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Environmental Protection Solutions in the Process of Modernisation of the Polish Railways[1]

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Abstract: The authors discuss examples of solutions currently applied in the process of modernisation of main railway lines undertaken by the Polish PKP PLK S.A. in order to =assess compliance with the applicable environmental conditions. The solutions described pertain to nature conservation and restoration in the vicinity of railway routes. They are developed according to three assumptions: protection of animals along transport routes; traffic noise reduction; natural compensation which consists in restoration of the lands adjacent to railway lines in order to enhance water regimes and habitat conditions for animals.

Keywords: main railway lines, modernisation, environmental protection.

1. Introduction

The modernisation works currently conducted at the main international railway lines administered by the Polish PKP PLK S.A. are assumed to adapt them to the requirements imposed under the European Union directives and Technical Specifications for Interoperability of Conventional Railways (TSI CR) (Railway Scientific and Technical Centre, 2009). The basic

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document which standards should be implemented in the design and contracting works performed by PKP PLK S.A. is entitled "Technical Standards – Detailed technical conditions for modernisation or construction of railway lines for speeds of $v_{max} \leq 200$ km/h (for conventional rolling stock) and 250 km/h (for tilting rolling stock)" ("Standardy techniczne – Szczegółowe warunki techniczne dla modernizacji lub budowy linii kolejowych do prędkości $v_{max} \leq 200$ km/h (dla taboru konwencjonalnego) i 250 km/h (dla taboru z wychylnym nadwoziem)"). This document was developed in 2009 by the Railway Scientific and Technical Centre (Railway Scientific and Technical Centre, 2009). Volume XV of the aforementioned study is devoted to environmental protection.

In accordance with the Regulation of the Council of Ministers of the Polish government (*Regulation of the Minister of Environment of 14th June 2002…*), construction and modernisation of railway lines is considered to be an undertaking which may exert destructive environmental impact. Consequently, it is required that specific proceedings following dedicated procedures should be conducted, entailing analysis and assessment of all impact aspects of such investments. Such proceedings are concluded by issuing a decision on environmental conditions which includes specification of the actions to be undertaken in order to minimise negative environmental impact.

In the mentiones document, three important tasks aimed to develop a more environment-friendly transport route can be distinguished:

- protection of animals along transport routes,
- reduction of traffic noise,
- natural compensation (restoration of lands adjacent to transport routes, consequently leading to improvement of water regimes, establishment of habitat conditions for animals etc.).

Thus, the focus is on the impact of railways on ecosystems and biodiversity, as well as impact on human quality of life. The first impact is relevant for rural areas, in particular when new or existing railroad tracks cross protected nature areas. The second issue is relevant for urban areas, in particular for inhabitants of the neighbouring areas of a noisy railroad track. These issues are directly related to the (re-)construction of railroad tracks. The protection of animals is discussed and assessed based on innovative solutions currently used in Poland. Reduction of noise is discussed based on examples of France and Germany as technology is more developed in these countries, and a question to be answered is which technology should be implemented in Poland.

Finally, an example of natural compentation is elaborated and compliance with regulations assessed. The discussed cases can provide good examples for future environmental policy regarding investments in railways.

2. Environmental protection requirements versus technical standards

The purpose of *Technical Standards* (Railway Scientific and Technical Centre, 2009) was to adapt the technical solutions implemented under the railway transport infrastructure to the requirements of the speed of 250 km/h. The *Standards* also define technical conditions that should be respected in the investment performance process as well as in the operation stage, taking the relevant environmental protection requirements into account. The scope of volume XV covers numerous environmental protection problems including those referred to in this article, namely: protection of animals, protection against noise and vibration and natural compensation.

With regard to protection of animals, the *Standards* provide a broad selection of information including:

- the nature of animal protection according to the environmental protection law (Official Journal of Laws of 2001, no. 62, item 627),
- ways to ensure animal protection,
- passive and active methods of animal protection (including pros and cons of individual methods),
- hazards animals are exposed to in the course of construction, modernisation and operation of railway infrastructure,
- solutions aimed to reduce negative impact on animals during construction and modernisation of railway lines,
- main types of animal crossings.

Regarding the scope of protection against noise and vibrations, the *Standards* imply a necessity to meet the conditions set forth in domestic as well as foreign legal regulations, and stress the following factors:

- those affecting noise intensity levels in the railway line vicinity,

- those related to the impact of a contact between a vehicle wheel and a rail.

What has also been discussed is the specific noise protection measures, particularly artificial noise barriers. The variety of aspects touched upon include the classification, advantages, noise barrier types available in the market, recommendations concerning application of specific noise barrier types, conditions to be taken into consideration when designing noise barriers and their efficiency as a function of multiple variable factors. The *Standards* also mention natural noise barriers (e.g., embankments covered with greens) and vegetation strips which sometimes prove useful in noise suppression as well.

The notion of natural compensation is approached in the *Standards* against the background of provisions of the Polish environmental protection law (*Act of 27th April 2001 – Environmental…*), implying that:

- an investor performing construction works is obliged to take environmental protection in the vicinity of the works into consideration,
- it is permissible that natural elements can be transformed in the course of construction works,
- natural compensation (i.e., a body of actions aimed to restore natural balance and eliminate the damage inflicted upon the natural environment as a result of the investment performance) is only and exclusively to be undertaken when it is impossible to protect the nature.

Thus, the theoretically it seems that so-called strong sustainability, where the environment should remain in exactly the same state, receives priority (Borys, 2005). Whether such a situation is achieved, depends much on the system of protection and technology applied.

3. Systems of animal protection along railway lines

3.1. General information

Railway transport (similarly to road transport) may become a hazard to the correct functioning of ecological corridors, including a threat to animals' lives. The most common environmental protection requirements imposed under decisions on environmental conditions issued for the sake of modernisation of railway lines are as follows (Bęben, 2009, 2010; Skuła, 2010; Surowiecki, 2011, 2012):

- construction of crossings and homing facilities (penning) for animals,
- adaptation of the existing technical facilities (small bridges, culverts) to the animal crossing function,
- installation of acoustic devices preventing animals from entering the track (referred to preventers) automatically activated whenever a train is approaching,
- installation of visual preventive devices,
- adaptation of the railway line drainage systems to enable migration of reptiles, amphibia and small mammals in a manner allowing them to safely enter and exit the given structure (*Forum of Manufacturers…*, 2006; Skuła, 2010).

PKP PLK S.A. is a company which not only applies to the provisions of environmental decisions but also independently initiates animal protection campaigns and develops solutions preventing negative impact of railway transport on the natural environment (Skuła, 2010). Two types of acoustic prevention systems are discussed in the article, namely those applied in the PKP PLK main lines currently under modernisation. The main advantage of these devices is that a signal is continuously relocated as the train moves. Consequently, animals abandon areas near a railway line only when the train is approaching. Such devices may successfully replace the systems commonly applied in Western European countries, restricting access to high-speed lines by means of high net fences or underground and ground-based animal crossings.

3.2. Examples of acoustic animal protection devices

<u>UOZ-1 system</u>

In 2004, the first prevention system in Poland, UOZ-1, was fabricated and installed at the E-20 railway line from Mińsk Mazowiecki to Siedlce (Figure 1), and it comprised the following subunits (Skuła, 2010):

- UOZ-1 (animal repellent) devices in the form of a vertical, 1.1 m high cylinder of the diameter of ca. 0.3 m (tower type), installed next to a track in locations where animals tended to cross it on a regular basis,

- the EZG diagnostic module featuring software (cooperating with the UOZ-1 towers), installed in type SHL-12 automatic block signalling (ABS) containers manufactured by Bombardier Transportation Polska.

Figure 1. View of a section of the E-20 Mińsk Mazowiecki-Siedlce main railway line with the UOZ-1 preventers installed

Source: Bombardier Transportation Polska; 2010; Surowiecki, 2012.

Each UOZ-1 tower is an autonomous unit equipped with a power pack, electronic control systems and a head featuring acoustic transducers. Towers are alternately installed on concrete foundations developed in the track substructure (along catenary poles) on both sides of the track (Figure 2) (Skuła, 2010). In the upper part of the device, there are holes used to emit repelling signals. The device housing is grey and it is made of epoxy-glass composite materials. The UOZ-1 devices are automatically activated shortly before a train arrives by means of signals received from the automatic block signalling circuits. The signals initiate the animal repelling procedure in due time at individual UOZ-1 devices. A complete repelling sequence takes 50 to 180 seconds, and its length is automatically adjusted to match the variable traffic conditions in the railway line (train slowing down, accelerating or stopping at a station).

Each ABS container of the SHL-12 type may be coupled with up to 32 UOZ-1 devices (which ensures full track protection along the entire isolated section and may prove particularly useful when the railway route cuts through a nature conservation area). Whenever smaller areas are to be secured, the number of UOZ-1 repellents may be adjusted to match the area dimensions (e.g., 4 UOZ -1 devices enable protection of a railway line along the section of ca. 250 m). The effective coverage of a single UOZ-1 unit is more than 70 m. Devices are cable-powered from automatic block signalling (ABS) containers which ensure power supply for at least 8 hours. UOZ-1 devices are interlinked and connected with the automatic block signalling (ABS) container by means of a cable conduit ensuring synchronisation of the device operation as well as comprehensive auto-diagnostics and supervision from a service centre (LCS). Every UOZ-1 tower features a set of sensors responding to attempts of theft and vandalism (all UOZ devices installed within the given region generate an acoustic alarm signal and send information to the LCS control centre about the theft attempt). In the section of the E-20 main railway line from Mińsk Mazowiecki to Siedlce, the technical solutions applied, the emission method as well as the range of acoustic repelling stimuli have been verified under operating conditions (Figure 2) (Skuła, 2010; Surowiecki, 2011, 2012).

Figure 2. UOZ-1 device (tower) installed at the E-20 main railway line section from Mińsk Mazowiecki to Siedlce

Source: Directive no. 2002/49/EC of 25th June 2002; Skuła, 2010; Surowiecki, 2012.

SOLAR TUX system

The system consists of the following subunits (Figure 3) (Skuła, 2010; Surowiecki, 2011, 2012):

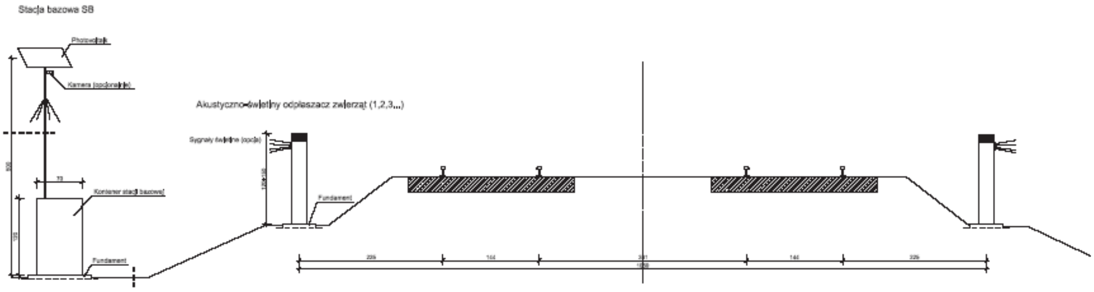
- autonomous preventers (tower type) holding animals off the track, installed on both sides of the track with a clearance of ca. 70 m (the system comprises 239 preventers in total, and they are linked into sections of 8 pieces at maximum);
- base stations installed on the same side, away from the track, each managing up to 8 tower preventers (i.e., one section); a system signalling the approaching train, installed along the railway line with a clearance of ca. 840 m.

The preventer is an electronic device enclosed in a permanent tubular housing (tube) of the diameter of ca. 0.24 m, minimum wall thickness of 6 mm and the height of 1.2-1.5 m. The housing is mounted on a reinforced concrete foundation. It holds an acoustic transducer with a speaker. The device is responsible for emitting a modulated set of sounds at the frequency of 2-6 kHz, changing as the air temperature fluctuates. The electronic systems are secured against moisture and extreme temperatures.

Base stations are made (like the preventer) from a steel cylinder of the diameter of ca. 0.7 m, height of ca. 1.2 cm and the minimum wall thickness of 6 mm. The base station housing is also mounted on a reinforced concrete foundation. It features the following subunits: a battery, an electronic system for the train approach signal receiving and transmitting, and an electronic system warning about theft attempts. Both devices, i.e., the preventer and the base station, are secured against devastation and theft. The base station housing is also a support for a mast (made of galvanised steel and coated with epoxy enamel) of the height of 3-4 m, featuring a solar battery. At the mast top, one may install a special-purpose video camera for supervision of the device operation and monitoring of animal behaviour.

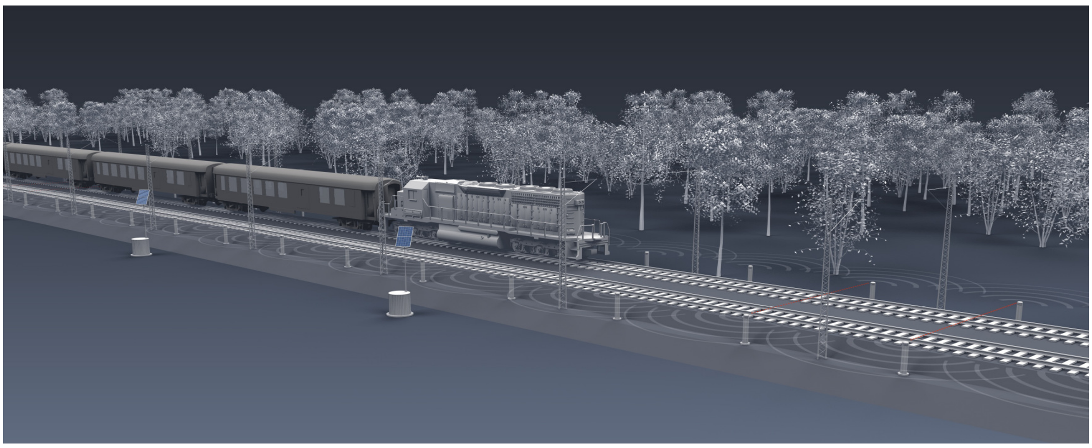
The system enables the devices to be activated several seconds before the train arrives. The acoustic signal is generated simultaneously along the entire section (comprising 8 preventers), which corresponds to a segment of ca. 210 running metres of railway track. Depending on the train running speed, successive sections (also comprising 8 preventers) are activated a few seconds in advance. The system works in a cascade. The sound emission time is from several to more than a dozen seconds. By intercepting the train warning signal in sections of the length of ca. 840 m, the system is capable of working precisely and in short periods only. And since the sound is short and variable, animals do not get used to the new environmental situation and it does not exert any negative influence on the nearby acoustic climate. The SOLAR TUX system is presented schematically in Figure 4 (Skuła, 2010).

Figure 3. Cross-section of a railway track featuring the SOLAR TUX system



Source: Skuła, 2010.

Figure 4. Illustration of the SOLAR TUX system's operating principle



Source; R. Skuła, 2010; Surowiecki, 2012.

4. Traffic noise reduction methods

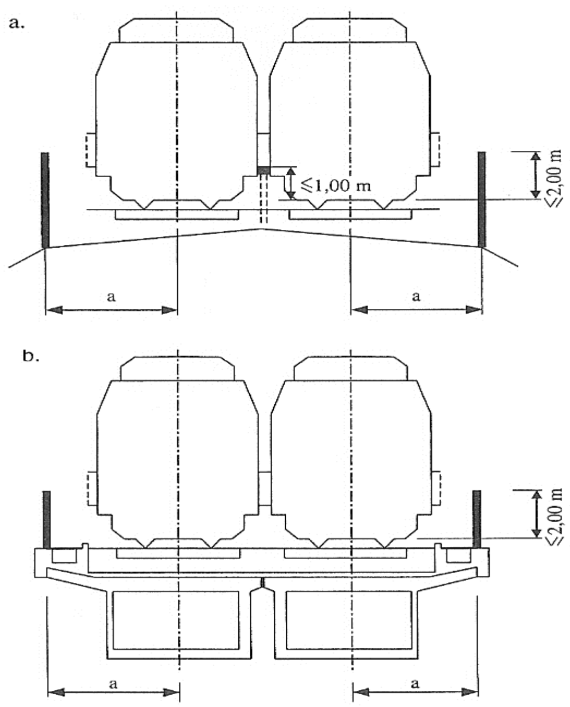
In order to ensure protection against noise and vibrations generated by railway vehicles, minimum distances between railway infrastructure elements and residential as well as public utility buildings have been specified in the applicable environmental protection guidelines (Gronowicz, 2003), depending on the railway traffic intensity. The relevant conditions can easily be met when new lines are constructed in areas of scattered housing development. However, construction or modernisation of railway lines in densely developed areas may pose certain problems related to exceedance of the permissible sound and vibration intensity levels. Such situations require appropriate means of protection to be used. Protection against transport noise and vibration is one of the issues addressed in *Technical Standards* (Railway Scientific and Technical Centre, 2009) as well as in guidelines and action schemes applicable in the sphere of environmental protection (Bęben, 2009, 2010; *Regulation of the Minister of Environment of 15th January 2002…*; *Regulation of the Minister of Environment of 14th October 2002…*; *Regulation of the Minister of Environment of 29th July 2004…*; *Regulation of the Council of Ministers of 9th November 2004…*; *Regulation of the Minister of Environment of 14th June 2002…*; Skuła, 2010; Towpik, 2000; *Act of 27th April 2001 – Environmental…*, Surowiecki 2011, 2012; Railway Scientific and Technical Centre, 2009). There is also the Directive of the European Parliament and of the Council (Directive no. 2002/49/EC of 25th June 2002…) on assessment and control of noise levels in the environment. What is derived from the environmental protection related legal regulations applicable to traffic noise is a set of investors' and administrators' obligations, namely the necessity to apply specific noise protection methods. For several years now, the most common protective measure used in Poland is a noise barrier in the form of a partition arranged in parallel to the track axis between the noise source and the potential recipient. These partitions are standard elements of the main railway line sections being modernised where they cut through densely developed areas. Such noise barriers have also been installed near the traffic control points of Dąbrowa Niemodlińska (railway station) and Jaśkowice Legnickie (passenger stop), operating at the E30 main railroad track.

The efficiency of a sound barrier depends on multiple factors, only to mention the barrier positioning against the noise source: the barrier height, the length and shape; the material the barrier is made of; the type of the traffic noise generated; the intensity of the vehicle traffic

(Bęben, 2009, 2010; Surowiecki 2011, 2012). As proposed in literature (Bęben, 2010; Surowiecki 2011, 2012), the maximum efficiency of a noise barrier can be attained by following the composition principle, e.g., by developing a set composed of an artificial barrier and a vegetated earth embankment (resulting in the noise level reduction up to 20 dB).

Vertical and inclined noise barriers are most commonly used in railway transport. Figure 5 illustrates a sample arrangement of vertical noise barriers used for German railways (Gronowicz, 2003). Clearance *a* between the barrier and the track axis equals 3.0 m on bridges, for speeds of $v \leq 160$ km/h, 3.5 m in the existing lines and the modernised ones, for speeds of $v \leq$ 200 km/h, and 4.5 in new lines, for speeds of 250 km/h.

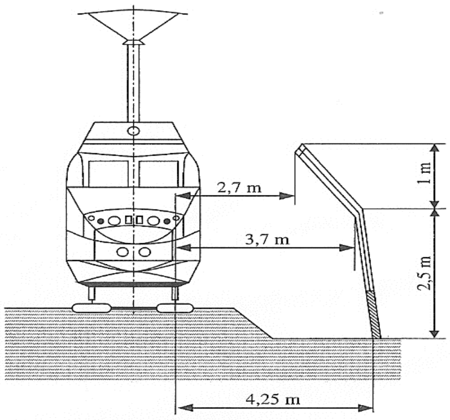
Figure 5. Arrangement of vertical noise barriers for German railways: *a* – on-route track, *b* – overbridge track



Source: Gronowicz, 2003; Towpik, 2000.

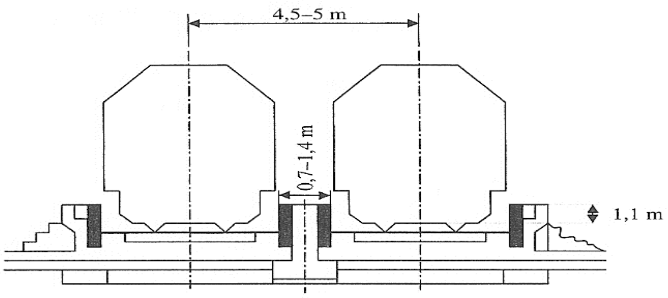
Inclined barriers are used when the acoustic wave must be channelled outside the protected zone. Figure 8 illustrates an inclined noise barrier installed at the TGV line in France, and Figure 7 shows a low vertical barrier dissipating acoustic waves (Gronowicz, 2003).

Figure 6. Inclined noise barrier next to a TGV line track in France



Source: Gronowicz, 2003.; K. Towpik, 2000.

Figure 7. Low vertical noise barriers dissipating acoustic waves



Source: Gronowicz, 2003.; K. Towpik, 2000; Surowiecki, 2011, 2012.

Noise barriers are subject to classification according to the material they are made of (concrete, glass, wood, mineral wool, plastic, steel, ceramics etc.), the working mode (reflection, dissipation, absorption) and height (Bęben, 2009, 2010; Surowiecki, 2011, 2012).

Noise barriers are most frequently built of a mix of several materials.

Depending on the height, one may speak of the following types of noise barriers (Bęben, 2010):

- high (height of H = 6-7 m): their acoustic efficiency may exceed 10 dB;
- medium-high (height of ca. 5 m): most common in Poland, with the efficiency of 7-10 dB;
- low ($H < 3.5$ m): efficiency ≤ 8 dB, commonly used in locations of protected development below the track grade line;
- very low (height of ca. 1.0 m): efficiency of ca. 3 dB.

The *Technical Standards* (Railway Scientific and Technical Centre, 2009) define a typical noise barrier height as 3-5 m. Lower barriers may be used when they are developed from earth embankments, or when the railway line runs in an embankment, whereas higher barriers should always include special support structures due to considerable wind pressure forces.

Detailed studies on the efficiency of noise barriers featuring a diffusion surface (with a Schroeder diffuser) compared to a standard reflection surface barrier have been discussed in publications (Kamisiński, 2010; Surowiecki, 2011).

5. Natural compensation

5.1. Subject matter of the problem

Main railway lines being modernised are often routed through the protected nature areas of Natura 2000. Consequently, they require appropriate safeguards and specific measures to be applied as defined in decisions on environmental conditions issued for the sake of investment performance permits. All these procedures involve the obligation to maintain standards specified in the environmental protection law (A*ct of 27th April 2001 – Environmental Protection Law…*; Surowiecki 2011, 2012). An example of such measures, commonly referred to as natural compensation, may be found at a section of the E30 main railway line running across Lower Silesia. The purpose of natural compensation has been assumed to be restoration of the land adjacent to the main line, i.e., improvement of water regimes and establishment of appropriate habitat conditions for animals. The relevant undertakings conducted under this framework have particularly comprised construction of simple dammings in forest ditches (small-scale water retention) and restoration of the Wykrotnica stream by its repeated meandering. The area where the restoration works were planned to be conducted in the natural environment is managed under the forest administration regions of Pieńsk and Węgliniec, and it surrounds the route of the E30 main railway line subject to modernisation between the Węgliniec and Zgorzelec stations (CONSORTIUM of Ekobel Schall Schulz, EGBUD, Carbologistic, 2002; Skuła, 2010; Surowiecki 2011, 2012).

5.2. Small-scale water retention facilities

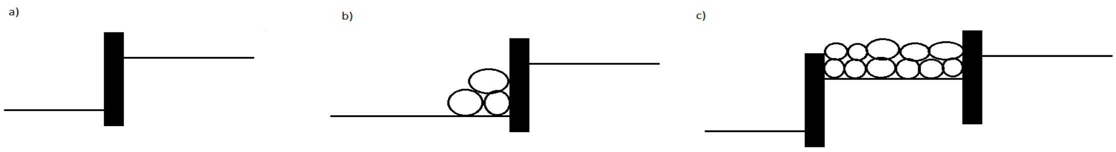
Within the area in question, 20 simple dammings have been designed with the purpose of raising the water horizon by ca. 0.5-0.7 m in drainage ditches scattered around the state forests surrounding the E30 main railway line. It has been projected that the dammings planned to be developed in agricultural drainage ditches and water courses draining marshes should improve the water regimes compromised by the transport investment and enhance the restoration of animal habitats.

Dammings in drainage ditches

The following types of simple-design fixed dammings have been envisaged:

- non-reinforced wooden ones (Figure 8a), forming leak-tight walls of wooden boards driven into the ground to the depth of 0.8-1.0 m; overflow height ≤ 0.5 m, water course bottom width – 2-4.0 m;
- reinforced wooden ones (Figure 8b), forming (as above) leak-tight walls of wooden boards driven into the ground to the depth of 0.8-1.0 m; overflow height ≤ 0.8 m, water course bottom width exceeding 4.0 m;
- wooden-stony ones (Figure 8c), forming two leak-tight wooden walls with rock filling between them (two damming steps); overflow height up to 1.0 m, with cascades of several dammings being permissible.

Figure 8. Drainage ditch damming diagrams: *a* – non-reinforced, *b* – reinforced, *c* – wooden-stony



Source: CONSORTIUM of Ekobel Schall Schulz, EGBUD, Carbologistic, 2002; Surowiecki, 2011, 2012).

The expected environmental outcomes of the solutions envisaged include increased surface water retention, prevention of water outflow via redundant ditches, initiation of overgrowing and silting of ditches which lead to their gradual fading. Once the ditches fade out, the thresholds made of natural materials will gradually decompose in time. However, there is an environmental risk of aquatic organisms being unable to migrate involved in interruption of the water course ecological continuity following a damming being established. Moreover, negative effects of the potential impact of the artificial damming created must also be taken into consideration.

Damming structures in forest water courses

Structures increasing water retention within forest areas have been appropriately adapted to match the natural and landscape conditions in order to enable unconstrained migration of aquatic organisms. It is recommended that materials of natural origin (stone, wood, fascine etc.) should be used, and that every structure is ensured a service life of more than a dozen years without the need for repair. The following damming (threshold) types have been designed:

- wooden: a wooden threshold with overflow made of round timber or boards; bottom reinforced with fascine or paved; edges basically sodded. Environmental effects: damming in the water course, surface water retention increase, initiation of overgrowing and silting of ditches; a threshold made of natural materials will gradually decompose as time passes;
- wooden-stony: made from wooden planks or battens combined with rocky filing. Environmental effects: as above, plus the rock filling enables free migration of fish and does not block the migration of aquatic organisms;

- damming developed into a fascine and rock sill, with the overflow section made from a wooden leak-tight wall comprising wooden planks with a wooden cap. The ramp is formed of filling of 0.25 m thick rocks in fascine boxes of the dimensions of 1.0 m x 1.0 m. The environmental effect is the prevention of the water course bottom erosion, and the resulting benefit is that the water course flow is maintained.

5.3. Meanders of the Wykrotnica stream

The Wykrotnica stream is a left-bank tributary of the river Czerna Wielka. Its drainage area at the mouth is 25.6 km^2. Assuming appropriate means of maintenance, there is no flooding hazard for the developed areas near the water course. The water-logging hazard is only imminent for green arable land directly adjacent to the stream, where there are no embankments. The restoration of the Wykrotnica stream planned, which is assumed to consist in meandering a section of ca. 1.5 km, is expected to foster appropriate habitat conditions for certain species of birds, fish and microorganisms. The structures in question should regulate the water flow, decreasing the flow rate and, at the same time, increasing retention of surface waters which, due to infiltration, will cause the surface water horizon to be raised and underground reservoirs fed. The meanders planned to be developed in the stream will additionally contribute to fire protection of nearby forests and meadows. Individual variants of the meanders designed (water course dams) have been described below:

1) Variant I: a palisade made from wooden stakes or a dam with a wooden plank stabilised with wooden stakes. The dam range is ca. 1/3 of the water course width. The damming departs by 30-45° from the water course bank line (downstream) depending on the flow rate. It is the simplest damming design, only composed of natural materials expected to gradually decompose as time passes. Purposes of the damming:

- local alteration of the flow direction;
- below the damming, on the opposite bank, a process of local water course widening is expected (meandering);
- local flow deceleration upstream of the damming and sedimentation of deposits to form a natural barrier and route the water flow.

Damming advantages: unconstrained migration possibility for aquatic organisms.

2) Variant II: damming identical to Variant I with an additional rock filling in the wedge between the bank and the damming, downstream the damming.
3) Variant III: wooden-stony dammings arranged in series, alternately on both banks of the water course.

6. Concluding remarks

In this article, solutions currently applied in the process of modernisation of main railway lines by PKP PLK S.A. aimed to ensure compliance with the requirements of decisions on environmental conditions issued for the sake of the investment performance approval were discussed. The solutions proposed pertain to nature conservation and restoration in the vicinity of railway routes according to three main concepts: protection of animals along transport routes, reduction of traffic noise, natural compensation (restoration of the areas surrounding transport routes).

Two solutions applied for animal protection were discussed (UOZ-1 and SOLAR TUX) as they are currently being implemented by PKP PLK and perceived as innovative ways to protect natural environment along main railway lines. The purpose of these devices (acoustic in the operating principle) is to prevent animals from entering tracks while the train is passing. There are numerous advantages of these devices. For instance, service (protection) costs for a 500 km long section of railway line when using the UOZ-1 devices is equivalent with the costs involved in construction of a single ground-based animal crossing.

As regards the SOLAR TUX system, the following advantages have been identified:

- reliable adaptation of the system to the approaching train; train face monitoring at every ca. 840 m, enabling the acoustic signal to be emitted for a short time and just in time;
- considerably low service costs;
- complete and secure separation from railway power supply and control devices, which is particularly vital when relocating the system.

What must be stressed is that both prevention systems were verified with a positive result under field studies conducted in the years 2004-2005 by the Forest Research Institute.

Specific environmental protection requirements have been characterised, as provided in "Technical Standards – Detailed technical conditions for modernisation or construction of railway lines for speeds of $v_{max} \leq 200$ km/h (for conventional rolling stock) and 250 km/h (for tilting rolling stock)," a document prepared by the Railway Institute.

The presented noise-reduction systems show possibilities which could be implemented in Poland. The example provided for the natural compensation undertaken in the course of modernisation of a section of the E30 main railway line (Węgliniec and Zgorzelec) constitutes a confirmation of compliance with the provisions of the European Commission applicable in the scope of environmental protection. This could be an example of good practice, to be followed in other projects.

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Rozwiązania z zakresu ochrony środowiska w procesie modernizacji polskiej kolei

Streszczenie:

Streszczenie: Autorzy omówili wybrane przykłady rozwiązań wykorzystanych przez PKP PLK S.A. podczas modernizacji głównych linii kolejowych w Polsce w celu dostosowania się do uwarunkowań środowiskowych. Opisane rozwiązania odnoszą się do ochrony i odnowy przyrody w pobliżu szlaków kolejowych. Opracowano je na podstawie trzech założeń: ochrony zwierząt wzdłuż szlaków transportowych, ograniczenia hałasu, kompensaty przyrodniczej obejmującej odnowę obszarów przylegających do linii kolejowych w celu poprawy systemu wodnego oraz warunków środowiskowych dla zwierząt.

Słowa kluczowe: główne linie kolejowe, modernizacja, ochrona środowiska.