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EXPERIENCE IN STRENGTHENING TECHNOLOGICAL FOUNDATION AND MONOLITHIC REINFORCED RETAINING WALL IN BUILDING INFRASTRUCTURE FACILITIES FOR PRODUCTION FACILITIES EXPANSION

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Abstract. The article contains experience in strengthening critical large-cast reinforced concrete monolith structures under heavy-load conditions on the operating construction enterprise. Herewith measures aimed to strengthen reinforced concrete loading ramp retaining wall resulted in the change of operation scheme as flagstone with outline abutment to classic operation scheme of retaining wall with reverse transom. All the main stages of the strengthening process technique are described in detail, in particular starting from the examination stage of the structure mode of deformation, its monitoring during implementation of works, and ending with stage of exploitation of both reinforced concrete technological foundations and retaining wall under operational loadings.

Key words: reinforced concrete structures, retaining wall, technological foundations, reverse abutment

STATEMENT OF THE PROBLEM

Within comprehensive designing of the mixing plant technological foundations and loading ramp for the purpose of servicing of inert materials bunker storage facility, working drawings for constructives were designed separately by different organizations and lacked associativity of the agreed design solutions. Herewith not completely appropriate solutions in designed construction of reinforced concrete components (Fig. 1) were chosen, particularly in terms of selection of the depth markings for laying foundation

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and designing some sections of retaining wall (Section C). Besides, during construction works, retaining wall subgrade was laid on insufficiently packed soil which was earlier laid in base through foundation pit reverse filling following the completion of foundation erection of mixing plant technological sink. Calculations for section C of the retaining wall was made as for flagstone with outline abutment including reinforced concrete counterforts.

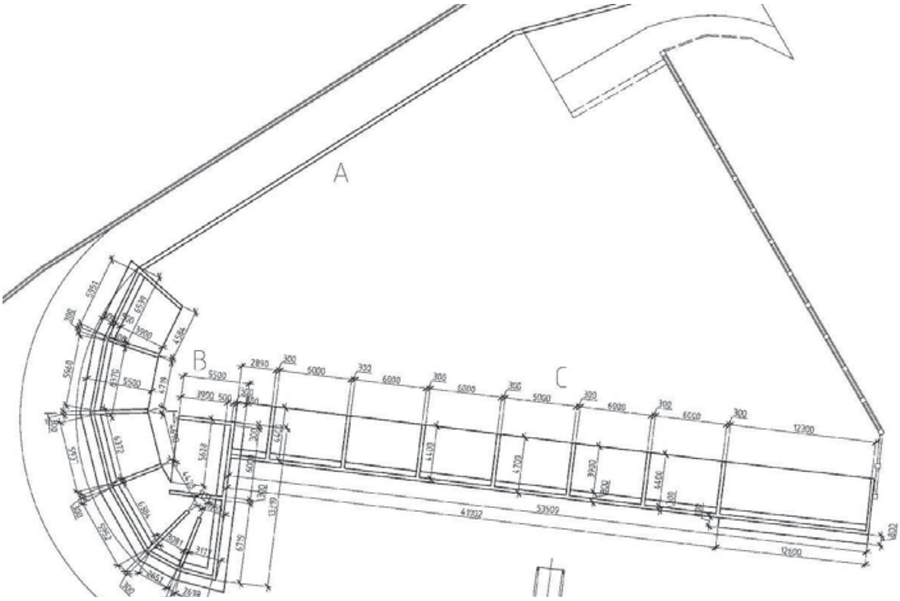

Fig. 1. Layout of reinforced concrete loading ramp retaining wall of mixing plant (sections "A", "B", "C")

Rys. 1. Schemat lokalizacji wzmocnionej żelbetowej ściany oporowej rampy załadunkowej węzła (strefy „A", „B", „C")

As the result of errors made during designing and construction, yielding of the reinforced concrete retaining wall on the overall ramp 41 running long meter occurred on the facility in the way that the wall subgrade bottom appeared to be 160 mm lower than the designed level of the edge upper marking of technological sink concrete foundation (pillar) (Fig. 2).

ANALYSIS OF PUBLIC RESEARCH AND PUBLICATIONS

Similar defects in reinforced concrete structures during construction were subject to strengthening using latest technologies and special calculation methods as well as strengthening of construction components separate sections during erection. In order to fairly estimate the mode of deformation for the reinforced concrete retaining wall guidelines of normative documents in force were used [Ivanyk et al. 2007, 2008].

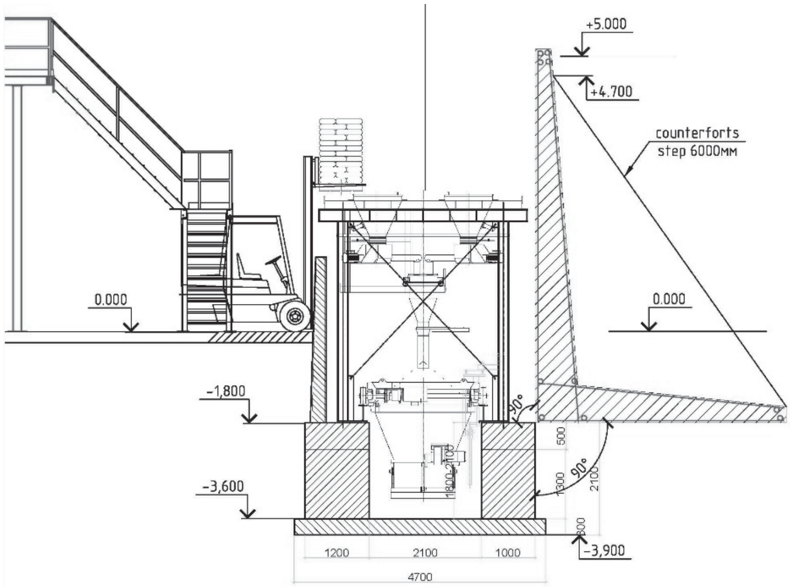

Fig. 2. Construction diagram for the technological sink mixing plant and its tangent reinforced concrete loading ramp retaining wall

Rys. 2. Konstrukcja komory technologicznej węzła i styczna do niej żelbetowa ściana oporowa rampy załadunkowej

STATEMENT OF THE PURPOSE OF THE ARTICLE

The purpose of this article is to analyze the chosen method of strengthening of reinforced concrete retaining wall and the implementing technique for certain stages of strengthening construction structures under the conditions of the operating facility.

Yielding of the abovementioned construction structure up to critical value resulted in appearance of cracks in the body of retaining wall reinforced concrete surface with up to 3 mm opening width. At the same time retaining wall 7.5 m high began to lean towards location of mixing plant reinforced concrete technological sink and maximum deflection value of the top edge from the vertical in the central section was 140 mm (Fig. 3). Remarkably this process became apparent in places of cracks and on the deformation section of the monolith reinforced concrete transom in the area of technological niche in the foundation sink on the marking 1.800 m. Character of location of cracks which appeared on the reinforced concrete transom indicated that they appeared due to pressure by the reinforced concrete retaining wall during yielding. Opening width and cracks development trends in the abovementioned transom indicate that this construction structure was subject to deformation as a result of twirling process due to insufficiency of structural reinforcement in the reinforced concrete component for transverse force imbibing caused by retaining wall pressure.

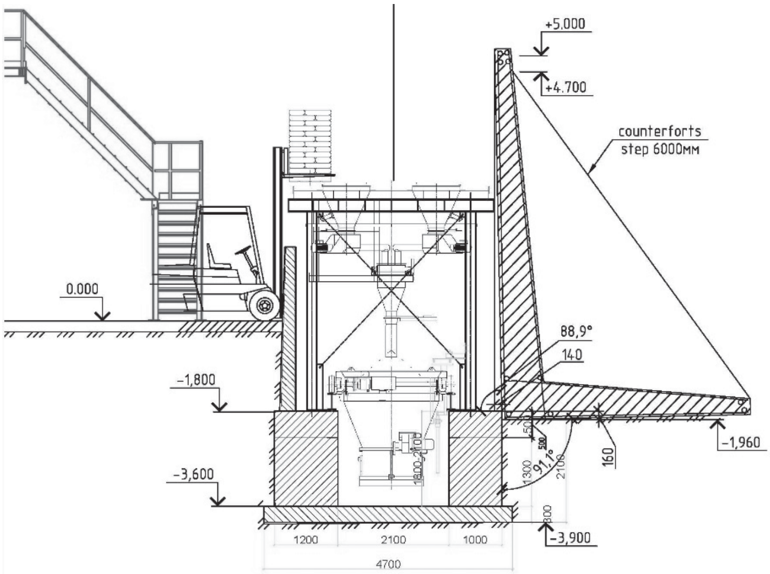

Fig. 3. Real deformation condition of the retaining wall and location of the loading ramp technological sink during construction of mixing plant

Rys. 3. Faktyczny stan deformacji ściany oporowej i schemat lokalizacji komory technologicznej rampy załadunkowej w trakcie budowy węzła

STATEMENT OF BASIC MATERIAL

In order to stop development of cracks and yielding of reinforced concrete retaining wall before the moment of destructive force, examination of defective sections was conducted and comprehensive design for strengthening of bearing components of technological foundations and loading ramp retaining wall was developed.

Specialists of the Scientific and Research Laboratory of L'viv Polytechnic National University accomplished structure calculations and proposed a comprehensive option of strengthening construction structures in several stages:

- removal of niche in the technological sink of mixing plant foundation through strengthened reinforcement and niche building in for the purpose of inclusion into overall operation of the monolith foundation section with transom, which was deformed due to the pressure from retaining wall during its leaning;
- concrete casting of the additional reinforced concrete cambered arch between the two pillars of the trough-shaped technological sink of the mixing plant foundation for the purpose to transfer efforts caused by pressure of soil loaded retaining wall onto reinforced concrete foundations;
- arrangement of superimposed reverse abutment in the reinforced concrete retaining wall through anchoring of 7 reinforcement bars ∅ 32A400C in the wall body with 500 mm step in staggered order at the whole length of the loading ramp, which is 41 running meter long.

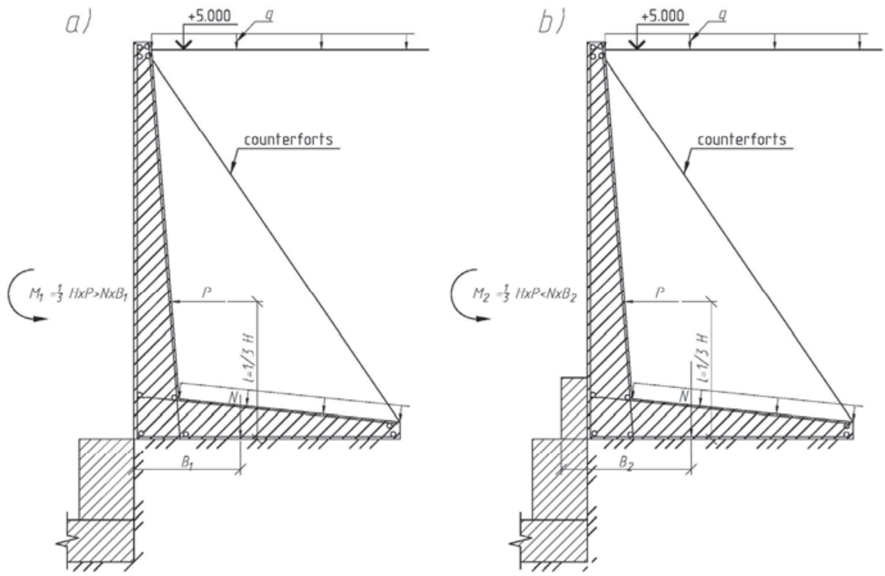

Fig. 4. The retaining wall calculation scheme: a – before strengthening, b – after strengthening

Rys. 4. Schemat obliczenia ściany oporowej: a – przed wzmocnieniem, b – po wzmocnieniu

Figures 5, 6 and 7 shows implemented construction solutions at each stage of strengthening of the retaining wall.

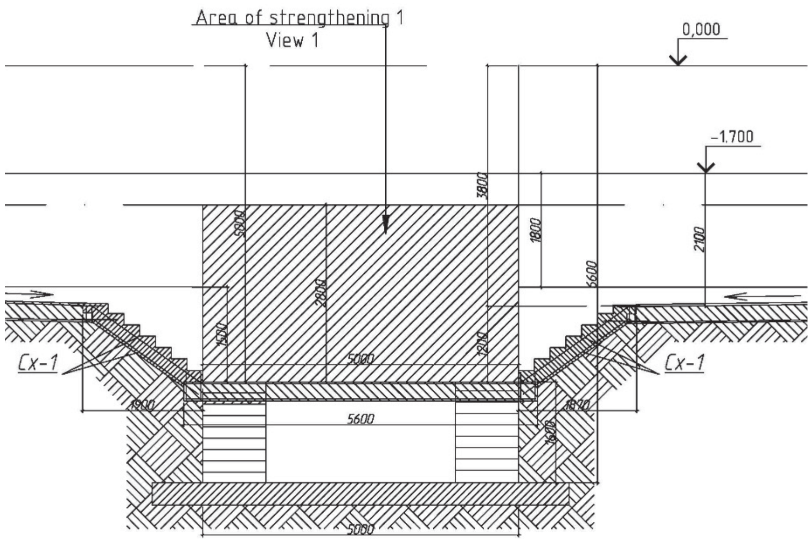

Fig. 5. Section of strengthening mixing plant technological sink (zone of strengthening 1) in the niche of the right section (pillar) of monolith reinforced concrete foundation (section)

Rys. 5. Wzmocniony odcinek komory technologicznej węzła (strefa wzmocnienia 1) w niszy prawego odcinka (postument) żelbetowego monolitycznego fundamentu (przekrój)

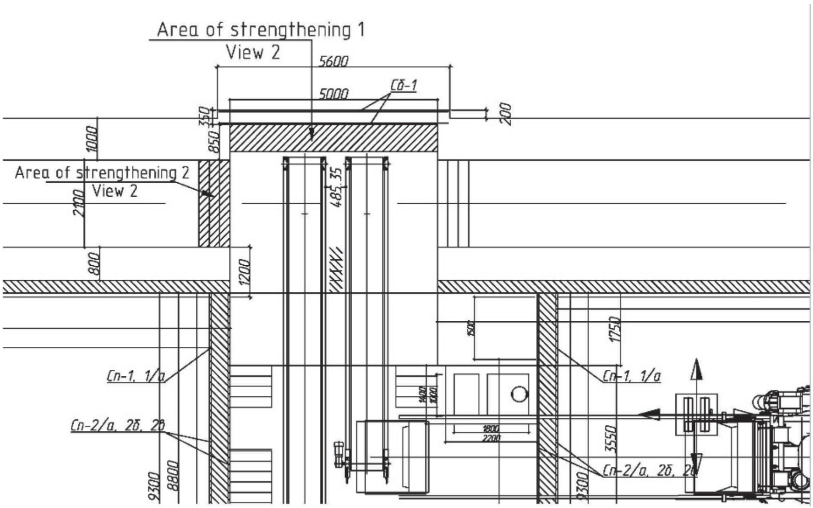

Fig. 6. Section of strengthening mixing plant technological sink (area of strengthening 2) within the section between the two pillars of the monolith foundation (layout)

Rys. 6. Wzmocniony odcinek komory technologicznej węzła (strefa wzmocnienia 2) w odstępie pomiędzy dwoma postumentami monolitycznego fundamentu (przekrój poziomy)

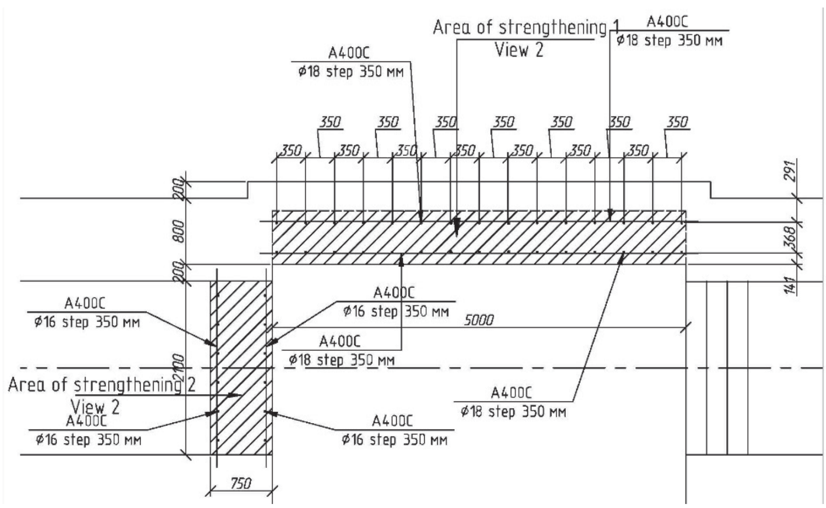

Fig. 7. Reinforcing strengthening zone 1 and 2 in mixing plant technological sink

Rys. 7. Zbrojenie wzmocnionych odcinków 1 i 2 komory technologicznej węzła

Herewith the following sequence of works in strengthening defective sections was followed:

1. Drilling holes ∅ 40 mm and 300 mm (20d) deep with perforator in the retaining wall body (Fig. 8).

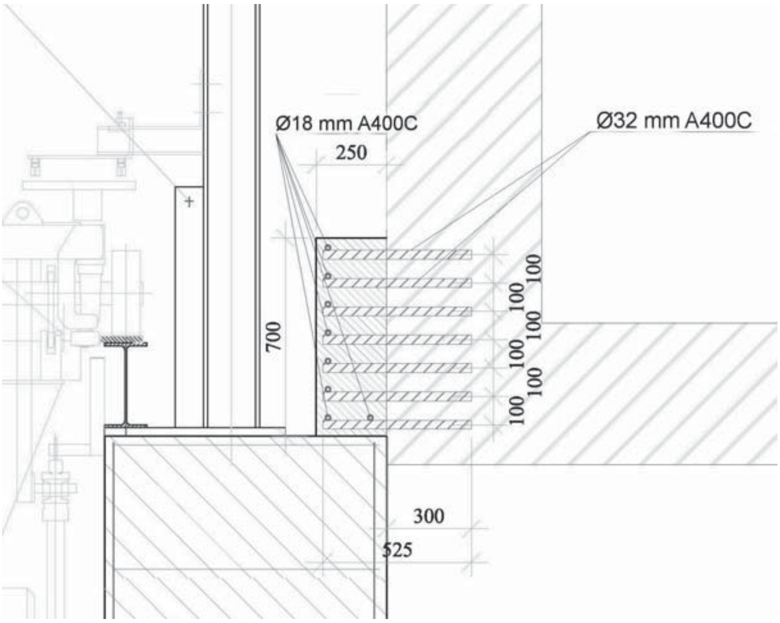

Fig. 8. Strengthening design solution and arrangement of additional reinforced reverse abutment on the retaining wall section C

Rys. 8. Konstruktywne rozwiązanie wzmocnienia i urządzenie dodatkowej żelbetowej odsadzki ściany oporowej w strefie „C”

2. Anchoring of reinforcement anchors through building in reinforcement bars 550 mm long in prepared holes and injecting these holes with FIX-10 plugging cement (Fig. 9).

Fig. 9. Anchoring of the retaining wall reverse transom with reinforcement anchors ∅ 32 mm A400C

Rys. 9. Kotwienie odsadzki ściany oporowej prętami zbrojeniowymi ∅ 32 mm A400S

3. Reinforcing retaining wall reverse transom of the constructive reinforcement with reinforcement anchors 6∅18A400C at the whole length of strengthening area (Fig. 10) along section C.

Fig. 10. Building in anchors ∅ 32 mm into loading ramp retaining wall body with FIX-10M plugging cement

Rys. 10. Utrwalanie prętów zbrojeniowych ∅ 32 mm żelbetowej ściany oporowej rampy załadunkowej szybkowiążącym cementem montażowym FIX-10M

4. Building in reverse reinforced concrete transom (tooth shaped) with fine concrete mixture class B35 using vibration through manual oscillators at the whole length of strengthening area (Fig. 11).

5. As a result of comprehensive measures aimed at retaining wall strengthening, strong reverse transom was made along the whole length of the loading ramp, which resting upon the mixing plant technological sink provided stability of the whole reinforced concrete trestle construction mass. In order to provide perception of temperature effects during loading ramp operation, two movement joints with 13 m step were made in the monolith reinforced concrete structure reverse transom along the whole length of the loading pier of the inert materials bunker storage facility. At the same time, retaining wall calculation operation scheme was altered in principle, in particular operation scheme as flagstone with outline abutment was substituted with classic operation scheme of retaining wall with reverse transom (Fig. 12).

Fig. 11. External appearance of the section of the retaining wall reverse transom in the area of maximum crack openings (pos. 4–5) along the height of retaining wall reinforced structure

Rys. 11. Zewnętrzny widok odcinka odsadzki ściany oporowej w strefie maksymalnego otwarcia rys (pozycja 4–5) na wysokości żelbetowej konstrukcji ściany oporowej

Fig. 12. Concreted reinforced concrete reverse transom along section C (41 running meter long) of the loading ramp retaining wall

Rys. 12. Wylana z betonu odsadzka wzdłuż strefy „C" (długość 41 m) ściany oporowej rampy załadunkowej

CONCLUSIONS

Performed measures in terms of strengthening reinforced concrete retaining wall and mixing plant technological foundation sink provided significant effect, in particular:

- wall yielding stopped,
- increase of actual rigidity of reinforced concrete sink pillar due to building in of the technological sink resulted in stopping further crack opening,
- reinforced concrete wall careen fixed and stopped at markings, which were identified at the beginning of strengthening,
- the project of strengthening of high-durability large-cast reinforced concrete structures, which were beforehand designated to endure significant dynamic loads and difficult operation mode during exploitation provided conditions for normal operation of the technological facility without considerable expenses for elimination of errors in facility design and construction.

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DOŚWIADCZENIE WZMOCNIENIA FUNDAMENTÓW TECHNOLOGICZNYCH I MONOLITYCZNEJ ŻELBETOWEJ ŚCIANY OPOROWEJ PODCZAS BUDOWY OBIEKTÓW INFRASTRUKTURY W CZASIE ROZBUDOWY MOCY PRODUKCYJNEJ

Streszczenie. W artykule opisano doświadczenie wzmocnienia odpowiedzialnych wielogabarytowych żelbetowych monolitycznych konstrukcij, które pracują w ciężkich warunkach eksploatacyjnych działającego przedsiębiorstwa branży budowlanej. W tym wypadku środki wzmacniające żelbetowej ściany oporowej rampy załadunkowej spowodowały zmiany schematu obliczeniowego pracy – ze schematu płyty opartej konturowo na schemat pracy ściany oporowej z odsadzką. Określono szczegółowo wszystkie główne etapy technologii wzmocnienia, zaczynając od fazy badania stanu deformacyjno-naprężeniowego konstrukcji, poprzez monitorowanie całego okresu pracy, aż do etapu eksploatacji żelbetowych technologicznych fundamentów oraz ściany oporowej pod obciążeniem użytkowym.

Słowa kluczowe: konstrukcje betonowe, mury oporowe, fundamenty technologiczne, odwrotny obcas

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