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ПІДВИЩЕННЯ ЕКСПЛУАТАЦІЙНИХ ЯКОСТЕЙ ЕЛЕКТРОМЕРЕЖНИХ КОНСТРУКЦІЙ ПРИ РЕКОНСТРУКЦІЇ

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Анотація. Стаття присвячена питанням підвищення експлуатаційних якостей електромережних конструкцій при реконструкції або переобладнанні. Важливу роль при вирішенні питань посилення виконує матеріал конструкцій, що визначає характер роботи споруди в цілому. Розглянуто питання посилення металевих і залізобетонних конструкцій. Як приклади посилення металоконструкцій представлено комплекс проектних, дослідних і ремонтних робіт, об'єктами яких були ділянки електричних мереж. На підставі аналізу результатів діагностики і виконаного перерахунку несучих конструкцій запропоновано ефективні методи посилення. Були запропоновані також додаткові заходи щодо посилення конструкцій опор у зв'язку із збільшенням експлуатаційних навантажень в порівнянні з проектними. Наведено методи посилення пошкоджених залізобетонних конструкцій. Застосування запропонованих методів посилення обґрунтовано економічною ефективністю в порівнянні із заміною конструкцій.

Ключові слова: електромережні конструкції, перерахунок, посилення, реконструкція.

ПОВЫШЕНИЕ ЭКСПЛУАТАЦИОННЫХ КАЧЕСТВ ЭЛЕКТРОСЕТЕВЫХ КОНСТРУКЦИЙ ПРИ РЕКОНСТРУКЦИИ

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Аннотация. Статья посвящена вопросам повышение эксплуатационных качеств электросетевых конструкций при реконструкции или переоборудовании. Немаловажную роль при решении вопроса об усилении играет материал конструкций, определяющий характер работы сооружения в целом. Рассмотрены вопросы усиления металлических и железобетонных конструкций. В качестве примеров усиления металлоконструкций представлен комплекс проектных, изыскательских и ремонтных работ, объектами которых были участки электрических сетей. На основании анализа результатов диагностирования и выполненного перерасчета несущих конструкций предложены эффективные способы усиления. Были предложены также дополнительные мероприятия по усилению конструкций опор в связи с возросшими эксплуатационными нагрузками по сравнению с проектными. Представлены методы усиления поврежденных железобетонных конструкций. Применение предложенных методов усиления обосновано экономической эффективностью по сравнению с заменой конструкций.

Ключевые слова: электросетевые конструкции, перерасчет, усиление, реконструкция.

IMPROVEMENT OPERATIONAL CHARACTERISTICS OF POWER SUPPLY STRUCTURES AT RECONSTRUCTION

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Abstract. The article is devoted to the questions of improving operational characteristics of power supply structures under reconstruction or re-equipment. Not the least of the factors of strengthening is a structure material that determines the character of the structure operation in the large. There are considered the question of strengthening metal and reinforced concrete structures. As examples of strengthening metal structures there is taken a complex of design, investigation and repair works at the sections of the power supply systems. On the basis of analysis of the results of diagnostics and re-calculation of carrying structures there were suggested some effective methods of strengthening. Additional measures on strengthening support structures in terms of larger operating loads as compared to the design ones were suggested too. There are considered the methods of strengthening of the damaged reinforced concrete structures. Application of the suggested methods of strengthening is grounded by economic efficiency as compared to the replacement of structures.

Keywords: power supply structures, recalculation, strengthening, reconstruction.

Introduction

Power supply structures are a considerable part of the basic production facilities of power supply enterprises of any state. Failures of the overhead power transmission lines (OPTL) and outdoor switchgears (OS) greatly damage customers and operating organizations [2, 7]. That's why research institutions and energy companies are so much interested in the development of effective preventive and repair measures to increase a service performance of structures [12-15].

The problem is that more than 1/3 of the power supply structures under operation have exhausted their resources [2, 5, 7]. Because of a sharp decrease of the development in the energy field, a principal significance belongs to the technical measures undertaken to prolong the service life of the existing structures.

The main measure to increase a carrying capacity of structures under reconstruction is their reinforcement that means an increase of their carrying capacity in the operating position [1, 3]. A necessity of reinforcing power supply structures can be caused by two reasons: first, a reduction of their carrying capacity caused by defects and damages as a result of a continuous service and second, an increase of loads at their reconstruction and re-equipment.

Until recently problems of reconstruction of power supply structures connected with a change of design loads and re-equipment remained aside from the main trends of construction in power engineering. More often there appeared the problems connected with a reinforcement of metallic structures which had a considerable corrosive wear and operational damages [1, 3, 4]. Meanwhile, the essence of repair measures usually came to the elimination of these damages by increasing the sections. Some questions of the repair emerged when carrying structures of the OPTLs crashed because of natural climatic phenomena [2, 7]. Such repair measures were of a global recovery character and aimed at a speedy recovery of the damaged power supply systems at the expense of a complete replacement of the structures damaged.

Strengthening works caused by changing the design loads seem to be the most interesting from the point of view of performing revised designs taking into account the changes in the normative documents [8-11].

Not the least of the factors when solving the question of strengthening is the material for these structures that determines the character of a structure operation in the large. Further we shall separately consider the questions of strengthening metallic and reinforced concreted structures.

1. Strengtheing of metal structures of the overhead PTLs

There is presented a complex of design, survey and repair works performed in 2006-2007 at the OPTL section "Kurakhovskaya thermal power plant (TPP) – Novoselka" of 110 kV of Donetsk West electric networks of the public company "Donetskoblenergo". The purpose of the work being performed by a team of design people with the author's direct participation was a complex reconstruction of the OPTL section providing necessary conditions of the OPTL getting as far as the public company "Electrostal". A necessity of these works performance was specified by the customer's demands to re-equip the OPTL and guarantee its further safe operation.

Design characteristics of the OPTL constructive part. The OPTL was put into operation in 1971. The line route is located on the territory of the Kurakhovskaya TPP. Before reconstruction the OPTL had 10 double-chain metallic towers with a wire suspension only on the right chain mounted.

This overhead line consists of 5 anchored sections (No. 1-3, 3-6, 6-7, 7-10, and 10-11) separated by water barriers. The line twice crosses the cooling channel (see Fig. 1) in sections No. 11-10 and No.7-6, and twice crosses the lock channel of hot water in sections No. 1-2 and No. 2-3.

The section is planned to be re-equipped into a double-chain OPTL for its to get as far as the public company "Electrostal". As the section between towers No. 10-7 is in an immediate vicinity to the territory of the public company "Electrostal", the entry is to be done from the corner dead-end pole No.7 (the left chain) and tower No. 10 (the right chain) is to be unsoldered.

By the construction arrangement all towers are made of steel, of the tower type, double-chain, with the cross arms arranged in three tiers and wires suspended by the scheme "barrel". The towers are made of steel of the industrial welded brands with the bolt assembly connections.

At the first stage of the design works there were formulated and solved the following basic tasks:

- an in-situ study of tower building structures of the OPTL section, that is localization of faults and damages of metallic OPTL towers and bases using visual and instrumental testing methods;
- an estimation of the tower technical state on the base of the in-situ study methods taking into account the analysis of their operating conditions;
- recalculation of the OPTL carrying structures to specify a real stress-deformed state of the structures by the improved loads taking into account a planned re-equipment of the line and the existing defects and damages;
- development of measures to improve a carrying capacity and to prolong a service life of the OPTL structures.

When examining, there were found out and analyzed specific OPTL defects and damages.

All towers of the OPTL section had a paint-and-lacquer coating damaged. The towers located

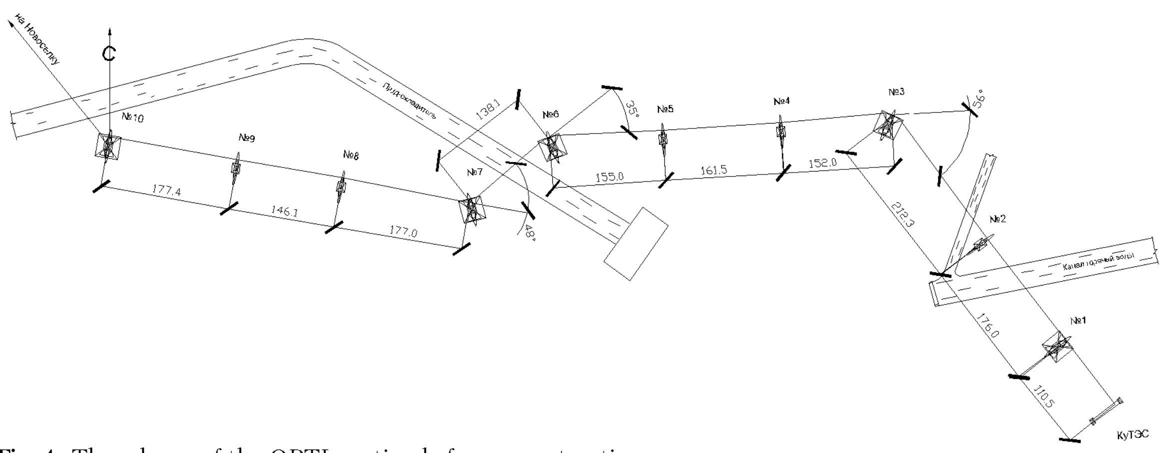

Fig. 1. The scheme of the OPTL section before reconstruction.

in an immediate vicinity to a water storage basin had a more corrosion damaged upper part because of wind flows of a higher humidity. An average depth of the corrosion damage of the elements was about 0.5...0.8 mm (up to 10% of the profile).

A local unequal corrosion got its development at the level of the tower foundation edge, these towers are located in thick plantations where moisture and dust impurities accumulate because of a poor airing and activate the process of corrosion. The depth of the corrosion damage of the tower elements here is about 2.5...3.0 mm (up to 30% of the profile).

There was fixed a development of crevice corrosion for almost every edge joint on the superimposed and overlapping: joints accompanied by a loss of carrying capacity of the joints because of a clearance of up to 6...9 mm, cavities being filled with the corrosion products, the latter results in a curvature of joint plates, in cracking of weld seams, in failure of weld and single bolt joints with the lattice elements being torn.

Most of all crevice corrosion influences the section bolt joints (Fig. 2 a, b) into which moisture flows by vertical elements and accumulates in the joints if dust impurities are available there.

The corner dead-end poles greatly suffer of the deformation of tower diagonals, angle flanges and lattice pressed elements within a panel, that is an indicative of the element stability loss (Fig. 2, c).

There is observed a protective layer damage, breaks of the foundation concrete as deep as 50...80 mm, armature exposure and corrosion on some towers. On the foundation surface there are observed cracks as wide as 1...1.5 mm.

In the large, using the results of the technical diagnosis found out that the OPTL section "KuT-PP" of 110 kV could not be used for a normal operation and needed to be reinforced.

Recalculation of the tower building structures was done to specify a real stress-deformed state of their structural elements, and to control the sections taking into account load changes of wires as a result of the OPTL re-equipment.

Another purpose of the recalculation work was to register an increase of the design wind and icing loads [7] in accordance with the new norms [8] adopted in 2006 due to a thorough regionalization of the territory of Ukraine by different climatic factors and changes of the design principles in comparison with those built into the standardized design before. The rules of arranging electric devices [8] take into account positions and conceptions fixed in basis of foreign norms [9-11, 16].

The results of re-calculation exposed the elements of supports, which it is necessary to strengthen (Fig. 3).

a) b) c)

Fig. 2. Tower element damages: a, b – crevice corrosion of multiple-bolt joints of tower sections; c – deformation of rod elements.

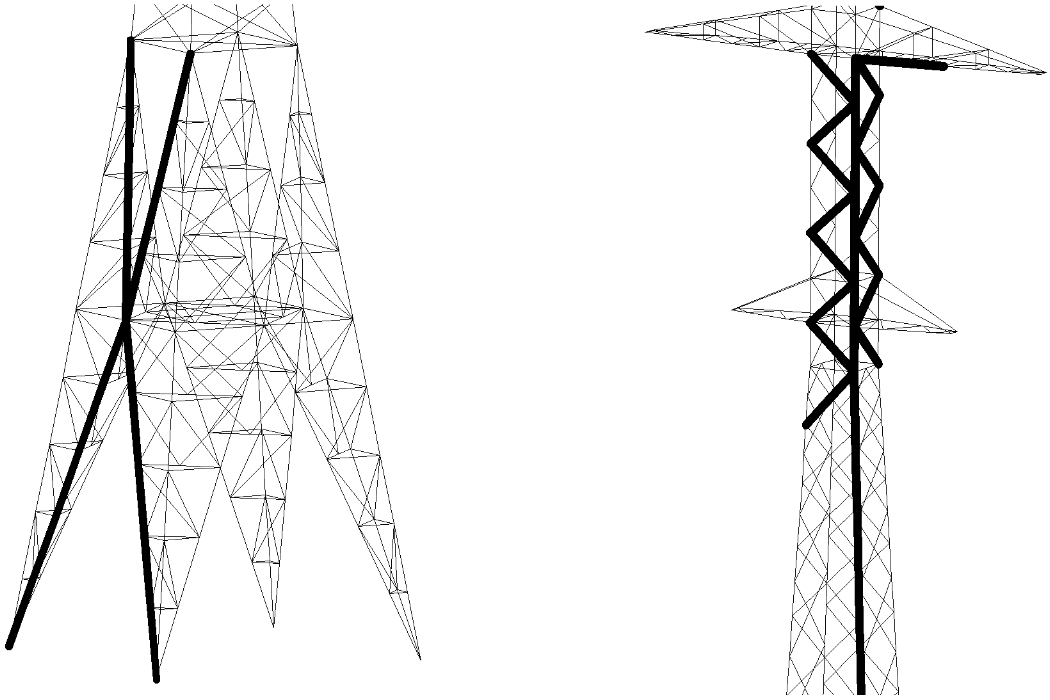

Fig. 3. Elements of supports OPTL, which it is necessary to strengthen.

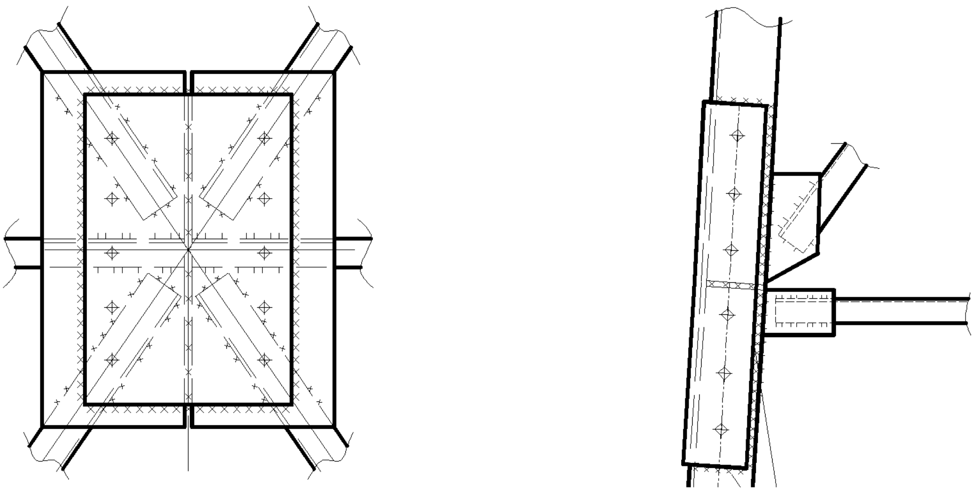

Fig. 4. Strengthening of damaged tower section joints.

Fig. 5. Strengthening of rod elements.

At the second stage there was worked out a contractor that provided a complex reconstruction of the operating OPTL section, an entry of the OPTL left chain onto the territory of the public company "Electrostal", as well as a right chain unsoldering and an arrangement of a standby approach.

There were solved the tasks connected with planning repair measures for metal structures caused by tower operational damages:

- repair of section junctions at a partial replacement of connecting elements and bolts;
- repair of arm-cross edge joining with a tower body;
- repair of attachment joints of lattice diagonals and tower belts;
- leveling the belt rods and lattice elements;
- strengthening of the deformed rods of diagonals and belts, as well as elements that require an increase of their carrying capacity by the recalculation data regarding a planned re-equipment of the line;
- installation of the tower elements absent;
- strengthening of a support foot and concrete solidification of tower foundations;
- tower coating with a protective anticorrosive material.

Below there are given the main methods applied to the contractor design to repair and strengthen the OPTL elements and joints.

To repair the joining units of a tower body, there was suggested to perform a scalding of plates connecting tower sections (see Fig. 4), crevice corrosion preliminary removed and element leveling performed.

A repair of the deformed rods of diagonals and belts, and their strengthening in accordance with the recalculation on the planned loads meant an accomplishment of leveling of the elements whose bending was not more than 50 mm, at larger values of bending strengthening with additional elements is needed (see Fig. 5).

In view of a necessity to re-equip an OPTL into a double-chain one, on the base of the recalculation done there were put forward additional measures to strengthen tower structures because of larger operational loads in comparison with the design ones, in particular to strengthen tower diagonals in the lower sections along every face of corner dead-end poles.

The design measures of strengthening structures being approved by a customer, the suggested technologies were applied to the object.

At this stage, there were fulfilled the tasks of the field supervision of the works under way connected with the OPTL repair, strengthening, and reconstruction.

2. Strengthening of reinforced concrete structures

Until recently the problems of reconstructing power supply structures of pre-cast reinforced concrete were aside of the basic trends of construction in energy. Active measures usually meant a complete replacement of the damaged structures, no preventive measures connected with the repair works being done.

The essence of the measures suggested by the group of developers is to increase a carrying capacity and prolong the service life of reinforced concrete power supply structures by their strengthening. Below there are considered real examples of strengthening bases for the outdoor switchgear (Fig. 6).

To prolong the service life of the structures of reinforced concrete column bases that can not used for a normal operation and to recover the working capacity, there were suggested three variants of performing repair-and-renewal operations [6].

Variant 1. Strengthening of column bases by air-placed concrete. An increase of the carrying capacity of column bases is done by putting air-placed concrete on the existing structure of a column base. Strengthening is done with the help of four flat frames installed on the whole height of the column base under strengthening and connected into a spacious framework. A strengthening structure rests on a monolithic reinforced concrete foundation around the existing column base.

Variant 2. Strengtheing of column bases by monolithic reinforced concrete collars. In this case the strengthening of reinforced concrete column bases is reached by making a monolithic concrete collar (a shirt) around the existing structure. The wall thickness of the collar (80...100 mm) is specified by a possibility of performing a concrete mixture vibrocompaction when carrying out concrete works, and by a possibility of arranging a reinforcing cage along the length of a column base and a foundation pile.

Fig. 6. Damages of column bases for outdoor switchgears.

Variant 3. Strengthening of column bases using the up-to-date production of building chemistry. To recover a carrying capacity of reinforced concrete structures of column bases for outdoor switchgear, the up-to-date materials for restoring concrete (on the example of the production of the firm «MAPEI») were suggested for using.

To strengthen reinforced concrete column bases in accident conditions, a *method of their strengthening with steel collars* was recommended (for example, for outdoor switchgear of 220 kV in the settlement "Mikhailovka" of the Donbas electric energy system of the National energy company "Ukrenergo"). The collar design is given in Fig. 7.

A strengthening collar is a tetrahedral rod structure made of metallic angles connected by plates at welding. A collar resting on the foundation is done by a base made of two angles. When strengthening column bases for current transformers, for bus isolating switches, and for linear isolators, a metallic color head is supplied to the overlying metallic structures and are rigidly connected with them. At a similar design concept, climatic loads and loads of the equipment are simultaneously taken by a reinforced concrete column base and by a reinforcing structure. At a further concrete damage, a reinforced concrete structure is taken away from the operation and acting loads are taken by a metallic collar only. When strengthening column bases for insulators, they directly rest on a collar head and the reinforced concrete column base is fully taken away from the operation. The collar rests on a monolithic reinforced concrete foundation put around the existing column base.

The practice of repairing strengthened structures showed a high processability of the design concepts taken, and the operational practice confirmed reliability and efficiency of the suggested methods.

Conclusions and the prospects of further researches

1. Edition of new «The rules of arranging electric devices» requires realization of new approaches at the decision of questions of reconstruction.
2. Application of the suggested methods of strengthening is proved by an economic efficiency in comparison with the replacement of structures. Besides, these methods make it possible to avoid significant economic losses connected with switching off the systems of power supply during the reconstruction period.
3. A decision either to use these methods or not is quite individual, and in every case it should be taken after considering the existing technical possibilities and rational financial expenditure.
4. The suggested methods of strengthening require a new approach to the problem of renewals and the development of the fidelity criteria of the technical decisions taken.

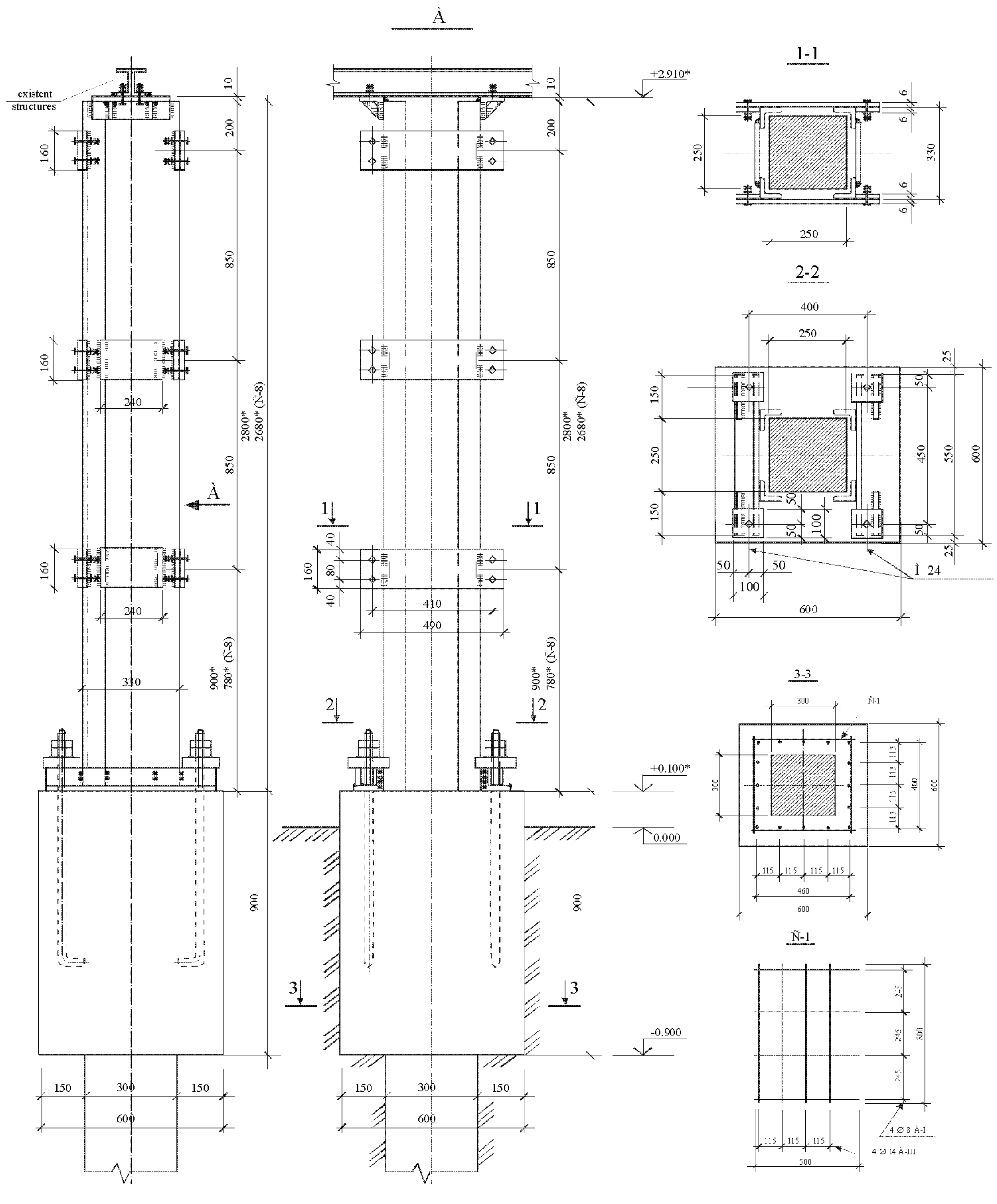

Fig. 7. The scheme of a structure for strengthening with a steel collar.

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