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Resource-Saving Technology for Dismantling the Supporting Decking of Reinforced Concrete Ribbed Slabs during Reconstruction and Demolition of Buildings

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Abstract

Introduction. Construction industry is currently in need of resource-saving technology that allows dismantling of coatings during reconstruction and demolition of buildings with maximum preservation of the integrity of reinforced concrete ribbed slabs for them to be possibly reused for their intended purpose, thereby not only preventing environmental pollution with construction waste, but also saving energy, labor and material resources for their disposal, as well as for reproduction of slabs.

Materials and Methods. While developing resource-saving technology, a set of methods and means for solving each of the tasks was used, including:

– visual inspection of reinforced concrete ribbed slabs during dismantling of the supporting deck of the roof in order to identify their suitability for them to be reused for their intended purpose;

– identification of the parameters of the equipment required in order to release seams and joints between slabs from mortar and concrete based on a study of the factors affecting the filling of seams and joints;

– identification of the parameters of special grips and devices for lifting ribbed slabs with damaged slinging loops using physical and computer models.

Results. As a result of the research, a new resource-saving technology for dismantling the load-bearing flooring of reinforced concrete ribbed slabs was proposed which is based on the methods developed by the authors:

- mechanical removal of the material filling the seams and joints between the slabs and the established parameters of the necessary equipment;
- release of the slabs from the existing connections with the rafter beams and cover trusses;
- testing of the remaining slinging loops of the slabs;
- slinging of slabs with damaged slinging loops with specially designed load-gripping devices.

Discussion and Conclusions. The new resource-saving technology allows dismantling the load-bearing reinforced concrete decking without additional damage to the slabs with them possibly being reused with a minimum amount of waste, saving labor and material resources, significantly reducing energy costs that would be required for the disposal of reinforcement waste and crushing concrete.

Keywords: reconstruction and demolition of buildings, dismantling of coatings, load-bearing reinforced concrete decking, ribbed slabs, monolithic seams and joints, sling loops

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Оригинальное эмпирическое исследование

Ресурсосберегающая технология демонтажа несущего настила покрытий из железобетонных ребристых плит при реконструкции и сносе зданий

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Аннотация
Введение. Строительное производство в настоящее время нуждается в ресурсосберегающей технологии, позволяющей производить при реконструкции и сносе зданий демонтаж покрытий с максимальным сохранением целостности железобетонных ребристых плит для возможности их повторного использования по прямому назначению, тем самым не только предотвращая загрязнение окружающей среды строительными отходами, но и сберегая энергетические, трудовые и материальные ресурсы на их утилизацию, а также на воспроизводство плит.
Материалы и методы. При разработке ресурсосберегающей технологии был применен комплекс методов и средств решения поставленных задач, в том числе:
– визуальное обследование железобетонных ребристых плит в процессе разборки несущего настила покрытия для определения их пригодности для повторного использования по прямому назначению;
– определение параметров оборудования, необходимого для освобождения швов и стыков между плитами от раствора и бетона на основе изучения факторов, влияющих на заполняемость швов и стыков;
– определение с помощью физических и компьютерных моделей параметров специальных захватов и приспособлений для подъема ребристых плит с поврежденными строповочными петлями.
Результаты исследования. В результате выполненного исследования предложена новая ресурсосберегающая технология демонтажа несущего настила покрытий из железобетонных ребристых плит, в основу которой положены разработанные авторами методы:
– механическое удаление материала заполнения швов и стыков между плитами и установление параметров необходимого оборудования;
– освобождение плит от имеющихся связей со стропильными балками и фермами покрытия;
– испытание сохранившихся строповочных петель у плит;
– строповка плит с поврежденными строповочными петлями специально сконструированными грузозахватными устройствами.
Обсуждение и заключение. Новая ресурсосберегающая технология позволяет производить демонтаж несущего железобетонного настила покрытий без дополнительного повреждения плит с возможностью повторного их использования с минимальным количеством отходов, экономя при этом трудовые и материальные ресурсы, в разы снижая энергозатраты, которые потребовались бы на утилизацию отходов арматуры и дробление бетона.

Ключевые слова: реконструкция и снос зданий, демонтаж покрытий, несущий железобетонный настил, ребристые плиты, замоноличенные швы и стыки, строповочные петли

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Для цитирования. Жолобова Е.А., Жолобов А.Л., Иванникова Н.А. Ресурсосберегающая технология демонтажа несущего настила покрытий из железобетонных ребристых плит при реконструкции и сносе зданий. *Современные тенденции в строительстве, градостроительстве и планировке территорий*. 2025;4(2):96–105. https://doi.org/10.23947/2949-1835-2025-4-2-96-105

Introduction. The production of precast reinforced concrete structures is a highly material-intensive, labor-intensive and energy-consuming process. Costly reinforcement products requiring significant energy consumption to be made as well as high-quality cements are used in their manufacturing.

Ribbed coating plates are leading the way when it comes to the volume of production of precast reinforced concrete structures. In compliance with GOST 9491-60 "Large-Panel Reinforced Concrete Ribbed Prestressed Slabs Sized 1.5×6 m for Coatings of Industrial Buildings" in this country from 1960 to 1978, reinforced concrete ribbed slabs of the same standard size — 1.5×6 m were produced for coatings of industrial buildings. Such slabs have a thin shelf (30 mm thick) and narrow ribs, which explains why the thickness of the protective layer in lots of places has a minimum allowable value of 10 mm. It is such coating plates that are most commonly found at reconstructed industrial facilities of capital construc-

tion. Under normal operating conditions, reinforced concrete load-bearing floor coverings, as well as other internal reinforced concrete structures of buildings, are capable of remaining operational for more than 150 years [1]. There is information available that after many years of operation in a non-aggressive environment, the strength of the concrete of the ribbed coating plates does not decline, but actually sees a slight increase with the reinforcement retaining its properties [2–3].

In case of reconstruction of buildings, it is frequently essential to partially or completely dismantle the load-bearing flooring in good condition of the ribbed plates, e.g.:

– to be used in covering lighting and light-aeration lanterns, as well as mounting openings;

– while replacing existing slabs with those with increased load-bearing capacity or with special holes;

– during the demolition of a building or its components.

With large amounts of demolition work on buildings with a precast reinforced concrete frame, the load-bearing flooring is commonly dismantled along with the frame using the collapse method of the so-called "concrete destroyers" based on tracked excavators with an elongated boom using hydraulic grinders as a working body [4–6]. The volume of waste generated is beyond that of disassembled structures, and it is measured in tens of thousands of tons nationwide [7]. Researchers from Denmark found that during the disposal of these wastes, 2 times as much carbon dioxide is released into the atmosphere than during the reuse of the coating plates obtained during dismantling of reinforced concrete flooring [8].

In spite of attempts made by scientists and specialists to come up with efficient technological solutions, it has been impossible to cut down the amount of waste as much as possible by piecemeal dismantling of reinforced concrete load-bearing flooring of ribbed slabs for them to be possibly reused for their intended purpose, due to permanent, hard-to-reach welded joints in sealed seams and joints between slabs, as well as to the massive damage of their sling loops [9–10].

In order to provide construction production with a resource-saving technology allowing dismantling of reinforced concrete flooring with maximum preservation of the integrity of the ribbed slabs, thereby not only preventing environmental pollution from construction waste, but also saving energy, labor and material resources for their disposal and reproduction, a study was carried out at the Department of Technology of Construction Production of the Don State Technical University to identify opportunities for:

– improving the method of removing mortar and concrete from joints and spaces between ribbed slabs;

– using slinging loops while slinging ribbed plates for lifting or developing special grips;

– increasing productivity and safety of dismantling flooring of ribbed slabs;

– expanding the field of reuse of ribbed coating plates.

Materials and Methods. The parameters of the resource-saving technology for dismantling the load-bearing flooring of building coverings, as well as equipment and technological equipment for its use, directly depend on the shape and size of the ribs, as well as the slinging loops of the reinforced concrete ribbed slab shown in Fig. 1.

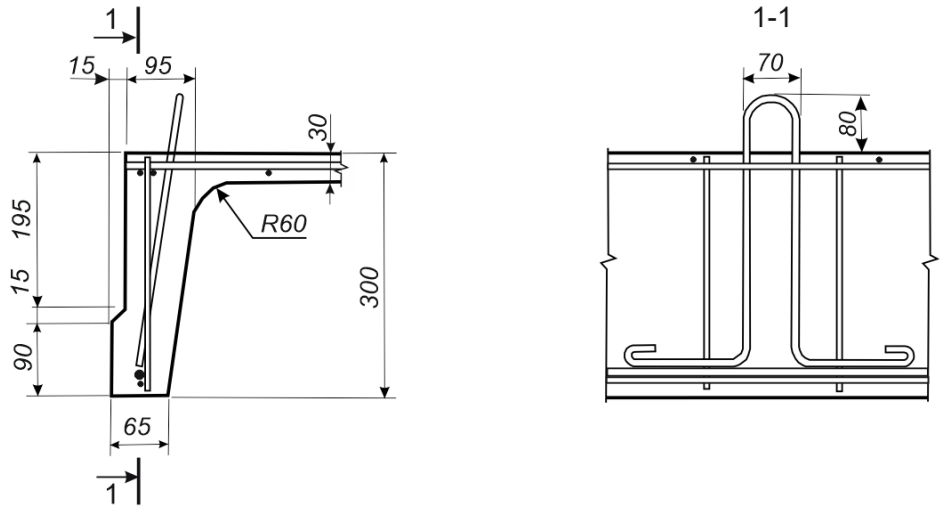


Fig. 1. Dimensions of the longitudinal ribs and slinging loops of the coating plates in compliance with GOST 9491-60

Accounting for these dimensions, the depth and possible thicknesses of the joints between the plates, the shape and dimensions of the grippers for slinging plates with damaged slinging loops, and the dimensions of the release wedge for tearing adjacent plates from each other were identified.

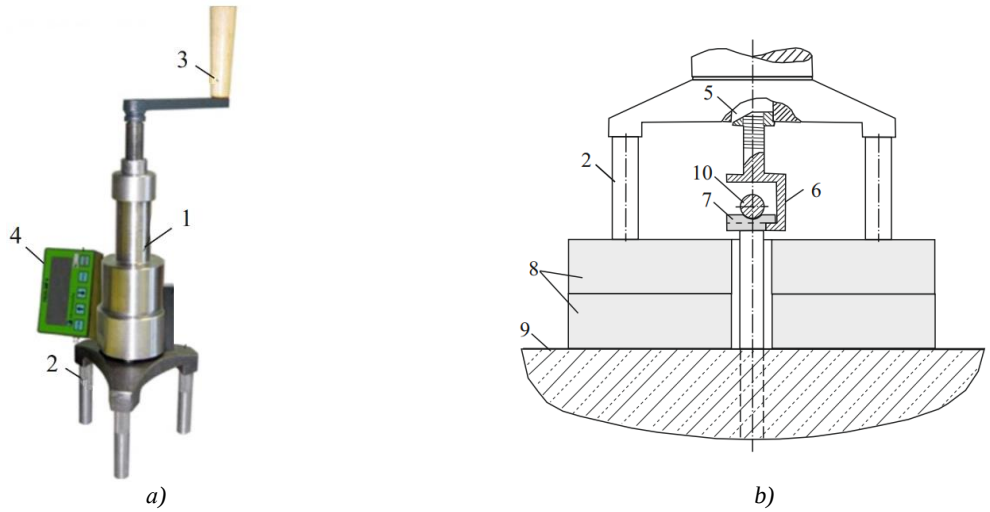
In order to identify the optimal parameters of the resource-saving technology being developed, as well as the necessary equipment and tools, a set of methods and tools for solving each of the above tasks shown in Table 1 was applied.

Table 1

Methods and tools used in solving the problems of developing a resource-saving technology for dismantling load-bearing flooring of buildings made of reinforced concrete ribbed slabs

Tasks of investigating the opportunities	Research methods	Research tools
Improving the method of removing mortar and concrete from joints and spaces between slabs	Analytical: – questionnaire; – identification of factors impacting the fillability of seams and joints	–
	Instrumental: checking the fillability of seams	Electric perforator with a drill bit with a diameter of 5 mm and a working length of 250 mm (as a depth gauge)
	Instrumental: identifying the adhesion of the solution	PSO-10MG4AD device (Fig. 2 *a*)
Using sling loops for lifting	Instrumental: checking the load-bearing capacity of the sling loops under a load of 10 kN	Same
Detecting plate defects before lifting	Visual inspection according to GOST 31937-2024 "Buildings and Structures"	–
Increasing productivity and safety of dismantling the ribbed flooring	Physical and computer modeling of grippers for slinging ribbed plates	Physical and computer models of grips
Expanding the area of reuse of coating plates	Analytical: – classification of ribbed slabs according to their condition; – studying the experience of reuse of slabs accounting for their technical condition	–

The load-bearing capacity of the sling loops was checked using a PSO-10MG4AD device based on aluminum plates with a total thickness corresponding to the height of the sling loop as shown in Fig. 2 *b*.



a) *b)*

Fig. 2. General view of the PSO-10MG4AD device (*a*) and the scheme of its application when checking the strength of sling loops (*b*): 1 — force exciter; 2 — support; 3 — loading handle; 4 — electronic unit; 5 — rod of the force exciter; 6 — gripper; 7 — lodgment; 8 — aluminum plate; 9 — coating plate; 10 – sling loop

Research Results. According to the analysis of the results of studying domestic and foreign experience in dismantling precast reinforced concrete floors of building coverings, at least 50% of ribbed slabs experience additional damage during dismantling, and about half occur due to the rupture of sling loops. In 5–15% of the slabs, the ribs are damaged while seams and joints between the slabs are being cleaned using a mechanized impact tool, and in the remainder, while holes are being punched in the corners of the slabs for access to the welded joints of the slabs at their resting points on rafter trusses or beams.

Hence due to rib chips formed during dismantling of load-bearing flooring, in particular at their end sections, as well as cracks, most of the coating plates are typically abandoned and disposed of as waste. It has also been found that in order to lift slabs, holes are most commonly punched in the shelf of ribbed slabs near damaged sling loops for two loop slings to pass resulting in a decrease in the load-bearing capacity of the slab.

Inspection of the side faces of the ribbed slabs after dismantling the flooring, as well as the results of selective drilling of holes in the joints between the slabs showed that the seams were mostly filled with mortar to a depth of 5–15 cm (Fig. 3 *a*). This might be due to the lack of requirements for the mobility of the mortar for sealing joints, as well as their low controllability.

It was fairly rarely that the seam turned out to be filled up to the ledges of the longitudinal ribs of the slabs, i.e., 20 cm deep. These are typical for ridge sections of a coating where the upper part of the seam opens by 90 mm at the standard slope of the upper faces of the double-pitched rafter beams 1:12 (Fig. 3 *b*). It is to be noted that even in these cases, the solution barely penetrated into the lower part of the seam between the ledges of the longitudinal ribs of the plates, just as with the usual opening of the upper part of the seam — by 40 mm. (Fig. 3 *a*).

Along the roof endowment, the seams between the slabs of the coating turn out to be completely unfilled owing to the lack of access to its cavity from above the slab. (Fig. 3 *c*).

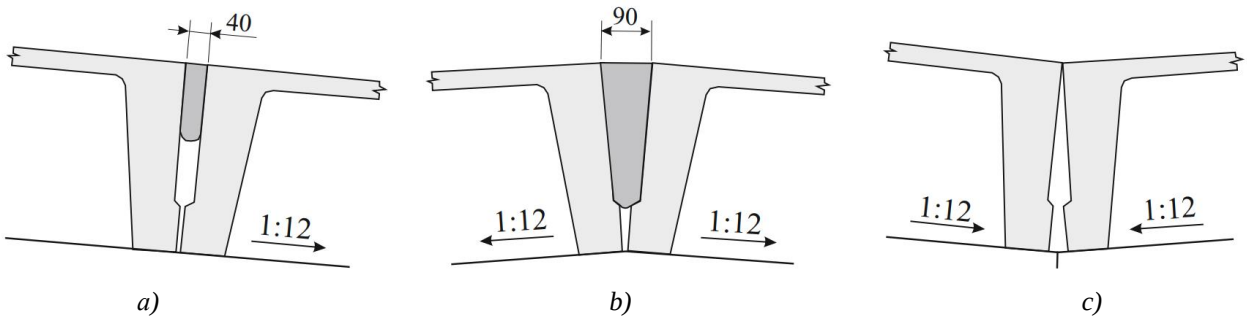


Fig. 3. Shape and size of the cross-section of the seams between the ribbed plates: *a* — regular seam*; b* — expanded seam; *c* — closed seam

Being aware of these features enabled us to identify the required cutting depth of the seam, which should correspond to the height of the upper (expanded) part of the longitudinal seam and be equal to 200 mm. This should prevent accidental damage to the ledges in the longitudinal ribs of the slabs by the rotating diamond cutter disc. In order to perform this technological operation, a seam cutter with a maximum cutting depth of 200 mm can be recommended, e.g., the TSS RH-500G brand, its general view is shown in Fig. 4.

Fig. 4. General view of the TSS RH-500G seam cutter with the diamond disc removed

Through the course of the study, the amount of adhesion of the solution to the side faces of the slabs was identified for 16 of them at four different sites. A large variation of these values (from 0 to 0.4 MPa) was observed, which can be accounted for by the lack of any instructions on the preliminary preparation of the slab faces for improving the adhesion of the mortar.

The resulting data enables us to conclude that after the slab has been freed from the welded joints with the rafter structures and at least the joints and seams between the slabs from mortar and concrete have been partially freed, the outermost slab in the row before lifting can be easily moved away from the adjacent slab using a self-contained wedge of the KRA1150 brand with a force of up to 10 kN, its general view is shown in Fig. 5, or two mounting crowbars.

Fig. 5. General view of the self-contained release wedge of the KRA1150 brand

At the next stage, the authors looked at the possibility of pre-evaluating the suitability of the slab for reuse before they had been lifted, even during dismantling of the flooring. With no visible defects, such as exposed reinforcement, cracks in the longitudinal ribs, deep chips of the lower edges and corners of the ribs, as well as rust spots and areas of concrete leaching, the slabs can be used for their intended purpose — when new or reconstructed coatings are being installed.

If there are minor defects, the plates can be used as permanent formwork for the construction of ribbed basement floors with increased load-bearing capacity in industrial buildings erected on peat and permafrost soils. If the edges of the slabs experience considerable damage with their shelf retaining its integrity, it is recommended that such slabs are used for installing temporary sidewalks and footpaths on construction sites. Other than that, the slabs must be recycled into crushed stone with scrap metal being separated.

The biggest challenge facing builders while dismantling decking is the most sling loops being non-operational and might break while a slab is being lifted. GOST 9491-60 for reinforced concrete ribbed slabs provided for slinging loops made of round hot-rolled reinforcement with a diameter of 10 mm. They should be positioned 1 m away from the end face of the plate.

As a result of investigating the experience of dismantling precast reinforced concrete load-bearing flooring and its individual parts, it was found that the most common damages experienced by sling loops are steel corrosion and mechanical destruction during construction while bent by blows of a sledgehammer at the bend point (flattening of steel, fracture). The statistical data collected and processed by the authors on the most common causes of sling loops being non-operational are shown in Table 2.

For mechanical testing of sling loops 70-80 mm high with a force of 10 kN, the authors employed the PSO-10MG4AD device mounted above each loop on several aluminum plates (20 mm thick with a rectangular hole sized 100 × 20 mm for the sling loop) used as a lining for the device, and a steel base for supporting the loop.

As a result of testing the sling loops (after the unbending), it was found that only 43% of the total number of straightened loops were able to withstand the specified load. I.e., at least two of the four hinges in each slab are at risk of being damaged while it is being lifted, and hinges that have been damaged are known to be beyond repair.

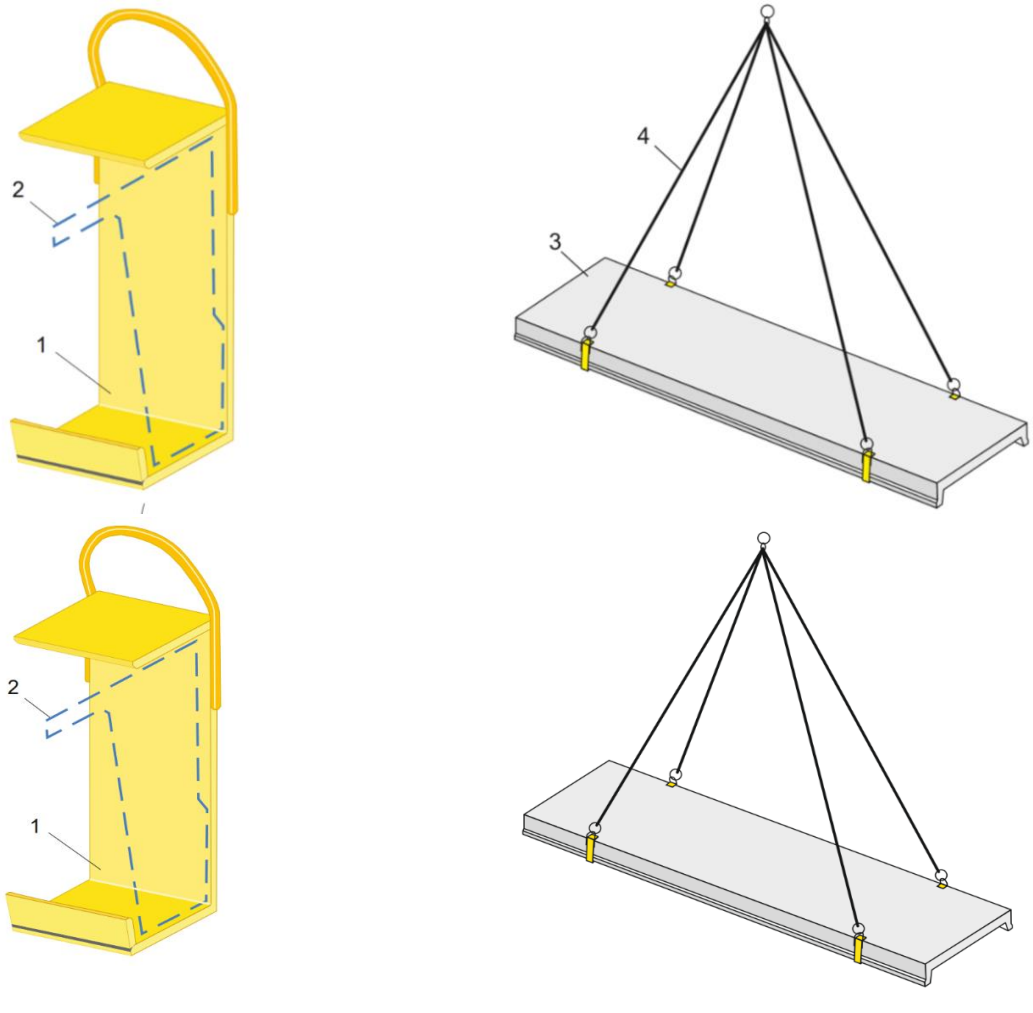
In order to make sure there can be slinging of plates with damaged slinging loops, the authors developed a special lifting device using computer and physical models named a sliding support grip in compliance with the classification given in GOST R 58520-2019 "Lifting Tools". The gripper is designed for a load-bearing capacity of 20 kN and can be used multiple times, as well as for reliable protection against uncontrolled disconnection from the plate.

Table 2

The most common causes of non-operability of slinging loops in reinforced concrete ribbed slabs

Causes of non-operability of sling loops	Conditions of causes of non-operability of sling loops	Average frequency of the cause, %
Significant corrosion of a sling loop material	Accumulation of atmospheric moisture in the coating thickness under the most vulnerable areas of the roof (under the eaves and overhangs), as well as where there is no vapor barrier or it was incompletely applied	15
Deformation of a cross section of a sling loop	The use of a sledgehammer while bending the hinges after laying the slabs in the design position	5
A bend with a radius of curvature of less than 5 mm	The same	25
Cracks and raptures	The same	8
The diameter of the reinforcement is less than 10 mm in compliance with GOST 9491-60	Factory defect occurring while a plate was being reinforced	5
No sling loops	The hinges were cut off after the slabs had been laid in the design position while the coating was being installed	11

The main gripper element is made of a 36P channel shorty in compliance with GOST 8240-97 "Hot-Rolled Steel Channels" with a length of 100 mm and a mass of no more than 10 kg. The grippers must be installed at the pre-cut slinging loops, i.e., at a distance of 1 m from the ends of the plate, as shown in Fig. 6 *b*.



a) *b)*

Fig. 6. General view of the sliding support gripper (*a*) and the loop-free slinging scheme of the coating plates (*b*): 1 — sliding support gripper; 2 — contour of the cross-section of the longitudinal rib of the plate; 3 — ribbed plate sized 1.5×6 m; 4 — four-branched sling

According to the results of a production inspection, four sliding support grippers, temporarily installed on the ribbed plate, allow not only lifting and moving it to the storage location, but also positioning it in a new manner or on a transportation vehicle.

It is suggested that dismantling and the proper dismantling of the load-bearing flooring is prepared in the following order:

– the physical wear of reinforced concrete load-bearing flooring is identified according to the signs of wear such as cracks in the joints between the slabs, cracks in the slabs, traces of leaks or freezing on the slabs, noticeable deflections of the slabs with exposed reinforcement;

– the existing sling loops are cut off;

– cuts are made with a depth of 200 mm along the longitudinal seams and transverse joints between the ribbed plates using a seam cutter, e.g., TSS RH-500G brand, with a diamond disc with a diameter of 500 mm;

– free access is provided to all of the three welded embedded parts of each coating plate, the load-bearing flooring in the span or cell should be dismantled in the reverse order to the way it was installed while the building was under construction. At the same time, plates can be freed from welds by means of an angle grinder or gas cutting equipment;

– plates with visible defects are identified that are unacceptable in compliance with GOST 9491-60 with the appropriate marking made;

– before a slab is lifted, it is made sure that it is completely released from attachment to the truss or beam of the coating by shifting from the adjacent slab along the supporting rafter structures by means of a sliding self-contained wedge KR2,5120 or two 20-30 mm mounting crowbars.;

– a slab is evaluated for further use in four possible ways;

– by means of a rack and pinion jack with a lifting capacity of 1-2 tons, free end of the plate by 20 mm is lifted by the end rib and two wooden pads are placed under it;

– on each longitudinal edge of the coating plate two sliding support grips are installed at a distance of 1 m from the ends of the plate;

– using a crane equipped with a four-branch sling, the plate is slung by the loops of the grippers, lifted and moved to the temporary storage area of the plates in compliance with the chosen direction of their further use.

The slabs should be evaluated after the dismantling of the load-bearing flooring based on the results of their loading tests in compliance with GOST 8829-2018 "Reinforced Concrete and Factory-Made Construction Products. Loading Test Methods".

While single-floor industrial buildings are under reconstruction, cutting welds and installing one of the ends of the plate on wooden linings is recommended from the mounting cradle of the hydraulic lift. The hazardous area for dismantling the load-bearing flooring must be fenced at the floor or ground level.

The above technological capabilities were validated over the years during the reconstruction and demolition of capital construction facilities in the cities of Rostov-on-Don, Astrakhan and Arkhangelsk. At the same time, the authors made use of the data from a questionnaire and expert assessments conducted by specialists with relevant experience in dismantling reinforced concrete structures of buildings.

Discussion and Conclusion. The study has allowed us to do the following:

– to justify the possibility and rational behind mechanized removal of mortar and fine-grained concrete from the joints between the coating plates with no damage to their edges to the depth of the existing groove by means of a 200 mm deep seam cutter;

– to prove the use of the known methods of slinging ribbed slabs during the dismantling of precast reinforced concrete load-bearing flooring of building coverings dangerous and inefficient. An alternative method of slinging has been set forth using the retractable support grips developed by the authors;

– expand the scale of possible use of coating plates in the presence of minor defects as permanent formwork for ribbed basement reinforced concrete floors and large-sized paving slabs.

Therefore as a result, a new resource-saving technology has been developed that allows dismantling of the load-bearing reinforced concrete flooring with no additional damage to the slabs with possible reuse with minimal waste, while saving labor and material resources, considerably cutting down the energy consumption for disposal of reinforcement waste and concrete crushing.

The resource-saving technology of dismantling the load-bearing flooring of reinforced concrete ribbed slabs is set to be in common use in restorating damaged buildings in the territories of the Russia’s new territories liberated during the special military operation.

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