ANALYSIS OF PERFORATED STEEL TAPE USAGE POSSIBILITY IN CONSTRUCTION

M. Lisicins, V. Mironovs, L. Kaļva
Riga Technical University,
Institute of Building Production,
Division of Building Machines and Building Mechanisation
mihails.lisicins@gmail.com; viktors.mironovs@gmail.com

ANNOTATION

This work is devoted for analysis of perforated steel tape, in this case also manufacturing remnant, usage possibility. There are defined physically-mechanical properties and geometrical characteristics for different types of tape. The perforated tape samples tension strength is noticed in the amplitude of 168 to 921 MPa, compressive strength of profiled stands – 350 MPa, but surface hardness in the amplitude of 830 to 3030 MPa. It is proved that tape by its physically – mechanical and esthetical features can be effectively used as a design element, reinforcing and constructive material in the construction processes. Effective solutions for use of perforated steel tape are form elements, reinforcing in reinforced concrete constructions and brick masonry, floor spacers, elements of wall constructions and other construction load-bearing elements.

Key words: perforated steel tape, technological rubbish, reinforced concrete, strength, hardness.

INTRODUCTION

Construction is an area for which fast development, unstoppable searching of new solutions and investigating of new technologies are characteristic. One of the tendencies is usage of light constructions. Light constructions can be made from perforated steel tapes, plates and profiles.
Perforated profiles and tapes using in the construction let to reduce metal usage, make faster preparation and montage of the construction, reduce the amount or necessity of welding works.
However, determined making of perforation visibly make bigger manufacturing costs that is why the biggest meaning is being achieved of perforated tapes as usage of manufacturing waste.
Valuable usage of the materials is one of the significant modern tasks of the material science (Mironovs, Serdjuks, 2003). One of the ways of solution of this task is reiterative manufacturing waste usage. Latvia also has a number of factories, whose production waste can be re-used for different targets. Perforated steel tape as waste material after punching in Latvia is obtained in JSC "Ditton Driving Chain Factory" (*Perforated tape…*). Now as example of successful usage for realization of building solutions perforated steel tape is shown (Миронов, Сердюк, Муктепавела, 2004).

THE ROPERTIES AND EXPERIMENTAL EVALUATION

In the work are researched mechanical and geometric properties of the perforated steel tape which is waste of the manufacturing processes. They differ with the cross-section area, form and size of the perforation and with the amount of it. Some geometrical characteristics are shown in Table 1.
Samples of perforated tape with the standard method were tested on the tension strength. The test of the tension strength was made with the device INSTRON 8802.
The experimental results showed that the tension strength depending on type of tape changes are in the interval 168 – 921 MPa.
The critical load, tensile extension and tensile strength of samples from Table 1 are shown in Fig. 2 and Table 2. Results were obtained using the weighted average of the 5 test attempts.
With Brinels method a test on hardness at 50 and 300 N big load was made, using a device which allows to make larger load up to 1000 N. In the result of the test was achieved material hardness that was from 830 to 3030 MPa. The results are matching with the steel mark hardness which are shown in Table 2.

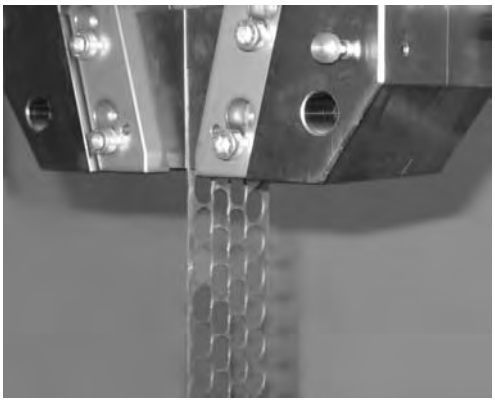


Fig.1 The test of perforated steel tape tension strength.

Table 1

Different types of perforated steel tape and their geometric properties

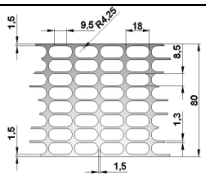
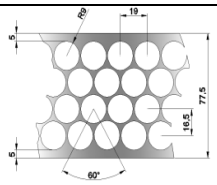
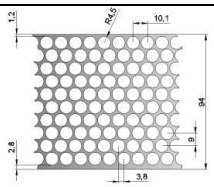
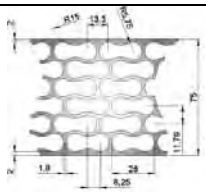
Type of tape				
	LM - 1	LM - 2	LM - 3	LM - 4
Width, mm	80,00	77,50	94,00	75,00
Thickness, mm	1,20	1,50	1,00	1,80
Cross-sectional area (Brutto), mm^2	96,00	116,25	94,00	135,00
Cross-sectional area (Netto), mm^2	14,60	24,27	12,35	29,27
Permeable area, %	74	69	67	63

Table 2

The mechanical properties of different types of perforated steel tape

Type of tape	Steel mark, Standard	Max load, N	Max tensile extension (to collapse), mm	Tensile strength, N/mm^2
LM - 1	St 50 ps, AUSS 2284-79 [5.]	13457,63	2,45	921,76
LM - 2	St 08 ps, AUSS 503-81 [4.]	14056,56	2,49	579,17
LM - 3	St 08 ps, AUSS 503-81	5703,45	8,45	461,82
LM - 4	St 08 ps, AUSS 503-81	4944,92	6,21	168,94

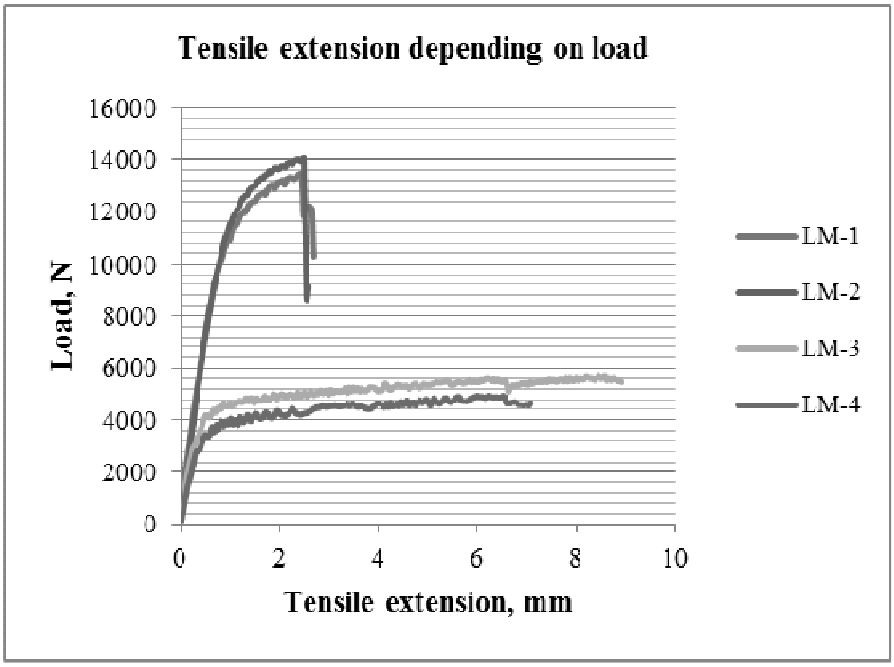


Fig.2. Load - tensile extension curves for 4 types of perforated steel tapes.

The achieved results let us to conclude that the viewed different mechanical features of the perforated tape waste can be equated to these steel tape mechanical features which are now used in the realization of different building targets. For example, steel tape which is used as different type surface load bearing elements strength is in limits of 380 – 900 MPa (Ермолов , 1991).

ANTI CORROSION EVENTS

As with every metal element, including also steel, there is disposition to corrode with the time and with it to lose the initial mechanical features and then there is a necessity to make anti-corrosion events.

One of the protection methods is zincing. As zincing disadvantages we can consider higher process costs nd possible material rolling by its dipping in the bath with zinc fusion.

Many samples were overlaid with zinc coat in the density of 30-40 mkm. The hardness measurements using the Brinel method on the most of the surfaces showed relation to the initial values – HB = 1060 – 1200 MPa.

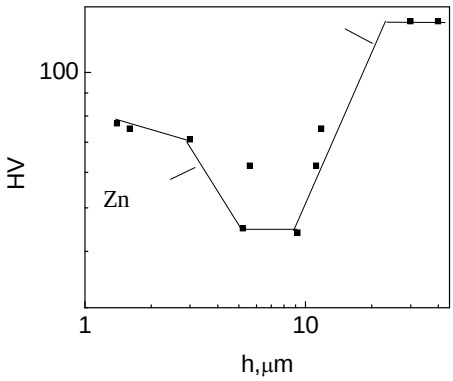


Fig.3. Micro hardness (HV) dependence on ferrule absorption (h) zinc overlay on steel surface.

For notification of micro hardness an accurate measuring device was used [9] that let us to use a load from 3 mN to 2 N. Micro hardness notification relating from the ferrule pressing depth let us evaluate the surface hardness and adhesion with the base. As we can see in Figure 6, micro hardness in dipped diapason up to 10 mkm corresponds to the zincing galvanic overlay with good adhesion. Whereas rising of micro hardness at bigger dipping depth is related with hard steel influence.

As cheaper anti-corrosion way we can mention polymeric overlay which is laid with help of thin disperse powder. For putting thin disperse powder on the perforated tape surface we used a method with putting it in electronic area (Герасименко, 2001).

After putting on 30-40 mkm lay, the tape or construction with its usage was subjected to thermal heating in the term camera till temperature of polymerization of the overlay. But we must notice, that polymeric overlay adhesion with the steel surface in the given case is not big. It is expediently at first to subject the tape to mechanical cleaning from oil or other dirt and further subject to chemically – thermal processing, for example, phosphoting. In this case the overlay adhesion with the steel tape is higher.

USAGE POSSIBILITIES IN THE CONSTRUCTION

Interior and exterior elements

Perforating tape is possible to use in interior and exterior decorative formatting, this let us find interesting and unusual solutions. For example, it is possible to make decorative sieve wicker works, panels (possible usage area – making of saving elements of blast, fireplace and stove). In Figure 4 a sample of blast panel in which the base is sieve from perforated steel tape is shown. Decorative type is achieved overlaying two layers perpendicular one to another performed tape samples with the same perforation (in the given case on its basics there is round punching).

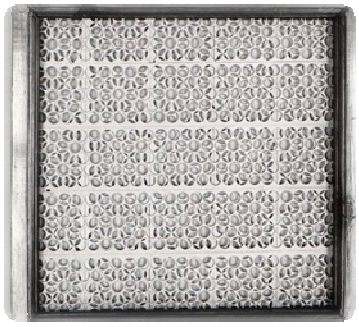


Fig.4. Decorative blast panel from perforated steel bands.

In the same way on the basis of perforated elements it is possible to make different limiting constructions inside and outside (for example, for borders of balconies and loggias).

Without the samples mentioned before, from perforated steel tape it is possible to make lightning systems with unique light separation (Mironovs, Truļins, 2009), different furniture details, for example, table legs (Kaļva, 2010), shelf systems, and perforated benches.

Bricklaying works

It is possible to use perforated tape for reinforcement of bricks and other materials of brick walls (Mironovs, Lapsa, 2006). The reinforcement sieve which is laid in the brick horizontal joints (Figure 5), for manufacturing it is possible to use industrial waste at which belong also in this work overviewed perforated tape and it is considered as a pretty rational approach.

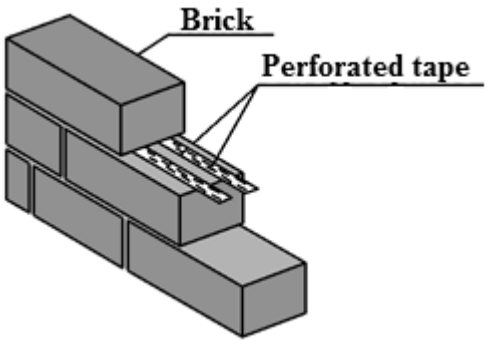


Fig.5. Brick wall reinforcement with perforated tape.

At first, due to brick wall reinforcement, its load-bearing ability is rising (due to this that reinforcement delaying longitudinal tension deformation development in the bricks and delaying vertical cross curve distribution in all height of the bricks) and secondly, expediently raw material waste is used.
For this kind of brick reinforcement technologies establishment also patents are known (Mironovs, Lapsa, 2006).
Reinforcement sieves which are made on the basis of perforated tape (sieve fragment is shown in Figure 6) have high functionality, they have high strength characteristics, the tape sizes are easy comparative with the brick sizes, whereas the perforation curves, which constituting about 60 – 70%, ensure good adhesion with brick java.

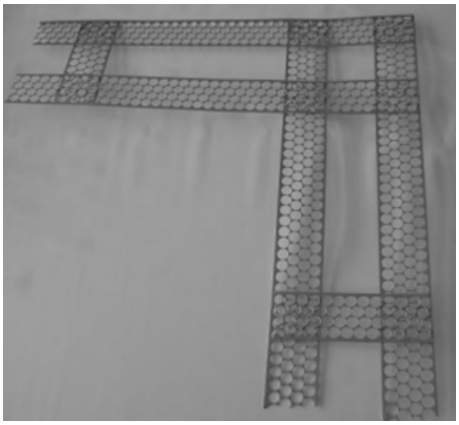


Fig.6. Reinforcement sieve fragment which is made of perforated steel tape.

Perforated tape usage in brick reinforcement already has achieved good references from builders – it is better placed in joint places and easier cut in the necessary pieces.
In addition, worth nothing that perforated waste tape is up to 3 – 4 times cheaper (0,08EUR/m) than special reinforcement (Bi - armature) – 0,28EUR/m (*Steel reinforcement*…..).

Internal and external finishing works

- Perforated steel band and its products in plastering works

Riddles made of perforated steel band rolled with a small thickness, can be successfully used in plastering works for wall surfaces. For this purpose elements of the perforated steel band are first connected by welding in riddles.
Another variant of using perforated steel band in plastering works – profiles made of perforated steel band can be used as guide profiles, finishing profiles and corner profiles. Corner profiles provide a connection between a plaster of two perpendicular walls, so developing of cracks is prevented.

- Using perforated steel band profiles for insulation fixing in wall and ceiling constructions

One of the possible ways for fixing heat insulation using perforated double-T shaped profile is shown in Figure 7. In this case into the hollow space of the double-T profile a heat insulation material has been put in, from outside this construction has been covered with gypsum slabs.

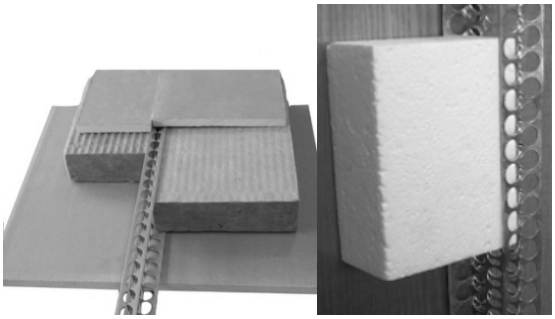


Fig.7. Using of perforated profiles in wall construction solutions..

Fig.8. Connection of perforated steel band and gypsum plate with adhesive on gypsum basis.

Road-adherence between perforated steel profile and gypsum plate is possible get by using quick-hardening adhesives on gypsum basis (Fig. 8) (Lapsa, Mironovs, 2005). The strength tests of this kind of joins showed that the shear strength of the joint is from 0.75 to 1.50 MPa. The main characteristics of this method is its simplicity, high

productivity, so this method of joining perforated steel profiles and gypsum plates is advisable in montage of non-responsible building constructions (Mironovs, Boyko, Sedjuks, 2006).
The load carrying capacity of the double-T shaped and U-shaped struts (Li, John, Maricherla, 2006) with a joint support was evaluated as centrist-pressed elements with constant cross-section.
For example, with the folding methods there were made 2 U-shaped profiles, with the „wall" height h=53 mm, these profiles were connected together by using the spot welding method, thus creating a double-T shaped perforated profile.

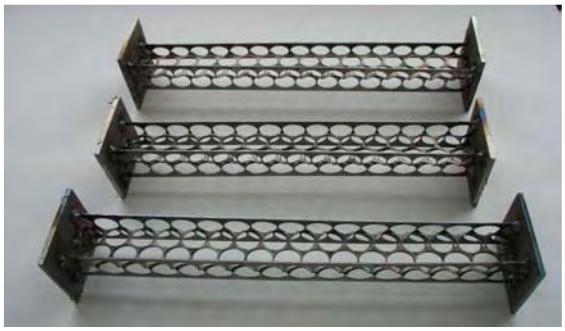


Fig.9. Perforated struts before pressure strength test

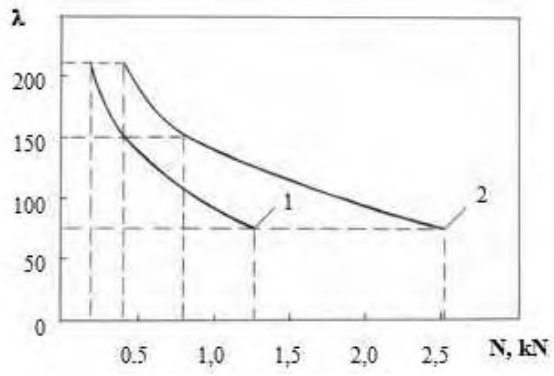


Fig.10. Load bearing capacity N of struts, depending on flexibility λ (1 – strut with U-shaped cross-section; 2 – strut with double-T cross-section).

As a result the max load bearing capacity of the struts was gained, when the flexibility of the struts were λ = 75. The yield strength was 350 MPa. The load bearing capacity depending on the flexibility of the struts with different cross-section is shown in Figure 10.

- Perforated steel band in suspended ceiling constructions

When making suspended ceiling constructions, there are different ways how to brace the ceiling plates, for example, we can use strands; use hang up elements with a special upper part; it is also possible to fasten the plates directly to the wooden elements (beams). It is also possible to use perforated steel band as a hang up element, as it is shown in Figure 11.

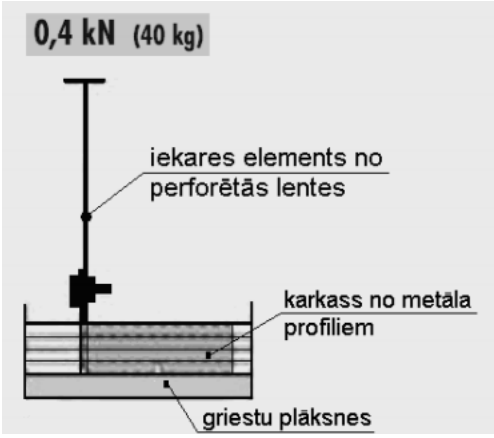


Fig.11. Perforated steel band in suspended ceiling constructions

According to DIN 18 168, the load carrying capacity of the perforated steel band hang up element is 0,4 kN.

Perforated steel band as a reinforcement element

- Perforated steel band reinforcement for sewerage tubes

For this purpose spatial spiral-shaped carcasses have been created, as it is shown in Figure 12. In the manufacturing process this spatial carcass is covered with a rubber layer from both sides and then vulcanization is carried out in special ovens. Thus, we get tubes that are a safe and resistant building material, suitable for non-pressure sewerage networks.
The main physical-mechanical characteristics of the sewerage tubes made in such way meet the requirements set up for sewerage tubes (for example, water absorption less than 8%) (Kaļva, 2010).

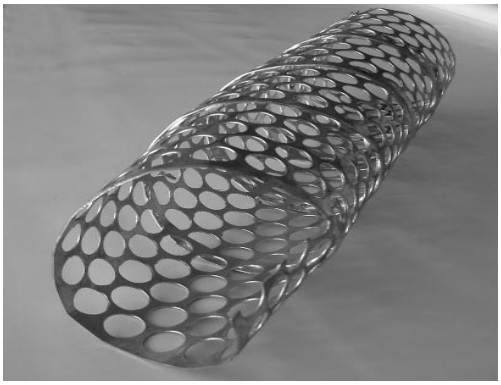


Fig.12. Spatial spiral-shaped carcass for manufacturing of tubes.

- Manufacturing of reinforced rubber

It is rubber that has reinforcement of reinforcement nets, made or perforated steel band elements. Reinforced rubber is used for manufacturing, for example, rugs for vibration smothering. These rugs are used under motors, vibrating-tables, air-pumps and other devices that make noise and vibration.

- Road surfacing with reinforcement from perforated steel band

A fragment of the decorative pedestrian road with reinforcement from perforated steel band is shown in Figure 13. Wide bands of the reinforcement prevent the birth of cracks as a result of concrete compaction.

Fig.13. Fragment of decorative pedestrian road.

Also motorways are made using reinforcement of perforated steel band. Reinforcement nets are made for this purpose and embedded before asphalt is covered.

Concrete works

- Block constructions

Perforated materials can be used also in making block constructions (Figure 14).
Block elements consist of a frame and reinforced-rubber shields. Perforated steel band is used as reinforcement for the shields. Reinforcements can be made of double-T shape perforated profiles as well. The dimensions, thickness of perforated profile depend on the size of the block element. The gain is that by using reinforced-rubber block elements, road adherence between the concrete and block element is minimized.

Fig.14. Shield block made using reinforced-rubber and perforated profiles.

Block elements after removing are very clean, there is no need to clean them. Reinforced-rubber shields also give a possibility to make decorative patterns on the concrete surface. Strong and safe block element construction provides repeated usage of the block element, and because of its small weight it is quick to install.

- Spacers for floor and covering concrete works

One of the most perspective ways how to use perforated steel band in building constructions is manufacturing spacers (Lange, Song, 2004) that can be used in concrete works.
The main tasks of the spacers is to fix reinforcement in stable position while performing concrete works, also to provide the necessary thickness of the concrete layer for anti-corrosion.
Spacers made as concrete prisms (Тепиченко, Лапидус, 2005), plastic spacers (Chudley, Greeno, 2001) and „small-bench" type spacers from reinforcement steel (*Betomax*…..) are already known.
If we compare the spacers mentioned this line above, the spacers made of perforated steel band have the following advantages:

1) In comparison with plastic spacers the load (common weight of reinforcement carcasses and workers) bearing capacity is higher;
2) Lower manufacturing costs (using perforated steel band which is as a manufacturing waist product);
3) Usage of metal working products – thus ecological factors have been taken into consideration (Lapsa, Mironovs, 2006).

The physically-mechanical characteristics of perforated steel band gives a possibility to bend it, also to weld it, so it is possible to make different spacers with a wide range of shapes.
T-shaped spacers can be made by welding, when two L-shaped elements are welded together; another way is bending T-shaped spacer from one element (Figure 15).
Double-T shaped spacers can be with different whatnot width (Figure 16, a), or with similar whatnots (Figure 16, b). This kind of spacers is made of two U-shaped elements

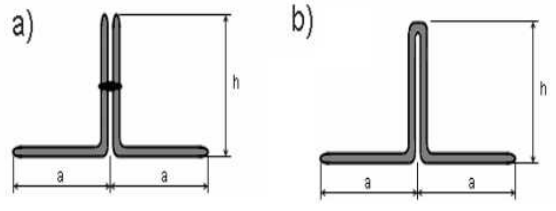


Fig.15. T-shaped spacers (a – welded from two L-shaped elements;
b – curved from one element).

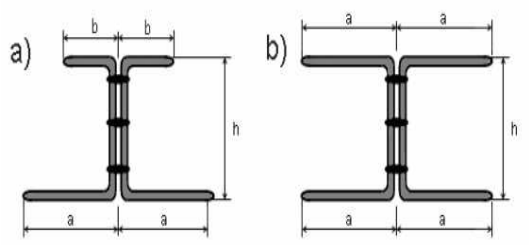


Fig.16. Double-T shaped spacers, weld of two U-shaped elements (a – with different whatnot width; b – with similar whatnots).

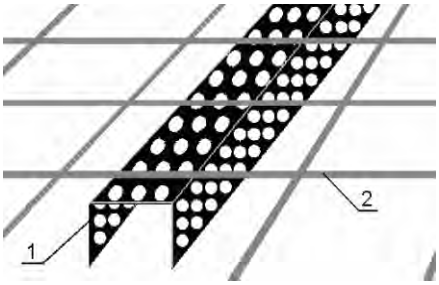


Fig.17. Support of reinforcement on long U-shaped spacer (1 – spacer; 2 – reinforcement).

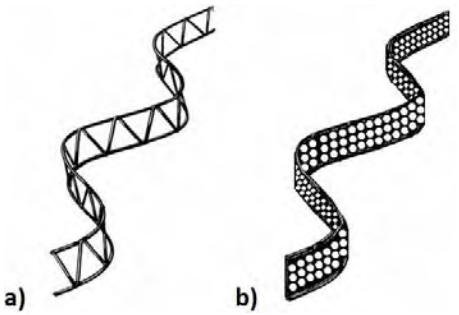


Fig.18. „Serpent-shaped" spacer (a – traditionally known „serpent-shaped" spacer; b – spacer from perforated steel band).

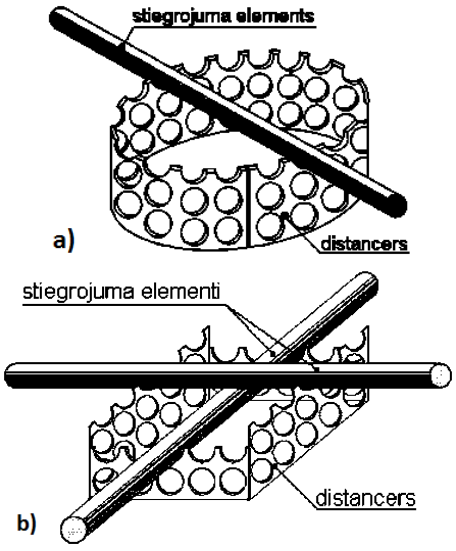


Fig.19. Round (a) and quadrate (b) shape spacers from perforated steel band.

One of the spacer kinds, which is most easy to be made and also most stable in its construction is the U-shaped spacer. U-shaped spacers can be used in two ways – with their whatnot position to top or to bottom.

This kind of spacers can be made short, and then it is suitable for placing reinforcement nets in their cross-points. They can be made also tall, then spacers will be more stable, but in this case the material usage will be larger (Figure 17).

In Figure 18,a a traditional "serpent-shaped" spacer is shown, widely used for upper and lower reinforcement nets upheld. This kind of spacers can be easy made from perforated steel band, by modulating it in the desirable shape (Figure 18,b).

One more very efficient kind of reinforcement spacers is round and quadrate shaped spacers, bended and welded from perforated steel band (Figure 19).

The shape of the spacers gives high stability, but perforation wholes give stability for upheld reinforcement and also a possibility to choose the direction of upheld strands.

Quadrate shaped spacers can be made also with dissimilar height of their sides. In this case it is possible to place oblong-reinforcement and crosswise-reinforcement together.

CONSCLUSIONS

On the basis of the test results and analysis of possible usage of perforated steel band in civil engineering, we can conclude that:

1) perforated steel tape have very different geometry, area of perforation is not less than 60 % of the total area;

2) the tensile strength of different types of tape is noticed in amplitude 168 – 921 MPa, but hardness 830 – 3030 MPa;

3) the load bearing capacity of double-T shaped struts is between 0,4-2,6 kN when the flexibility λ is 75-220. The maximal pressure strength is 350 MPa, when the flexibility λ=75;

4) the possibilities to use perforated steel band in civil engineering become wider, if we perform profiling of the band;

5) Thus, physically-mechanical characteristics of perforated steel band, also as a manufacturing waist product, allow using it not only for decorative interior and exterior purposes, but also for different kind of constructions. Reinforcement of brick and stone walls, masonries; using of armo-rubber shield blocks and spacers of perforated steel band can be known as most efficient.

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