation of the higher territorial unit;
- Documents and the database of defined animal migration corridors of the Czech Republic, Poland and Austria located in Slovakia’s border regions.

Table 1  Animal categorisation – medium-sized mammals

<table>
<thead>
<tr>
<th>Common name (scientific name)</th>
<th>Distribution in Slovakia</th>
<th>Migration behaviour</th>
<th>Nature of migration</th>
<th>Influences on the design of migration structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>European badger (<em>Meles meles</em>)</td>
<td>Common in most of the country, territory 500 ha</td>
<td>Territorial species, migration of young individuals</td>
<td>Local migration between sources of food, water and rest. Migration of older cubs. Local population is not particularly sensitive to disruptive anthropogenic influences</td>
<td>The size of the migration structure is not the main factor. In areas of migration pressure, a distance between migration structures (500-1000 m) is suitable</td>
</tr>
<tr>
<td>Red fox (<em>Vulpes vulpes</em>)</td>
<td>Common in most of the country, territory up to 20 km²</td>
<td>Territorial species, migration of young individuals up to 15 km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roe deer (<em>Capreolus capreolus</em>)</td>
<td>Common throughout the entire territory of Slovakia</td>
<td>Constant in summer; migration for food in winter</td>
<td>Local migration between sources of food, water and rest. Local population is well-adapted to disruptive anthropogenic influences.</td>
<td></td>
</tr>
<tr>
<td>Wild boar (<em>Sus scrofa</em>)</td>
<td>Common throughout the entire territory of Slovakia</td>
<td>Mobile species, up to 40 km/24h, long, uncoordinated migrations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mouflon (<em>Ovis musimon</em>)</td>
<td>Non-native species, appears in approx. 40% of the territory of Slovakia</td>
<td>Constant in summer; migration for food in winter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallow deer (<em>Cervus dama</em>)</td>
<td>Non-native species, appears in approx. 30% of the territory of Slovakia</td>
<td>Territorial species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>European otter (<em>Lutra lutra</em>)</td>
<td>Native species, appears in most of the country, with the exception of western and parts of southeastern Slovakia</td>
<td>Seasonal migration between summer and winter bases and trophic migration, related to fish movements to spawning nests</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2 Animal categorisation – large mammals

<table>
<thead>
<tr>
<th>Common name (scientific name)</th>
<th>Distribution in Slovakia</th>
<th>Migration behaviour</th>
<th>Nature of migration</th>
<th>Influences on ecoduct design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red deer (Cervus elaphus)</td>
<td>Appears in large numbers in Slovakia</td>
<td>Regular migration for food, mating, long dispersive migration</td>
<td>On established long-distance migration routes without disruptive anthropogenic influences</td>
<td>Demanding width dimensions of migration structure and demanding accompanying elements; natural bridging of deep valleys is optimal; design on flat territory is difficult</td>
</tr>
<tr>
<td>Brown bear (Ursus arctos)</td>
<td>Appears in mountainous areas of Slovakia</td>
<td>Migration over great distances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eurasian lynx (Lynx lynx)</td>
<td>Sporadic distribution in mountainous areas</td>
<td>Territorial species, long-distance migration of young individuals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey wolf (Canis lupus)</td>
<td>Sporadic appearance</td>
<td>Mobile, long-distance migration over hundreds of kms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eurasian elk (Alces alces)</td>
<td>Very rare</td>
<td>Does not respect territory, long-distance migration over hundreds of kms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wildcat (Felis silvestris)</td>
<td>Rare, territory of only tens of hectares.</td>
<td>Very small migratory ability.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.1.4 Evaluation of supporting landscape elements
The routing of the corridor is specified by the supporting landscape elements. They include:
- protected nature and landscape areas in Slovakia and protected zones thereof pursuant to Section 17 of Act No 543/2002 Coll.;
- territories of European significance in Slovakia, pursuant to Section 27 Act No 543/2002 Coll.;
- elements of the TSES, i.e. biocorridors and biocentres at supra-regional and regional level.
The drawing ‘Map of supporting elements for landscape sustainability’ is rendered in accordance with the aforementioned documents.

3.1.5 Evaluation of restrictive landscape elements
The basic types of elements considered to be fundamental barriers include:
- the road network, assessed according to the load intensity and technical modifications (according to data from the NDS (National Motorway Company) and the Slovak Road Administration),
- Residential areas and sites, evaluated according to the documents and database of Slovakia's land cover classes (CORINE Land Cover 2006: urbanised and technical areas, agricultural areas),
- unforested areas, evaluated according to the documents and database (CORINE Land Cover 2006),
- protected bedding areas and mining areas, evaluated according to the documents and database of Geofund SR,
- prepared industrial zones, evaluated according to the documents and database documentation of the Territorial Development Policy, zone planning documentation of the higher territorial unit, the regional development documentation and the zone planning documentation for cities and municipalities.
The drawing ‘Map of restrictive landscape elements – migration barriers’ is rendered in accordance with the aforementioned documents.

3.1.6 Evaluation of local documents on the territory of the corridor’s concrete route
The routing of the corridor is specified by local documents. Terrain research is used for the detailed evaluation of the local documents on supporting and restrictive elements and relief relations. The minimum spatial requirements for large and medium-sized mammals and the nature of use of the crossing’s specific location are established during this stage.
In addition to the routing of the main direction of migration, the specification of the corridor’s route requires the evaluation of the overall landscape structure of the broader surrounding area, which contributes to the draft, as well as of the potential lines of the migration corridors, which contribute to the selection of the most suitable corridor once the barrier effects have been evaluated.
The main components of the barrier types on the territory of the specific corridor route are:
- the category of the roads, the technical execution of the road and the intensity of traffic;
- the category of railways and their technical execution;
- the category of rivers and bodies of water as well as their technical execution which restricts access to the river and the size of the current;
- the category of fences and hedges and their technical execution as well as the width of free passage between the fences;
- the category of settlement, width and length of free passage between settlements and the transition between built-up terrain and open terrain;
- the category of unforested area; landscape with agricultural product without scattered vegetation and landscape with a significant proportion of scattered vegetation.
3.1.7 Alternate definition of the corridor route

The results of the terrain research and evaluation of the barriers to passability make it possible to define the corridors’ basic migration profiles (migration corridor variants) in detail.

A migration corridor is defined as a 500 m wide belt connecting two nodal points in a network of corridors.

A nodal point is defined as the junction of two or more corridors.

The corridor axis is defined as the line passing through the centre of the corridor. It constitutes the ideal trajectory of movement of the migrating individual. The corridor is divided into sections with different potential passability in the sense of the barrier categorisation.

A corridor section is a part of a single corridor with a minimum length of 200 m and a width of 500 m.

The drawing ‘Map of the alternate definition of the migration corridor route’ is rendered according to the aforementioned documents, as is an orthophotomap with the detailed route of the corridor.

3.2 Migration study

The result of the passability evaluation is the migration study, which evaluates the road’s overall passability, estimates the basic migration profiles (migration corridor variants) and confirms its feasibility. The initial migration study (Chapter 4.2), which is specified and supplemented during the compilation of the zoning decision documentation (Detailed migration study – Chapter 4.3), is compiled during the study.

The migration study on the route contains a text part and an illustrated part with a draft design with the following contents:

- a definition of the main migration route for the individual categories of animals;
- the size of the main migration route;
- elements supporting and resolving migration and the connection of the migration structure’s location to the surrounding landscape;
- a draft of the number of migration structures and their migration potential;
- a definition of the relevant areas from the nature and landscape protection areas (elements of the territorial system of ecological stability, legally protected territory, biotope distribution), ownership relations of the properties affected.

The study’s conclusion contains the significance of the migration route, an approximate determination of the migration structures’ locations, their categorisation, the requirements for their parameters, soil contact, a draft of the measures to ensure the factors of comfort for the migrating animals (noise protection measures, reduction of visual and movement perceptions, illumination and similar). The study is compiled in cooperation with the road project engineer and ecologist. At the same time, it is presented to nature and landscape protection employees, hunting association representatives and affected municipalities for consultation.

3.3 Definition of the borders of the territory affected by the construction of the migration structure

The following types of affected territory are defined in the proposed design for the migration structure construction:

- a territory being designed is a territory of the actual area of the proposed structure’s body;
- a territory being evaluated is a territory divided based on the following criteria:
  - the extent of the migration structure’s potential effects,
  - the current and future use of the territory,
  - the situation of nature protection and TSES elements,
  - a definition of the main migration corridors;
- a territory being monitored is a territory in which analyses and research on the components of the environment have been conducted;
- a monitored section is a road section which is defined by its location, at which a traffic accident with an animal was recorded in recent years according to police records.
3.4 Migration routes

Animal migration refers to long distance movements of animals away from their original home area. A migration route is a route regularly used by wildlife for migration. It exists regardless of roads and its parameters are evaluated before road construction is commenced. Migration routes can be divided according to meaning as follows:

- supra-regional migration routes,
- regional migration routes,
- local migration routes.

3.5 Factors affecting the passability of migration routes

All roads, railways, rivers, industrial zones and built-up areas constitute obstacles to the free movement of wildlife. A road affects its immediate vicinity by noise, emissions, illumination and visual disruption. The intensity of this effect is directly proportional to the intensity of traffic. The area around the road which is most affected by these factors is referred to as a disrupted zone. The width of this zone must be minimised using suitable ecological means.

Roads with a low traffic intensity of up to 1,000 vehicles/24 hours without fencing are not sufficient warning for most animals and do not constitute an obstacle to animals crossing the road, but instead they are associated with a large number of animals being killed. Measures to improve visibility in critical sections for drivers as well as for animals are a frequent solution to this problem.

Road sections with moderate traffic intensity (1,000 to 10,000 vehicles/24 hours) frequently discourage animals from crossing the road. At the same time, they constitute a disrupted zone along the road, which animals avoid. Its width on both sides of the road is approximately equal to the width of the monitored road. The road can be crossed in some cases, leading to frequent collisions between animals and vehicles.

But sections of roads with a high traffic intensity in which the intensity reaches (10,000 to 30,000) vehicles/24 hours (meaning that one car drives by every 3 to 9 seconds) have a strong deterrent effect on animals. Animals only attempt to cross the road in stress situations. The disrupted zone, in which animals minimise their stays, is approximately twice the width of the road on both sides. Furthermore, such roads are frequently bordered by fencing or noise protection walls and constitute an insurmountable obstacle for wildlife attempting to cross the road. Animals which still succeed in crossing nearly always end up being killed. This means that bridge structures are the only way that animals can cross. But these locations are primarily used by large numbers of cars and are not suitable for being used as crossings by wildlife. For that reason, special structures for undisturbed animal migration (ecoducts) are designed on roads with great traffic intensity.

In addition to the total traffic intensity, the distribution of traffic during the day is also important, especially in the night time, when animal migration becomes more intense. One of the main reasons why motorways are such fundamental barriers to migration is the intense traffic during the night time, which prevents animals from safely crossing the road.

3.6 Animal migration-related measures on roads

From a practical standpoint, animal migration-related measures on roads can be divided into two basic groups:

- measures to facilitate migration – migration structures (overpasses, underpasses);
- measures to reduce mortality – installations preventing access to the road (fencing, noise protection walls, artificial deterrents).

Safe migration structures must be arranged in such a manner that wildlife can use them in any situation and feel safe. Other uses of migration structures, especially for transportation purposes, are ruled out. Two construction types of migration structures come into consideration for measures to facilitate animal migration:

- underpasses – culverts, bridges on roads,
Ecoducts with a suitable width or underpasses with sufficient underpass height are a suitable solution for migration route crossings with roads. Dark, narrow and low underpasses do not encourage hoofed animals to cross beneath the road. Foreign research projects monitoring animals using ecoducts indicate that ecoducts are not only used for crossing by deer, roe deer, wild boar and other mammals, but also by invertebrates such as beetles, spiders and reptiles.

The determination of the structure’s dimensions is not the only factor which has a decisive effect in designing migration structures; so does the comprehensive design of the entire structure and its immediate vicinity, such as the migration structure’s integration into the surrounding area, vegetation modifications on the structure and in the territory connected to the structure, as well as the minimisation of disruptive effects of road traffic on animal movements. All of these measures must give a feeling of safety to animals wishing to use the migration route. The following modifications must be emphasised to make the crossing more comfortable for animals:

- vegetation modifications to the structure – the animal should have as little sensory contact with the road as possible and as much contact with the natural surroundings and vegetation as possible;
- the surface which the animal crosses on – the most suitable surface is grass, or soil without vegetation; asphalt, concrete and gravel surfaces which may disturb animals’ movement are not suitable;
- noise protection measures – noise protection walls, minimisation of the noise from crossing installations on bridges in the case of underpasses;
- protection from illumination – natural or artificial screening measures.

### 3.7 Migration structure categories

The following categories of migration structures can be determined based on the migration routes’ significance and the type of migrating animal:

- **category A** – on all supra-regional migration routes for large mammals;
- **category B** – on all regional migration routes for large mammals and on supra-regional roads for medium-sized mammals;
- **category C** – on all local migration routes for medium-sized mammals and individual large mammals.

### 3.8 Migration structure distances

The following maximum migration structure distances are given for crossings of migration routes and the proposed road:

- **category A** – at least one structure shall be placed on all supra-regional migration routes for large mammals;
- **category B** – the maximum distance is 10 km on all supra-regional and regional migration routes – this figure also includes category A migration structures;
- **category C** – maximum distance of 3 km between individual structures – this figure also includes all structures of categories A+B+C.

The maximum distance of migration structures may be increased on the basis of an assessment by the competent environmental office. The minimum distances from the nearest standing residential buildings, neighbourhoods, wind power plants and agricultural structures are specified in Table 3. The minimum distance applies to each point of the structure being assessed.

<table>
<thead>
<tr>
<th>Individual residential buildings, isolated farmsteads</th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 m</td>
<td>200 m</td>
<td>100 m</td>
</tr>
<tr>
<td>Enclosed settlements, neighbourhoods, wind power plants, agricultural structures</td>
<td>500 m</td>
<td>350 m</td>
<td>200 m</td>
</tr>
</tbody>
</table>
4 Solution to the animal migration problem in individual stages of investment preparation

A functional draft of a migration structure for animal migration which is technically and economically optimal requires cooperation between the ecologist and project engineer from the very beginning of road project preparation, from the construction study to monitoring animal movement to the migration crossing’s placement into operation. The results of this monitoring indicate whether the migration structure fulfils its task or whether it is necessary to take measures to improve the conditions for the better use of the migration structure on the migration route.

In some cases, it is also possible to create natural conditions for certain species of animals so that said animals will not feel the need to cross to the other side of the road, by means of a new modification to the area on both sides of the road (planting woody plants and bushes, creating a lake or body of water to provide water for the animals). This solution may prove less expensive than the construction of a migration structure. Otherwise, the construction of a migration structure can be avoided by suitably shifting the road body away from the wild animals’ migration route, which may also result in significant savings. Considerable amounts of money can be saved by an appropriate modification to bridge structures over rivers which offer sufficient space for crossing migration routes. A suitable modification to the height of roads in rugged mountain terrain can be used to design multi-pole valley bridges, which are a very good solution for preserving an existing migration corridor in combination with an overflowing river and the preservation of an ecosystem. Considerable amounts of money can also be saved by modifications to the bridge’s bearing structure and technical equipment, which remove disruptive barriers and increase the passability of the migration route (by providing acoustic insulation on the bridge head on bridge structures, etc.).

4.1 Zone planning

The selected width of the territory, intersections of settlements and roads with main migration corridors (especially routes of regional and super-regional significance) is conceptually designed in the scope of zone planning. When determining migration routes, it is also necessary to take into consideration long-term solutions for settlement expansion, industrial parks and other constructions or activities which could create new barriers to animal migration in the future. Based on these long-term projections, the path of the migration route may be diverted by adjusting natural conditions (by planting woody plants and bushes and establishing bodies of water).

The goal of zone planning is mainly to ensure that basic migration routes are not interrupted along their entire length in the given territory. It is pointless to use costly measures to resolve animal migration in relation to the motorway when the migration route is interrupted by another investment activity in the following section. Zone planning and SEA are of paramount importance for ensuring that landscape is passable for wildlife.

The strategic migration study (SEA) is the basic document for zone planning. At this stage, it is mainly necessary to focus on the following problems:

- ensure migration passability in the entire territory assessed;
- spot locations where migration barriers may arise;
- ensure that no migration routes will be disrupted by the establishment of new barriers in the future;
- establish a traffic count in cooperation with a traffic engineer and establish a qualified estimate of traffic intensity for a longer period of time on existing and proposed roads;
- compile a categorisation of the territory in terms of its migration importance to wildlife in the scope of preparing the territorial plans;
- ensure that the initial migration study was compiled during the planning of new roads, followed by the detailed migration study, which demonstrates the required passability via migration crossings on the migration route;
4.2 Study

The study serves as the basic document for processing the subsequent construction documentation (technical study) and simultaneously serves for documenting the initial data and documents on the decision process in the state of assessing the construction’s effect on the environment (intent). Multiple design variants are studied in the scope of the technical study when drafting new roads. Said design variants start with corridors determined in the zone plan, and the path routing is specified on the basis of the technical, economic and ecological criteria. Emphasis must be placed on the passability of the migration routes when selecting the recommended variant. For this purpose, the initial migration study is compiled in the scope of the intent.

The main objective of the initial migration study is the design of the overall passability concept for wildlife on long motorway and road sections, and not the details of the individual structures, to demonstrate that the given route with the proposed animal crossings will be sufficiently passable for wildlife. This study details the basic migration profiles and confirms their feasibility on the municipal level. The compiler creates the following drawings in the scope of the initial migration study:

- a map of the supporting elements for landscape sustainability (Chapter 3.1.4 of these TCs);
- a map of restrictive landscape elements – migration barriers (Chapter 3.1.5 of these TCs);
- a map of the alternative definition of the migration corridor (Chapter 3.1.7 of these TCs);
- a map of the main migration routes of the individual categories of wildlife and the proposed migration structures, specifying the category thereof (Chapter 3.7 of these TCs).

The procedure for compiling the study is as follows:

- cooperation and work coordination between the project engineer and ecologist is necessary at this stage of the project;
- the ecologist determines the main migration routes which must be respected;
- the project engineer designs the structures which may be used for animal migration;
- the ecologist evaluates all the proposed migration structures on the proposed road route and determines whether their passability complies with the conditions of the given migration route;
- in the event that the number and distribution of proposed migration structures is insufficient, the ecologist shall search for a suitable location to build special migration structures or the possibility of modifying migration parameters on the original proposed structures with the active participation of the project engineer;
- this cooperation results in the draft of the road section, where sufficient wildlife passability is achieved at the place of crossing with the migration route;
- the main migration routes of individual categories of wildlife, elements supporting and disrupting migration and proposed migration structures are marked in the map document in the scope of the intent;
- a detailed design of the migration structure is the subject of further stages of project documentation; the technical basis for processing the study is map documents (and not terrain alignment), so a specification of the road route and the technical design of the specific structures is calculated; the approximate placement of the migration structures which ensure that the migration route is sufficiently passable and their categorisation is entered in the scope of the intent; only the minimum dimensions of migration structures determined according to the category established in the initial migration study are entered in the technical design.

4.3 Zoning decision documentation (ZDD)

Research is conducted in the scope of compiling the project documentation on the zoning decision (ZDD), in accordance with TC 03/2006, as well as the geodetic alignment of the territory in the area where the migration structures are being designed (it is necessary to correspondingly expand the
alignment area as well as the access part of the migration route across the road axis at locations of migration crossings). The directional and altitudinal routing of the road path is designed on the basis of this alignment. This route specification may cause deviations from the conditions which were anticipated during study compilation, thus making it necessary to adjust the technical parameters of structures which were specified in the initial migration study.

The objective of the ZDD in ensuring the passability of migration routes is the draft of the final positioning and specific technical design of migration structures, including traffic and ecological elements, such as vegetation modifications and connection to the surrounding landscape. The detailed migration study is compiled at the same time. The basic documents for compiling this project documentation are the initial migration study, a standpoint from the competent office of the EIA process and ongoing technical documents during the compilation of the ZDD.

The course of action in compiling the ZDD henceforth requires close cooperation between the project engineer and the ecologist:

- the project engineer designs the directional and altitudinal routing of the path based on the geodetic alignment, during which he must observe the suitable altitudinal routing of the path and the barrier-free connection of migration structures to the surrounding terrain; at bridge locations, he must adjust the altitudinal routing of the path so as to ensure a sufficient clear height for underpasses for trouble-free animal crossing and must direct the road route at overpass locations in a channel in order to minimise terrain modifications (terrain filling) in the guiding area on the overpass;
- in cooperation with the ecologist, the project engineer inspects the integration of the migration structure into the ecosystem on the terrain and specifies the position of the animal crossing (direct connection to the forest vegetation or refuge in field areas) so that animals will have safe and undisturbed access to the structure in question;
- the project engineer establishes precise dimensions and technical characteristics of the structure based on the migration structure category which is determined during the compilation of the initial migration study, the conditions of the connection of the migration structure, existing disruptive effects on animal migration and other terrain conditions;
- the ecologist revaluates whether passability conforms to the conditions of the migration route in question in observance of the detailed technical design of the migration structure and the structure’s specified integration into the surrounding terrain – he compiles the detailed migration study and, if necessary, proposes an optimised design with the project engineer;
- the ecologist negotiates the resulting design with the competent nature protection bodies;
- the project engineer includes all measures minimising disruptive effects on animal movement in the draft, i.e. protection from noise, illumination, visual contact, fencing all terrain and vegetation modifications, which are projected into the structural composition of the construction;
- the ecologist compiles documentation of vegetation and garden modifications according to the requirements and interests of the construction procurer (the investor), monument protection, nature and landscape protection (such as the appearance of protected species); he proposes the use of an assortment of woody plants and grassing, the extent of greenery modification and functionality, the surface area of the vegetation modifications and care; the graphic part contains the broader relations of the territory, types of greenery and its functionality, as well as terrain and vegetation modifications;
- in the scope of the ZDD, it is also necessary to resolve the question of property ownership in the area where the migration structure connects with the surrounding terrain of the landscape; it is necessary to negotiate with the owners of affected properties with the participation of the municipality’s administration and the investor (NDS, a.s., SSC) on the consequences of building migration structures (or gain their preliminary consent for the proposed modifications);
- in the scope of the ZDD, it is necessary to ensure that migration structures are incorporated into the zoning plan of the affected municipality and to ensure that the municipality does not approve any construction or other activity (removal of woody plants in the animal’s territory
connecting to the ecoduct, and similar) within the distance specified in Chapter 3.8 of these TCS from migration structures or migration routes which may disrupt the free movement of wildlife and thus impair the use and functionality of the migration structures.

4.4 Documentation for the building permit (DBP)
The road route is fixed during the preparation of the documentation for the building permit (DBP) and a detailed design of the individual structures is compiled. At this stage of the project, sufficient attention must be paid to vegetation modification, the nature of the terrain beneath the bridge and the selection of materials, which have a great effect on the overall effectiveness of the migration crossings. Unsuitable use thereof may create sufficient barriers to animal movement. The detailed project of the migration structure’s vegetation modifications and the project of vegetation modifications surrounding said structure is compiled to the extent specified in TC 03/2006. At the same time, it is necessary to incorporate the comments from the zoning decision. A separate project on animal migration is not compiled at this stage.

4.5 Documentation on construction execution (DCE) and construction execution
During the compilation of the documentation on construction execution and during the construction execution itself, it is necessary to ensure that all conditions established in the previous stages of project documentation are complied with unconditionally and that the proposed materials are used. In the event of changes in the field of migration routes, the changes must be coordinated with the applicable project engineer and ecologist. At this stage of project documentation, the detailed vegetation modification project is compiled (drawing on a scale of 1 : 1000) with precise markings of the proposed types of woody plants and number thereof; said project must include the broader relations of the territory, the types of greenery and their function.
During construction realisation, it is necessary to pay increased attention to nature protection and minimise avoidable negative consequences which the construction may have on nature, thoroughly monitor the proper performance of vegetation modifications on the migration structure itself, as well as its connection to the surrounding area. It is necessary to ensure that thoughtless construction activities do not create new barriers on the anticipated migration route.

4.6 Operation
Once the construction has been put into operation, technical inspections and maintenance of the migration structure are conducted, which are governed by the applicable standards and regulations for bridge structures and tunnels. It is furthermore necessary to pay increased attention to caring for greenery, watering it and potentially renewing vegetation and woody plants.
At the time of use, it is very important to check whether animals use the migration route after the migration structure has been constructed. For that reason, animal movement is monitored for 2-3 years after the migration crossing is put into operation. The results of this monitoring indicate whether the migration structure fulfils its task, whether animals become accustomed to the new conditions on the migration route, or whether it is necessary to take measures to improve the conditions so that the migration structure can be used better.
Solution to the animal migration problem in individual stages of investment preparation

Technical part

Zone planning
- Zoning plan

Study
- Technical study
  - Migration structures
- Placement and dimensions of migration structures

ZDD
- Detailed migration structure design
- Compliance with DBP conditions

DBP
- Detailed migration structure design

DBP Execution
- Technical inspections, maintenance and repair of migration structures

Operation
- Monitoring of animal movement
  - Care of greenery

Environmental part

- Strategic migration study
  - Migration routes
- Intent
  - Initial migration study
- EIA process
- Detailed migration study
- Vegetation modification project
- Inspection for correct execution of vegetation modifications
- Monitoring of animal movement
  - Care of greenery
Migration structures serve to establish barrier-free crossings for animals above or below existing (or planned) roads. These structures prevent migrating animals from entering the road body and from colliding with motor vehicles. They significantly reduce the accident rate on roads, vitalise and support the function of existing biocorridors of ecological landscape stability on all levels.

Underpasses and overpasses at the location of a migration route crossing are functionally equivalent when properly designed. The terrain conditions and altitudinal routing of the path determine the suitability of using an underpass or an overpass. Underpasses are used on roads on embankments and overpasses are used for roads in channels.

All migration structures where animals cross over the road, i.e. above the level of traffic, are classified as overpasses.

5 Technical design of overpasses

5.1 Overpass classification

Overpasses can be divided into the following categories on the basis of the technical design and purpose of use:

- multi-purpose bridges;
- special bridges – ecoducts;
- tunnels.

5.1.1 Multi-purpose bridges

A number of bridges which serve to shift local routes, fields and forest routes over the road are proposed in the scope of constructing motorways and expressways. Upon being expanded and suitably modified, these bridges can simultaneously be used as migration structures for invertebrates, small vertebrates, predatory animals and hoofed animals. Multi-purpose bridges cannot be an alternative to ecoducts. They constitute a barrier for large, shy animals, but may improve the overall passability on the migration route for certain species of animals. The parameters and dimensions of these structures are determined in accordance with Chapters 5.2.2 and 5.2.3 of these TCs. Their lower economic costs are an advantage.

5.1.2 Special bridges – ecoducts

Special bridges (ecoducts) are primarily built on multi-lane roads or roads with high traffic intensity (motorways, expressways). They constitute expensive but highly effective solutions and are suitable for all types of animals. Ecoducts’ parameters are determined on the basis of the migration structure’s category and on the basis of the target species of migrating animals, which in most cases are large or medium-sized mammals and hoofed animals (Chapter 5.2.1 of these TCs). These bridges may also serve for flying species (birds, butterflies) by making it easier for said animals to fly over the road. Overpasses for squirrels are a special type of bridge, for which a construction for measuring rental fees can be used by establishing wooden bridges for squirrels.

5.1.3 Tunnels

The minimum length of a road tunnel is determined at 100 m. Road structures shorter than 100 m shall also be classified as road tunnels (STN 73 7507) if their construction procedure or structural arrangement has the character of a bored or excavated underground linear structure.

Using a tunnel on a migration route is very effective. Depending on the construction type, tunnels may be divided into bored tunnels, made without removing the hanging ceiling, and excavated tunnels, made by excavation, i.e. with temporary removal of the hanging ceiling or built on the surface, but subsequently backfilled. Their minimum length, technical equipment, integration into the surrounding area, minimisation of disruptive influences and maintenance must correspond to the requirements established for ecoducts.
5.2 Determination of ecoduct dimensions

Migrating animals must be helped to find and use migration structures spontaneously during their roaming and without being forced. For that reason, structures on supra-regional and regional migration routes have fundamentally greater dimensions than those at local crossings. Ecoducts are designed as straight bridges; skew bridges are only used in exceptional cases for narrower bridge widths.

The project engineer establishes the structure’s precise dimensions and technical characteristics based on the migration structure category, which is determined when compiling the initial migration study on the study level (Chapter 4.2 of these TCs), or in the scope of compiling the ZDD in the detailed migration study (Chapter 4.3 of these TCs), the conditions of the local migration structure connection, existing disruptive effects on migrating animals and other terrain conditions.

5.2.1 Mean ecoduct width

The mean ecoduct width is the width of the migration route measured on the terrain surface in a direction parallel to the axis of the road being bridged in the centre of the bridge (the free width between fencing on the ecoduct), which is determined from the basic width of the ecoduct in observance of factors affecting the determination of the mean ecoduct, but may not be allowed to drop below the minimum width of the ecoduct under any circumstances. Ecoducts are bridge structures which no form of traffic is allowed on and no public routes are established on.

Establishment of the basic ecoduct width according to the category of the migration structure:
- **category A** – width 80 m – on all supra-regional migration routes for large mammals;
- **category B** – width 50 m – on all regional migration routes for large mammals and on supra-regional roads for medium-sized mammals;
- **category C** – width 25 m – on all local migration routes for medium-sized mammals and individual large mammals.

Factors influencing the determination of the mean ecoduct width:
- if the position is ideal, free of disruptive influences, with great probability of unhindered access to the structure, and the ecoduct is optimally connected to the surrounding terrain and ecosystem, i.e. there is no large break in the terrain within 100 m on both sides of the ecoduct,
then the basic width of the ecoduct can be reduced, but it may not fall below the following minimum ecoduct width values under any circumstances:

- category A – width 50 m,
- category B – width 30 m,
- category C – width 15 m,

- the length of the bridging, equal to the value of 30 m, is taken as the basis for establishing the basic ecoduct width (Figure 3). If the length of the bridging is less than 30 m, the value of the basic ecoduct width may be reduced by 1.5% for each metre by which the supports’ clear distance is reduced; if the length of the bridging is greater than 30 m, the basic or minimum width of the ecoduct shall be enlarged by 1 m for each metre by which clear distance of the outer supports is increased;

- the basic ecoduct width may be increased by up to 50% in the event of a preponderance of unfavourable influences on the migration structure, i.e. a large break in the terrain at a distance of 100 m on both sides of the ecoduct, in the case of lower expectations of natural guidance for animals to the structure, in the event of anticipated disruptive influences due to the proximity of buildings, huts or wind power plants.

In order to ensure that the ecoduct is effectively integrated into the ecosystem, it is favourable to expand the width of the migration route from the centre to the supports so that the connection to the surrounding area is as seamless as possible, especially with narrow bridges. This expansion is designed in accordance with local terrain conditions and vegetation modifications in the part tapering up to the ecoduct.

5.2.2 Mean multi-purpose bridge width

If a multi-purpose bridge is designed on a migration route, a converted road (local, field or forest road, or cycling path) shall be placed on the edge of the bridge, outside of the migration route, at a distance of at least 1.5 m from the edge of the migration route. The minimum width of the multi-purpose bridge consists of the width of the migration route, the width of the converted road according to its category and the separating lane width of at least 1.5 m. The following requirements apply when establishing the width of the migration path:

- if the daily vehicle frequency on a field or forest road is less than 200 vehicles/day, then the width of the converted road shall be added to the mean width of the ecoduct (Chapter 5.2.1 of these TCs);
- if the road is made of asphalt and has an intensity of less than 200 vehicles/day, then a width equal to two times that of the converted road shall be added to the mean ecoduct width (Chapter 5.2.1 of these TCs);
- if the daily vehicle frequency on a field or forest road is greater than 200 vehicles/day, then a width equal to four times that of the converted road shall be added to the mean ecoduct width (Chapter 5.2.1 of these TCs).
5.2.3  Ecoduct length

The length of the ecoduct is the distance which animals must travel when crossing from one side of the road to the other. A shorter length of crossing is more favourable for migrating animals. The width of the bridged road and terrain surrounding the bridge is decisive in establishing the length of the ecoduct.

5.2.4  Slope inclinations

The form of the terrain in the immediate vicinity of the ecoduct should be modelled in consideration of the terrain forms in the surrounding area in order to naturally guide animals to use the ecoduct. On flat territory, a roof-shaped inclination of the embankment on the ecoduct is used with a maximum inclination of up to 20% (the recommended value is 14%), with a radius of the embankment tangent lines at the top and a seamless connection (radius) to the existing terrain. In mountainous environments, a single-sided embankment inclination can be used as conditions allow, but it should not exceed the value of 20%.

Figure 2  Mean width of multi-purpose tunnel
5.2.5 Depth of extra banking on the ecoduct and drainage thereof

Scrub plants with a maximum growth of up to 5 m may predominantly be planted on the ecoduct. Pedological conditions on the overpass will differ from those of the immediate vicinity. The vegetation layer on the bridge is not connected to the groundwater level; the vegetation must be cultivated using rainwater alone. The minimum depth of the overfilling on the ecoduct is 0.75 m. In dry areas, this depth can be increased up to 1.5 m, depending on the composition of the individual layers. The embankment is made up of the following layers:

- vegetation and water accumulation layer – the basis of which is made up of ordinary topsoil – serves for the rooting and nourishment of the vegetation;
- filtration layer – intended to prevent fine soil particles from the vegetation layer from washing away into the drainage layer and thus blocking it up (polypropylene synthetic fabric – geotextiles);
- drainage layer (depth 50-100 mm) – serves to drain excess water; simultaneously prevents water from accumulating in flat areas; the use of light-construction drainage panels with a great drainage capacity is preferable to the use of gravel; a dewatering system of drainage profiles is part of the drainage system.

The following insulation layers are located beneath the layers of the extra bank:

- protective insulation – protects the insulation layers from damage,
- insulation from root overgrowth – special foil is used for this purpose,
- waterproofing – protects the bearing structure from the effects of water – conventional bridge construction materials are used.

The bearing structure, insulation and drainage layer are bevelled towards the ecoduct supports, so that seepage water can freely flow away from the bridge beyond the supports. The back face of the supports is drained the usual way according to the bridge template sheets. Surface water which does not soak in is drained into the terrain away from the bridge using channels along the ledges. Small retention basins may be established up to (0.6 – 1.0) m on the edge of the ecoduct slope to catch rainwater from the modified terrain and channels. The basins must have a base sealed with a clay-like layer with a layer of humus soil on top. A small lake of this kind, which may have reeds planted around it, presents an opportunity to attract animals to drink from it and thus simultaneously fulfils the function of guiding animals to the ecoduct, which increases the migration route’s passability.

5.3 Technical ecoduct equipment and loading

The width and height arrangement of the road beneath the bridge, its directional and altitudinal routing, potential lighting in the underpass and natural bridge loading play an important role in
establishing the technical parameters of ecoducts. All of these influences are established in accordance with the applicable standards.

5.3.1 Width and height arrangement of the road beneath the bridge
The width and height arrangement of the road beneath the ecoduct is determined based on the category of road being bridged (STN 73 6101) in accordance with STN 73 6201. If the width of the ecoduct is greater than 100 m, then it is not a bridge structure but a tunnel, and all tunnel parameters shall be established in accordance with STN 73 7507.

An expansion of the shoulder lane or unpaved shoulder to the width of 3.5 m for a length of 40 m is designed in front of the entrance beneath the ecoduct structure. It shall provide a place for maintenance vehicles to stop to inspect and maintain the ecoduct. This expansion shall be made in both directions of travel; for wider ecoducts, it is recommended to conduct expansion on the exit side as well.

5.3.2 Road lighting beneath the ecoduct
If public lighting is designed on the road in front of and after the ecoduct, it will be necessary to design lighting beneath the ecoduct in the draft as well; this must be taken into account when establishing the clear height of the underpass (Chapter 5.3.1 of these TCs).

On roads where public lighting is not being considered in front of and behind the ecoduct, lighting beneath the bridge is not necessary up to a bridge width of 100 m. If the ecoduct width is over 100 m (which is already a tunnel according to STN 73 7507), then it will be necessary to proceed in accordance with the applicable regulations on the lighting of short tunnels.

5.3.3 Ecoduct materials and structural design
The bearing structure of ecoducts is primarily designed to be made of monolithic reinforced concrete, prefabricated reinforced concrete, or pre-stressed concrete. Other materials suitable for bridge bearing structures such as wood or steel may also be used in the design. Concrete is the most favourable material in terms of long-term maintenance and costs. With wood and steel, the coating must be renewed on a regular basis. Great attention must be paid to waterproofing and drainage of seepage water from the surface of the bearing structure.

Wider ecoducts are divided by dilatation joints into dilatation units (25 to 30) m in length. Bolts made of stainless steel or metallised bolts are embedded into the dilatation joints in order to limit the mutual shifting of the neighbouring dilatation units. Sealing belts are used to seal the dilatation joints from seepage water.

5.3.4 Ecoduct loading
It is necessary to proceed in accordance with the applicable loading standards of STN EN 1991 when establishing ecoduct loading. The constant load, i.e. the bearing structure’s own weight, the weight of the soil filling, the individual insulation layers, the weight of the vegetation and the snow load must be taken into account.

Ecoducts are intended as a crossing for animals over a road. Most of their surfaces are overgrown with bushes and woody plants up to a maximum height of 5 m. No vehicles of any kind are allowed onto ecoducts, with the exception of vehicles intended to care for vegetation. For traffic load on bridges, it is recommended to take the values of the related load of sidewalks and foot bridges for pedestrians into account with consideration of the load from service vehicles (STN EN 1991-2). When assessing the bearing structure, it is also necessary to observe the load acting during the construction of the bridge and loading from construction machines.

**Note 1:** No other traffic load effects are anticipated on the ecoduct surface, which is overgrown with vegetation. The height of the vegetation is limited to 5 m and its weight should not exceed the load values of (4 to 6) kN/m². Based on this consideration, it appears suitable to take the traffic load into consideration on the entire width of the
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When designing a multi-purpose bridge, it is necessary to take the road traffic load into consideration in the portion of the converted road according to the category of the road in question (STN EN 1991-2). Vehicle movement is not allowed on the portion of the bridge intended for animal migration. The same principles apply to loading on this part of a multi-purpose bridge as those which apply to ecoduct loading.

6 Integration of migration structures into the surrounding area

Terrain modifications play an important role in the natural integration of migration structures into the surrounding area. The functional connection of migration structures with adjacent landscape areas is a fundamental prerequisite for their adequate use by wildlife. Technical requirements which relate to the construction of the ecoduct are not diametrically opposed to landscape requirements. This means that the routing of the road and ecoduct structure shall be integrated into the landscape and must fully respect the landscape. Hard layouts are not allowed. Instead, they should be adapted using terrain segmentation, modulation without steep embankments and trenches, rounding of the terrain body profile in the cross section and longitudinal section with a harmonious transition to the formation of the existing landscape.

The negative effects of technical intervention are dampened by natural elements, especially vegetation. The nature of greenery on devastated or otherwise altered areas depends on the type and intensity of the negative changes which the ecoduct’s construction introduced to the area. The landscaping function of greenery for the ecoduct and its surrounding area is far-reaching: it reduces dustiness, protects nature, regulates hydrological conditions, facilitates the sanitation and recultivation of devastated areas, improves landscape elements such as forests, neighbouring water flows, etc.

Optimisation measures on the structure itself, such as planting greenery and constructing opaque noise protection walls, contribute to integrating the ecoduct structure into the landscape. Vehicle movement of any kind is not allowed on the ecoduct, except for vehicles conducting vegetation maintenance, which is why measures must be taken to prevent unwanted vehicles from accessing the structure. Proceed in accordance with TC 04/2010 when designing terrain and vegetation modifications.

6.1 Terrain modifications

The following principles must be respected when modelling terrain in the area of the ecoduct:

- it is necessary to minimise the area on which nature is devastated as a result of construction work when building the bridge;
- the form of the terrain in the immediate vicinity of the migration structure should be modelled based on the terrain forms in the surrounding area (elevations, depressions);
- terrain forms must guide animals towards the migration bridge;
- it is recommended to use suitable supplements (boulders, piles of stones, fallen tree trunks), which may provide cover, primarily for smaller animals.

The composition and depth of filling for the ecoduct bearing structure are specified in Chapter 5.2.5 of these TCs.

Part of the terrain modification is also soil preparation, which comes before planting and grassing the ecoduct in terms of time and technical implementation. The objective of soil preparation is to improve the physical and chemical properties of the soil, limit competition, retain spring soil moisture and hold woody plants. A condition is that the subgrade below the humus soil layer must not be rocky – it may not contain a large proportion of stones and construction materials up to a depth of 100 cm at locations where trees are planted and up to a depth of 50 cm at locations where bushes are planted. Once the backfilling material has been brought, the slopes and flat areas intended for vegetation modifications are disrupted by ploughing to counteract the compression of the surface by the machines used during construction. A 150 mm thick layer of topsoil is placed on the disrupted surface, spread evenly and
applied throughout the area. At the same time, the soil is fertilised with forest substrate at a dosage rate of 10 l/m² and NPK granulated fertiliser at a dosage rate of 25 g/m².

In the construction of larger migration structures, the terrain modifications will extend beyond the properties on which the road body is being built. For that reason, it is also necessary to integrate properties on which terrain modifications are conducted to integrate the migration structure into the surroundings in contact with the properties. It is also necessary to cooperate with the owners of surrounding properties at a greater distance from the structures when conducting modifications for attracting animals to the ecoduct by means of replacement planting.

6.2 Vegetation modifications

Vegetation modifications include planting grass on the soil and the selection and planting of woody plants.

6.2.1 Grassing

Grassing is the most widely used means of biological preparation for planting compositional elements of the ecoduct’s vegetation. The grass seed sowing rate is (3 - 7) g/m². The land is rolled after the grass seed has been sown.

Grassing and regular mowing of the grass growth at least one year before the actual planting is most favourable. The grass growth will develop sufficiently and weeds will be suppressed over the course of one year. The soil water regime is adjusted over the course of the year. The capillarity is particularly important in this process.

6.2.2 Selection of woody plants

The composition of woody plants is proposed on the basis of dendrological research, anticipated local conditions and requirements of the proposed types of woody plants, in which local native species of woody plants are preferable. The composition and aesthetic properties of the proposed species of woody plants as well as the safety standpoint are taken into account. The selected species are of domestic origin and can endure the temperatures, air pollutants and other specifics of the given local conditions on the road. The selection of woody plants is based on terrain research in the territory and stock-taking of woody plants.

In all cases of woody plant selection, emphasis must be placed on the woody plants’ tolerance to dry locations, the woody plant’s growth in the future and its size and weight features, good root system properties and effects on migrating animals’ behaviour. It is favourable to plan a greater proportion of coniferous trees, such as spruce (Picea abies) and Scots pine (Pinus sylvestris) in the area for attracting animals, in order to ensure coverage function throughout the entire year. The selection of woody plants which are attractive to migrating animals is a sure course of action: Common hazel (Corylus avellana), field maple (Acer campestre), hawthorne (Crataegus oxyacantha), blackthorn (Prunus spinosa), European cornel (Cornus mas), wayfaring tree (Viburnum lantana) water elder (Viburnum opulus), dog rose (Rosa canina), common dogwood (Swida sanguinea), fly honeysuckle (Lonicera xylosteum), common privet (Ligustrum vulgare).

Woody plants must be selected in such a manner that the height and weight of the woody plants do not jeopardise the stability of the ecoduct body (max. vegetation height is 5 m). We recommend planting woody plants from local horticultural establishments and nurseries because of the seedlings they have.

6.2.3 Draft of compositional vegetation modification design

The starting point for the ecoduct’s vegetation modification concept is ensuring animal migration, preserving the continuity of the ecosystems by renewing the original terrain and vegetation on its surface as well as the need to minimise the negative effects of motorway operation (light, noise) on the migrating animals.

The planting of the ecoduct, the planting of moderately high guidance embankments and the planting of the transition to the surrounding area are planned on the available areas.
6.2.3.1 Planned planting on the ecoduct

two-metre-high opaque protective walls (wood fencing is suitable), which will limit the light and noise from the motorway and prevent animals from jumping or falling from the bridge, are installed on both edges of the ecoduct. The protective walls are seamlessly connected to the fencing along the motorway.

Insulation vegetation (insulation belt) is designed along the protective wall at a distance of 1.5 m. Scattered plantings (boundary vegetation) are planned along the insulation belt in the remaining portion of the area. The remaining grassed area with a width of (3 to 5) m is left without planting using the natural process of succession.

Insulation belt

The insulation belt is planned to be planted in mowed groups of plants and permanent grass growth with a gap of 1.5 m x 1.5 m. The woody plants are arranged in three rows. This standard spacing of the gaps enables machines to be used when tending to the plants and is also conventional in forestry practice.

The size of the hole is adjusted to the size of the plant and its root system. Watering is important after planting. Woody plants are watered abundantly with a dosage of 10 l per bush planted or 15 l per tree planted. Woody plants should be watered at least four times during the dry period.

Maintenance three times a year is planned once the insulation belt has been established. The space between the rows shall be mown regularly three times a year. This ensures that the new planting will be protected from excessive drying.

A free 1.5-metre-wide lane is left between the belt and the adjacent protective wall when the insulation belt is being marked. The goal of this measure is to separate the growth for aesthetic reasons – to leave an open area around the wooden wall. The wooden wall should be painted brown. We suggest planting the wall with self-supporting vegetation (such as ivy) from the side which faces the motorway users.

Edge vegetation

The edge vegetation will be a scattered planting of trees (free spacing). The edge vegetation serves to suppress the hard geometric line of the insulation belt and create sufficiently functioning thin growth over the course of 3-5 years.

In both cases, the planted trees will be secured after planting using an individual protector against animals. The grassy areas of the edge vegetation will also be maintained regularly together with the insulation belt. Species of woody plants which are resistant to chewing by animals should be used.

6.2.3.2 Planned planting for slopes of moderate height

The first row of fill slopes for the ecoduct will be situated 4 m from the edge of the road; the first row is recommended to be placed at a distance of 4.0 m from the base of the embankment on the indented slope. The spacing of the bush plantings is adjusted to the type of woody plant. The recommended distance of bushes from one another in rows is 1 m, and 1.5 m between the bushes. The woody plants shall be arranged in triangular patterns.

We recommend covering the surface of the soil with non-woven planar mulching sheets with a thickness of (4 – 5) mm, which cover the soil with a 100 mm thick layer of mulch, in order to prevent excessive drying. It is important to water after planting. The plantings on the slopes should seamlessly connect to the road’s existing greenery.

6.2.3.3 Planned planting for transitions to the surrounding area

The border of the ecoduct property will be suitably adjusted by recultivating the surface affected by the construction activity (the surface will be levelled and then sowed with grass seed) and the planting.

The transition to the surrounding landscape is rendered using what is called ‘attracting vegetation’. The majority of this greenery is made up of coniferous trees (spruce and cedar), which also fulfil a covering function throughout the entire year, and bushes which are attractive to large mammals (hawthorn, beech, hazel).
6.3 Fencing
Fencing on the ecoduct forms a barrier for animals which prevents them from jumping over and falling from the bridge. It is seamlessly connected to the road fencing. The shape of the fencing’s footprint must guide animals onto the ecoduct. It is favourable to render the fencing so that it is not transparent and at the same time fulfils the function of protection from noise, light and optical contact (wooden fencing and similar appears to be ideal).
In order for the fence to be an effective barrier, it must be designed so that animals cannot jump over it (a height of 2 m is recommended), get under it or pass through holes in the fence. The height of the fence and the size of the holes depends on the target species of animals. Lockable gates which enable access for maintenance on the ecoduct and vegetation by vehicles parked on the expanded road in front of the bridge are designed in the fencing in front of and behind the bridge on both sides of the road.

7 Minimisation of disruptive influences
Measures to provide protection from disruptive influences are mutually added. A combination of vegetation and technical modifications may achieve a sufficient effect in eliminating these barriers.

7.1 Protection from noise
One obstacle to animals’ use of the ecoduct may be noise from motor vehicles passing overhead on bridged roads. Animals in the immediate vicinity of the road are exposed to this noise load. Anti-noise walls are used to eliminate these barriers. For this purpose, it is very useful to design the ecoduct fence so that it fulfils the tasks of a noise-protection wall as well as protection from light and visual contact at the same time. An optimal solution here has proven to be wooden fencing in combination with self-supporting vegetation which, together with the vegetation modification on the ecoduct, provides sufficient protection for the animals while they are deciding on whether to use this structure to cross. It is recommended to use a special road surface with sound suppression on the section in the immediate vicinity of the migration crossing. This modification ensures that the animals will have a section in front of them which does not produce disruptive noises, so they will continue on to the prepared migration crossing.

7.2 Protection from light
Another barrier for the use of the ecoduct is light from the road, which manifests itself most on narrower ecoducts, where the vegetation on the structure does not prevent this influence. The solution described in 7.1 of these TCs is recommended.

7.3 Protection from visual contact
Visual perception of the traffic is also a disruptive influence which has a negative effect on the use of migration structures. Vegetation modifications, noise protection walls and protection from light serve to provide protection from visual contact with vehicles from the perspective of animals arriving at the migration structure.

8 Ecoduct maintenance and repair
When the structure is being used, it is necessary to pay sufficient attention to inspecting the technical condition and maintenance of the bridge, caring for vegetation and monitoring whether animals are using the ecoduct for migration. Prompt discovery and rectification of minor technical problems with the ecoduct can avoid subsequent time-consuming repairs to the structure.
8.1 **Ecoduct technical maintenance and repair**

During technical maintenance and repair, it is necessary to proceed in accordance with these TCs and the structure administrator’s internal regulations as with other types of bridges. Increased attention must be paid to waterproofing and the tightness of dilatation joints between individual dilatation units.

8.2 **Greenery care**

Greenery care consists of the following tasks:

- mowing grass areas,
- watering grass and plants – 4x/year,
- weeding – 1x/year,
- treatment with mulch and sheets on the ecoduct slopes – 1x/year,
- adjustments to stakes, ties and protectors – 1x/year,
- removal of dry plants and replanting thereof – 1x/year,
- check to ensure that the vegetation on the ecoduct does not exceed the height of 5 m; if necessary, trimming or removal of the woody plants in question and replanting with new woody plants – 1x/year.

TC 04/2010 must be taken into account during greenery care.

8.3 **Monitoring**

Monitoring animal movements in the broader territory surrounding the ecoduct is very important during use. It is important to verify whether animals use the migration route as anticipated after the migration structure has been built. Once 2-3 years as of the migration crossing’s placement into operation have elapsed, the results of this monitoring indicate whether the migration structure fulfils its task, whether animals become accustomed to the new conditions on the migration route, or whether it is necessary to take measures to improve the conditions so that the migration structure can be used better. Observing local hunting associations plays a very important role during monitoring. Actions to be taken into consideration include modifications to the ecoduct itself (vegetation modifications, improvement of anti-noise measures or measures against light and visual contact) or on the adjacent terrain (terrain modifications – placement of boulders, tree trunks or vegetation modifications – planting of new, more suitable bushes and woody plants).

Proceed in accordance with TC 06/2008 during monitoring.
9 Examples of ecoduct design

Switzerland – A16 Métairie de Nidau

Switzerland – A8 Brienzwiler
Switzerland – A7 Kreuzlingen
Switzerland – A1 Font

Switzerland – A1 Utzensdorf/ Neu-Ischlag
The Netherlands – A 50 Woeste Hoeve

Canada – Trans-Canada Highway – Banff National Park
Germany – B 96n Wilmshagen
Austria – A6 Kittsee - Parndorf
Austria – A6 Kittsee - Parndorf

Germany – A-31 Dorsten / Schermbeck
Czech Republic – D1 Ekodukt Kocanda
Slovakia - D1 Mengusovce – Jánovce III. úsek
10 Literature

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