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Autor: Kartopoltsev, Vladimir / Kostelyanets, Boris

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Reinforcement of Bridges Piers Foundations

Réparation des fondations de piles de ponts

Verstärkung von Brückenfundamenten unter Stützen

Vladimir KARTOPOLTSEV
Professor
TSAAB
Tomsk, Russia

Vladimir Kartopoltsev,. born in 1947, received his Dr degree at the Tomsk State Acad. of Archit. and Buildings (TSAAB). He is Prof. and Dean of the Dept of Bridges and Constr. of TSAAB. Corresponding Fellow of the Int. Acad. of Science of Higher School (1994).

Boris KOSTELYANETS
Lead Engineer
TSAAB
Tomsk, Russia

Boris Kostelyanets, born 1925, received his eng. degree at the Kharkov Road Institute, Kharkov. For 30 years he was involved in design and construction projects of roads and BAM (Baikal-Amur Magistral). At TSAAB, he is responsible for the design of bridges and constructions.

SUMMARY

The authors propose a method to repair the disorganised masonry of a foundation pier by means of prestressing with a corrosion-proof steel lining in a closed circuit. The service life of the lining is expected to be more than fifty years.

RÉSUMÉ

Les auteurs proposent une méthode de réparation de la maçonnerie désorganisée d'une fondation de piles de pont, au moyen de précontrainte réalisée avec des barres d'acier inoxydable. La durée de service de la fondation réparée est estimée à plus de cinquante ans.

ZUSAMMENFASSUNG

Die Autoren schlagen eine Reparaturmethode für ein Stützenfundament mit Hilfe eines vorgespannten rostfreien Stahls vor. Die Lebensdauer nach der Reparatur soll mehr als 50 Jahre betragen.

1. INTRODUCTION

A latitudinal corridor of the Transsiberian main line (Glavsib) containing a railway and highway polygon of the Siberian region is examined. Here are included meridional branches also. A corridor length of main axe is about 4 500 km. A meridional branches length is about 2 000 km. Engineering and geographical conditions are unfavourable. The polygon is consisted of a north building-climatic area that includes about 30 % of Baikal high-seismic zone.
A polygon net crosses the Ob, Enisei, Lena and Amur rivers of a first and a second orders and passages also large and out-of-class bridges that erected from 1950 to 1990.
For the most part, a stable work of the road polygon depends on the bridges. Bridgeworks are classified as barriers of the transport network. The highways insure the Glavsib in difficulties.
A normalized service life of the bridges is limited by viability of the piers, as more durable structures. That is way, restoring and maintaining the total service life of the river piers it is an important problem of reliability and stability of the big bridges.
In this paper, term "pier" without a foundation is presented.

2. THE ENVIRONMENT OF WORK OF PIERS

It is distinguished an influence of environmental conditions on the foundations and the piers. Environment exerts influence on the foundations one or two time order more slowly, which is almost equally a bridge service life, as compared with one on the piers. Exceptions are river bed deformations. Therefore, a priori, the foundations are considered as with quasi-steady states, apart from pier states and then may be excluded from our discussion. It is an actual problem to retrieve a technology and materials to restore and support operation resources of the river bed piers of the big bridges.

3. TECHNICAL DECISIONS

The Department of Bridges and Constructions offers, as radical decision, a method to restore operation resources of the river bed piers on the basis of a lining of a corrosion-proof steel sheet (steel grade 15ХСНД) and filling in by a concrete with a crushed stone of fine-grained fraction or a cement mortar a clearance between the lining and a support body. However, technical and economical evaluations of the decision making are subject of another work.
As necessary and sufficient conditions of technical and economical evaluations of usage of the steel lining it is recommended to consider a operation reliability of one in during of half a normalized bridge service life. It is limited by resistance of the lining to a chemical corrosion.
There are no analogous samples in the world construction practice.
In The Department was designed and carried out the multiyear and multicriterion (modeling theory) experiments. It generalized the fullscale experiments of two river bridge piers of Yaya river by an inclement iced climate and winter air temperature under - 40 C:
- in the middle part of river (t. Anjero-Sudjensk, Kemerovo region)
- in the lower part of river (t. Bolshoye Dorokhovo, Tomsk region)

The experiment was carried out in natural conditions; an experimental object corresponds to an application; the time consists of 40 % and 16 % of the normalized service life without an extrapolation; a purity of the experiment it is undouptedly.
As a result of the experiment it is determined that the steel lining, in running water, may be in long-term usage without a corrosion-resisting coating or other applying a dressing. A corrosion-

resistance of the experimental lining is more stable than prognosed one by Norms [3]. An ice abrasion resistance of the experimental lining is more als ten times as large one of a prefabricated reinforced concrete and it is compared with a stone facing of strength volcanic rocks (basalt, granite). The service life of the steel lining (steel grade 15ХСНД) may be continued to 55-60 year.
Usually, to repair and reinforce the piers with disturbanced massif continuousness and external surface integrity it is necessary to disassemble a bad masonry, to restore it and inject a cement mortar in the massif in order to fill in cracks and voidnesses.
It is disadvantage to disassemble 40-50 % massif volume with breaking off a bridge transport traffic and removing a transport load from the piers to execute a construction works and, moreover, to expect possibilities of repeated deformations of a repaired masonry and abrasion working of external surfaces by drifting an ice and drawing river deposits (river drifts). An efficiency and the service life of aforesaid technical measures are not predicted and a cost it is compared with one of new piers.
It is a subject of investigation to restore pier maintenance resources by means of erecting the high-resistance to mechanical action and stands up to attack by chemical corrosion sheet steel lining on a pier perimeter for anyone massif forms and external surface dislocations.
Our investigation is realized by forming the steel lining, as a renewal construction (masonry into collar), by means of filling in a concrete in a tunneled lining clearance from wall to wall with the massif. The high-strength lining steel takes up all internal loadings; a steel resistance to an abrasive wear is more high als one of anyone concrete; an anticorrosive strength permits to predict in practice the service life with a sufficient authenticity The collar permits 100% usage of the pier masonry without to disassemble it for the expensive repair and construction works.
A quality and state-of-the-art of the collar-lining correspond to known technologies to erect metall welded tank-reservoirs of cylinder forms to store oil products. It is borrowed erecting a vertical walls of large-size prefabricated half-finished products without a bottom and roof, its assembling and welding on a construction site.
The collar-lining of closed contour squeezes the pier massif by means of the concrete of tunneled lining filling in, limits a crack-formation, stabilizes a massif internal stress, protects safety external surfaces from shocks and ice abrasive wears and drawing river deposits. A collar function is based on principle of the tunnel lining.
A design position of the collar-lining on the pier has been fixed by insert parts of a merchant-mill product (rolled steel) or a reinforcement. Filling in a tunneled lining clearance has been realized by a concrete pump and compacting a concrete by adjustable external and internal vibrators.
The bridge piers contain a masonry of prefabricated and monolithic concretes dislocating by crack-formations and also a protection coating of 50 % damage surface processed by an ice drifting action and drawing river deposits.
The lining of prefabricated panels had been assembled and welded by field erection welds.
Design position and tunneled lining clearance, filled in by a concrete with crushed stone small fractions, have been supplied by clamps.
Steel tunnel lining for a general overhaul of the river piers allows to restore completely design technical characteristics bringing the service life to normalized one and to exclude routine repairs.

4. CHARACTERISTIC PROPERTIES OF WORK OF THE COLLAR-LINING

It is important characteristic property of the collar-lining construction that it provides 100 % usage of prefabricated masonry, gives an opportunity of a bridge transport traffic without limitations and requires small quantities of building works on a construction site, material consumption capacities and costs.
A function of the steel lining of a support body depends on a complex stressed-deformation state. Three composite components interact in the collar-lining construction, Fig. 1:
1 - available pier massif;
2 - filling in tunneled lining;
3 - steel tunnel lining.
There are contact surfaces (1-2) and (2-3) between adjacent bodies. Interaction character of the adjacent bodies by means of contacts is ambiguous and depends on an internal stress state and a lining construction technology. Body masses of 1, 2 and 3 match up one for other as 90:8:2.
As a main factor, environmental temperature variations (air, water) determine a stress-deformed state of the piers and the lining. When no exothermic forces exist in the massif then it is recommended to limit by a temperature action only.
Two nature factors that positioning (adapted) a design technology of the river piers lining are following:
- ice regime and hydrological regime of river;
- outside-air temperature [4].
The level regime is characterized by year graph of construction levels of probability of difference of height from 10 % to 50 %. It is statistical variable behaviour and it may be different from real one. In Summer-time, the lining is submerged and therefore it is in stable and softening temperature regimes (as compared with air environment). In Winter time, the lining is exposed to subzero outside-air temperature that is considered as unfavourable regime.
Tangential stresses of the lining squeeze the pier massif and form radial stresses of the masonry; it both are interlocated with known formulae of momentless theory of thin-walled shells. The steel lining is not to expose to the force ice actions before it filling in the tunneled lining in order to save a design geometrical state, form and strength of one.

5. CONCLUSION

A technology and work scheduled network are to limit by environmental conditions. That is to be on schedule at four winter months. Co-working 1, 2, 3 components begins from a moment of interlocking under where that is supposed to fill in the tunneled lining clearance by the concrete to a design level with taking a strength. This concluding operation is to realize with positive temperature of the massif [1].
Presented method for Siberian region may be recommended as a reliable modeling the problems of the bridges of Russian road network.

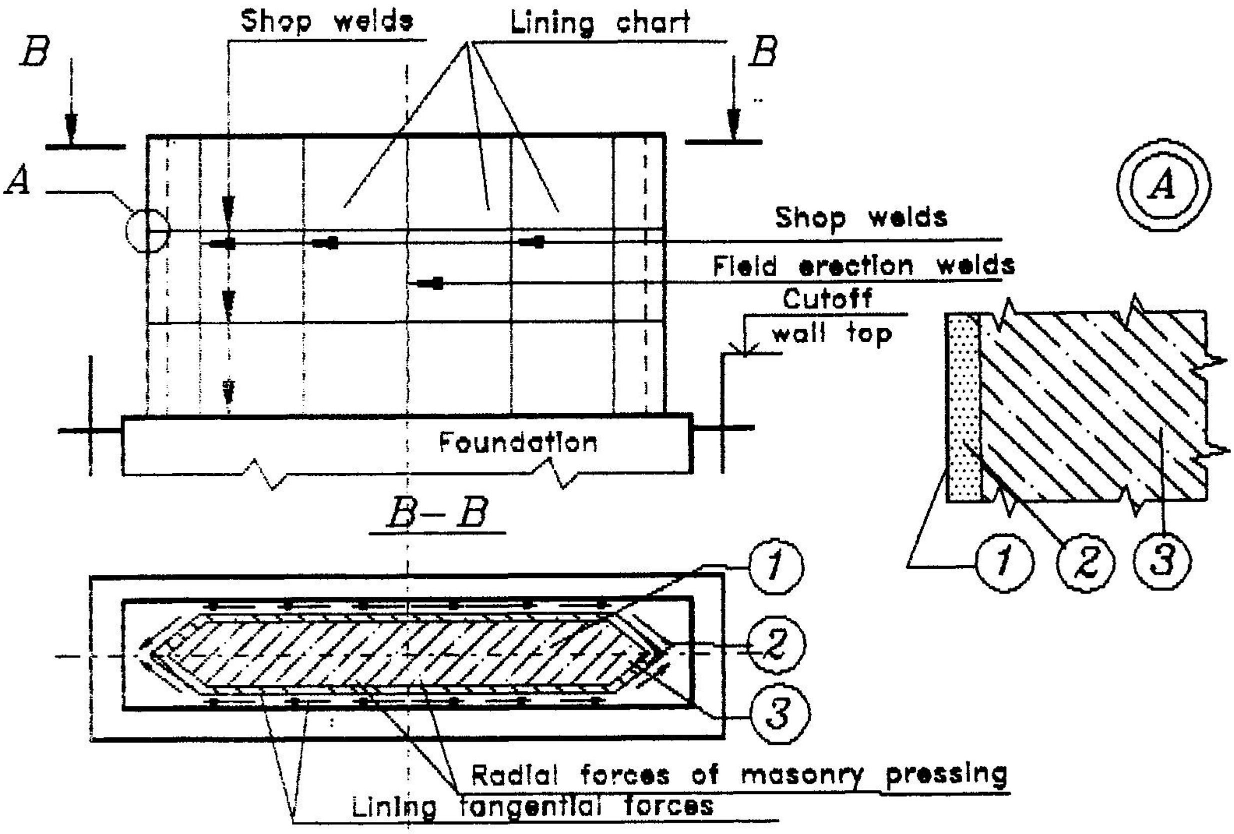

Fig.1 Basic circuit arrangement of steel lining piers

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