DESIGNING AND CONSTRUCTION OF ROADS, SUBWAYS, AIRFIELDS, BRIDGES AND TRANSPORT TUNNELS

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BRIEF HISTORICAL REVIEW AND ANALYSIS OF SPIRAL-WINDING TECHNOLOGIES FOR THE INSTALLATION OF CULVERTS IN MODERN CONSTRUCTION

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Statement of the problem. A method for the construction of drainage pipes in road construction using the technology of arranging coiled pipes from polymer profiles with a metal core is considered. This technology has some unique properties and characteristics that make it possible to bring road construction to a new technological level.
Results. In the course of the study, an analysis of the spiral-wound technology for the construction of pipes was performed, the three most common technologies for the device of spiral-wound pipelines were considered in detail. A comparative analysis of the effectiveness of spiral-wound technologies in terms of characteristics, labor costs and cost of work is provided.
Conclusions. Spiral-wound technology is the most promising and optimal for road construction. The design features of the culverts built using this technology have no restrictions on the form factor, they allow one to arrange pipes of a wide range of diameters. The installation of ten meters of a coiled pipeline in a closed way is almost 3 times more efficient than that of a similar metal pipeline, requires 1.86 times less money, and is environmentally efficient. Adaptation of methods for calculating and designing pipelines to the features of spiral wound technologies will speed up and simplify the design and construction of culvert pipelines as part of the roadway.

Keywords: drainage pipes, spiral-wound technology, form factor.

Introduction. Profile pipes of various cross sections are commonly used in road construction. Using tubular structures, engineering problems are solved for drainage from the roadway, the passage of water and oversized vehicles under the road body, and the wiring of various networks and communications. Also, by means of pipes, cattle passes and other non-standard designs can be implemented. Of particular note is the use of various pipes in the reconstruction, replacement, restoration and strengthening of existing structures. In engineering practice, the methods of "stocking", "pipe in pipe", "internal winding" are commonly used. These methods allow addressing a broad range of problems in the repair and reconstruction of existing facilities. At the same time, the use of these methods can significantly reduce the complexity and cost of construction work.

In modern road construction, a wide range of tubular structures is utilized. Pipes of various form factors and sizes are used, made of various structural materials (reinforced concrete, steel, polymers), having different wall sections, etc. Each structure has its own positive and negative properties and is used in various engineering conditions having different operational properties. The technology of winding pipes made of polymer profiles with a metal core has become common lately. This technology has a range of unique properties and characteristics that make it possible to bring road construction to a new technological level. The use of coiled pipes in road construction allows one to:

— considerably reduce labor costs in the construction of pipelines for various purposes;

— reduce economic and time costs for the construction of one object;

— eliminate the logistics costs for the delivery of finished structures to the construction site;

— arrange pipelines in a closed trenchless way without blocking existing roads and without costly earthworks;

— design pipelines of variable diameter and various form factors;

— design pipelines of a wide range of diameters without major technological changes and the involvement of additional construction equipment;

— improve the strength characteristics and reliability of existing facilities during their repair and reconstruction.

Therefore the study of the strength characteristics of coiled pipes, the possibility of their application, the development of methods and recommendations for their construction are important scientific and technical problems in road construction.

1. Analysis of actual spiral wound technologies of culverts. As part of the study, three technologies were examined that were most widely used in the Russian Federation.

1.1. Spiral-wound technology "Polyplastic". This is a domestic technology for the manufacture of spiral-wound pipes for various purposes. The technology makes it possible to produce both finished pipes of a fixed diameter and length, and to lay pipelines directly at the construction site. The length of finished products varies from 1 to 6 m. The technology allows the production of round pipes with a diameter of 100 to 1200 mm. Typical types of pipe sections made using this technology are shown in Fig. 1.

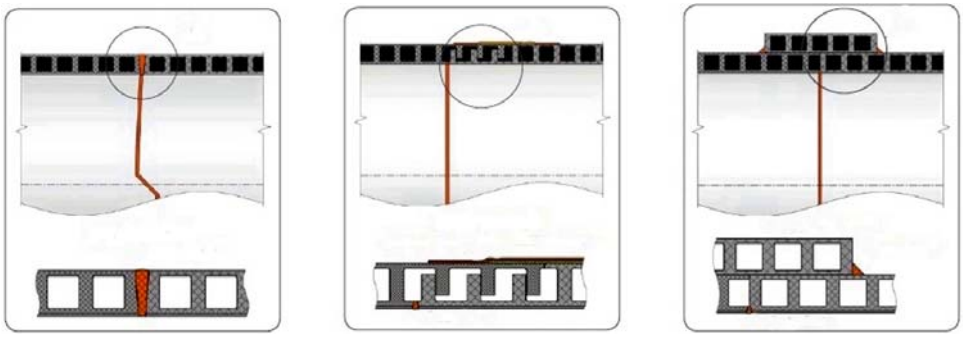

Fig. 1. Sections of pipes of the spiral-wound technology "Polyplastic"

1.2. Spiral wound technology SPR EX / SWP DF. The technology relies on the principle of a self-supporting static pipe used to restore pipelines with a diameter of 200 to 1000 mm. After repairing the channel, the casing pipe fits snugly against the old pipe. The technology has been specially developed for seismically active areas, regions with subsidence, landfill sites. Pipes produced using this technology have the maximum density and load resistance. A view of the self-supporting fabric of the casing pipe is shown in Fig. 2. Typical elements of this technology, as well as ways to connect them, are shown in Fig. 3.

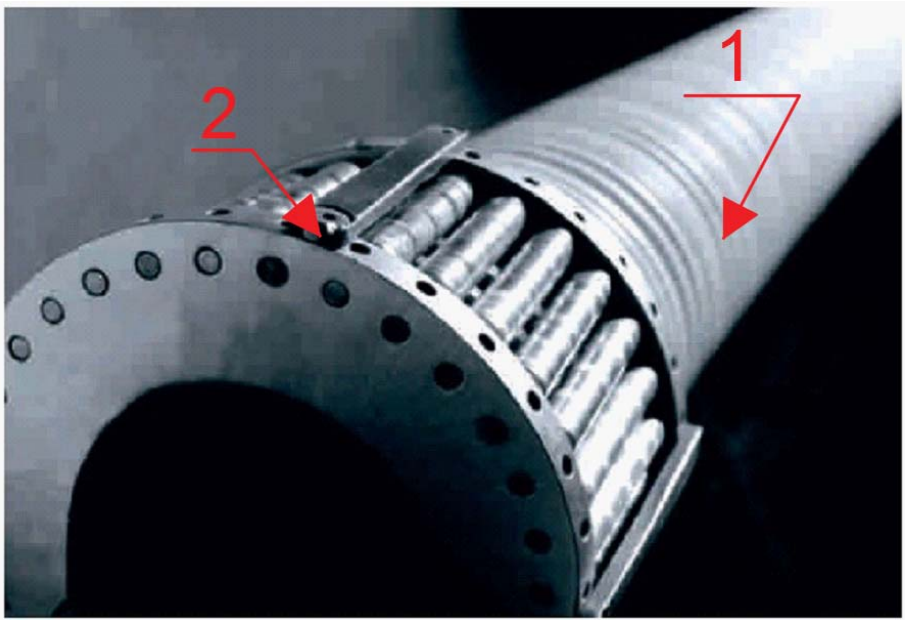

Fig. 2. Self-supporting casing sheet using *SPR EX / SWP DF* technology:
1 — pipe body; 2 — winding machine

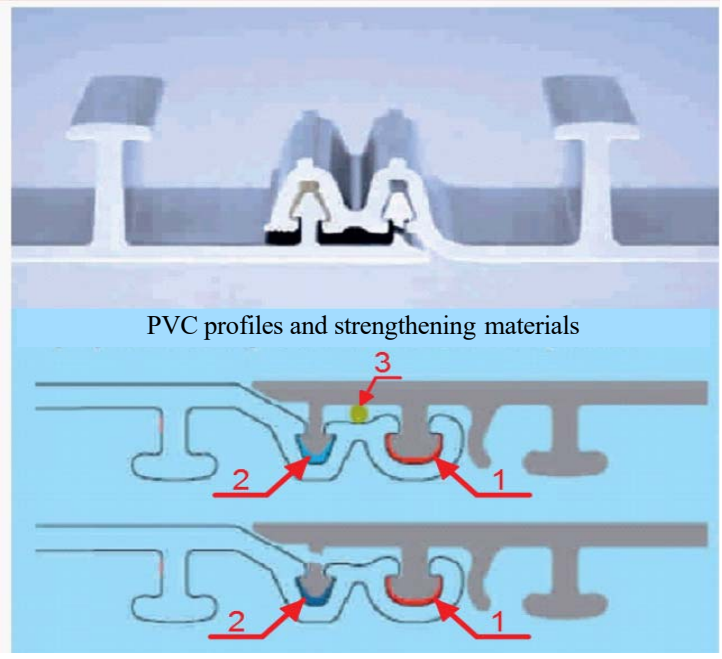

Fig. 3. Type of typical elements and their connections by means of thermal welding:
1 — lubricating sealant;
2 — glue;
3 — cutting thread

1.3. Spiral wound technology *Danby, SPR SL.* *Danby* system is a pipeline rehabilitation system that allows humans to pass through it. The technology is the most optimal and cost-effective for the restoration of large diameter culverts, culverts and irregularly shaped sewer pipelines. The technology was developed in Australia in 1984 and has been uccessfully applied in North and South America, Europe, Asia and Japan. *SPR SL* technology uses an interconnected PVC profile with a steel core to form the casing (Fig. 4).

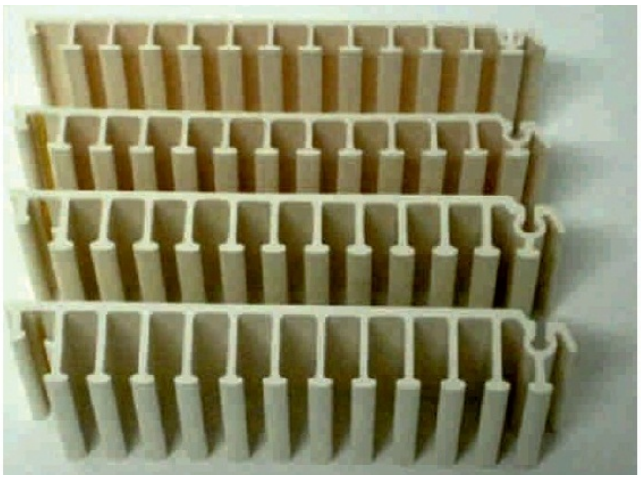

Fig. 4. PVC Casing Profile *SPR SL* technologies

SPR SL spiral wound technology is a further development of *Danby* technology. Its main feature is the ability not only to restore existing pipelines, but also to install new structures using the trenchless method, to apply this technology in vertical structures of mine shafts, wells, etc. The technology has no restrictions on the length and form factor of structures being installed. Pipe diameter can vary from 800 to 5500 mm. Examples of structures made using SPR SL technology are shown in Fig. 5, 6.

Fig. 5. Examples of structures made designed *SPR SL* technology:
1 — body of the drainage pipe (collector) before reconstruction; 2 — collector body after the application of the wound technology; 3 — typical element of *SPR SL* technology

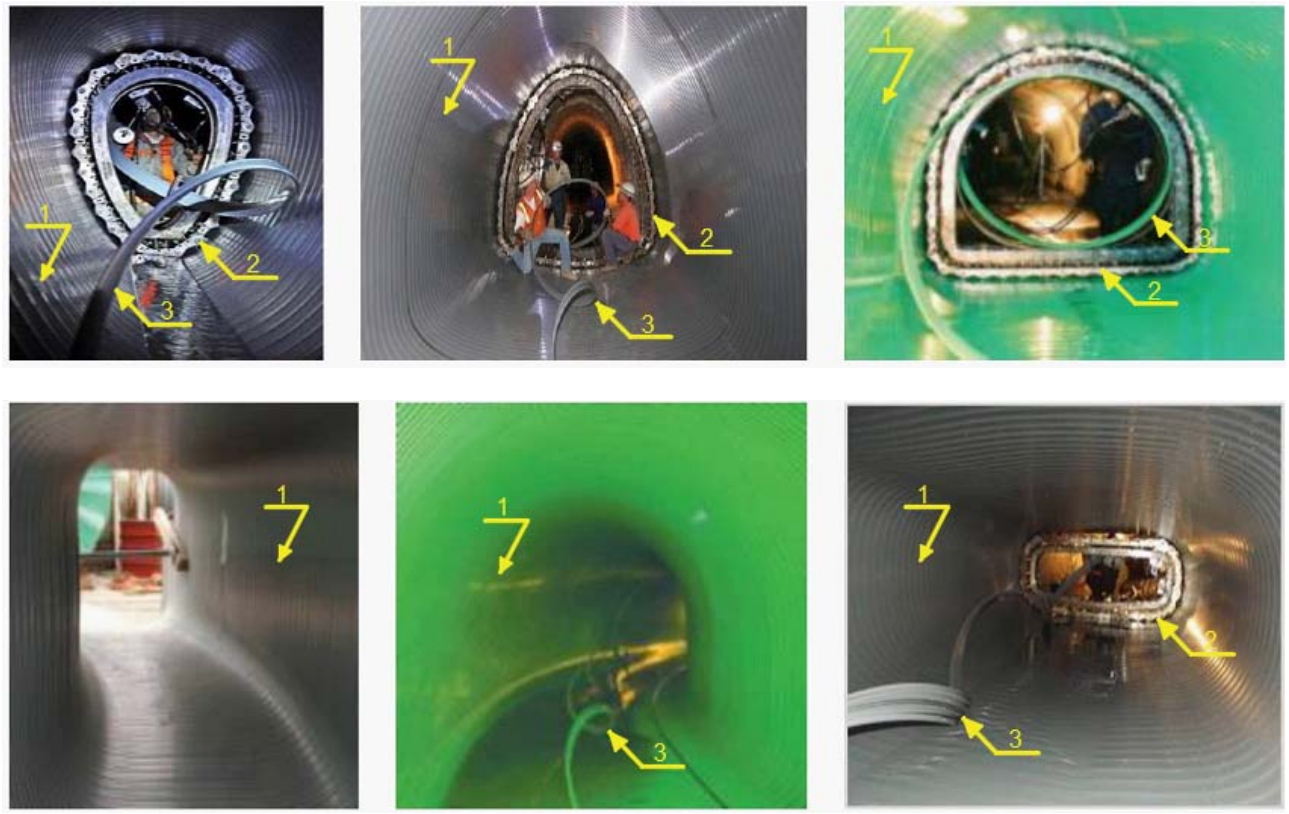

Fig. 6. *SPR SL* technology design form factors:
1 — body of the pipe (collector) after the application of the winding technology; 2 — winding machine;
3 — typical element of *SPR SL* technology

2.2. Analysis of the effectiveness of the examined spiral-wound technologies. Analyzing the characteristics of the technologies under consideration, it can be concluded that for the needs of road construction, Polyplastic and *SPR SL* technologies are of the greatest interest.

For a comprehensive analysis and justification of the effectiveness of *SPR SL* spiral-wound technology for road construction, the calculation of labor and economic costs for the construction of a 10 m metal culvert pipeline using standard technology and a spiral-wound roadbed in the body of an embankment was performed. The calculation results are shown in Table.

Table

Piping costs

Description of works	Labour intensity, person/hour	Cost, roubles
Installation of a 10 m metal pipeline in an open way		
Ground works		
1. Soil development with excavators	14.12	76910
2. Movement of developed soil	186.72	112873
3. Chipping work	9.559	44650
4. Pipeline laying devices	75	144081
5. Reverse laying considering sand	22.4637	585236
6. Compaction, clotting of laying soil	135.625	86815
7. Soil preparation for lawn	39.375	126209
8. Lawn laying	39.375	21520

End of Table

Assembly works		
1. Movement of structures	93.36	79396
2. Laying pipe sections	4.1	210663
3. Docking of pipe sections	1.99	32456
4. Installing pipe sections	1.55	22363
5. Изоляция стыков	3.27	22362
6. Санитарная обработка	15.5	10597
Итого	642.0077	1576131
Installation of a 10 m winding PET pipeline in a closed way		
Ground works		
1. Installation of a drilling rig 100 tf	8	42309
2. Soil development	8.557	46609
3. Movement of the developed soil	46.68	46126
4. Installation of a closed underground passage	118	462781
5. Dismantling of a drilling rig 100 tf	8	42309
Description of works	Labour intensity, person/hour	Cost, roubles
Installation of a 10 m metal pipeline in an open way		
Assembly works		
1. Installation of a winding setup	4	32465
2. Underpass tunneling	5.6	118954
3. Dismantling of the winding plant	4	32465
4. Joint insulation	0.257	10317
5. Sanitary works	15.5	10597
Total	218.594	844932

Conclusions. An analysis of the design features of various spiral-wound technologies, labour intensity and economic efficiency indicators made it possible to draw the following conclusions:

— *SPR SL* spiral wound technology is the most promising and optimal for road construction. The design features of culverts built using this technology do not have restrictions on the form factor, they allow arranging pipes of a wide range of diameters;

— the installation of ten meters of a coiled pipeline in a closed way is almost 3 times more efficient than that of a similar metal pipeline. When constructing a winding pipeline, significant savings are possible both in machine hours of the equipment used and in the labor costs of workers. The terms for the construction of such a pipeline can be significantly reduced, which will positively impact the commissioning of the entire complex of structures and structures of the highway;

— in terms of economic efficiency, the coiled pipeline also outperforms the standard metal one. The installation of ten meters of a coiled pipeline requires 1.86 times less funds compared to a standard metal one. It should also be noted that the use of the closed method of laying coiled pipelines requires much less technical and material resources.

It should also be noted the environmental efficiency of the installation of coiled pipelines in a closed way. Local development of the soil and the compact size of the laying machine have a positive effect on the ecology of the roadside area. The landscape adjacent to the roadway undergoes minimal changes, the ecosystem is not disrupted. Also, upon completion of the installation of coiled pipeline structures, no restoration work is required such as backfilling, restoration of lawns and green spaces.

Therefore further studies of the strength characteristics, various form factors and the stress-strain state of a coiled pipeline as part of road construction are extremely relevant. Further calculations will make it possible to identify the most optimal sizes and form factors of culvert systems for the road industry, mathematical modeling of the elements of a coiled pipeline will contribute to the formulation of recommendations for the construction of standard structures. Adaptation of methods for calculating and designing pipelines to the features of spiral-wound technologies will speed up and simplify the design and construction of culvert pipelines as part of the roadway.

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