Construction of a complex object

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Abstract: The peculiarities of application of nodal method in the construction of large and complex industrial systems, the principles of the spatial division of the object on the technological, building and public spaces, the basic documents on the use of nodal method. As an example, we consider the use of nodal method in the construction machinery manufacturing enterprises. To this end, provides a general description of space planning and designs of single-floor and multi-floors buildings of this industry, the composition of industrial complexes and sub complexes engineering, their basic units and plots, schemes interlinkages units and energy supply. It includes steps for the development of complex aggregated network diagrams network diagrams and working with the justification of continuous work flow.

1 Introduction

An effective method of construction of large industrial complexes is the nodal method.
The essence of the nodal method is that the composition of the starting complex stands out in a constructive and technological separate parts - spare parts for organizations focused and technologically sound production work and achievements in the shortest possible time frame for technical readiness of autonomous testing and commissioning of individual production lines, offices and plants.
The use of nodal method allows you to:
- clearly coordinate within each node and the whole complex;
- to create a reliable basis for planning the construction and installation works, acquisition of material, technical and human resources, operational management and supervisory control over the course of construction;
- to provide the necessary details of the organizational and technological documentation for all building production management levels;
- maximize the combination of work and organize protection production of construction and installation works on the basis of long-term specialized streams;
- Concentrate and most efficient use of material and technical manpower;

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determine the intensity of loading and rhythmic work of the organizations and participants in the construction period.

Node - structurally and technologically separate part to be erected industrial complex (object), the technical readiness which, after completion of construction and installation work allows for commissioning and testing machines, tools and devices.

When forming the nodes must be considered:

- structural completeness of the allocated industrial complex (object);
- ensure spatial stability of the building or structure is part of the assembly;
- completeness single technological cycle in total industrial production technology;
- possibility of production start-up and stand-alone unit for delivery of the working act of the customer;
- the possibility of mounting on the nodes lead singer given the predominance of its work profile;

creating conditions for the mass production of works;

- the efficient operation of construction machines and mechanisms;
- the possibility of opening in the shortest possible time to the front of works related organizations.

When forming the nodes must be considered the characteristic features of the complexes under construction in various industries:

- completeness of technological conversion of feed components, prompro-product or process;
- consistent capacity building.

2 Application procedure of Node method

On a functional purpose sites are divided into technological, construction and Organization of the work sites.

Technology unit is a structurally separate part of the process line or installation within the boundaries of which are made to RMC technical readiness required for the commissioning and testing of assemblies, mechanisms and devices. The structure of the processing unit mainly includes - foundations for process equipment, technological equipment, related to the site underground utilities (flume, Electro cable, transport tunnels) and underground structures (pumping of all kinds, oil), technological metal structures and pipelines built premises the main production facilities (control panels, electrical devices), flooring and fine finish.

The construction site includes building (structure) of the main production facilities or a structurally separate part, within which are made of construction and installation work to the technical readiness necessary for the transmission assembly by mechanical assembly work. The boundaries of the construction unit can be placed one or more processing units. The most characteristic nomenclature construction site is under the frame of the building foundations, supporting and protecting the building structure, roofing and finishing works, built facilities and ancillary service facilities, overhead cranes, electric building.

Organization of the work sites nodes are - preparing the construction site, the objects of administrative-residential and utility-of subsidiary purpose, power, energy, water recycling, transport, agriculture and the improvement of the industrial site.

The composition of the industrial complex of nodes includes:

technological components: boiler, gas station, hardware management framework, wood and sawmill, Wood Factory, refrigerator, laundry factory, factory cleaning, fire station, billet plant, training center, medical center, a waste treatment plant, mechanization base The foundations of the oil sites, asphalt plant, playground equipment base, base production and

processing equipment, concrete testing ground to impregnate the wood shop, shop insulating pipes and fittings, etc.;
Construction units: industrial buildings and units, office buildings, dining room, garage, a dispensary, a cattle-breeding complex, pension, fire station;
Organization of the work sites components: transport rack, sewerage system, interior and exterior (industrial, household, rain, etc.), Mobile (inventory) buildings and structures, work on site preparation, construction and electricity networks, roads and driveways, buildings and network communications (internal and external), water supply system (industrial, household, drinking and fire), heating networks (internal and external trunk), the communication tunnel, gas supply network, air and fuel, work on landscaping, traffic management facilities, complex of warehouses, security measures, the base of sanitary cleaning, universal supply base, the base operation of utilities services, nursery with a greenhouse, jetty and basic storage, a playground for the reception and storage of materials, water intake from underground sources, the station iron removal, water intake from the reservoir, the station purification of river water, ash dump TPP, wastewater treatment plants, the main pumping station, storage pond, active storage of chlorine, the connecting path, industrial plant, CHP station, factory station, railway track.
At the same time, the application method hub has the following drawbacks: the formation of knots is often one construction site area includes both of the process, and the construction Organization of the work sites nodes; within the boundaries of the construction site can be located several process units; when fixing at the sites of the leading performers of the ability of their uncoordinated actions.
Many years of experience in the application node of the method in the construction of such complex objects like plate mill "3000" metallurgical plant. (Mariupol), Pellet Plant mining complex, oxygen-converter shop of the Dnieper Metallurgical Plant them. Dzerzhinsky, and others. Showed that the elimination of these drawbacks is achieved by the formation of technological units, combining technological lines, buildings and structures, as well as the adjoining utility networks. At the same time the construction and installation work on the construction of the object considered as a stage of the corresponding processing unit, and the objects of administrative-residential and utility-auxiliary facilities, engineering and transport communications - both Organization of the work sites. Thus, the existing nodes of the method remains the same, but provides a significant simplification of the design and estimate documentation and reducing the complexity of its design, creates the necessary conditions for the formation of long-term flows and increases the efficiency of the operational management of the construction industry.

Construction Management Project consists of four parts - I - the text part; II - graphical part; III - part design; IV - application.

The main documents required for the use of nodal method, developed at the stage of the project of works (PPR); they contain passport units and operating a rolling roadmap.

Passport complex components - a set of documents consisting of a breakdown of the circuit nodes on the list and the composition of components, circuits, technological coherence and energy supply units.
The initial data for the development of the passport sites are:

- title list;
- design and estimate documentation;
- breakdown of the scheme on the list of nodes and structure nodes;
- technological interlinkages units and energy supply circuit;

Typical solutions for nodes:
In drawing up the passport scheme specified breakdown on the list of nodes and the composition of components and circuit technology interlinkages nodes developed at the design stage of the project and working as part of PIC.

Work node roadmap is an integral part of the design work and production is developed in order to:
- identifying and linking technological sequence of performance of works on the sites;
- linking the work of all artists (sites, teams) participating in the construction site;
- clarifying and specifying the timing of the work fronts related organizations;
- ensure at all stages of the construction site of a single continuous planning and management in all production units with the use of computer technology;
- rational distribution of logistical and human resources;
- organization of operational control over the progress of construction and installation works;
- focusing on the work of the leaders, lying in the critical zone.

The source document for the development of the working node network schedules are as follows:
- nodes passport;
- organizational and technical measures;
- working project documentation;
- projects or production work flow diagrams;
- Categories of standard routings and standard flow sheets linked to a specific node.

Working nodal network diagrams develop general contracting trusts together with specialized organizations with the involvement of design institutes.

In the development of the working node and the network schedule is necessary to strive for a level of detail that the work had one unit and one artist.

During the construction of complex objects and large industrial complexes there is the need to establish operational service management start-up complex construction. The main objective of launching complex is to ensure the effective operation of general contractors and subcontractors, providing enterprises and farms on the basis of systematic monitoring and control at all stages of construction - from the development of design estimates, technological, organizational and technical documentation to the delivery of objects into operation.

3 Results of Nodes method

Practical experience in the construction of industrial complexes using the nodal method has gained in the construction of the enterprises of ferrous metallurgy, machine building, gas, chemical and other industries. By branches of engineering built of heavy and transport engineering, electrical industry, chemical and oil engineering, machine tool and tool industry and others.

Production engineering buildings made, usually in the form of large dimensional blocks by combining various plants based processes, unification and unity of design solutions. The most typical are the four types of buildings - with bearing metal structures with application of effective profiles (type 1), with the bearing and enclosing structures made of reinforced concrete (type 2), made of light metal structures complete delivery (type 3), with the bearing and enclosing structures AI Seriesmbe-04 (type 4). In the development of space-planning decisions envisaged scheme of carcasses of buildings with a minimum number of height differences.

Buildings can be a multi-floors and single-floor. For single-floor buildings spread a net 24x12m columns and 30x12m. Building frames span up to 24m are executed, as a rule, in precast concrete structures, and a span of 30m and more with bridge cranes with lifting capacity of 50 tons and a height from the floor to truss bottom exceeding 14 4m, - metal structures.

Administrative buildings are designed largely free-standing as close to the production. For the device of foundations and structures used piles 12m (for collapsible soils), bored piles with a diameter of 600-1500mm and more than 12m in length (for heavy loads), a natural base (for unsettled sandy soils). As the foundations for increasing application framework are prefabricated foundations weighing up to 25 tons, and for foundations for technological equipment - prefabricated monolithic foundations with enlarged blocks.

More and more are beginning to be used for type 1 metallic columns of buildings in the form of Wide-I-Beams at full height (mounted bezvyverochnym way), and for buildings of type 2 and 3 - reinforced concrete rectangular construction (instead of the traditional two-branch).

Covers the main production buildings are carried out in large blocks, assembled to complete construction readiness on conveyor lines.

The exterior walls of buildings consist of light ("sandwich") for light (for example, "KZHS" 3x24m) panels, and for administrative and residential buildings the panels have a textured finish. Roofs are made roll with booking the bed bindings window openings - from roll-formed closed section profiles at 1.436-6 series or series of joint ventures with wooden windows.

Roof lights have sizes 3x6 and 3x12m.

Flooring according to the technological requirements can be concrete, because of high oil-resistant plates with disperse reinforcement and wear-resistant coating of silica sand and grit; of large-sized slabs of refractory concrete, pressed mosaic tiles for administrative and household premises.

As partitions are used large-industrial, with disperse reinforcement of structural glass, lightweight aggregate panels and blocks.

Engineering support for the main production building at the expense of the location of the main networks in the area and cross-farm areas of crane tracks.

The initial data for the development of technological schemes interlinkages units and energy supply are: a list of nodes and composition; description of technological processes; general plan; schemes supply facilities with electricity, water, gas and other essential energy resources.

Launch Complex are based on technical - economies-who study for construction. Each launch complex should provide for the implementation of the scope of work, ensuring the normal operation of the facilities put into operation. For example, in the starting housing complex #1 includes objects and structures listed in Table 1 below.

Table 1. The composition of the starting complex of housing #1

Nodes	plots
1	2
Node 1.1 Case #1	Thermal circuit - 1.1.01 Internal engineering network - 1.1.02 workshop #1 – 1.1.03 workshop #2 – 1.1.04 workshop #3 – 1.1.05
Node 2.1	ABC-1, ABC-2 - 2.1.01 Factory ATS 600 rooms - 2.1.02
Node 4.12 - off-site water supply	HVL 200 kV p / o 500 kV to kV RP Prom site - 04/12/01 Substation GPP-220/110 kV - 12/04/02 110 kV overhead line between 220/110/10 kV GLP - 12/04/03

Node 1.8 - intra-electricity 1.9 Node - inside networks and communication underground installation	110/10 kV modular package #1; GPP- 1 220/10 kV RP-5 conductors - 01/08/01 Rainwater and industrial sewage around the body and from the tunnel to the exit from the industrial site - 01/09/01 Industrial and domestic sewage around the body; potable water main collector sewer - 01/09/02 The communication tunnel with the networks of drinkable water pipe water recycling - 09/01/03 Onsite networks and facilities of water supply, a network of drinkable running water tanks - 09/01/04
Node 3.18 - inside networks of heat and steam	Network Elevated gaskets; piping, condensers - 3.18.01 underground installation network - 3.18.02
1	2
Node 1.11 - onsite road	Onsite road around the body - 1.11.01
Node 1.12 - intrasite railway tracks	Access track to the body - 12/01/01
Node 4.21 - off-site water supply system and water intake facilities	Water intake pump 1 lift - 4.21.01 The pump station of lifting II - 4.21.02 Pumping station III lift - 4.21.03 Water pipeline from the pumping station lifting III - 4.21.04
Node 4.22 - offsite utility fecal sewage network and wastewater treatment plant	Pumping pumping station - 4.22.01 Off-site sewer - 4.22.02 Sludge ponds with sludge pumping water - 4.22.03 Storm sewage - 4.22.04
Node 5.24 - off-site roads	The expansion of the road - 5.24.01 Viaduct interchange - 5.24.02 North Road and the road to the industrial base - 5.24.03
Node 5.25 - off-site railway tracks	Development of the connecting station - 5.25.01 Access track - 5.25.02 The bypass route - 5.25.03
Node 4.26	External communications network - 4.26.01
Node 1.20	Landscaping - 1.20.01

Once the start-up complex objects compiled statements: the estimated cost of the starting complex objects; the volume of work on the launch complex; the need for building structures, components, semi-finished products and the basic materials on the launch complex, on the launch complex of the equipment.

Comprehensive enlarged roadmap is developed with a degree of detail that allows to link the West the process of creating complex in time from design to putting it into operation.

Operating a network schedule for construction of the facility is the organizational and technological model that reflects the interconnection of all types of work. Scheduling is carried out in stages.

In the first phase set volume installation and terms of their performance. At the second stage - the entire volume of construction and installation work is divided into separate parts, and assigned to the responsible executives. In the third phase the responsible executors specify initial data for the completion of the network schedule. In the fourth stage are calculated the main parameters of the chart - foundations under the framework of buildings,

installation of frame buildings, installation of wall fencing, installation of built-in premises, roofing, etc. (Table 2).

Table 2. The parameters for calculating the network schedule

Code phase	works	event #		work code	Code resources
		I	II		
1	2	3	4	5	6
200	Vertical planning	1	2	24	190
200		2	11	24	190
201	Driving of reinforced concrete piles	2	3	42	150
201		3	4	42	150
202		4	7	42	237
202		7	12	42	237
201	Arrangement of bored piles	2	5	46	150
202		5	14	46	150
202		14	21	46	150
201	Concrete preparation device	3	6	70	11
201		6	15	70	11
202		15	22	70	11
202		22	24	70	11
201	Foundations for the frame	6	8	54	11
201		8	9	54	11
201		9	16	54	11
202		16	25	54	11
202		25	30	54	11
201	Backfilling	8	10	20	150
201		10	13	20	150
201		13	18	20	150
202		18	28	20	150
202		28	32	20	150
201	Columns	10	17	146	234
201	Communication			147	234
201	Crane beams			167	234
201	Columns	17	26	146	234
201	Communication			147	234
201	Crane beams			167	234

In addition, due to the low duration of work on the site flows provided by the foundation for the equipment, concrete preparation, installation of process equipment, Ventilation equipment installation, installation of secondary and technological metal structures. In turn, the rhythmic flow is largely determined unmounted enlargement of building structures and technological equipment.

Thus, for the large-assembly coatings are widely used conveyor lines for the assembly of reinforced concrete structures, construction of complete delivery with structural coatings, metal structures.

Construction of the Krasnoyarsk plant of heavy excavators with capacity of 140.000 tons per year mehanoizdely all nodes were built parallel to the five streams - streams of 1, 2, 3 on the main body, flow 4 administrative buildings, stream 5 on buildings and facilities auxiliary facilities. The first three streams served conveyor assembly line coatings, equipping them with electrical, plumbing and industrial installations and communications: prefabricated buildings (housing optional equipment), from designs complete supply structural coatings (building service shops), of metal structures (body smith workshop #1). Conveyor line for the housing cover assembly smith workshop #1 (MSC-1), a total area of

331.6 thousand m² had a U-shaped arrangement in the plan to reduce the extent and ease of installation of plumbing and electrical communications and included 18 sites:

- Assembling the main load-bearing metal block designs #1, 2
- Installation runs and roof lights #3
- Lapping units, conducting sanitary works #4
- Painting. #6, 7
- Installation and mounting corrugated #8, 9
- Installation of roof fans. #10
- Electrical work #12
- Glazing of the roof lights and device #13-17
- Delivery unit for mounting #18
- Reserved parking #5-11

Moving blocks on the conveyor carried by individual groups (up to four blocks) special winches and K-701 tractor. Supply and installation of tower blocks were carried out using the installer load capacity of 120 tons, moves along the span on the crane tracks. For the unit to lift installer used railway crane MRS-2600 load capacity of 130 tons. Total weight of the complete unit reached 120 tons.

Widespread use in the construction of facilities for the Krasnoyarsk water-heavy excavator received conveyor for manufacturing and installation of complete supply of buildings. One such object is the CEC, which is a building in terms of size 521x253m. The grid columns in the main spans accepted 24x12m. The load-bearing structure are the spatial coverage of cross-core building blocks (of tubular elements) with the size in terms of 24x12m. Enclosing cover designs are structurally composed of a steel corrugated galvanized sheet and a layer of insulation. The coating applied skylights series 3230.

Coating to be assembled on the line, there has been a total area of 123.000 m^2. The total number of blocks is equal to 423 pieces. Clearing the pipeline capacity was 3 units a day in two shifts at his job. Driving conveyor line consists of 8 work sites, the drive pre-engineered, post unit overload of conveyor trolleys for transportation. Conveyor line provides access to the complete installation of the unit construction readiness, fully equipped with technological equipment.

Stacking carried on stand representing arranged in a particular order established stationary pedestals for supporting the lower tier node elements during assembly and the entire unit prior to installation of the assembled conveyor trolleys. As you move the coating unit on the working conveyor line parking areas it is saturated with sanitary and electrical equipment, and arranged roof unit is brought to a complete construction readiness.

After installation, the blocks in the design position remains sealing of joints between the blocks and the connection of communications, being in a previously assembled unit.

Served two conveyor line tower crane - one directly in the production and installation works and other (gantry) at a construction warehouse. Lifting and installation of blocks in a design position carried out by crane crawler ICG-100 in the tower-boom performance. Rigging block made with the help of four-branch balancer sling load capacity of 25 tons.

At present, the development of large-block construction method the installation is carried out primarily in the direction of increasing the size and weight of the blocks. So, if at the plant were applied coating blocks span of 36m and weighing up to 200 tons and an area of 300m^2, on the construction of the industrial complex of the Ulyanovsk coating units already had 24x72m size with an area of about 1.800m^2 and a weight of up to 500 tons.

With the construction of engineering systems widely used and large-block installation of technological equipment. For example, in the construction of the first stage of the plant "ATOMMASH" 51 bridge crane was installed in the spans of the main building, located on two levels of 30 and 42-meter spans. All possible operations on the installation of cranes have been moved down to the assembly area. As a result of mounting blocks half-bridges

have a weight of up to 150 tons, and trucks up to 70 tons. The unit includes the main beam half-bridges, service platforms, end carriages with balancing trolleys, drives, and in some cases, and electrical systems. A number of overhead cranes were installed fully assembled. In particular, the bridge crane 160/32 tons and a span of 28m was set at design elevation jib crane rail MRS-2600 all over the two lifting. Most of the crane weighing 97 tons was collected on a free site and then delivered on trailers under jib crane hook and raised on the runways. trolley was installed the second rise.

4 Conclusion

Hub is the recommended method to use in the design, organization and management of construction and reconstruction of complex objects and large industrial complexes. The degree of complexity of objects is determined based on the number of constructed buildings and structures that make up the complex, and construction conditions, the level of unification, typing and standardization of design solutions, the need for special support structures, devices and systems, a variety of construction processes, the number of contractors and subcontractors, involved in the construction industry. An indicative list of complex objects and large industrial complexes are listed in Table 3.
Industrial objects and facilities, design and construction (reconstruction) which is advantageously carried out using a nodal method, determined jointly by the building organizations and the contracting authority with the participation of general designer and design organizations.

Table 3. An indicative list of complex objects and large industrial complexes

Name of industrial construction industry	Name of industries, buildings and structures
1	2
Ferrous metallurgy	Iron and steel Sinter plants. Product coke plant. Complexes of blast furnaces. The oxygen-converter shop. Continuous steel casting installation. Electric smelting plant. Rolling mills. Tube welding mills.
	Seamless pipe mills. Oxygen station. Workshops for the production of ferroalloys. Factories pelletizing concentrate mining and processing. Workshops for roll forming.
Wood and paper industry	Sawing and woodworking enterprises. Pulp Mills. Pulp and paper and cardboard factories. Forest chemical plants.
Chemical and petrochemical industry	Various large production of basic chemistry products. Factories rubber products. Plants asbestos products. Major production of chemical fibers. Nitrogen fertilizer plant. Plants of varnishes and paints. Production of plastics. Tyre factories.
Mining industry	The mines with open pit development. Land mines mining complexes. Crushing-sorting-paid-factory. Concentrating factory ferrous and nonferrous metallurgy.
Non-ferrous metallurgy	Aluminum plants. Plants of secondary non-ferrous metals.
Electrical power	Thermal power plants (TPP, TPP). Nuclear power plants. Hydroelectric power plants.
Oil and gas industry	Refineries. Plants for the processing of oil for various purposes at existing refineries. Gas processing plants.
Coal and oil shale industry	Land complexes coal and shale mines. Coal and shale sections. coal preparation plants.
Mining and Chemical industry	potash plant
Building materials industry	Cement plants. Plants asbestos. Plants roofing materials. Factories and production of glass and glass products. Plants for the production of precast concrete. House-building plant.
Engineering	Plants for the production of cars, machines and equipment for various purposes. Complexes of large plants and production at the existing plants.

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