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Selected problems of shaping the reinforced-concrete road bridges

INTRODUCTION

Bridges constitute a critical link in the road network and require capital investment for construction and maintenance. That is the reason to keep standards during the design, construction and maintenance phase. Each year increasing traffic lead to bridge loads far higher. As a result many bridges will lose their capacity in the nearest future years [2].

A major reason for bridge defects is the inadequate construction quality and maintenance. Existing damages on bridges along with increasing traffic loads and environmental pollution conditions result in rapid deterioration of bridge elements requiring maintenance actions. The large number of bridges in a road network and the high maintenance costs justify the development of approaches to bridge maintenance management and paying attention on the design and construction phase.

There are several properties that influence on the bridge durability. Among others permeability, drainage, quality of construction, maintenance are properties that play a significant role in the overall bridge performance [3].

1 INFLUENCE OF BRIDGE DECK ON THE PROPERTY OF PERFORMANCE

In the paper some reasonable technical solutions, material properties that influence on the bridge’s life are discussed.

Pavements of bridges play a special role in the durability of the entire bridge structure. Work Loads from both traffic and climatic conditions, such as sunlight, freezing temperatures, rain, snow, de-icing salt acting on the structure, in both horizontal and vertical direction [1].

The construction of the transportation is the most basic and key contribution to the economy. All countries put their best attention and efforts into building their own transportation network.

Bridges play an important role in the transportation facilities.

There are some general standards that should be kept in the design and construction phase. Road reinforced concrete bridges should meet the following general requirements [6,7]:
- the length of the object should ensure the safe movement of vehicles and pedestrians while maintaining the required extremely,
- where there is no such barriers, the barrier extends beyond the bridge at specific distance,
- barriers are extended beyond the bridge at a distance which protect pedestrians from falling down,
- in the case of location on the built-up area, where there are sidewalks for pedestrians on the bridge, stairs for pedestrians should be placed on a slope or embankment of the abutments,
- if nearby there is no access for people with disabilities, addition ramps should be installed for these purposes,
- bridges should be also equipped with sidewalks for service if there is no other possibility to get on the bridge; control access in the pillars and abutments; Inspection trolleys suspended to the bridge,
- roadways on the facility, together with bands and shoulders should be limited by curbs installed outside the bridge,
- bridges over the road class A and S should be performed as separate for each roadway regardless of the length of the object,
- zone between roads shall not be less than 3.00m,
- sidewalks should be placed on the outer side of the bridge,
between the sidewalk for pedestrians and the road should be kept a minimum distance of 50cm, 
number of lanes on the object should meet technical conditions to be met by traffic engineering 
regulations and requirements for specific conditions, 
bridge should be adjusted to geometrical elements of road, especially grade line of the road by 
making the appropriate vertical and horizontal arcs, providing longitudinal and transverse 
inclinations.

2 MAINTENANCE AND REPAIRS OF BRIDGES

According to general idea of sustainable development of surrounding also in the bridge branch we 
are required to keep the environmental in good conditions [Fig.1]. 
Pavements play special role in the stability of the entire bridge structure. Both traffic and climatic 
conditions such as sunlight, freezing temperatures, rain, snow, de-icing salt, are the loads acting on 
the bridge. Bridge deck is subjected to forces in both horizontal and vertical direction. The main tasks 
of road surfaces include [4]:
– the acquisition and distribution of loads onto bridge slab,
– transfers of deformations of the plate, which are caused by temperature changes,
– suppression of dynamic effects coming from loads caused by vehicle traffic,
– to provide traction of vehicle to the ground.

Fig. 1. Diagram of significance

2.1 Causes of destruction of the surface of concrete bridge

The main causes of the destruction of the surface include: the high susceptibility of the substrate, 
the variable stiffness of the substrate locally, vibration, local places of occurrence of a shock load, 
lack of free water infiltration.

These factors have different effects depending on: the nature and quality of the material from 
which surface was made (asphalt, concrete, cube - small sized elements, wood), traffic intensity, type 
of dehydration, quality of works, thickness of pavement layers [5].

The cause of the destruction is also large change of temperature acting as both the bottom and top 
of the structure. This causes a change in stress, which overlap with the stress arising from the 
vibration plate. This in turn leads to the formation of microcracks and cracks in the surface. Microcracks also arise due to the difference in thermal expansion coefficients of asphalt concrete and concrete.
Acting on the object temperature changes and the differences between the coefficients of thermal expansion causes [1]:
- detachment of the surface of the insulation or isolation from the bridge plate (the cause is delamination forces and shear)
- cracking pavement surface (due to the rapid contraction of the wearing layer)
- thermal fatigue (due to undergo alternating surface shrinkage and expansion).

2.2 Types of defects and repair methods for concrete pavement of road bridges

Pavement made of stone.

The most common were made of granite, now this type of pavement is not made. They are very durable pavement, resistant to traffic and weather conditions. In the case of heavy traffic top layer of cube becomes slip, so even if you do not see serious damage after about 15-20 years it must be rebuilt.

Sometimes the subbase is wrong executed so subsidence may occur in areas of movement of vehicle wheels. Then there is accumulation of water that penetrates between the cubes to the subbase, increasing its weight, and in the winter causes frost heave. Repairs of this type of pavement rely mainly on rotating cubes in a different direction for the party was no longer slippery surface. In the case of large damage this pavement is replaced in the bituminous pavement. It is not recommended to cover the stone cube, since it does not ensure sufficient adhesion between the layers and greatly increases the weight.

Bituminous Pavements.

Bituminous pavement is the most commonly used surface in Poland (mainly mastic asphalt and asphalt concrete). The durability of this type of pavement depends mainly on the rigidity of the bridge plate and the connection of surface with subbase by the insulation. Freezing water in the pores of the pavement destroys its structure. This in turn causes the loosening the pavement of the insulating layer, cracking and chipping elements. It is therefore necessary to remove the water rapidly from the object, using the filter layers occurring at the contact of pavement and insulation. However, after several years of operation the filter channels are subject to clogging, which results in retention of water on the contact of pavement and the insulation. It is therefore often used for tight bituminous pavement surface, which allows the extraction of water from its surface. Generally we have to pay attention into all layers that structurize the bridge construction [Fig.2].

![Bridge structural layers](image)

Fig. 2. Bridge structural layers

The most common damage of the pavement begins in contact with the curb, and therefore should be further strengthened and adequate construct by:

strengthening the insulation on width of about 30cm, filling the gap between the pavement and the curb with special mass provides good formability, use of so-called. "counterdrop" in roadway in the adjacent to the curb lane, removal of wheel track, holes, performance of the new abrade layer over the entire surface of the road, replacement of the entire pavement.

If one replace the entire pavement one must also, if necessary, correct the transverse and longitudinal declines, repair insulation, seal any leaks (at inlets, expansion, etc.).

Folds are removed by milling or chipped by pneumatic hammer. Before starting the work, part of which is intended to be cut, it should be cut at the edge (in the shape of a rectangle). One must pay attention not to damage the insulation.

Wheel track- if they have a depth of not more than 9mm, it is removed in the following manner:
1) the fixation of the pavement by grit 6,3-10mm performed in the cavity
2) another fixation of the pavement with grit 4-6.3mm of asphalt emulsion, Where the wheel track are deeper than 9mm they must be milled or cut.

Cutouts place should be clean, lubricate the edges of the asphalt at a temperature of 130-150°C and fill mastic asphalt or asphalt concrete. Dropouts to a depth of 1.5 cm: the place of damage is cleaned mechanically with a brush, then this place should be sprinkled by asphalt emulsion. Consecutively during the first fixation should be made by grits 6.3-10mm. Next, a second single scattering surface dressing should be performed by 2-4mm (using an asphalt emulsion), or 4-6.3mm (using asphalt). Finally the surface should be cured by rubber-roller. Dropouts deeper than 4cm: in this case the losses should be completed in two layers: first a coarse asphalt, followed by asphalt medium or fine. Maximum size of aggregate should not exceed two thirds of the lower layer and half the dimension of the upper layer.

Minor surface defects, cracks: bitumen emulsion is spreaded on the pavement, and then fine aggregate is crumbled.

3 DRAINAGE OF BRIDGES

One of the crucial point is to ensure the suitable water drainage from the construction of bridge.

Devices for drainage of rainwater from bridges fulfill a very important role in ensuring the durability of the object.

3.1 Elements of drainage system

Nearcurb wastewater treatment: they are mostly located directly nearby the curb. System is made of a material such as roadway or mastic asphalt, stone slabs, precast concrete or polymerconcrete. Bridge Drains [Fig.3,4]: collect rainwater and technology effluents from the road surface. They consist of the elements as shown:

Usual size of bridge drains are 300x500mm or 500x500m.

Longitudinal and transverse drainage: Drainage is laid in longitudinal axis in the form of filters and drains, collects water from the water-proofing and take away longitudinally from the object.

Transverse section is used to drain water from the water-proofing, in the transverse direction in the area of expansion joints.

Fig. 3. Bridge inlet
Filters take water away from the waterproofing that penetrate through the surface layers and collected by drainage.

Fig. 4. Bridge drain

Disposal system: The purpose of such systems is draining rainwater and technology water with from filters and drains to the receiver or the sewage system.

Collectors, pipes and fittings made of plastic, stainless steel, cast iron. Plastic parts can be joined by welding, thermoplastic socket joints with seal.

Elements made of iron can be connected by steel clamps with rubber seals or by compression fittings.

The so-called cleaners are used to control the purity of pipes. They are installed nearby inlets, bends of pipes and at the lowest point.

Reception facilities: operating the adjacent area, ditches, storm water drainage, water ponds and reservoirs.

3.2 Materials used for drainage systems

In order to select appropriate materials for the drainage system of the object, one may consider:

– durability of materials
– availability in the market
– solutions of connections
– material costs

Cast: is mainly used due to its high durability, availability in the market and the ability to adapt to the existing pavement structure. It is not necessary to cover the elements made of cast with additional corrosion protection.

Fittings made of cast iron are connected with chrome or stainless steel fasteners. Interior and exterior surfaces of such elements are protected with epoxy zinc phosphate painting.

Their disadvantage is a very heavy weight.

Thermoplastics: components are usually made of polyethylene (PE) and polypropylene (PP). Such cables are manufactured by extrusion through forming head. Elements are connected together by welding or using heat shrinkable sleeves.

They are currently the most popular material for installation of drainage due to the low weight, easy and quick installation, no need for protective layer, resistance to corrosion and leaks. However, also have their drawbacks such as high extensibility, brittleness at low temperatures, sensitivity to UV radiation.

Stainless steel: includes min.10.5% chromium and max.1.2% of carbon. Currently the steel pipes of unalloyed and low-alloy steels by welding longitudinal are most commonly used, spiral welding or high frequency welding. Elements are connected by welding or steel clamps with rubber seal.

Hardening plastics: resins, fiberglass and fillers: calcium carbonate, quartz sand are used for production of polyester. Their advantages include resistance to abrasion, corrosion, UV radiations, tightness, aesthetic appearance. There is a possibility of staining. The disadvantages is low impact resistance, difficulties in connections with elements of other materials.
3.3 Design of drainage system

Bearing structure: The bridging plate, surface roads and pavements should have adequate lateral and longitudinal declines, place the drains and filters to drain water.

Slopes:
- slopes of the longitudinal min. 0.6%
- slopes - on the road min. 2.5%

In the case of objects with length up to 30m is possible not to use anti-slopes. For objects longer than 30m long, axis of drainage is placed min. 20cm from the curb. When the longitudinal gradients of less than 0.6% of wastewater longitudinal slope should be broken for long stretches. To 3.0m. Effluent width 0.15m, and the recess from 0.01 to 0.05m.

Waterproofing: bituminous materials or of plastics are most commonly used. The thickness of the waterproofing should be at least 5 mm (sheet) or a minimum of 2mm (coating). Such isolation must be resistant to chemical agents, steam, water, gas, facilitate water runoff by having a smooth surface, transfer surface temperature differences between surface and slab, have good adhesion to the slab.

Waterproofing can be applied to properly prepared, smooth and clean concrete subbase at least 14 days after is laid.

Basic design guidelines: installation pipes should have a minimum diameter of DN200mm, pipe of diameter DN150mm is possible to use the only when the collecting duct are, connected to a maximum of three inlets and when its length is max. 40m, slope of the busbars should be at least 2%, it is possible to apply the slope of 1% by increasing the diameter of the pipe, clean out are placed in every connection to the discharge pipe, at each change of direction and its lowest point, elements connecting drains with aggregate lines should have the slope min. 5%, drainage pipes from the filters should have a minimum diameter of 50mm, such pipes can pass directly through construction or have casing pipe

Fig. 5. Solutions of pipes suspension to bridge, a/ horizontal, b/slope

Fixing busbars:

The following figure shows diagrams suspension manifolds. At length of manifolds should be the fixed points: at 25m for pipes of cast iron, stainless steel and hardening plastics, and at 6m for plastic pipes. Such points are placed at the inlets in fixed location on the structure of the object, while changing the direction of the pipe.

Distance between sliding points depends on the type of material used for pipe diameter and is determined in each case by designer.

Fixing of pipes [Fig.5].

The diameter of the pipe is adjusted to the diameter of drain pipes. It is not recommended to concrete the pipes in pillars or abutments.

CONCLUSIONS

In the paper issues that are important for operating the bridges, and which come from negligence at design, construction and the maintenance stage of bridges are presented. Factors that affect an
repair costs, expensive renovations and also contribute to traffic problems is drainage systems, which in many cases are done wrong and are repaired only when the damage from poorly drained water has already caused visible destruction of the bridge.

Abstract

In the paper some reasonable technical solutions, material properties that influence on the bridge’s life are discussed. Pavements of bridges play a special role in the durability of the entire bridge structure. Work Loads from both traffic and climatic conditions, such as sunlight, freezing temperatures, rain, snow, de-icing salt acting on the structure, in both horizontal and vertical direction. The construction of the transportation is the most basic and key contribution to the economy. All countries put their best attention and efforts into building their own transportation network.

Wybrane problemy kształtowania żelbetowych wiaduktów drogowych

Streszczenie

W artykule przedstawione zostały wybrane zagadnienia techniczne, własności materiałowe, które odgrywają rolę w czasie użytkowania obiektów mostowych. Nawierzchnie mostowe odgrywają szczególną rolę w trwałości całego obiektu mostowego. Działają na nie obciążenia pochodzące zarówno od ruchu pojazdów jak i warunków klimatycznych, takich jak nasłonecznienie, ujemne temperatury, deszcz, śnieg, sól odladzająca. Konstrukcja mostu poddawana jest zarówno siłom poziomym jak i pionowym. Ze względu na wysokie koszty utrzymania i napraw obiektów mostowych konieczne jest utrzymanie odpowiednich standardów projektowych, wykonawczych, konserwacji i utrzymania obiektów mostowych.

BIBLIOGRAPHY

6. Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 2 marca 1999 r. w sprawie warunków technicznych, jakim powinny odpowiadać drogi publiczne i ich usytuowanie.
7. Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 30 maja 2000 r. w sprawie warunków technicznych jakim powinny odpowiadać drogowe obiekty inżynierskie i ich usytuowanie.