Method of complex organizational and technological designing underground structures and services

Pavel Oleynik

1 Moscow State University of Civil Engineering, 129337, 26, Yaroslavskoye Shosse, Moscow, Russia

E-mail: angela-1309.m@yandex.ru

Abstract. In the article it is considered a linkage of underground services construction sequence with buildings and constructions which allows imagining development model of entire underground space. For this purpose, it is proposed to divide the whole underground services into sections with their subsequent integration into homogeneous organizational and technological groups. Each of these groups has strictly defined erection sequence parameters in time schedule of facility construction. For the purpose of unification one developed organizational and technological solutions as rational schemes for above mentioned groups – schemes of temporary underground services functions replacement permanent, schemes of laying underground services under transport routes of construction site, etc.

1. Introduction

Rationale and choice of organizational and technological solutions for underground services and transport communications arrangement in combination with underground parts construction of buildings and structures of industrial facilities is carried out in construction designs as part of project documentation. First of all the major purpose of such solutions is to form sequence of facility underground space development.

As part of construction arrangement project for industrial facilities, there is a number of documents containing various aspects of the above solutions: construction time schedule linking sequence of construction of buildings, structures and underground services; construction master plan with placement of permanent and temporary buildings, structures and underground services; table of work quantities by objects and construction periods; schedule for construction structures and materials supply by construction periods and other documents. Therefore, in construction time schedule one addresses to technological linkages underground services laying with foundation arrangement, in construction master plan one addresses abilities to provide construction needs in energy and transport routes following project infrastructure. In accordance with this one is scheduling demand for structures, materials and table of quantities by facilities and construction periods. Herewith, in project text part it is justified adopted organizational and technological scheme determining sequence of underground parts of buildings and structures construction, underground services construction in compliance with adopted normative or directive duration of construction.

2. Method’s essence

Linkage of combined underground services laying with buildings and constructions represents a complex problem because of multivariance of organizational and technological solutions and
conditions of work producing. The most time-consuming are places of service lines adjunctions to buildings and structures and their mutual intersections, as well as places of new service lines laying extra to existing ones and places of underground services laying on facility territory due to cramped underground space and its intensity. As analysis shows, it is in these particular areas destruction of underground service lines occurs most often as a result of pocket of insufficiently compacted soil.

One should also take into consideration when separately laying pipelines, tunnels, channels and blocks, it is not possible to indicate mutual excavation slope overlays between underground service lines and foundations of buildings and structures, which ultimately leads to re-implementation of significant amount of excavation work with parallel service lines laying and at their mutual intersections. Many examples might be given when excavation works within intersecting excavations slopes were produced twice during construction of a number of service lines.

The proposed method of complex organizational and technological designing is based on spatial division of construction site into areas grouped into homogeneous organizational and technological groups, each of which links the organization and technology of construction of individual facilities with adjacent sections of underground services at all stages of facility construction.

The organizational and technological group means a set of underground services sections for various functional services (pipelines, tunnels, channels, blocks), constructing order of which follows construction sequence of facility.

As proven by research and construction practice, it is advisable to foresee distributing underground service lines in five groups of organizational and technological features (Table 1).

3. Sections composition of organizational and technological groups

Let us illustrate a fragment of combined plan for underground and aboveground service lines, buildings and structures in the area of engine room of coke oven battery installation (Figure 1) with territory division into sections of five mentioned groups.

| Functional groups                                      | Location                                                                 | Scope of civil and erection works, % |
|--------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------|
| I. Temporary underground services functions replacement permanent | Territory close to objects of energy resources consumption                | 10                                    |
| II. Temporary transportation routes functions replacement permanent | Under temporary and permanent construction site roads                    | 11                                    |
| III. Combination of underground services laying with buildings and structures construction | Sections of facility territory mutual excavation slope overlays between underground service lines and foundations of buildings and structures | 7                                     |
| IV. Providing of rational functioning organization for erection and storing object sites of facility | Under erection and storing sites of constructed buildings and structures | 22                                    |
| V. Autonomous objects construction and service lines laying, traced out of erection areas of facilities | Out of buildings and structures erection areas                            | 50                                    |
The first group includes sections of permanent and temporary underground services located more closely to objects of energy resources consumption (water, steam, air, etc.). In given example, this is a section of drinking water supply to well VK-1. The purpose of this group is maximum possible providing of construction needs at expense of adapting permanent underground services with minimum cost for laying temporary ones.

The second group includes sections of underground services traced under construction site roads. These sections are indicated by the number II on Figure 1. The purpose of this group is to prevent transport routes destruction (roads and railways) by being layed underground service lines during facility construction. Such a solution ensures advanced permanent roads construction and their usage during facility construction instead of temporary ones (permanent road No. 27).

![Figure 1. Fragment of combined plan for underground service lines in the area of engine room of coke oven battery installation.](image)

The third group includes sections of underground services, passing in combined excavation with underground parts of buildings and structures. In Figure 1 these are inputs into buildings of cable tunnels, blocks and pipelines, indicated by the number III. Allocation of this group provides combined construction of buildings (structures) foundations with underground service lines, having common excavations.

The fourth group includes service lines, untimely laying of which holds aboveground objects construction, i.e. underground service lines passing under erection and storing sites facility construction. In Figure 1 these areas are indicated by the number IV. The purpose of this group is to ensure rational organization of functioning of on-site erection and storing areas.

The fifth group includes sections of underground services traced outside erection zones of facility construction, as well as sections passing through operating facility territory while facility reconstruction or expansion. In given example, these sections are indicated by the number V. The purpose of group V service lines allocation is to determine sections, laying of which does not affect
organizational and technological solutions for facility buildings and structures construction and makes it possible their autonomous laying in any of construction periods.

Approximate distribution of civil and erection work volumes between groups of underground services and coefficients values of labor input reduction of service lines laying are given in Table 2.

**Table 2.** Distribution of civil and erection work (CEW) volumes and coefficients values of labor input reduction of underground services groups laying.

| Group of service lines | CEW volume by group, % | Labor input reduction coefficient value |
|------------------------|-------------------------|----------------------------------------|
| I                      | 10                      | 0,70                                   |
| II                     | 10                      | 0,63                                   |
| III                    | 9                       | 0,90                                   |
| IV                     | 24                      | 0,12                                   |
| V                      | 47                      | 0,26                                   |

Allocation of I and II groups of underground services on construction master plan as part PCO (project of construction organization) allows at design stage to identify sections of permanent underground services to provide the needs of construction in energy resources and transport routes.

While designing projects of construction organization the criteria to define rational sequence is the maximum value of laying duration reduction for five groups of underground services.

Groups I and II provide laying duration reducing for underground services and transport routes at the expense of physical volumes of work reduction for temporary service lines and transport routes through their replacement permanent. Groups III, IV and V provide laying duration reducing for underground services at the expense of physical volumes of excavation reduction while combined laying those groups of underground services.

While calculating the maximum duration reduction one defines construction sequence for sections of underground services groups in particular areas and level of underground services groups laying combination between areas.

**4. Solutions unification**

For unification, it is designed organizational and technological solutions as rational schemes of underground services groups laying. For group I it is specified options of use permanent service lines instead of temporary ones. For group II – solutions of mutual intersections for underground services and transport routes. For group III – options of underground services laying parallel and perpendicular to buildings and structures foundations in areas of mutual excavation slope overlays. For groups IV and V one specifies options of combined laying between service lines of different functional purpose.

Therefore, for example, rational schemes of temporary functions replacement permanent (group I) are designed out of condition that one or the other resource type (water, steam, electricity, air) might be used for both operational needs of facility itself and construction needs.

Within temporary operational period, sections of permanent underground services are adapted to temporary construction site needs by their temporary re-arrangement. Thereof projected sections of permanent and temporary underground services are temporary interconnected. Rational schemes options include: usage of pressure and gravity pipelines for functional and opposite purposes, combination of temporary and permanent pipelines for period of ensuring construction needs. After service life ends, temporary installations are eliminated, and permanent pipelines are restored to design schemes.

Developed rational schemes (Table 3) of options for functions of temporary underground services replacement permanent allow determining rational number ratio of temporary and permanent service lines used for construction.
### Table 3. Rational schemes for functions of temporary underground services replacement permanent.

| Pipelines | Functions replaced | Scheme |
|-----------|--------------------|--------|
| 1. Direct purpose | water | ![Diagram](image1) |
|  | air |  |
|  | heating |  |
| 2. Direct and other purpose | water | ![Diagram](image2) |
|  | air |  |
| 3. Only other purpose | water | ![Diagram](image3) |
|  | air |  |
| 4. On permanent and temporary networks | water | ![Diagram](image4) |
|  | air |  |
| 5. On permanent pressure and temporary rearranged gravity networks | water | ![Diagram](image5) |
|  | air |  |
| 6. On permanent gravity networks with inside laying temporary ones | water | ![Diagram](image6) |
|  | air |  |
|  | heating |  |
|  | electric cables |  |
| 7. On permanent gravity and temporary rearranged under gravity networks | water | ![Diagram](image7) |
|  | air |  |
| 8. On permanent underground and temporary service lines | water | ![Diagram](image8) |
|  | air |  |
|  | heating |  |
| 9. On permanent pipelines at existing aboveground overpasses | water | ![Diagram](image9) |
|  | air |  |
|  | heating |  |
| 10. On permanent under- and above-ground networks | water | ![Diagram](image10) |
|  | air |  |
|  | heating |  |
11. On temporary underground and permanent aboveground networks

12. On existing underground tunnels and permanent networks

13. On existing tunnels and temporary pipelines

Legend

- temporary service lines
- direct purpose permanent service lines
- permanent service lines foreseen under temporary
- permanent gravity service lines

Rational schemes of underground services laying under transportation routes of construction site (group II) foresee advanced laying of their intersections with roads to enable construction and permanent roads operation while facility objects erection. The schemes are applied for underground services laying under transportation routes in preliminary construction period and the first stage of facility construction. Such schemes expect stowing of enclosures with service lines and without, laying service lines in open trenches, grouping of transitions into combined excavations, co-laying to existing intersections, laying of underground services after roads arrangement.

On this group reduction of labor costs temporary roads construction is achieved due to advanced underground services and permanent roads construction.

Rational schemes of underground services erection along with buildings and structures foundations (group III) foresee combined excavations for foundations and service lines at their adjunctions or at parallel location of service lines not far from foundations. Works on schemes options are produced either separately or combined.

Rational schemes of combined construction options are typical for all groups of underground services, regardless of their construction sequence.

5. Application

Underground services dividing into groups is a basis for designing time schedule, coordinating sequence of buildings, structures and service lines construction, allocation of permanent and temporary underground services and transport routes on construction master plan, is a basis for table of work quantities by periods of underground services construction, demand schedules in structures, pipes and materials within mentioned periods.

When designing large facilities using component method the whole scope of pipelines, tunnels, channels and cable blocks is advisable to be included into unique general site components.

The proposed method of integrated design of laying arrangement for underground services and transport routes allows at construction projects development stage foreseeing rational solutions for underground services and transport routes construction, providing increase in facilities construction efficiency.
6. Conclusion

The results of statistical data processing and analysis of multiple regression equations confirmed high importance of organizational and technological groups’ content as the decisive factors for reduction of civil and erection works cost, their complexity and duration.

The stated provisions were the basis for principles formation of engineering preparation of construction site territory, providing both advanced arrangement of engineering service lines to create normal production and living conditions for workers, and their combined laying among themselves and with underground parts of buildings and structures construction.

References

[1] Kievskiy I 2008 Planning and arrangement of engineering service lines (Moscow: SvR-ARGUS) p 464
[2] Kievskiy I, Roitman S 2006-2014 Sequence definition for engineering supply of civil construction objects. City development. Collection of proceedings (Moscow: SvR-ARGUS) pp 267-270
[3] Kogan U, Argunov S 2006-2014 Consolidated indicators of development costs for engineering infrastructure. City development. Collection of proceedings (Moscow: SvR-ARGUS) pp 271-277
[4] Oleynik P 2018 Technology of combined laying of engineering service lines. Industrial and civil engineering 8 pp 84-89
[5] Oleynik P 2017 Arrangement of trenches, foundation pits and combined excavations. Scientific review 8 pp 24-28
[6] Pogodina L 2010 Engineering networks, preliminary engineering and equipping of territories, buildings and construction sites (Moscow: Dashkov & Co) p 474
[7] Surin G 2005 Industrial and civil engineering 8 p 53
[8] Shulzhenko S, Volkov A 2011 Vestnik MGSU 1 pp 383-386
[9] Shulzhenko S 2011 Vestnik MGSU 6 pp 507-512