



Extension of the Service Life of Reinforced Concrete Bridge Structures

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Annotation

This article addresses a pressing issue today, namely, one of the important factors in improving the transport and operational condition of highways and artificial structures is optimizing their service life between repairs.

Keywords: polymer mixtures, epoxy compositions, polyvinyl acetate emulsion, epoxy compositions, dibutyl phthalate, polyethylene polyamine.



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Introduction. A scientifically based approach to determining the service life of structures between repairs consists in studying the processes of interdependence and interchangeability of various types of repair actions and, based on them, determining the optimal strategy for performing all types of repair work. To solve the problem, a probabilistic and statistical dependence of the wear and tear (volume of repair work) of certain types of structural elements on their service life is proposed.

Statistical characteristics of the distribution of the volume of permanent repair work are determined depending on the timing of its implementation, as well as the volume of major repairs and the possible timing of their implementation. As a result of untimely repair of individual elements of the bridge, the intensity of roads and the volume of cargo transportation by vehicles will also decrease.

Main Part. In order to extend the service life between the repair of highway bridges using modern methods of eliminating gaps, cracks on the surface of structures and restoring the protective layer, many researchers have conducted research based on various directions and approaches to find a solution to this problem and have achieved certain effectiveness. In particular, among the scientists of our republic, Rashidov T.R., Ishankhodzhaev A.A., Radjabov T.Yu. studied various problems.

It is performed to seal cracks in building structures using epoxy adhesives or polymer mixtures, to protect reinforcement from external environmental influences, and to restore the integrity of structures damaged by cracks.

Depending on the width of the crack opening, two methods of crack closure are proposed:

- a) using polymer mixtures - with a crack opening width of less than 0.3 mm;
- b) injection using epoxy compositions - with a crack opening width of 0.3 mm or more.

The method of injection with epoxy compositions during the restoration of structures ensures complete restoration of structures with damaged integrity. During injection, high-strength adhesive compositions are injected into pre-sealed cracks under high pressure.

When closing cracks in the structures of reinforced concrete span structures, the preparation of repair sites is carried out in the following order:

- a) The surface of reinforced concrete structures must be cleaned of various impurities - asphalt, oil, cement paste, old bitumen mastic and paint traces, steel brushes, other tools, or by sand flow method. Fatty contaminants are cleaned with acetone;
- b) cracks are cleaned at a depth of 2-3 mm at an angle of 45-60°;
- c) the damaged surfaces of the concrete are knocked off (the boundaries are determined by hammering);
- d) The exposed reinforcement is cleaned of rust, metal filings, or other contaminants using steel brushes until it becomes a pure metal color. The cleaned reinforcement is dusted and degreased with acetone;
- d) The concrete surface is washed with water under pressure and dried.

When eliminating cracks using polymer mixtures, the following composition of mixtures is recommended:

1. Portland cement M400 according to GOST 10178-85 contains no more than 10% tricalcium aluminate - 10;
2. Fine sand - 3.5-10;
3. Drinking water - 4.5-5;
4. Polyvinyl acetate emulsion PVAE
water value 50% - 2.53

The preparation and use of the polymer mixture are carried out in the following order: 1) Polyvinyl acetate emulsion is mixed with water.

2) Portland cement and sand are added to the mixture and stirred until a lightweight, movable mortar is prepared.

A small amount of polymer mixture, up to 3-4 kg, can be prepared by thoroughly mixing manually. When preparing large quantities of mixtures, it is recommended to use vibro-mixing or other types of mixing devices.[7]

The application of polymer-cement mortars is carried out using simple mortars, spatulas, etc. Approximately 1 hour after applying the mortar, it is moistened with water, cemented, and leveled. When the ambient temperature is high (T_{30C}), the repair site is moistened 2-3 times a day.[3]

Epoxy compositions of various compositions are used to eliminate cracks using epoxy adhesives. The types of compositions differ from each other in composition and liquid, and are selected for use depending on the ambient temperature and other indicators. The recommended epoxy compositions are presented in Table 4.3. When the ambient temperature is $t > 15C$, it is

recommended to use 1-10 (except 8), 13 types of compositions, and when the temperature is $t \leq 15^\circ\text{C}$, 8, 11, 12 compositions.

The amount of filler in the composite is selected depending on the crack category and weather conditions.

Table 1

Cracks category	Crack opening width, mm	Amount of filling per 100 parts of glue mass
I	0,1-0,3	0
II	0,3-1	0-100
III	1 - 2	100-200
IV	greater than 2	300-400

Note: depending on the ambient temperature, the amount of filling can be changed for each case.

A combined hardener is used for the preparation of compositions with adhesive survival from 1.5-2 hours to 7-8 days:

Preparation of epoxy compositions. The preparation technology consists of the following sequence:

- if necessary, the epoxy resin is heated in a water bath (heating ED-16 to 80°C and ED-20 to 40°C is permitted) and weighed in a clean polyethylene or metal container;
- the plasticizer or modifier is weighed and placed in a resin cooled to 25°C and mixed;
- a filler is added to the mixture (if necessary) and stirred for at least 5 minutes (when the glue mass is 0.5-1 kg). The filler used is dried at a temperature of $t = 120-150^\circ\text{C}$ to a constant weight. When adding filler to the mixture, its temperature should be within $20-25^\circ\text{C}$. [7]

Note: The measurement accuracy of the mixture elements should be within 0.1% of the mass according to the recipe.

A practical assessment of adhesive quality is the appearance and breakage of threads during the work process. Hardened glue is unusable and should not be used in subsequent work.

Glue must be prepared in special rooms. These rooms must be equipped with exhaust ventilation or exhaust cabinets and ensure technical supervision. Glue can also be prepared outdoors, observing all safety regulations and fire safety requirements.

The relative liquidity of epoxy adhesives and polymer mixtures is determined in cm^2 using a viscometer VP-3 at a temperature of $18-20^\circ\text{C}$ based on the change in the surface area of the remaining trace.

Technology of crack injection using epoxy compositions.

Crack injection is performed in the following order:

- preparation of fissures for injection;
- opening of cracks;
- injector installation;
- concrete drying.

Cracks in concrete are opened in the form of wedges (Figure 4.2, a) or rectangles (Figure 4.2, b). In cases where the eroded concrete surface is large and the reinforcement cores are exposed, additional reinforcement grids are placed in these areas and attached to the main reinforcement. [7]

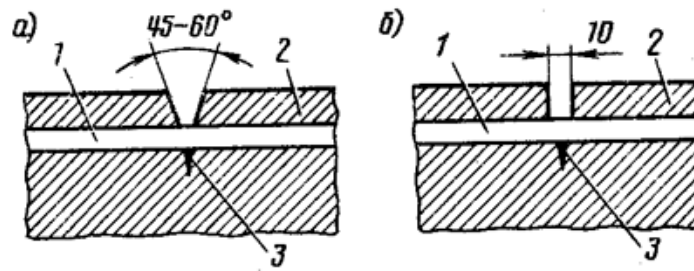


Figure 1. Diagram of crack opening: 1 - reinforcement core; 2 - concrete protective layer; 3 - crack.

Injection of epoxy mixtures and sealants into cracks is considered the most perfect method of treating cracks. For this purpose, manual and pneumatic syringes and injectors (tubular or attached) are used.

Inserting glue into cracks is carried out using fittings. Along the crack, holes are created at a depth of 15...40 mm with a pitch of at least 500 mm using a perforator (the diameter of the holes depends on the diameter of the injector nozzle).

Sections of cracks between the gaps are closed manually using epoxide glue.



Figure 2. Damaged part of the bridge structure

The injector nozzle is inserted into the slit and epoxy compositions are introduced. The injection is carried out until the glue composition comes out of the next slit, and the work continues in this way.

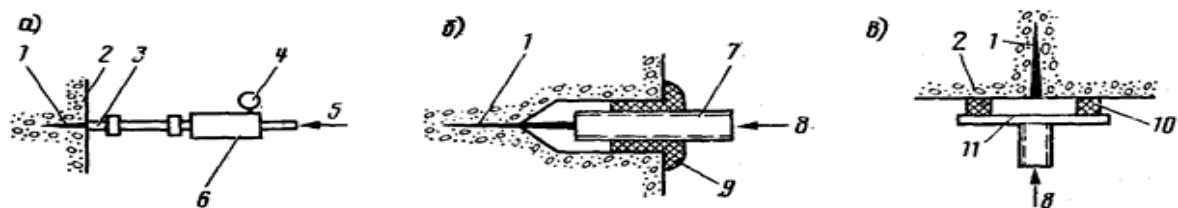


Figure 3. Scheme of crack injection:

a - schematic diagram; b - tubular injector; c - attached injector; 1 - crack; 2 - structural concrete; 3 - injector; 4 - manometer; 5 - compressed air; 6 - container with mortar or hermetically sealed; 7 - injector tube; 8 - mortar or hermetic inserted into the crack; 9 - epoxy adhesive lubricant; 10 - porous rubber; 11 - metal plate.

When using injectors, the technology of work is selected based on the instructions for using the device, and the composition of epoxy compositions is selected according to Table 2.

At all stages of the work, the quality of injection work is monitored by the specially responsible person and documented in the work log.

The materials used are according to SHNK 2.05.03-11 "Bridges and Pipes"; QMQ 3.06.04-97 "Bridges and Pipes"; SHNK 3.06.07-09 "Bridges and Pipelines. Rules for Verification and Testing."

The quality of polymer materials is checked a week before the start of work, during laboratory tests, by moving glued sample concrete cubes.

The adhesive and cohesive strength of adhesives and polymer mixtures is determined during laboratory tests of glued concrete cubes, where the class of concrete must correspond to the structure being repaired.[7]

The quality of all work performed is also checked by inspecting the injected cracks, with all washers and corners removed. The adhesive seam should be clearly visible in all parts of the cracks. If necessary, the sealing layer is removed and the injection seam in the crack is checked.[2]

Conclusion. If we proceed from the stationarity of all considered processes of structural elements, i.e., taking into account the average values of the volume of repair work, it is very simple to formulate possible options for solving the problem - taking into account the discount factors for each year of current and capital repairs, the amount of costs for their implementation, as well as losses in vehicles, if they occur for each structural element, are calculated.

The minimum total cost (for all elements) determines the best option for the service life of artificial structures between repairs.

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