CONSTRUCTION LOGISTICS OF BELGRADE WATERFRONT

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Abstract: *"Belgrade Waterfront" is the one of the most important projects of the city of Belgrade and currently the largest investment project in this part of Europe. The undisturbed project realization requires serious planning and management of the complex and intensive flows of goods, freight, material, people and information, as well as the flows of vehicles and mechanization, so it is the major challenge for the city logistics and construction logistics. This paper describes the construction logistics problems of "Belgrade Waterfront" and possible solutions. The location of temporary logistics centres, the problems of supplying the construction sites with materials, the supply chain management and the role of the reverse logistic during the project realization are considered.*

Keywords*: construction logistics, delivery flows, reverse logistics, logistics consolidation centre*

1. INTRODUCTION

The construction logistics involves all technologies, rules, methods, knowledge and solutions related to the movement of material and other types of resources in construction flows (Duiyong et al., 2014). From the aspect of the project realization scheduling, it could be divided into three segments (Duiyong et al., 2014). The first segment is related to the logistics before starting the construction and involves supplying a construction site with necessary goods, labour force and mechanization to start the work. This construction logistics' segment is very important and allows undisturbed construction starting. The basic project is following by the logistics during the construction, where the good communication among all construction site sectors is of particular importance for efficient logistics flows realization and undisturbed construction. The third construction logistics' segment is related to the period after the completion of construction works and involves the activities related to the removal of various types of waste for their proper disposal at landfills, recycling and other renewal options. This paper presents the general project overview, construction logistics problems, possible solutions and the logistics concept of "Belgrade Waterfront" project.

2. "BELGRADE WATERFRONT" PROJECT

According to the project, "Belgrade Waterfront" covers an area of 1.85 millions of squared meters and envisages the construction of about 200 facilities for various purposes and functions on the right riverside of Sava, between Railroad Bridge and Branko's Bridge, up to Karadjordjeva and Savska Street. The project implementation was conceived to be realized in four phases

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(Figure 1). The biggest part of the area, about 60%, is planned for the construction of residential units, 17% for commercial properties, 8% for hotels and a shopping mall, separately, 5% for shops and about 1% of planned areas for cultural and leisure activities. The buildings standing out are “Belgrade Tower”, 170 m tall, and the shopping centre which will cover more than 148,000 of square meters. When it comes to the street network, it was planned to keep the existing street matrix which will be linked by newly constructed boulevards. The project appreciates the cultural and historic heritage of the city of Belgrade, thus some buildings will not be razed during the works (http://www.rapp.gov.rs).

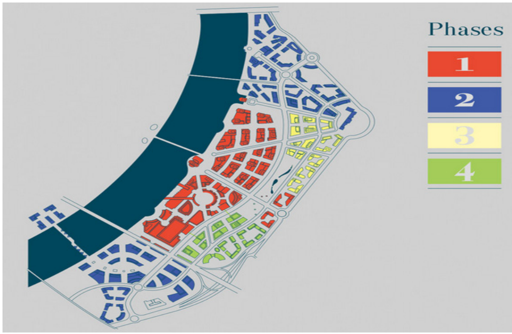

Figure 2. Phases of “Belgrade Waterfront” project realization

3. CONSTRUCTION LOGISTICS

The construction logistics involves planning, organization, coordination and costs of flows and logistics activities that are related to the construction project realization (Duiyong et al., 2014). The large construction project realization requires precise and clear organization of all operations at the construction site, implying developed supply chain. The supply chain includes all logistics activities, production operations and process coordination management and activities related to marketing, sale, product development, finance and information technologies, but their relationships too, as well as the coordination and collaboration among partners being in the same chain (Miljuš M., 2015). The supply chain may have a different impact on the construction site depending on the point of view (Vrijhoef R. & Koskela L., 2000). It is possible to consider the inherent relationship between the supply chain and construction site, the supply chain as an independent unit, activity shifting from the construction site to the supply chain and the construction sites (Vrijhoef R. & Koskela L., 2000). The experts in this field have attempted to define the main problems with construction work realization (Rogers P., 2005.): underused loading space of vehicles, waiting at the transshipment front, qualified staff engaged for unqualified tasks such as unloading, material are often transferred from one to another place within the construction site, poorly planned work time schedule for professional tasks, the large amount of material and waste and very poor training of logisticians for the work in the construction industry. Figure 2 shows the problems in the construction process.

Poor logistics implementation may cause a series of consequences such as: unnecessary costs, poor image of the construction industry, poor construction quality, prolonged designing time, additional health and security risks etc. (Rogers P., 2005). On the other hand, by implementation of good logistics the many positive effects could be achieved, such as: reduction in movement volume, reduction in credit-linked capital, reduction in waste amount, rapid construction time, improved quality, lower health and security risk of the workers, more efficient use of labour force results in construction cost decreasing and, generally, in the improvement of industry’s image (Rogers P., 2005). The good logistics can reduce the unnecessary material movements, shorten the production process and increase the productivity up to. It is possible to monitor system performances (both quantitative and qualitative) in two ways: 1) observation and monitoring of systems and its functioning; (2) comparison of implemented solutions, i.e.

monitoring how much the applied solutions are appropriate and to what degree they improve the system (Wegelius-Lehtonen T., 2001).

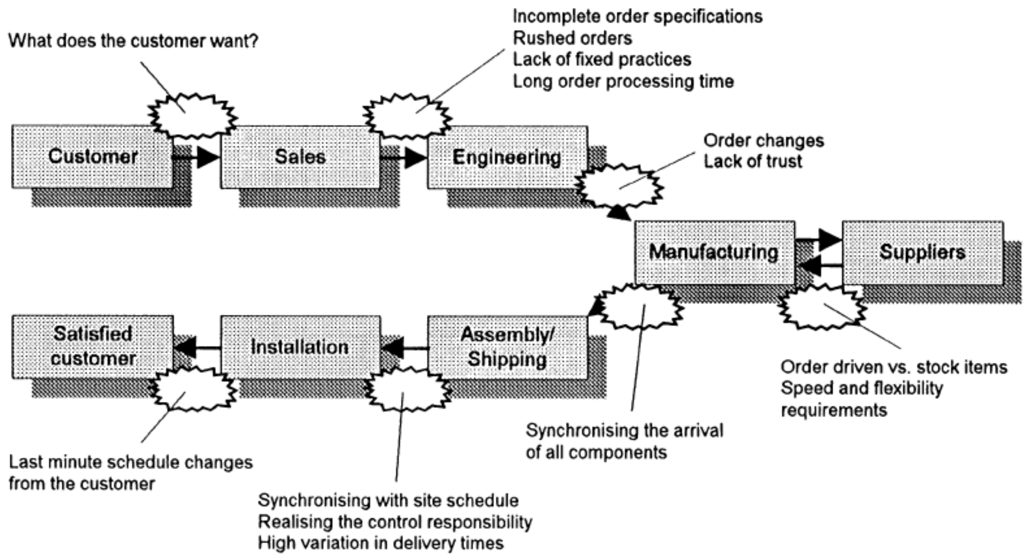

Figure 3. Problems in the construction process (Vrijhoef R. & Koskela L., 2000)

When designing, it is possible to use "Last Planner" method. The reasoning is to meet all prerequisites that are necessary for performing various construction tasks before these tasks are assigned to a working group. By this method, all the tasks related to the project could be classified into four categories (Ala-Risku T. & Karkkainen M., 2006):

- SHOULD – tasks that need to be performed in the near future according to the overall project plan.
- CAN – tasks that have all their prerequisites ready: e.g. previous project steps are completed, necessary materials are at hand, and work force is available.
- WILL – the tasks that are commenced before the next planning round.
- DID – the tasks that are completed.

4. CONSTRUCTION LOGISTICS OF "BELGRADE WATERFRONT"

The construction of "Belgrade Waterfront" involves the processes of transport, storage, loading, unloading, packaging and stock management related to numerous of various types of materials and equipment. It is necessary to provide that all activities are taking place in a simple, quick, continual and controlled manner. In order to provide material availability in the moment of the request occurrence at the construction site, it is necessary to develop both long- and short-term plans for the material delivery which could be adjusted and upgraded during the project realization. During this period, each construction sector is obliged to submit a list of required materials for the next period (day, week and month) to the logistic centre. In order to make this system function, it is necessary to have a well-developed supply chain.

4.1 Supply chain

The implementation of the supply chain into the project has many advantages: shorter time of the request realization, precise amount of material for the production, decreasing in stock and trapped capital level, quick realization of the logistics processes, electronic data processing and exchange, quality of service improvement, reduction in total costs etc. Considering that this is a long-term project, it is necessary to make contracts among all participants in "Belgrade Waterfront" construction process and define their rights and obligations in order to secure the undisturbed supply chain functioning. To make supply chain function, it is primarily necessary to make a special IT platform in order to provide a high-level communication and data exchange and processing. The material and information flows have different movement directions within a system. To consolidate smaller deliveries and provide the timely material delivery to different locations within a construction site, it is proposed to implement the construction material consolidation centre. Its implementation is temporary and it is determined by project duration.

4.2 The location of temporary logistics centre

After detailed analysis of the project and schedule of "Belgrade Waterfront" realization, the authors identified some possible location of the logistics consolidation centre. Based on the estimation by several criteria (the available surface area, time distance from all construction phases, transport infrastructure development, connection to main roads etc.), the location of future "Belgrade Park" is proposed. However, the location of the centre may vary in different phases of the project construction if it is economically justified. The chosen location covers 40,000 m^2 of space, occupies the central position on the project map, being situated near the riverside and connected to other construction phases by main roads. Within the centre, there will be the entry/exit check point, administration building and warehouse for construction material, parking facility for freight and construction vehicles, fuel tanks, maintenance system, the space for waste and unused material disposal. The planned area for the logistics centre installation is also convenient from the aspect of the arrangement after the completion of work. Nevertheless, the choice of a logistics centre location requires quantitative and qualitative analysis of potential locations from the aspect of a larger number of criteria and the application of operational research methods.

4.3 Types and amounts of material

With the aim of flow volume estimation and for the purpose of this paper, only basic material categories are considered in the facility construction process. Besides the steel poles, which presents the frame and gives shape to the facility, this paper involves steel floor coverings, through which the concrete is poured for the purpose of the fire protection, armature, bricks for room separation, sheet material (marble, ceramic tiles, parquet) and windows that provide a futuristic look to the buildings. The material amounts are estimated by phases (Table 1), based on the scope of work, i.e. the planned area in m^2.

Table 1. Estimated material amounts for "Belgrade Waterfront" construction

Type of material	Estimated scope					
	Phase 1 555.000 m^2	Phase 2 832.000 m^2	Phase 3 278.000 m^2	Phase 4 185.000 m^2	Total 1.85 mil.m^2	With 5% of reserve
Steel poles (t)	120.000	39.000	14.500	21.000	194.500	204.225
Floor coverings (t)	30.000	3.500	1.300	2.300	37.100	38.955
Concrete (m^3)	2.175.000	330.000	66.000	135.000	2.706.000	2.841.300
Armature (t)	110.000	16.500	3.500	6.700	136.700	143.535
Brick (t)	640.000	80.000	30.000	53.000	803.000	843.150
Sheet material (m^2)	2.100.000	245.000	91.000	164.000	2.600.000	2.730.000
Windows (m^2)	95.000	24.000	8.900	16.000	143.900	151.095

Among estimated amounts, the dominant material is the concrete, which will be used for the purpose of building stability, paneling of steel poles, forming of floor concrete slabs and public roads too. The large amounts of concrete and armature will be used in the construction of central support pillar of Belgrade Tower, on which the steel frame will be relied.

Besides timely material delivery, the successful project realization requires the delivery of the construction mechanization such as: earthmoving machines (bulldozers, excavators, loaders, levelers, vibratory rammers, rollers and pavers), lifting (cranes and elevators) and transport machines (trucks, tippers, dumpers) and mixers (towing mixer and truck mixer).

4.4 Problems, possible solutions, directions and methods of material delivery

It is well-known that the city of Belgrade has difficulties with traffic jams on the bridges and the street matrices in the old part of the city are mainly narrow and unidirectional, with the prohibition of large transport means' movements. Night delivery is not feasible for all flows, so the construction site supply will be a large traffic problem. Since "Belgrade Waterfront" is spatially relied on right riverside of Sava, one of the possible solutions to the problem is the use of the river transport. By choosing this delivery method, it is possible to enable the unloading of street networks, without vehicle accumulation and congestion occurrence, as well as the timely delivery of large amounts of the material by reduced number of transport means (one push barge-barge system replaces dozens of road vehicles). In addition, the transport cost will decrease and the environmental pollution will be significantly reduced.

The use of river transport was also justified by analysing the potential directions of material delivery: Smederevo Ironworks (steel materials), factories from Pančevo producing concrete and glass, brick production plant from Novi Sad and sheet material manufacturer from Šabac. For the delivery of the concrete, it is also possible to use river transport by choosing the vessels for transport of the whole road vehicles (mixers and truck mixers).

It is possible to establish the connection between the riverside and consolidation centre by installation of an adequate type of belt conveyor. For the heavy-weight and irregular-shape materials, it is possible to use cranes for reloading into road transport means for bulky loads. Nevertheless, the choice and use of transport and transshipment systems, as well as the opportunities for vessel docking, require a detail analysis.

4.5 Reverse logistics

The reverse logistics has a very important role in the construction project realization. Large construction sites generate a large amount of waste which could cause many problems (Nunes et al., 2009). The waste material could be classified into three main groups: the inert construction waste, which is disposed at landfills, the recycling waste (glass, steel, iron etc.) and the waste which is the overage in some facility construction, but it could be temporary reused in some other facility construction (marble slabs, windows, parquet, rod materials etc.). Waste collection from the active construction sites could be realized periodically, by special vehicles. The waste would be disposed at temporary landfill near the consolidation centre. With the aim of the vehicle movement optimization when delivering material from the consolidation centre and collecting the waste, it is possible to apply the travelling salesman method in order to minimize the distance and, consequently, the collection time and transport costs, and to maximize the capacity utilization of vehicles. After collecting a priori determined amount of waste, it is performed its ad-hoc removal, i.e. dial a removal. This method of waste removal from the logistics centre is good because the transport capacity of vehicles used for delivery is maximally exploited. Since there are various groups of material at the construction site, it is necessary to sort them, in terms of separating inert and recycling materials. It is probably better to sort materials at the construction site by placing containers for different types of waste, in order to reduce time interval until the later further sorting. The material which could be used for the construction of other facility is stored in the consolidation centre until the moment of requesting its re-delivery to the embedding site. Besides the reverse logistics of the materials, the return logistics of the construction mechanization must not be forgotten after the completion of work.

5. CONCLUSIONS

The construction logistics faces numerous technical and organizational problems, as well as environmental problems, which influence the costs and construction time and quality. In larger construction projects, such as "Belgrade Waterfront", which includes a broad scope of work, numerous contractors and extensive and complex material flows, an inadequate logistics concept and a lack of coordination result in serious disturbances. The logistics centralization and supply chain introduction implies the reduction in total costs of project, quality improvement and shorter time for completion of the construction. Numerous studies have showed that the most of the problems in the supply chain occur in the previous phases of the chain. The information exchange among the participants is often very poor, resulting in poor synchronization of construction project's processes and activities. The solution to these problems lies in cooperation among all participants in the construction project and in coordination of all activities and processes in its realization. One of the main strategies would be the integration of basic logistics function in the supply chain with marketing, production and finance.

ACKNOWLEDGMENT

This paper was written on the basis of the seminar work for the subject City logistics. We would like to thank Prof. Slobodan Zečević and Asst. Prof. Snežana Tadić, lecturers, for their support during the entire paper development, for sharing their professional experiences and for assistance in solving problems that have arisen during the paper development, thus enabling the realization of the project.

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