Pauliuchuk Yu., Ciekanowski Z., Nowicka J.

METHOD OF IMPLEMENTING JUST IN TIME CONCEPT IN CONSTRUCTION

Pauliuchuk Yu., Ciekanowski Z., Nowicka J.

Annotation. The article focuses on implementing Just in Time concept in the construction industry when engineering buildings using "just-in-sequence" method. The essence of the concepts and method, their positive aspects are considered in the broadest expression. The study describes the logic of interaction between three subsystems of the construction production system: installation sites, vehicles, and warehouses of finished products supplier plants. An algorithm and a method for formulating an operational daily plan for "just in time" supplying construction sites with precast concrete structures, taking into account the technological sequence and deadlines set at the stage of developing the calendar plan for facility construction, are proposed. The method comprises the temporal settings of the beginning and end of sets installation, scheduling vehicles to load in loading points at supplier plants, and the calculation of the required number of vehicles. The elaborated method makes it possible to implement Just in Time concept in buildings construction based on operational daily working plans of construction companies, supplier plants, and transport companies.

Keywords: Just in Time concept, just-in-sequence installation, construction company, supplier plant, prefabricated structure, delivery.

Introduction

As known, one of effective management principles is reservation, or creation of inventory, which are used in case of any interruptions in the system functioning. Naturally, the maintenance of any reserves is associated with certain costs, which should be recouped due to the timely fulfillment by enterprises of their contract obligations (any contract includes penalties for non-fulfillment by the parties of their obligations, both time and volume-related), and creating reputation as a reliable partner, which is crucial under tough market competition.

The Just in Time (JIT) management concept, also called a logistics concept, implies the delivery of resources needed for any activity, to the place of their use exactly in time, which is determined by the plans (schedules) for implementing this activity. Some of basic principles of this concept include [1,2]:

zero inventory, both in suppliers and consumers;

minimizing the waiting time for subsequent production operations;

high quality: the basis for effective JIT concept use is the defects reduction in the course of production and better product quality,

reliability, i.e., all operations must be performed in an uninterrupted manner.

The JIT advantages include:

reduction of inventory and uncompleted work;

reduced time for order fulfillment;

reduced time for production;

performance improvement;

using equipment with a higher load;

improving the quality of materials;

waste reduction;

more responsible attitude of staff to work;

improving relations with suppliers;

the habit of constructively solve problems arising in the course of work.

In the construction production system, the Just in Time concept is implemented in constructing large-panel buildings with just-in-sequence installation of precast concrete structures. The essence of the just-in-sequence installation method is that all precast structures are delivered to the construction site according to hourly schedule in strict technological sequence and installed by an assembly crane in the design position from vehicles without intermediate storage [11].

Installation of buildings from vehicles allows to eliminate the costs for organizing on-site storage of precast elements and warehouses at concrete structures factories, minimize on-site loading, unloading and warehouse operations, eliminate unproductive costs for storing precast elements.

To organize transportation with on-site warehouse unloading, a pendulum traffic scheme is used. With the pendulum scheme, a truck or a road train is loaded at the factory, then it runs to the construction site, unloading, and runs empty for a new cargo.

When installing precast concrete structures using the just-in-sequence method, they may be delivered using a shuttle method. In this case, a truck is coupled with three trailer: one trailer is loaded at the factory, another with truck is on the way (loaded to the construction site or empty to the factory), and the third one is unloading on the construction site.

The shuttle method of products delivery significantly increases the performance of vehicles, since their downtime during loading and unloading is excluded. To cut the time spent on site, structures may be installed sequentially on two nearby and simultaneously operating construction sites. For example, a vehicle has delivered two structures, then one structure is unloaded with the crane at one facility, and the car relocates immediately to another facility where the second structure is installed [12].

The analysis of studies on using the Just in Time concept [1-9, 17-20] indicates the absence of specific instruments to introduce this concept in various sectors of the economy, including construction. The authors focus on the concept philosophy, the history and analysis of its use in various industries and enterprises, its goals, principles, advantages, theoretical aspects, efficiency and problems of implementation.

But "just in time" is not a strategy that can be implemented as it goes. This system requires appropriate preparation before being implemented. First of all, this is due to a thorough analysis of the supply chain, functioning of all participants (elements), processes and technologies for their implementation.

Logical description and problem statement

When installation is made from a warehouse, all technological operations are performed directly on the construction site. Structures are transported to central and on-site warehouses, structures are loaded and unloaded, sorted and stacked in warehouses, structures are fed from pre-assembly or warehouses for installation, materials, semi-finished products, parts and accessories are transported to the installation area. When storing structures, their quality, dimensions, marking and completeness are especially controlled. When installing buildings from vehicles, unloading and sorting processes are excluded, since structures are immediately delivered for installation. Preparatory processes include: checking the condition of structures, pre-assembly, temporary (installation) reinforcement of structures, preparation for installation and arrangement, delivery of structures as an assembly unit directly to the installation site.

JIT installation involves only mere installation processes performed on the construction site. Fully manufactured and prepared for installation structures are delivered to the construction site from the manufacturing plants at exact time and these structures are brought directly from the vehicles to the place of their installation in the design position. Such an organization of the construction process ensures complete and rhythmic delivery of only those structures that need to be installed at this particular moment.

This method of structures installation practically eliminate the need for on-site warehouses, intermediate reloading of precast elements, creates favorable working environment on confined construction sites, the working process on the construction site begins to resemble the factory assembly process, it ensures the rhythm and continuity of the construction process.

Installation of buildings from vehicles allows to eliminate the costs for organizing on-site storage of precast elements, minimize on-site loading, unloading and storage operations, eliminate unproductive costs for storing precast elements. The use of this method ensures synchronous with the installation and complete delivery of precast elements.

Just-in-sequence method of installation makes it possible to use mounting mechanisms more effectively, significantly increase the productivity of installers, shorten the time and reduce the cost of construction and, most importantly, sets a certain rhythm in the work of all companies involved in buildings construction.

In construction, as already noted, the main elements of the system for completing construction facilities with precast structures are: construction facilities, vehicles, warehouses of finished products of supplier plants. The types of construction and installation works, the technological sequence and deadlines, the required material, technical, labor resources and their amount are determined by facility construction calendar plans developed as part of the work project. The working shift assumes a specific time of its beginning and end, and a lunch break. The process flow may contain technological and organizational breaks. Products loading to vehicles in the warehouse of finished products of the supplier plant is performed in special places, hereinafter referred to as loading points. Each warehouse can have several loading points of structures equipped with the necessary installation equipment and may serve only one vehicle at each given time. The working shift at the warehouse also assumes its specific start and end time and a lunch break. The latter also concerns the work of transport. It is also necessary to take into account the time of installing particular sets at construction sites, the time of their loading in warehouses, transportation time from the warehouse to the installation site, and the time of trailer return from the facility to the warehouse.

All these real conditions must be taken into account when elaborating an operational daily plan for completing construction facilities. Fundamental prerequisites for prompt completion of facilities with precast concrete are: timely completion of works on objects installation, reduced downtime of installation teams in waiting for structures, as well as reduced downtime of vehicles in waiting for loading and unloading. In some cases, it is possible to increase transportation costs, if this will reduce downtime of installers waiting for structures.

This is due to the fact that the main objective of the construction production system is the timely commissioning of buildings and structures built with required quality and in compliance with the design documentation. Therefore, when developing documentation related to Just in Time concept, this must be taken into account, and warehouses and transport should be treated as service subsystems.

It should also be noted that, as a rule, a construction company simultaneously builds several, in some cases dozens, of facilities, each at any given time requiring different structure in terms of nomenclature and size. Of course, the time of their loading in the warehouse and installation on the construction site has its own significance. In addition, the construction sites are geographically located at different distances from supplier plants and the time of structures transportation to these sites is not the same.

Following the above, formulation of daily operational plans for completing construction facilities with precast structures using Just in Time concept seems to be rather time-consuming, creative, multivariate task, which requires considering a large number of various factors.

The objective function of the problem can be expressed as follows:

$$C_{к}(T, q, Ik, W) \rightarrow \min$$

where Cк are total losses from installation teams downtime at construction sites;

T is the number of vehicles;

q is the number of loading points in the finished products warehouses;

Ik is the number of semi-trailers on the installation site;

W is the number of logical options considered for drawing up an operational supply plan (a variable that depends on the logics of drawing a schedule).

Restrictions have the following form:

T = min

q = const

Ik = const

The problem is formulated as follows:

There is a construction association that functions as a manufacturer of precast concrete structures using them for facilities construction K. Its production base is the number W of factories of concrete structures producing the whole range of products for the houses being built. The factories are located in a single complex. Each W-th factory has m warehouses of finished products, specialized by product types. Each specialized warehouse includes q spans (all spans are interchangeable by the types of stored products).

It is required to develop an operational daily plan for all K construction projects of the association, taking into account the use of "just-in-sequence" installation technology, in which installation teams downtime at construction sites will be minimal.

Formulation of an operational plan for precast structures delivery to sites

The logistics chain of precast concrete structures delivery to construction sites includes the following main processes:

products loading on trailers at finished products warehouses of concrete structures plants;

structures transportation to construction sites;

Just-in-sequence installation of structures.

Time of structures loading on trailers depends on the type of products and is constant for a certain number of products. Products are loaded from the warehouse to construction sites in three shifts, no loading performed during lunch time of loading crewes in the warehouses of finished products.

The distance from each site to the plant which determines the transportation radius may vary, either the same for a number of sites, or different.

Installation is performed simultaneously at K sites to which it is necessary to deliver nk structure sets daily.

Installation works are performed straight from trailers on an hourly schedule using a pendulum-shuttle method of operation, when one truck serves several trailers. As one trailer is loading and transporting, others are on the way or at construction site. By the time the panel truck arrives on site, products from one of the trailers being there must be fully installed so that truck can pick up a free trailer for loading.

The number of vehicles T required to fulfill the daily transportation plan depends on:

the number of sites (K),

the number sets ordered by each site (n k),

time from factories w to sites k (t wk.).

Precast structures are transported out by one type of truck with uncoupled trailer.

With "just in time" method adopted in the construction association, the precast structures should be delivered on site strictly in temporal and technological sequence according installation schedule for each constructed section.

The plan for the operational sites completion with precast concrete structures should be developed for one day and contain shifts, hours and minutes-specific data. The planning unit is one set, i.e. a set of products per one truck run.

The plan formulation logic can be described as follows.

Pursuant to facility construction schedule which determines the technological sequence of structures installation and actual situation on site, the work producers formulate structures delivery orders for the planned day for each site. The order is made for a delivery set which includes separate sets. At the same time, the installation time of each set and technological intervals between installing individual sets (if any) must be taken into account. The main criteria for orders formulation are compliance with the technological sequence of installation and the minimum possible amount of installers and construction equipment downtimes.

Based on per-site orders, a consolidated order is formulated for the supply of reinforced concrete structures for the planned day for all constructed facilities. Formulating a consolidated order is a time-consuming creative process since it must take into account the technological requirements for constructing several facilities indicated in per-site orders, the capacities of warehouses of finished products, both in terms of availability of the necessary structures and technical capabilities of loading sites in warehouses of finished products. Availability and capacities of vehicles involved in structures transportation must also be kept in mind.

Formally, this process mey be described as follows. First, we need to identify the the beginning L b knjm and the end L e knjm time of an interval when a truck may load at the m-th warehouse of finished products to make the n-th run to the k-th facility with a j-type set. As a possible loading interval, an acceptable period of time is taken during which loading may start while ensuring timely delivery for installation.

The value of the interval of possible set loading depends on the number of trailers on the installation site I k and is defined as follows. If there is one trailer at the facility from which the structure is installed, then in the absence of a technological break, the next set of products must be delivered not later than the mounted set has been installed. Only then will there be no interruption in structures installation and trucks downtime in waiting for the trailer. If there is a technological break between installation of two consequent sets, the set delivery must be performed before installation of the supplied set begins. Let's call this period the period of possible products delivery on site. If there is no technological break between the end of the first installation and the beginning of the next installation, then the period of possible product delivery on site becomes a moment in time, graphically presented as a dot.

If there are two trailers on site, the period of possible products delivery is extended due to the time of installing the set from the second trailer. It equals the period between the end of installing the nth set and the beginning of installing the (n+2)th set.

If we subtract from the beginning and end of the period of possible product delivery the time to uncouple the trailer, the run time from site to warehouse and time of set loading in the warehouse, then we define the interval of possible loading.

Provided there is one trailer on site, i.e. I k = 1, the interval beginning for the first run L b knjm = T o, the interval beginning for all subsequent runs:

Lbknjm = [(te(n-1)kj – (tmk+tjm+Jk)],

end of interval for all runs:

Leknjm = [tbknj – (tmk+tjm+Jk)].

Provided there are two trailers on site, i.e. I k = 2, the interval beginning for the third and all subsequent runs:

Lbknjm = [te(n-2)kj – (tmk+tjm+Jk)].

where: t e(n-1)kj is the end of installing the (n-1)-th set at the k-th facilty;

t b knj is the beginning of installing the n-th set at the k-th facility;

t e knj is the end of installing the n-th set at the k-th facility;

t e(n-2)kj is the end of installing the (n-2)-th set at the k-th facility;

t jm is the loading time of the j-th set at the m-th warehouse;

t b jm is the start time of loading the j-th set at the q-th loading point of the m-th warehouse;

t mk is the run time from warehouse m to the k-th facility;

J k is the recoupling time at the k-th facility;

T o – start of the first shift in the warehouse.

If it turns out that the found moment of the beginning of the interval for possible loading is ahead of the start of the warehouses, then it should be equal to the start of the warehouses.

If the end of the interval for possible loading is ahead of the start of the warehouses as well, then the interval for possible loading is taken as the time corresponding to the start of the warehouses T o. In this case, the value of the delay for installation is calculated as follows:

To – [teknj – (tmk+tjm+Jk)],

and then, for all trucks of this facility, the intervals of possible loading are shifted by the resulting value of delay for installation.

When developing a delivery plan, it is necessary to define the type of warehouse where the set in question can be loaded; figure out if any loading point q is free in this warehouse at the time when this set must be loaded, and adjust the loading start time t b jm depending on the availability of a free panel truck.

Formulating the delivery plan starts with the set which has the earliest end of the possible loading interval, i.e. (L e knjm) = min.

To formulate each truck run, it needs to determine the beginning of loading the j-th set at the q-th loading point of the m-th warehouse, the n-th truck run to the k-th site, depending on free loading point specialized for this type of products, and the availability of free vehicles.

Given that the beginning of loading the truck run coincides with the start of the possible loading interval, i.e. Lbknjm, we determine if there is a free loading point at this moment, i.e. check the condition tqm $\leq$ Lbknjm, where tqm is the time when it is possible to start loading the required set at the q-th loading point of the m-th warehouse.

Meeting this condition allows to identify the necessary loading point q and fix the time when it is free, equal to the condition (t qm + t jm).

If this condition is not met, then it is necessary to check the possibility to start loading the set in question prior to the end of its interval for possible loading, i.e. check the condition t qm $\leq$ Leknjm.

Meeting this condition allows to identify the necessary loading point q and fix the loading start time at this loading point.

If this condition is not met at any loading point, then the set loading time must be assigned at the earliest available loading point, i.e. find the loading point where (t qm - L e knjm) = min. This value represents the downtime in awaiting for products that have emerged due to the busy warehouse.

Next, it is possible to adjust the found loading start time depending on the availability of free panel trailers. To do this, the found set loading start time L b knjm is compared with the time of arrival at the factory of those panel trailers that are already working or are to work this shift. Formulation of the final loading plan depends on the choice of one of the possible logical options W of operational planning of vehicles loading:

as long as there are vehicles not starting to work, they are considered when formulating the next run;

the next run involves the vehicles that have the earliest time of arriving at the factory;

the next run involves the vehicle with the minimum difference between the found start time of set loading and the time the vehicle comes to the factory from the previous run.

If there is not a single vehicle that allows set loading without being late for installation, then all orders for this site are shifted by the time of installation delay caused either by the absence of the vehicle, or by busy warehouse, or both in total.

Finding the minimum number of vehicles required per shift to implement the precast structures supply plan can be determined as a quotient of dividing the total cycle time for all runs claimed for the shift by the vehicles shift duration, i.e. by the formula:

$$T_{\min} = \frac{\sum_n 2t^n_{mk} + \sum_n t^n_{jm} + \sum_n J^n_k}{T_s} \tag{1}$$

where: t n mk is the duration of the n-th run from the warehouse m to the k-th site;
t n jm is the loading time of the j-th set at the m-th warehouse for the n-th run;
J n k is the re-coupling or unloading time of the n-th run at the k-th site;
Ts is the shift duration.

When formulating an operational supply plan or once formulated, it is necessary to develop specific recommendations on the use of the calculated minimum number of vehicles to implement the declared supply plan, determine the need for reserves and assess the reliability of the joint work of factories, transport and construction sites.

A diagram of the algorithm for formulating an operational daily plan for completing construction facilities with precast structures is shown in Fig. 1.

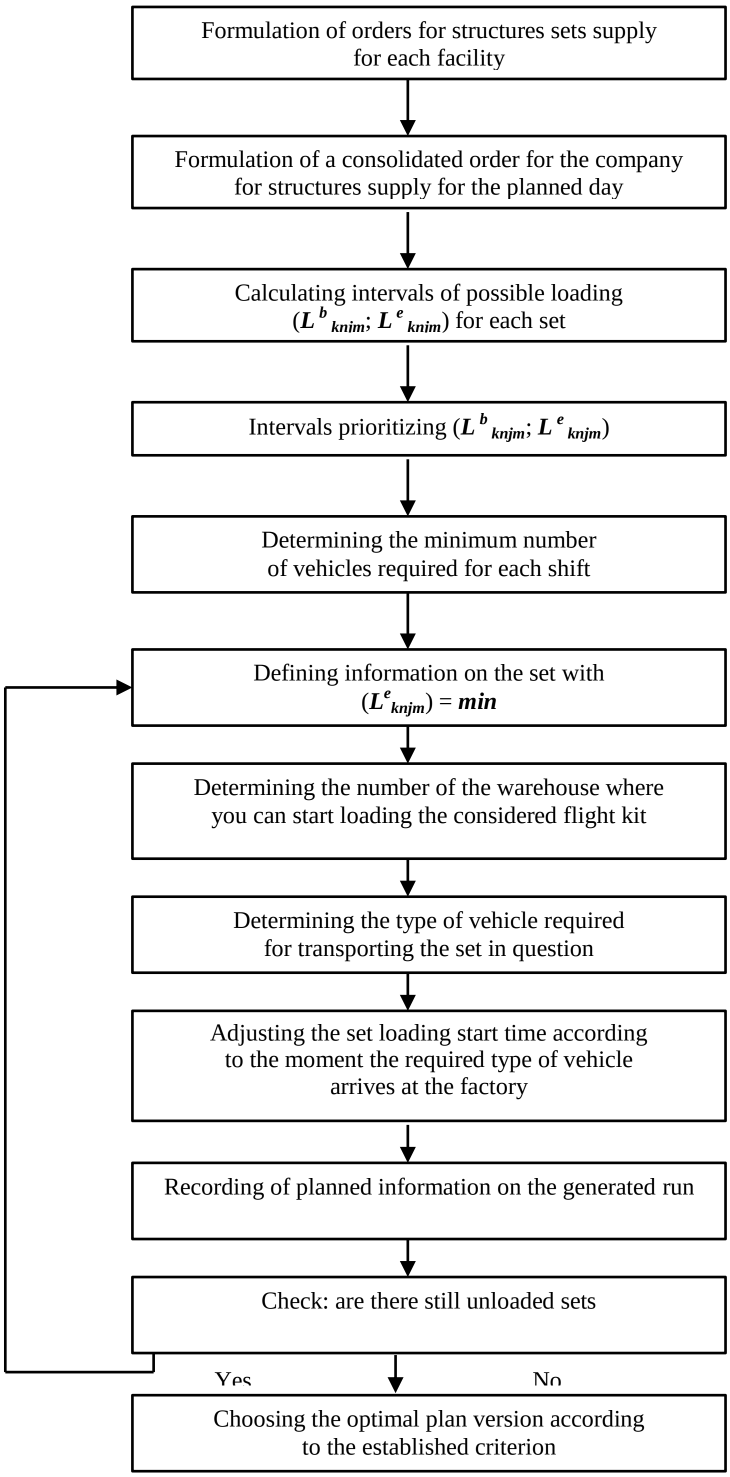

Figure 1 – Calculation algorithm

Practical experience shows that use of graphical method is very convenient and visual when forming operational daily plans for facilities completing. This will require drawing time axes to display the time of structures installation on site, the time when loading points in warehouses are busy, and the trucks operation time.

Conclusion.

The described method helps to implement the Just in Time concept and use its main positive aspects when planning buildings and structures construction using "just in sequence" installation technology. This takes into account, the actual status of all subsystems involved in facilities completing, production technology, employment, construction equipment, and transport. The practical experience of using this method shows that there are always several options for reasonable plans. The choice of the best of them is determined by specific conditions and options, both at construction sites and supplier plants and transport units.

References

1. Greene R.T. (1993). Global Quality: a synthesis of the world's management methods, Milwaukee

2. Grzechca W. (2012). Strategia Just in Time w problemie balansowania linii montażowej, „Logistyka – nauka”, nr 627

3. Lorenc A., Szkoda M. (2015). Zastosowanie systemu SAP ERP do obsługi dostaw Just-in-Time oraz Just-in-Sequence w branży motoryzacyjnej, "Logistyka - nauka", nr 2881

4. Witkowski J. (1998). Logistyka firm japońskich, Wydawnictwo Akademii Ekonomicznej we Wrocławiu, Wrocław

5. Эффективное управление запасами / Джон Шрайбфедер; Пер. с англ. - 2-е изд. - М.: Альпина Бизнес Букс, 2006. - 304 с.

6. «Точно вовремя» для рабочих. Группа разработчиков издательства Productivity Press. М. Издательство ИКСИ, 2007

7. Гаврилов Д.А. Управление производством на базе стандарта MRP II. – СПб.: Питер, 2005.

8. Канбан и «точно вовремя» на Toyota: Менеджмент начинается на рабочем месте = Just-in-Time at Toyota: Management Begins at the Workplace. – М.: Альпина Паблишер, 2014.

9. http://log-lessons.ru/jit/

10. http://www.elitarium.ru/sistema-jit-process-proizvodstva-kachestvo-rabota-vremja-rashody-celi-jeffektivnost/

11. http://gogolclubs.ru/234-krupnopanelnoe-stroitelstvo-montazh-s-koles.html

12. https://official.academic.ru/

13. https://my-dict.ru/dic/stroitelnyy-slovar/1580245-montazh-s-kols/

14. https://cyberpedia.su/12x3fd4.html

15. https://dic.academic.ru/dic.nsf/stroitel/2894

16. https://ru.wikipedia.org/wiki

17. https://studme.org/41432/logistika/proektirovanie_logisticheskih_sistem

18. https://logists.by/library/inventory-management/metod-tochno-v-srok-just-in-time

19. http://www.elitarium.ru/sistema-jit-process-proizvodstva-kachestvo-rabota-vremja-rashody-celi-jeffektivnost/

20. https://dom-srub-banya.ru/sistema-tochno-v-srok-v-stroitelstve/

Oksenchuk N.V.

DEVELOPMENT AND LOGISTICS OF E-COMMERCE IN THE WORLD AND THE REPUBLIC OF BELARUS

Oksenchuk N.V.

Recent years have seen an increasing development of e-commerce This is facilitated by scientific and technological progress in the field of information technology and electronics. E-commerce is an area of economic that incorporates all financial and trade transactions performed using computer networks, and business processes linked with performing such transactions.

E-commerce enables making purchases, sales, service, marketing activities, individual commercial transactions through Internet and computer networks [1].

Today, the latest Internet technologies and the global information network open up not only technical, but new economic opportunities as well.

Current progress in communication technologies have led to the creation of a global electronic environment for economic activity, which, in turn, has provided with new opportunities for the growth of e-commerce as a new form of organizing trade and economic activities of economic entities [2].

In 2020, China became the world's largest e-commerce market with e-commerce sales volume of $1.935 trillion, which is up three times against the United States ranking second with $586.92 billion [3].

It is necessary to note the experience of Russia in developing e- commerce.

According to Yandex.Market, the e-commerce market in the Russian Federation is estimated at 1 trillion rubles, its share in the total turnover of Russia is 4-5% [4].

Online platforms act both as an independent retail platform and a provider of digital trading platforms that unite consumers on the Internet and create a multi-lateral market.