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Sustainable Bridge Design

Zrównoważone projektowanie mostów

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Abstract

The work consists of two interrelated parts. The first one presents general issues relating to sustainable development. There are examples of the road investments, in which the problems arising from the lack of a general approach to environmental principles and consequently sustainable construction occurred. In the second part, on the examples of culverts and bridges, selected technical cases are discussed.
The aim of the paper is to characterize the inconsistencies appearing during the bridge design process and maintenance in accordance to environmental categories. Several examples of the road-bridge investments carried out in the last decade have created the basis to formulate some opinions and questions.
The difference between the approach of bridge engineers and that of environmental ones to the concept of animal transition is shown on the grounds of implemented technical and environmental standards. The existing problems are of dual nature, the first group being very general aspects i.e. concerning the concept of ecology, while the other one involves detailed tasks, e.g. shaping the image of a bridge. Several questions of great significance have been formulated and addressed to ecologists. The answers are indispensable for bridge engineers to solve technical aspects of the proper, sustainable design of environment-friendly bridges.
Last but not least, the suggestion to use bridges as places for monitoring the environment in their surroundings is presented. This research work might be crucial for further good cooperation of bridge engineers and environmental ones.

Key words: sustainable development, bridges, environment

Streszczenie

Praca zawiera dwie powiązane ze sobą części. W pierwszej zaprezentowano ogólne zagadnienia z zakresu zrównoważonego rozwoju. Przywołano przykłady inwestycji drogowych, przy których wystąpiły problemy wynikające z braku zrozumienia uwarunkowań zrównoważonego rozwoju, co przełożyło się na problemy budowlane. W części drugiej, stosując przykłady z budownictwa mostowego, poddano dyskusji wybrane problemy techniczne.
Celem pracy jest omówienie nieścisłości w kategoriach środowiskowych, pojawiających się w trakcie projektowania mostów, rzutujących na ich utrzymanie. Kilka przykładów spośród prowadzonych w ostatnie dekadzie inwestycji drogowych stworzyło platformę do formułowania opinii i stawiania pytań.
Różnice między podejściami inżynierów mostowych a środowiskowych pojawiają się wyraziście przy projektowaniu przejść dla zwierząt. Przedstawiono je, wykorzystując stosowane standardy techniczne i postulaty ekologiczne.
Istniejące sprzeczności są dwojakiego rodzaju. Z jednej strony obowiązują bardzo ogólne zasady ekologiczne, podczas gdy z drugiej występują elementarne zadania projektowe, czyli np. projektowanie geometrii lub szerzej – obrazu mostu. W tym szczegółowym zakresie sformułowano kilka ważnych pytań adresowanych do ekologów. Odpowiedzi na te pytania są kluczowe dla projektantów, po to by rozwiązywać problemy mostowe właściwie, tj. by projektować funkcjonalne, zrównoważone i przyjazne środowiskowo obiekty drogowe.
Na koniec poruszono problem monitorowania środowiska, z wykorzystaniem przepustów, mostów i wiaduktów. Powstałe zbiory danych mogą utworzyć bazę do prowadzenia badań o charakterze ilościowym, a takie wyniki będą owocować dobrą współpracą inżynierów środowiskowych i mostowych.

Słowa kluczowe: zrównoważony rozwój, mosty, środowisko

1. Introduction

Sustainable design and construction works are applications of the sustainable development concept. The Latin *sustentō* means sustain or endure. Now the term is more extended then the original Latin word meaning. In the case of construction – the contemporary understanding of the above is a sort of actions, which result in welfare of people and their surrounding (Kates, 2005; Quaddus, 2013). However, any development is the *unity* of adversities. On a very minor scale it could be observed when struggles between environmentalists opposing the expansion of a transportation net and civil engineers occur. The pure Kant *Praxis* category (Critchley, 2012), which is here only a technical tool, could be applied when estimating engineer processes. Building highway systems in the US and Germany in the 30s was a method against the economic crisis, which was manifested by high unemployment. This program changed the transportation systems revolutionarily and led to the industrial and economic growth.

The same program was applied in Italy after World War II, where the results were the same and where the development was spectacular.

So, bearing in mind positives of creating highway systems, one should put the following question – what is an alternative choice? If, looking forward, the road system is not done, will this be a compromise for generation to come or not? The similar problem applies all around the world, while creating linear and spatial structures of a various type, built with cements as a binder in concrete. The use of cement is one of the main sources of atmosphere pollution. However, until now, there is no substitute to it. Without question, tunnels, roads or cities already built and those being built at present, could be treated as developments that will be positive for further progress of future generations (which is the basic principle of sustainable development). Nevertheless, the pollution impact is also unquestioned. Where is the balance or, more strongly, where is the impassable limit for concrete technology (Aitcin, 2000)?

An interesting concept is presented in the article *Sustainable Development Revolution* (Pawłowski, 2009) where the author analyzes sustain development taking Ethics into consideration. It is true, that any changes start from mental disintegration which leads to the higher level of new integration (Dąbrowski, 1964). It is worth to recall the Gutenberg print technique followed in mass releases of the Bible or the Briand-Kellogg treaty (Stimson, 1932). Those were the turning points in human mentality, especially in ethics. Ethics is highly anthropological while the nature is governed by very crude rules, characterized by Darwin (1859). The everyday human life is full of behaviours, which could be treated as Darwin's type, being rather rare to ethics inherent to other religions. Therefore, Cuvier's concept (1825) that the nature could be divided into animals (humans are animals, too) and non animals is still valid. However, the ethical approach could be fruitful when the problem of natural catastrophes will be included into anthropological ethics. Natural catastrophes, e.g. a flow of the river high floodwater or volcano eruption though are independent, even if many barriers (warning systems, walls, etc.) are constructed to prevent them. In this perspective, on the time axis, the ethical approach will be a consideration valid locally only. Concluding, the ethical approach is consistent with the Hegel helix (Verene, 1998), additionally this approach fulfils all elements of Hegel's scheme[1].

Pure philosophy and the philosophy of nature become closer to engineering or, more precisely, to engineers. The philosophical considerations display their complexity when the designer starts to draw the axis of the future road. At this moment, the current problems between environmentalists and road engineers arise in respect of understanding sustainable development. This controversy will be discussed in the text below.

2. From the protests of *young lions of ecology* to the provisions of the European Union in the field of environmental protection

Protected natural areas are key places where some problems at the interface between the investment – protection of the environment frequently appear. In practice, the all EU countries are covered by the uniform legislation, which refers to the most valuable sites protected on account of their uniqueness of nature. For most European countries the development of transport net is now mainly associated with their maintenance and replenishment.

But there are countries, like Poland, where situation is different. Poland's transformation, which began in 1989, included a lot of political, economic and social changes. The first phase of the transformation required facing the lack of a modern transport net, as well as diagnosing current problems of sustainable development when the investment in infrastructure, mainly roads and railways, took place.

The initial attempts to solve these problems ended up, in the majority, in failures both due to the inconsistency of the national legislation with the EU's one, as well as poor understanding of the principles of a sustainable approach to transport investment problems, which should focus on the possible maximal number of sustainable development aspects.

[1] Die These-Antithese-Synthese, geistloses Schema.

The turning point was the so called Rospuda River case. In 2008 the road construction works were stopped because of the organized protest of the local ecological organizations. They wanted to protect the river and were suggesting the alternative route of the road. The protest had a form of blocking the road construction works. Since that time, the real, both technical and environmental, aspects have been applied in the design.

The Rospuda effect also caused the change in the law. Most of the legal acts modified the approach to the design solutions of future road and railway routes by the requirements of environmental and human protection. The costs of realizations of transport investments have increased, but in most cases they resulted in solutions fulfilling an important role associated with the development, while eliminating or strongly reducing the impact of transport facilities on the environment.

But there are cases, where any consensus is not achievable. The presentation of an example of the felling trees along the roads in Germany (Brandenburg, 2009) and Poland (Pomerania, 2010) may be indispensable. Supporters of the trees logging and a narrow road enlargement indicated a high risk for people using the road in the case of a vehicle collision with a tree. In contrast, proponents of leaving trees along indicated the need to preserve rare and, therefore, protected species inhabiting these trees (hermit beetle and bats). They proposed the introduction of traffic restrictions (mainly speed limit) to eliminate the risk of an accident. This example illustrates the similar approaches and understanding of protection. The difference relates to protecting various entities. The current rules in this case do not give a clear solution, despite the fact that in defence of man and nature an equally powerful pressure was applied.

The more spectacular action was conducted when the construction of a detour around the small town of Augustów (Poland) was commenced. In 1992 the decision on the design work of the circuit road was taken. Among dozens of bridges, overpasses and culverts there were also objects designed for small and big animals. All this, i.e. roads and bridges as project elements, was performed strictly according to the Polish and European standards on environmental conservation. On the road run was the nature reserve on the Rospuda River, which was intended to be exceeded by means of high road embankments and overpasses as well as bridges in the valley of the river.

It is necessary to emphasize that the life of citizens in Augustów reached the limit of uncomfortable conditions due to heavy transport traffic, high noise, difficulties for pedestrian and bicycle traffic and even dangerous accidents.

The road construction works started in 2007 but soon the works were blocked, due to an ecological action, which was supported by some TV channels. In 2008 the investment was stopped. Recently, after significant modifications of the project, the construction works were started again. Till now the Rospuda slogan is readable anywhere and anytime in Poland when one thinks of designing a road.

Here a question arises, why such a situation occurred (Directive, 1985; Directive, 1990; Directive, 2001). Firstly, there is an analogy to the case of the overpass highway of Pilzno, the Czech Republic. Also there, the young ecological movement blocked the road construction works, and also after ~10 years the construction was continued. Probably here and there appeared the same sociological mechanism. It is worth mentioning that those were the days when both Poland and the Czech Republic joined the European Union and when new circumstances provided a new range for independent critics and personal responsibility distrust to governmental decisions still existing. 10 years' time seems to be brought to gain the mature understanding of both road-bridge technical conditions and environmental requirements. This is the time, which allowed to avoid a really dramatic cost of struggle between the two sides of the investment process and to transform the two opposite sides into partners. However, civil engineers have been still waiting for more detailed and uniform rules related to the environmental requirements for design.

The above examples well illustrate the basic problems of the countries, in which the fast social and economic change have a very large impact on the problems of proper understanding of sustainable development and the rules directly and indirectly related Directive (Gałaś, 2013).

As it turns out, not only the countries that have recently become part of the EU, face such problems. In several countries the highly organized social groups and environmental organizations, with the help of appropriately shaped legislation packets, block many planned road projects. This applies mainly to the Natura 2000 sites, national parks and other particularly valuable natural areas.

The example worth looking at might be an attempt to build the Federal S18 road crossing national park Lauterbacher Ried (SAC – Special Area of Conservation) near Lake Constance on the Rhine at the northern foot of the Alps, where local and federal authorities recognized that there was no alternative option for the course of the road. The formal procedure of the S18 road course began in 1992.

The consultations regarding, *inter alia*, the course of the road began in 1994, and ended in 1997. In 1999 the procedures relating to the authorization of the construction of this road were initiated and ended in 2001. This decision appealed to the government of the Land of Vorarlberg in which the disputed areas of the national park are situated. At the same time, in 2001, there was a complaint brought to the European Commission. In 2002, the European Commission sent the Austrian Government a letter of formal notice. Nevertheless, the Austrian government upheld

the decision on the implementation of the road in 2003, but after half a year the execution of the decision was suspended due to the bringing of the action of the European Commission to the European Court of Justice. In March 2006, the Court of the European Commission pointed to the failure of the Austrian Government and the infringement of two *Birds and Habitats Directives*, (Directive, 1979; Directive, 1992) mainly for the protection of birds – especially the corncrake (Case No: C-209/04).

This type and similar cases also took place in other EU countries and ultimately were settled by the European Commission, and in some cases by the European Court of Justice. Let us recall here Italy (Case No: C 117/03), the Netherlands (Case No: C-127/02), Portugal (Case No: C-239/04, Case No: C-191/05), Spain (Case No: C-235/04), Germany (Case No: C-244/05).

The above examples show, how – in many cases – the problems associated with various aspects of sustainable development: environmental, social, economic, as well as political and legal interpenetrate. It seems that due to certain provisions of the EU issues (Directive, 1985; Convention, 1998) main areas and species specially protected, have been harmonized within the EU member states. Unfortunately, also in many cases, there are still differences in the approach to the issues of preparing the project – for example, the approach to skills investment from the point of view of their impact on the environment (COST, 2003; Gałaś, 2004). Even greater disparities between EU countries are at the technical level.

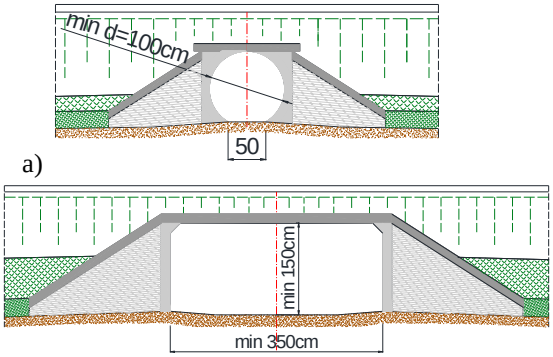
The examples described below are focusing on requirements for bridges and engineering facilities in Poland. Over the years, those environmental requirements, have become more difficult to meet and are sometimes economically unjustified.

3. Basic environmental requirements related to bridges – case study from Poland

There are no special technical standards to design bridge objects, regarding environmental needs. Instead of standards, there are paragraphs in the Polish Transport Regulations (Regulation, 2000) where such requirements are formulated in detail. Briefly, they go as follows:

For wild animals a non-collision path ought to be ensured to let them move from one side to the other of the higher class roads in the areas of the increased migration, in particular in larger forest complexes and areas of wetlands and other habitats of rare and endangered species, as indicated by the relevant government authorities or appropriate local government units. This ought to be done as:

– transition in tunnels across the body of the road of a width equal to min 10 m,
– viaducts over the road with the entrances equipped with a screening fence in the access passages to the facility, of an axis crossing at an angle close to 60 deg, and connecting with the green filming on the site – in order to lead wildlife, fig. 1-2.



a)
b)

Figure 1. The clearance gauge a) for small animals b) medium-sized animals

a)
b)
c)

Figure 2. Culverts for small animals – shapes of clearance gauge a) rectangular b) parabolic c) circular

In the case of large animals we practically have to deal with full-size viaducts. The rectangular clearance gauge under the viaduct is of a minimum height (H) of 4 m. The clearance width (B) is set by the following inequality:

$$B \geq \frac{N \cdot L}{H} = \frac{3}{2}\frac{L}{H} \qquad (1)$$

where N is the measure of narrowness of min value $N=1.5$; H – the height; L – the length of the passage. Another, more comfortable, parameters are proposed in COST (2003).

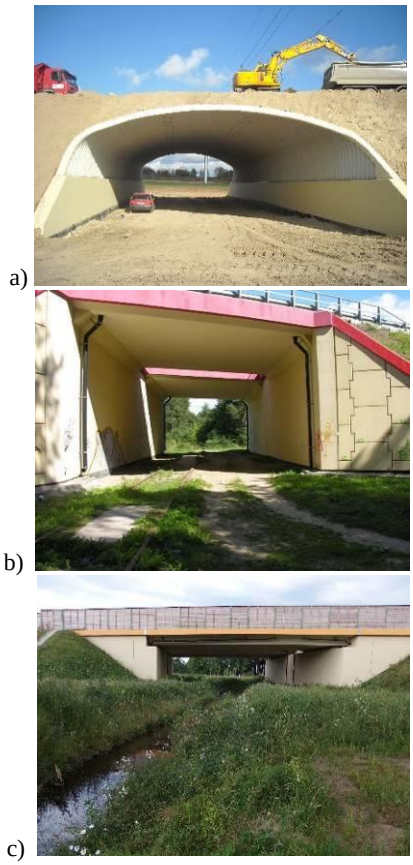


Figure 3. Animal transitions: a) for medium-sized animals b), c) for big animals

Basically the bridges were located over the rivers, while the viaducts over existing roads, agricultural fields or meadows. Such transition locations were the aim of environmental tracts (Karas, 2011).

There were three groups distinguished – small animals, medium-size and big ones respectively. In short – for small animals, like frogs or hares, for which it is necessary to build passes in form of circular tube culverts of the min. diameter of 100 cm (0,8 m^2) and walking paths of a min of 50 cm breadth, see fig. 3, culverts also leading along water-courses.

Outside of the culvert, the base of the passage should be designed according to the existing ground surface. In the case of water-courses some additional side benches running along the passage near the culvert walls should be constructed. The surface of the benches have to be placed above the average water level. To protect animal migration on the road, or train lanes, the appropriate fence system should be introduced to direct small animals to the safety zone where the culvert passage is located. The above mentioned fences could be made from different materials (steel shields) but in practice they are usually made of green colour plastics.

Finally, even though it is not written down in any technical or administrative document, the local stone, ground and vegetation are indicated to be used.

Figure 4. River culverts designed in accordance to old and new standards a) built in 2006 b) constructed in 2013

In fig. 4 the culverts present their beauty as elements of the river's landscape. Also the photos show differences occurring within the range of environmental approaches. In the first photo there are absences of side paths for small animals. In fig. 4b such a side bench was made. The scarp protection is made by use of openwork precast concrete heavy plates, which start being overgrown by grass. Technically, it is a typical and well verified solution, whereas the concrete stiff elements are extraneous in the natural river bed system.

Now, the dominating solution is to use more friendly gabion mattresses which are filled with crushed natural stones, appropriately to the mesh size, fig. 5. The gabion mattresses protection easily becomes overgrown by meadow grasses.

4. Long bridge – smaller environmental problem

A large river, or even a medium-sized river, always has a wide floodplain. Additionally, high water levels are significant because the height of the clearance gauge is large. Designing a long span bridge means to obey hydraulic and hydrologic criterions for the easy flow of high river water. This automatically fulfils the conditions for the minimum clearance gauge for big animals. Also, bigger distances from the carrying-deck to the ground level result in a more quiet solution considering road traffic but also, increasingly, for new rail bridges. For a long time this positive ecological impact was countered by extensive damage to the surrounding area caused during the construction of long bridges. Nowadays, however,

building technologies limit very strongly bad influence on bird habitats, especially during the breeding season (Rochelle, 1999; Garniel, 2010).

a)

b)


Figure 5. The bridge over the Lopa River in Lopiennik; transition for medium-sized animals a) in 2007 b) in 2009

a)

b)


Figure 6. The bridge over the Vistula River in Kamień, a) view in 2012 b) under construction, 2014

The existence of biotope in the surrounding of long bridges is a challenge for both environmental and bridge engineers. Locally, during the bridge erection the previously existing biotope is destroyed (fig. 6). Figure 5a shows a change of vegetation occurring during the replacement of the existing old RC (reinforced concrete) bridge with a new composite of a steel-concrete. According to the environmental rules, the previous condition of vegetation should be reconstructed in the coming 18 months after the construction works have been finished. As it is clearly visible, it is not possible in practice, as shown in figure 7.

a)

b)


Figure 7. The bridge in Neple over the Bug River a) an old one b) the new bridge

Also here, additional two views encounter. One of them, in a technical sense, the empty one i.e. a meadow clearance gauge, is perfect for the water flow. The other option is the clearance gauge, overgrown by bushes and trees. This is environmentally perfect solution. Here, bridge engineers are still waiting for the answer – which is better?

5. The attractiveness of environmental solutions for the people

While creating the environment surrounding for animals it was forgotten that the human, in a sense, is an animal too. Many rainwater reservoirs near the highways were practically immediately populated by amphibians, even when vegetation was not fully completed.

A water mirror, a green escarpment of highway embankments, an easy access i.e. in the vicinity of the city locations, all these were elements attracting people to camping, barbecue, fishing, bird-watching, in general, to relax, fig. 8. Let us notice that the noise of highway traffic at the foot of the road embankment is relatively low. All this provides the unity of nature and home for people around. Also, while building highways many secondary service roads were necessary. This service net discloses many interesting nature places. When one thinks *environment*, the human is excluded. This sounds like a very popular idea i.e. to separate nature from human activity or at least to limit the contact between them.

a)


b)


Figure 8. On the S17 road a) nature refuge b) place of recreation

This is the basic concept accompanying the foundation of national parks, for instance.
From the authors' point of view, the contact between man and nature is an elementary organic relation. It ought to be organized properly for both elements. To do this, the more commercial approach is necessary. At the design level the parking places must be taken into consideration. The administrator of such areas has to introduce clear rules of behaviour, such as entry fees, so, in short, all the elements which are in use in countries like Belgium or the Netherlands.
Here appears another mental barrier, which should be broken through. This one must be obvious for non-environmentalists and bring about some discussion among ecologists.

6. Questions that still need to be discussed and are waiting for answers

Building a bridge object proceeds according to proven, almost typical rules, which correspond to those given in the Eurocodes. The possible variation is only in term of details. Environmental engineers repeatedly questioned about the impact of the image on the behaviour of large animals, do not answer in a clearly way. Actually, there are two schools, not in congruence at all.
For example, the cones[2] of road embankments at bridge abutments may have at least two forms. The cone may be surface-enhanced by means of semi-rigid surfaces made of concrete blocks of the 15 cm thickness. The expression of such a solution is a strong colour image corresponding to the geological rock formation occurring in the rock mountains.

The other option is a solution used not so long ago, in which the cones of embankments were strengthened by laying turf. In this case, the image is characteristic of the lowland meadow views. Which is better? The thing is that one can get answer in two variants.
In terms of a bridge maintenance both of the discussed solutions are correct and equivalent. Therefore, arises the question mentioned above, which of these solutions is more pro-environment? There is also a twin question: how do large animals perceive the colour or the colour intensity? As far as colouring is concerned, bridges are designed only in the context of human acceptance.
Both questions are reasonable in a much broader context, namely: *what is the psychology of large animals* ? This question is so broad, that the problems of forming bridges constitute its small percentage.
Another issue is the cost of engineering and road bridges. It is estimated (Madaj, 2012), that the construction costs of passages for small, medium and large animals, noise screens, planting of trees and shrubs were from 10 to 20% of the total costs. This is a significant sum. What is the most expensive is upper transitions for large animals, which amounts to the cost of the normal typical overpass over the highway.
Another reasonable question arises concerning the effectiveness of these costs (Bohatkiewicz, 2014). Currently, the observations of the use of these objects by animals are commonly conducted. The answers are partial, but positive. The material collected from the observation includes animal trails and single images of animals passing, which indicates that animals use the constructed passages. However, so far no conclusions can be drawn in terms of statistics. Probably, animals need a generation or more to get used to the new situation. The answer to this question is very important, as cited, 10 to even 25% represent a significant compromise, involving the depletion of the possibility of achieving the objectives necessary to people (Karas, 2011).
Although the road-bridge standards in the field of ecology were formulated long ago and are precise and clear, the environmental criteria expressed in the relevant documents are not. In the field of environment there is an exponential growth in various regulations and instructions, which means that the goals are not clearly defined. Hence, their implementation may cause technical troubles. This is a major difficulty, which in the opinion of the authors, results from not enough professionalism of environmentalists.
Numerous mishaps show clearly, that this area requires a significant cognitive and technical discipline.

[2] Actually, in terms of geometry there are quadrants of a truncated cone.

As an example, the reference is made to a temporary break in the design and consequently the break in the building of an airport in Swidnik (eastern Poland). The area destined for the runway turned out to be inhabited by the spackled ground squirrel *(Spermophilus suslicus)*, which is protected.
The problem has become popular because of its multiple presentations in the mass media.
After a thorough understanding of the situation, it turned out that the existing colony of the spackled ground squirrel was the result of artificial release of a few individuals from a breeding home. Due to unfavourable natural conditions, and degeneration within the group, this colony disappeared.
The above example shows that good intentions must be supported by solid research.
Here comes, therefore another question: how fare is the recognition pure i.e. when is the recognition free from the anthropological point of view ? The above question is related to yet another issue of nature – the problem of locally favoured conditions.

7. Nature v. nature

The symbol of the last international conference on environment and road construction[3] was a stork preying at guiding fences. Another recorded instance was of a snake hunting along a guide fence. Hence comes a question – to what extent are human activities appropriate to protect nature and to what extent are the protecting processes leading to the imbalance of the whole system of fauna? Since nature is governed by the primary rule of survival, every convenience for some animals raises an increased risk for others. From the point of view of a road-bridge engineer this problem is of minor significance, but every road-bridge engineer is also an ordinary human for whom the idea of equality, justice, etc. is crucial.
As an example, for several years, beavers in Poland have been under strict protection. These animals are not very timid in the neighbourhood of man (Gałaś, 2004). Their nature is to build systems of dams, using trees growing along the rivers. Following the introduction of protective provisions there was a significant growth of the population of beavers. Hence, there was clearly a greater range of their activities which was manifested by fallen trees (fig. 9) and significant consumption of fish in rivers (sometimes up to 100%). Here and there a new flood plain river areas occurred, with the surface close even to 5 hectares. There was a visible change of the image of woodlots after some poplars, ashes and alder trees had disappeared. There were problems with the availability of grassland, maintenance of riverbed profiles, uncontrolled damming the water. In the case of bridges and culverts the problem strongly appeared during the high water flow, when the water carried logs of trees blocking the light of the bridges, causing additional stacking water and often blurring the bottoms of the rivers.

a)

b)


Figure 9. Effects of the beavers activity

Natural conditions such as extreme high water flows in culverts or under bridges after torrential rains cause havoc among birds during the breeding season, cause the destruction of nests and was the reason for the bird chicks deaths. The statistical distribution of such natural disasters means, that in large areas there is some averaging, which is depicted in a natural state.
If so, regarding to the environment, why road and bridge works are invasive like, why are perceived to be an attack on nature?
Let us emphasize the fact that a lot has been done to reduce the invasiveness to the minimum state, level which seems a safe one.
These questions are directed to environmental engineers. Questions need not be considered on the basis of the theoretical academic discussion. The form of response must be such, that their implementation in the process of construction will be possible. Lack of such responses could be a source of spontaneous public activity with a high emotional background, which is highly unrequired in construction works.

8. Conclusions

Achieving the full impact on sustainable development in investing activities, particularly in the field of linear structures, is currently a very difficult task.

[3] *6th International Conference on Environment and Aesthetics in the Road Construction*, which was held in Kazimierz Dolny, this year on 23-25 April; organized, among others, by the Road and Bridge Chair of Lublin University of Technology, http://wbia.pollub.pl/pl/o-wydziale/struktura-wydzialu/katedra-drog-i-mostow/konferencja-kazimierz-2014 (01.09.2014).

The road investments cover all elements of sustainable development: ethical, ecological, social, economic, technical, legal and political. Gaining an effect of the proper balance and ultimately of sustainable solutions can be extremely difficult and in some cases impossible. The reason is a varied level of understanding by many stakeholders of road investments. The hardest part is to understand the technical problems that are related to the economic and legal ones. The examples are culverts and bridges which in most cases, focus problems relating to the protection of nature and man. It is true, that animal migration corridors have been changed on a local and continental scale due to the building systems of highways.

Now there truly exists the consciousness of the must of protecting the environmental system which also requires additional work as a result of infrastructure development. This is the only way leading to the solution of the problem. It is necessary to conduct qualitative and quantitative research in accordance with the technical and environmental criteria.

Bridges are crossings of roads and railways on one side and of migration animal paths on the other. On this basis existing bridges should be supplemented by monitoring systems which will be able to record the continuous or selected events in the surrounding. Also, the distribution of temperature, moist, air pollution and a noise level have to be added to the recorded elements.

The monitoring of bridges, even if is not common, works in special cases. Lots of suspension or cable-stayed bridges are supplied with facilities to observe strain, stress or displacement processes. The archiving could be done on hard discs or in the cloud. The only action is to develop and unify the existing systems and adopt them to environmental needs. Having a good archive it will be easier and more reliable to formulate challenges for road-bridge solutions in sustainable design.

After ca 30 years of discussions on the sustainable development the *melting pot* still is observed. This is intellectually very attractive but for the civil engineers the results are still uncertain. Those engineers who create the current and future technical elements, still waits for clear and ordered recommendations, even instructions, which could be applicable in design and construction.

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