Control of Load-Bearing Structures of Technological Overpasses

S A Sazonova¹, S D Nikolenko¹, A A Osipov²

¹Department of Technosphere and Fire Safety, Voronezh State Technical University, 84 October 20th Anniversary Street, Voronezh, 394006, Russia
²Department of Construction Technology and Engineering Mechanics named after Professor N A Ulyanov, Voronezh State Technical University, 84 October 20th Anniversary Street, Voronezh, 394006, Russia

E-mail: ss-vrn@mail.ru

Abstract. The paper considers the process of examining the load-bearing structures of technological overpasses of an old production enterprise. The scope of work performed during the survey is given. The characteristics of each overpass are given. The main defects and damages of overpasses are given with an indication of their causes. All defects are listed for each overpass. A recommendation was made to eliminate defects and damages. The purpose of the inspection process was to determine the technical state of the operating technological racks of an industrial enterprise to ensure their further safe operation, taking into account the loads from additional technological pipelines.

1. Introduction

Some of them continue to operate at the present time.

These manufacturing plants have many technological processes and technological equipment that require the movement of a wide variety of technological products (for example, water, steam, acid, gas) to support technological processes.

To ensure technological processes, special pipelines are used, which are located on free-standing supports and overpasses. The supporting structures of technological overpasses are usually reinforced concrete or metal supports.

Considering that the service life of such overpasses often exceeds 30-35 years, they require regular inspection. In connection with the development of technologies, it becomes necessary to lay additional pipelines through the existing overpasses. And this leads to an increase in the load on the overpass and, in particular, on the supports. Which also requires a survey.

Since the information in the conclusions based on the survey results is confidential, we do not indicate the location of the overpasses.

2. Survey process

In the process of inspecting the building constructions of technological overpasses, separate drawings of the working project “Object No. K-1647 Overpass” developed back in 1963 were used. The object of the technical survey is the load-bearing building constructions of the technological overpasses around one of the workshops of JSC Voronezhsintezkauchuk. Within the framework of this work, the
tasks were to inspect the existing load-bearing structures of overpasses, assess their technical condition in order to make it possible to lay additional technological pipelines. The categories of the technical condition of building constructions or structures as a whole were determined according to the normative and technical literature [1-11].

Overpasses around the workshop are engineering structures designed to accommodate process pipelines [12, 13, 14]. Overpasses consist of intermediate, anchor and end supports, spans, traverses and ties. Technological pipelines have been laid along the entire length of the racks [15, 16, 17].

The following overpasses were subject to inspection, conditionally divided into 4 sections: section No. 1 (supports №2780-2784); section No. 2 (supports №1314-1322); section No. 3 (supports №2154-2161); section No. 4 (supports №2162-2175 and №2189-2192).

The division of the surveyed overpasses into sections is due to their geometric parameters, as well as the number of technological pipelines to be placed [18, 19, 20, 21]. The length of the overpass sections is different. The total length of technological overpasses subject to inspection is 308.7 m. 1 shows, for example, photos of two sections of overpasses [22, 23, 24].

Full technical inspection of the load-bearing building constructions of the overpasses included:
- visual inspection of building constructions of overpasses with identification of major defects and damages and drawing up a list of defects;
- control and instrumental measurements of load-bearing building constructions of overpasses with the implementation of dimensional drawings;
- determination of strength and homogeneity of concrete of load-bearing supports of overpasses using the Digi Shmidt 2000 device;
- determination of the relative elevation marks of overpass supports;
- inspection of foundations for overpass supports;
- verification calculations of the bearing capacity of building constructions of overpasses, taking into account additional loads and defects and damages revealed as a result of inspection.

Using the VIK-1 visual and measuring control kit, a DISTO laser rangefinder, steel tape measures, a caliper and a Leica TCR 803 power total station, the elevation marks of the supports were determined, as well as the geometric dimensions and sections of the supporting building constructions of the overpasses [25, 26].

3. Characteristics of restaurants

1 section of technological overpasses (supports №2780-2784). Supports №2780 and №2781 of the first section of the technological overpass are made according to the standard series IS-01-03 freestanding, reinforced concrete. The pillars of the supports are made of rectangular section 400 × 500 mm. Reinforced concrete racks are reinforced with steel clips [27, 28, 29]. The clips are made of equal angles Λ75 × 6 mm and plates –100 × 6 mm. The foundations for reinforced concrete supports are made of glass type from monolithic reinforced concrete. The size of the base of the foundations is 2.05 × 2.05 m. The depth of the base of the foundations from the ground surface is 2.0 m.

Spans between reinforced concrete supports №2780 and №2781 are made in the form of steel trusses with a span of 12.0 m. The upper and lower chords, braces and struts of steel trusses are made of paired steel corners [30, 31, 32]. The connection of the truss elements is carried out by welding, gussets and gaskets. On the upper and lower chord of the trusses, cross-shaped ties are made of equal angles Λ63 × 6 mm.

The traverses, on which the technological pipelines are supported, are made of steel rolling channels №12 and steel rolling angles Л63 × 6 mm. The support of the traverse is carried out on the upper belt and posts of steel span trusses.

Supports №2782 ÷ 2784 of the first section of the technological overpass are made of freestanding, steel. Supports #2782 and #2783 are made of two paired rolling channels # 30. The spans between the steel supports are made of steel beams with a span of 6.0 and 7.5 m. The steel beams are made of rolled channels # 40.
The support No. 2784 is made of a rectangular shape with a plan size of 2.48 × 4.7 m. The support posts are made of rolled steel channels No. 14 and No. 16. The racks are supported on the basement of the wall of a nearby building, as well as on their own foundations [33, 34, 35]. The spacers on the support posts are made in the form of running platforms. The platform beams are made of rolled steel channels No. 14 and No. 16. Site cover - solid steel sheet.

2 section of technological overpasses (supports No. 1314-1322). The intermediate supports of the second section of the technological overpass are made free-standing, reinforced concrete. The legs of the supports are made of rectangular section 400 × 600 mm and are reinforced with steel clips. The clips are made of equal angles L75 × 6 mm and plates −100 × 6 mm. The foundations for reinforced concrete supports are made of glass type from monolithic reinforced concrete. The size of the base of the foundations is 2.4 × 5.9 m. The foundations are made with two steps. The height of the steps is 600 mm. The pile of foundations has a rectangular cross section of 1.3 × 3.9 m. The depth of the foundation base from the ground is 1,900 m.

Anchor supports No. 1321 and No. 1316 of the second section of the overpass are spatial structures. The posts of the anchor supports are freestanding, reinforced concrete with a rectangular section of 400 × 600 mm. Reinforced concrete racks are reinforced with steel clips. The clips are made of equal angles L75 × 6 mm and plates −100 × 6 mm. The posts of the anchor supports are interconnected by means of cruciform ties and spacers [36, 37]. The spacers of the anchor supports are made of paired steel angles L100 × 63 × 8 mm, and the ties are made of paired equal angles L63 × 6 mm. Foundations for reinforced concrete posts of anchor supports are made of glass type from monolithic reinforced concrete. The footing of the foundations is 2.4 × 5.9 m.

Spans between reinforced concrete supports are made of two-tier ones. Spans of the first tier are made in the form of steel trusses with a span of 8.0 ÷ 24.0 m. The upper and lower chords, braces and struts of steel trusses are made of paired steel corners [38, 39]. The connection of the truss elements is carried out by welding, gussets and gaskets. On the upper and lower chord of the trusses, cross-shaped ties are made of equal angles L63 × 6 mm. Spans of the second tier are made in the form of transverse frames. The frame stands are made of steel equal angles L63 × 6 mm. The support of the racks is carried out in the nodes on the upper chord of the trusses of the lower tier.

The traverses on which the technological pipelines are supported are made of reinforced concrete and steel. Reinforced concrete traverses are made with a rectangular section of 300 × 400 mm. The reinforced concrete traverses are supported on the posts of the reinforced concrete supports. The length of the traverses is 4.9 m. The reinforcement of the reinforced concrete traverses is made of Ø25AIII and Ø10AIII rebar. Steel traverses of the overpass spans are made of steel rolling channels No. 12. The traverses are supported on the upper and lower belt of steel span trusses, as well as on the frame racks of the span structures of the second tier [40, 41].

In Fig. 1-4, the main defects that imply an instrumental examination of the structures of the overpasses are shown. Which will be the subject of further examinations.

3 section of technological overpasses (supports No. 2154-2161). Intermediate steel supports No. 2154 ÷ 2160 of the third section of the overpass are a flat structure oriented along the normal to the direction of pipeline orientation. Support width 900 mm. The racks of the trestle supports are made of paired non-equal-flange rolled steel angles L75 × 50 × 5 mm. The posts of the supports are interconnected by means of cross-shaped ties. Ties are made of unequal steel angles L75 × 50 × 5 mm. Spacers between the support posts are also made of unequal steel angles L75 × 50 × 5 mm. Each support is fixed to the foundation with four Ø 24 mm anchor bolts. Steel supports №2155, №2156, №2157 are lined with masonry of silicate bricks on a cement-sand mortar.

The foundations for steel supports are made of glass-type reinforced concrete [42, 43]. The size of the base of the foundations is 0.6 × 1.8 m. The depth of the base of the foundations from the surface of the earth is 2.150 m.

Intermediate steel support No. 2158 of the third section of the overpass, located at the hydraulic fracturing plant No. 28, is a flat structure oriented along the normal to the pipeline orientation direction. Support width 790 mm. The legs of the support are made of steel rolling channels No. 12.
The support branches are interconnected by means of cruciform ties. Ties are made of paired equal-flange steel angles $\angle 50 \times 5$ mm. The spacers between the legs of the support are made of paired equal-flange steel angles $\angle 75 \times 6$ mm. The struts of the superstructure of the support are made of steel equal angles $75 \times 6$ mm.

Anchor support No. 2161 of the third section of the overpass is a spatial lattice structure. The section of the anchor support in the plan is $800 \times 800$ m. Anchor support posts are made of steel equal angles $\angle 90 \times 8$ mm.

The posts of the anchor support are interconnected by means of cruciform ties and spacers [44, 45]. Spacers and ties of the anchor support are made of steel unequal angles $\angle 63 \times 40 \times 6$ mm. The anchor support is fixed to the foundation using eight $\varnothing 24$ mm anchor bolts.

**Figure 1.** General view of 1 overpass section and 2 overpass section.

**Figure 2.** Destruction of the protective layer of concrete, exposure and corrosion of the rebar of the supports.

**Figure 3.** Cracks in welds or loose support plate fasteners.

**Figure 4.** Lack of protective anti-corrosion coating, and as a result, corrosion of the elements of the span structures between the supports.

Spans between steel supports No. 2154 $\div$ 2161 are made of steel beams with a span of $9.0 \div 10.0$ m. Steel beams are made of rolling channels No. 16. Along the upper chord of the beams, triangular ties are mounted from unequal corners $\angle 63 \times 40 \times 6$ mm and equal angles $56 \times 5$ mm. The struts of
the superstructures are made of paired steel equal angles $56 \times 5$ mm. The traverses of the overpass, on which the technological pipelines are supported, are made of rolling channels No. 12 and equal-flange steel angles $\triangle 75 \times 5$ mm and $\triangle 63 \times 6$ mm.

Section 4 of technological overpasses (No. 2162-2175 and No. 2189-2192). The posts of the supports are made of rectangular section $400 \times 400$ mm. The foundations for reinforced concrete supports are made of glass type from monolithic reinforced concrete. The size of the base of the foundations is $1.6 \times 1.6$ m. The depth of the base of the foundations from the ground is $2,000$ m.

Spans between reinforced concrete supports No. 2174 and No. 2175 are made of steel beams with a span of $4.0 \div 6.0$ m. Steel beams are made of rolling channels No. 27. The cross-beams of the supports, on which the technological pipelines are supported, are made of paired and separate steel rolling channels No. 12.

The rest of the intermediate supports of the fourth section of the technological overpass are made according to the standard series IS-01-03, freestanding, reinforced concrete. The pillars of the supports are made of rectangular section $400 \times 500$ mm. The foundations for reinforced concrete supports are made of glass type from monolithic reinforced concrete. The size of the base of the foundations is $2.05 \times 2.05$ m. The depth of the base of the foundations from the earth's surface is $2.05$ m.

The spans between the reinforced concrete supports are made of steel beams with a span of $12.0$ m. The steel beams are made of rolling channels # 40. On the upper belt of the beams, cruciform braces are mounted from equal angles $\triangle 63 \times 5$ mm.

The traverses of the overpass, on which the technological pipelines are supported, are made of steel rolling channels No. 12 and No. 14.

4. Conclusion
The survey showed the following.

The detected defects and damages were formed as a result of long-term operation, lack of repairs and laying of additional technological pipelines along the building structures of technological racks.

Numerous defects (list of defects) were mainly formed as a result of exceeding the design loads on the building structures of overpasses.

For the further normal operation of the building constructions of technological overpasses, it is necessary to carry out repair measures aimed at eliminating defects and damages found as a result of the survey.

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