TRACK ON LONGITUDINAL CONCRETE BEAMS FOR METRO TUNNELS

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ABSTRACT

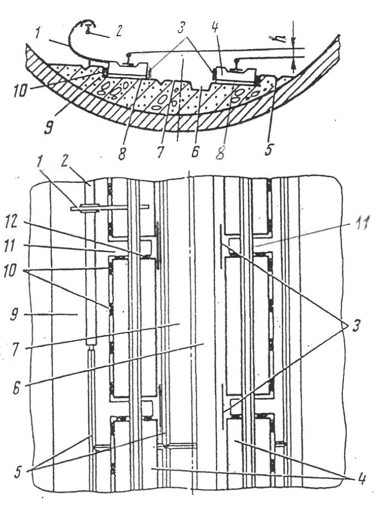
The article describes the design features and technology of laying of a vibroprotective track, wherein longitudinally oriented reinforced concrete beams (or sills) without transversal connectors, are used as a rail base. The advantages of this design as compared by substantial indicators with other constructions, used in metro, are shown.

Keywords: metro, tunnel, vibration protection track, longitudinal concrete beams, sills, control, gauge width, rail fastening.

Background. *With increase in the volume of metro construction in the cities of the country under favorable conditions, preference is given to embodiments of subsurface that are no less than three times cheaper than deep level projects. But on the facilities located on the surface of shallow tunnel, significant vibration from passing trains is transferred, affecting their strength performance and health of people living in houses near metro tracks [1].*

Even in Soviet times, in accordance with the decision of USSR State Committee for Construction the Ministry of Railways (in that period metro was subordinated to this ministry) was instructed to organize the development of a design of vibroprotective track for underground tunnels. In VNIIZhT [Russian research institute of railways] a laboratory with that special objective was organized. As a result, vibroprotective track with longitudinally oriented concrete beams (abbreviated VPTLCB) was developed [2, 3].

VPTLCB field tests were conducted in experimental ring of VNIIZhT and maintenance – in the curves of radius of 500 m of Kiev metro [3]. Based on the positive results experimental sections of construction of a vibroprotective track were accepted and transferred into operation from the category of test into standard. Kiev metro specialists completely abandoned the use of wooden sleepers in new tunnels. Instead of a track with wooden sleepers the construction of VPTLCB began.



Pic. 1. General scheme of a vibroprotective track with LOC-beams reinforced concrete rail base: 1– bracket of a contact rail; 2 – contact rail (with protection box); 3 – removable side pads; 4 – reinforced LOC-beams; 5 – drainage grooves; 6 – drainage gutter; 7 – a footpath; 8 – under-beam damping pads; 9 – track concrete layer; 10 – lateral dampening pads; 11 – longitudinal stops; 12 – damping pad of longitudinal stop; h – elevation of the outer rail.

In 2000, Novosibirsk metro mastered a vibroprotective track with an ability to use in tunnels, both of shallow and deep level. And in view of the earlier experience of Kiev and Novosibirsk metro Russian Gosstroy [then ministry of construction] finally approved vibroprotective track as universal solution regardless of laying levels.

Objective. *The objective of the authors is to consider a design of a vibroprotective track using longitudinal concrete beams without transversal connectors laid on concrete foundation and to prove its engineering advantages.*

Methods. *The authors use general scientific and engineering methods, comparison, modeling.*

Results. *Pic. 1 is an overall view of VPTLCB which is fundamentally different from domestic and foreign structures in which as a rail base, separately for each rail line longitudinally oriented concrete beams (or sills), are used. Rails are fastened to them using intermediate rail fastenings.*

Concrete beams do not have a rigid connection with an under-beam foundation and between each other in a laterally horizontal direction. [The so described longitudinally oriented concrete beams are shortly called after in the article LOC-beams – Ed. note]. So each separate rail line joint to a LOC-beam has a possibility of free movement in the lateral horizon.

Longitudinal supports, which are placed separately under each rail line between ends of adjacent LOC-beams and which are in a tight connection with under-beam foundation, resist movement of LOC-beams with rails in the longitudinal direction.

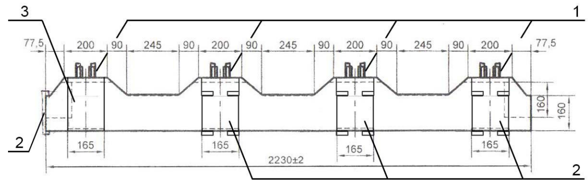
JSC Metrogiprotrans [Metro design institute] in 1993 under the technical project of VNIIZhT and with its direct participation, as well as using practices of Kiev metro, developed a project documentation of VPTLCB for tunnels of Moscow metro. It was approved in late December by senior management of Moscow Metrostroy [Metro construction company] and Moscow metro.

However, Metrogiprotrans adopted soon another track option, proposed by Moscow company «ABV» without a feasibility study. Vibration-protection track VPTLCB [5], however, compares favorably with the track of the company «ABV» basing on the following parameters [6, 7]:

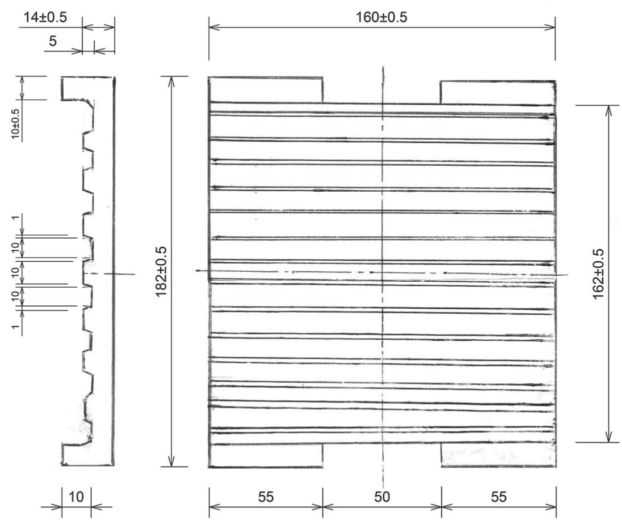
– extension of a life cycle of LOC-beams to 70 years;

– reduction by not less than 3,8 times (in 2006 prices) of the costs of the elements of track superstructure;

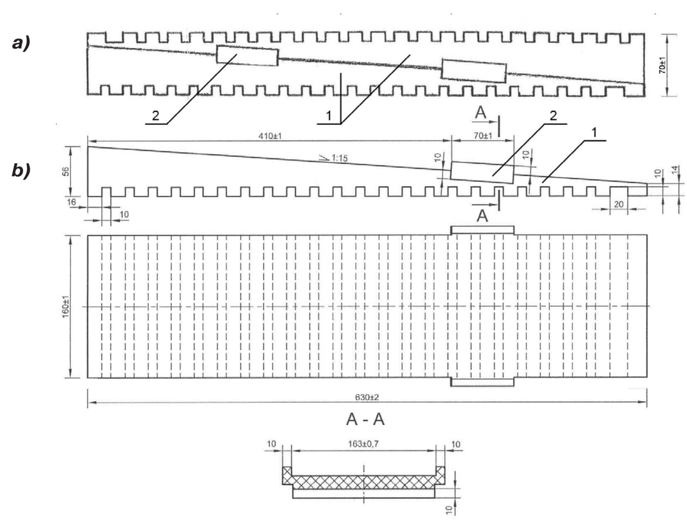
– exclusion of cutting-out of a track concrete layer when substituting a rail base (LOC-beams);



Pic. 2. Reinforced LOC-beams combined with the anchor threadless intermediate fastening ARS: 1 – metal fastening anchors ARS; 2 – uniform pads damping on the contact with lateral and longitudinal stops; 3 – site to place a pad.



Pic. 3. General view of unified electrical insulating gasket to be installed between lateral, longitudinal stops and LOC-beams.



Pic. 4. General view of under-beam dampening gasket (a) and wedge-shaped element electrically insulting element of under-beam gasket (b): 1 – wedge-shaped element of under-beam gasket; 2 – tides.

– increase in efficiency of vibration protection [8, 9];

– exclusion of threaded fastenings in the elements of intermediate rail fastenings;

– reduction by not less than 4,5 times the labor costs for the current track maintenance;

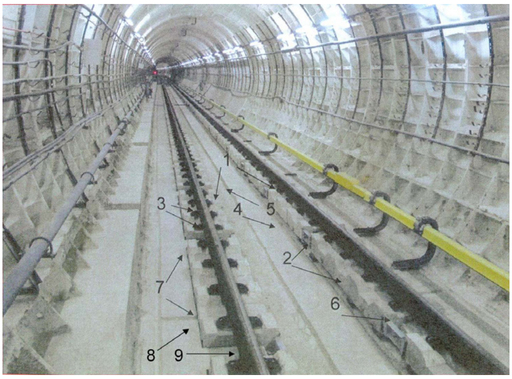
– substantial simplification of the smooth adjustment of the gauge width in turnout curves;

–the use of only the domestic elements of track superstructure;

– reduction of up to 7 units of the number of removable parts in the fastening assembly ARS versus 36 in the fastening assembly VGS- 2 of the company «ABV»;

–exclusion of the need for recycling of LOC-beams at the end of their life cycle as it is possible to use them for another purpose (it is possible, for example, to arrange them with a freshly prepared concrete foundations of some facilities, sidewalks, walkways, etc.).

According to the experience of the main railways, the cost of disposal of one concrete sleeper is several times more expensive than the cost of its manufacture. In Moscow region on a specially built factory utilization of concrete sleepers is produced by crushing concrete with the aim of re-using it, for example, as a base under the crushed stone ballast.



Pic. 5. General view of a vibroprotective track with LOC-beams on the haul from station Shipilovskaya to station Zyablikovo of Moscow Metro:
1 – reinforced LOC-beams; 2 – damping under-beam gaskets; 3 – intermediate rail fastenings ZHBR; 4 – footpath; 5 – drainage gutter; 6 – lateral clamping pad; 7 – lateral damping gasket; 8 – side stop; 9 – longitudinal stop.

The utilization technology leads to formation of highly crushed dust particles that spread in the air over long distances from the source of concrete crushing. The presence of people in a dusty area has a very negative impact on their health. Currently, experts propose to ban utilization of sleepers by crushing method.

The joint research and test center «Advanced Technologies» (MIIT) embodiments of a unified vibroprotective track for double-track tunnels, as well as for single-track and double-track bridges were developed and patented [5].

On each LOC-beam four rail seats for rails R65 are provided. The distance between the axles of rail seats of 625 mm is selected on the basis of sleeper density as 1600 pcs / km, for both direct and curved sections of railway track. The length of a LOC-beam is taken equal to 2230 mm and the distance between adjacent ends of LOC-beams is 270 mm, which as a whole is multiple of the standard length of the rails. The LOC-beams are made of concrete, corresponding in strength to class no lower than grade B40.

Side stops of LOC-beams are concrete vertical surfaces, protruding from under-beam base to the upper surface of LOC-beams. Reinforcement of side stops is made in conjunction with reinforcement of under-beam sites. On under-beam platforms and side stops should be laid concrete with strength not less than class B20.

Between LOC-beams and concrete longitudinal-side stops the setting of uniform electrically insulating damping gaskets is provided. Their locations are shown in Pic. 1 and 2. The general view of uniform electrically insulating damping gaskets in lateral and longitudinal directions is shown in Pic. 3. Along the direction of movement of scheduled passenger trains uniform electrically insulating damping gaskets are placed between the first ends of LOC-beams and longitudinal stops.

As an intermediate rail fastening is provided unlined threadless anchor fastening ARS, which is widely used on the track with concrete sleepers of main railways of Russia.

In the lower surface of each LOC-beam under rail seats and along its entire width 10-mm sockets with a width of 165 mm are provided in order to place in these areas electrically insulating damping under-beam gaskets. Each gasket consists of two similar wedge-shaped elements (Pic. 4). In order to avoid shift during operation in the longitudinal direction of one wedge-shaped element relative to the other from their lateral elongated surfaces, tides are provided. To exclude the shift of one element relative to one another they should be installed under a LOC-beam in such a way that from the track center the thinned end portion of the first (the lower), and thickened portion of the second (upper) wedge-shaped elements were located.

The material for manufacture of the wedge-shaped elements of under-beam pads is electrically insulting rubber, specially selected according to indicators of hardness, toughness, durability and laboratory tested.

In the area of both rail lines clamping pads are put from the track center in the field of longitudinal stops. They are used for pressuring LOC-beams in the transverse horizontal direction to the side stops.

The stable position of clamping pads during operation can be achieved with the use of devices with threaded or unthreaded connections.

Pic. 5 is an overall view of VPTLCB in conjunction with a threaded intermediate rail fastenings ZHBR on the haul between stations Shipilovskaya and Zyablikovo of Moscow metro. Fastening ZHBR as ARS, is widespread [10] in the track with concrete sleepers of main railways of Russia. However, threadless fastening ARS compares favourably with the threaded fastening ZHBR.

In accordance with paragraph 5.7.3 of SNiP [Russian designing & construction standard] 32–02–2003 «Metro» the regulations stipulate that the width of the track gauge must be in mm:

• on straight and curved sections of 1200 m radius and more	1520
• in curves of radius between 600 and 1200 m	1524
• the same from 400 to 600 m	1530
• from 125 to 400 m	1535
• from 100 to 125 m	1540

In this case deviations from the norm in gauge width on straight and curved sections should not exceed 2 mm.

It is known that in curved sections the wear of side working surface of a rail head takes place mainly on the outer rail line [11].

At current maximum speeds of metro trains movement the smoothness of retraction of the rail gauge width shall not exceed 1 mm per 1 linear meter of rail line. In these cases, withdrawal of smoothness of gauge of no more than 2 mm per 1 linear meter of track should be performed on one outer rail line. Moreover, in the vibration protection track installation of adjusting shims in fastening assemblies is not required.

On the track with certain concrete rail seat [12, 13] it is almost impossible to provide the named withdrawal of rail gauge width with taken smoothness – both broadening and narrowing on the model given by using different types of adjusting shims in size.

Unfortunately, during construction and operation of the track it is usually transferred directly to the width of the rail gauge in accordance with the data of paragraphs of SNIP 32–02–2003.

Ignoring normative data on withdrawal of width of the rail gauge, on turnout and circular curves leads to excessive high wear and tear intensity of side working surface of the rail head and wheel flanges of rolling stock.

VPTLCB greatly simplifies adjustment of the track width with controlled withdrawal of no more than 1 mm per 1 linear meter of the track (when retracting one rail line). In case of under-beam base the smoothness of withdrawal is provided with displacement of LOC-beams together with rails in the transverse horizontal direction to the desired values of displacement of rail lines.

Specialists of research and test center «Advanced Technologies» patented technological sequence of the smooth withdrawal of the track width using the rail base in the form of LOC-beams [5].

Taking into account the above, paragraph 5.7.3 of SNIP 32–02–2003 «Metro» should be abolished as not corresponding to an opportunity of withdrawal of the track width with a normalized value [7]. Vibroprotective track allows adjustment of the track width with controlled withdrawal of no more than 2 mm per 1 linear meter along the track center at the maximum permissible speed of trains in domestic metro.

Withdrawal of gauge width in turnout curves should begin with a width of 1520 mm from the beginning of the first (project) turnout curve and then with a normalized withdrawal to broadening before the start of the circular curve in accordance with the project. On the entire length of the circular curve the width of the track is constant. From the end of the circular curve to the end of the second turnout curve, narrowing of the track should be made with controlled withdrawal and entering the straight section of track.

Conclusion. *Presented design of vibration protection track reduces vibration level by 18 dB. And there is a resource that can reduce vibration by another 3–4 dB.*

In addition, in areas of transition from an adjustable track with a roadbed on an adjustable vibration protection track the dynamic load on the elements of track and rolling stock reduces by at least 1,5 times in comparison with the transition to a hard track of a tunnel or a bridge.

The arguments, named in the article, we believe, indicate the feasibility of a fuller use of VPTLCB design in metro.

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Article received 20.04.2016, accepted 06.07.2016.