FACTA UNIVERSITATIS
Series: **Architecture and Civil Engineering** Vol. 16, No 1, 2018, pp. 159-173
https://doi.org/10.2298/FUACE170710013M

CONCRETING PROCESS PRODUCTIVITY ANALYSIS

UDC 693.5

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Abstract. *During constructing of any structure, there are a large number of factors impacting the total performance of the construction site. One of very important factors is productivity. Because of the specific nature and importance of concreting works, when constructing a building structure, it is necessary to pay a special attention to execution of these works. In this paper is analyzed the productivity in general sense, as well as productivity in civil engineering, with a focus on productivity in the course of concreting works. The importance of concreting works is emphasized, and the concreting works technology is described. A review and a description of the factors affecting the concreting process productivity are provided. A productivity analysis is performed on the concrete construction site based on the data obtained by recording the concreting process, and some of the results are provided.*

Key words: *civil engineering, productivity, concreting process, concreting technology, impact factors.*

1. INTRODUCTION

The parameter expressing the rate at which a work has been executed is called productivity. For the first time, the work productivity was mentioned in an article by the French mathematician Quesnay in 1766. A century later, in 1883, Littre defined productivity as a “faculty to produce”. At the beginning of 20th century the productivity was more precisely defined as a ratio of output and resources used for obtaining of the output. A formal definition of productivity was introduced in 1950 by Organization for European Economic Cooperation: Productivity is the ratio between the achieved production (output) and the resources invested in the production (input) according to the expression (1), where the invested resources can be: work, material, finances, etc.

Received July 10, 2017 / Accepted January 22, 2018
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$$\text{Productivity} = \frac{\text{Output}}{\text{Input}} \tag{1}$$

The term productivity is often confused with other terms such as production and speed. This is because it is supposed that, if there is an increase in production or speed, an increase of productivity would occur, which may but also may not be true. Productivity is related to the efficient usage of resources (input) in production (output), and production is an activity of creating something, so in other words, production is a measure of the produced quantity, irrespective of the input used for that. As a result, production can be high, but productivity needs not necessarily be high. On the other hand, speed indicates output produced in a unit of time, irrespective of used resources. Again, speed can be high, but productivity needs not be high.

Figure 1 shows in a popular way the productivity: The right things should be performed in a right way in order to keep the production/process/work… productive. If the right things are performed in a wrong way, one becomes ineffective, or if the wrong things are performed in a right way – inefficient. Ultimately, doing wrong things in a wrong way is inconsiderate.

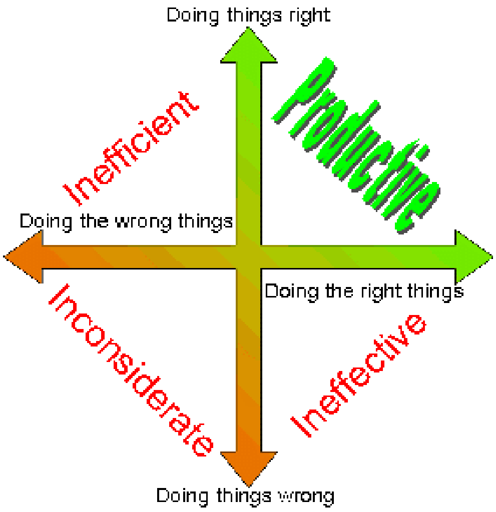

Fig. 1 Productivity (www.savjetnik.ba/šta-je-produktivnost/)

2. Productivity in Civil Engineering

Productivity is one of the most important factors which affect the total performances of any construction site, small or large. Production (output) is more often expressed through a unit of measure (volume, surface area, weight, etc.), and the input is mostly the time unit (hours, shifts, man-days, machinery-days, etc.). There is neither a universal nor a standard way for defining productivity of civil engineering processes, but in essence, the work productivity in civil engineering is most often expressed as realized production in a unit of time.

There are several ways for expressing and measuring productivity in civil engineering. Productivity can be expressed as ratio between the achieved quantity product and labor expenditure. A considerably broader view can be taken, which entails not only labor bu any other input element. In comparison to the observed level, there are several types of productivity. If the productivity is related to one activity (one position of work) where there is one type of the achieved product, and thus one unit of measure, it is then a single factor productivity. Productivity, observed at a higher level, in comparison to more than one activity, or one group of works, is expressed through (multi factor productivity). Also the productivity expressed at the level of the entire construction site, with all the activities included, defines the total factor of productivity. Measuring and studying productivity has a great impact on the shortening of deadlines and reduction of projects cost, quality enhancement, provision of efficient work execution supervision, feedback, increased profit, etc.

3. Concreting Works Importance

Concrete, as a building material has a very wide application in civil engineering industry, and for that reason it is a special subject of research. It owes its wide application to the relatively inexpensive natural materials: cement, aggregate and water, which are composite ingredients of a concrete mix. By adding water and determining the proper ratio of components and concrete making technology, the required physical-mechanical characteristics of concrete can be affected. The improved concrete technologies are based on the addition of admixtures which to a certain extent affect the concrete resistance to external effects. Various technologies are available for making and placing of concrete. The concreting process, starting from making of concrete in the concrete factory, over its transport to the construction site, and to the placing in a structure is the common construction process of a wide range of building structures. It can be rightly claimed that it is the most widely and most often used material in contemporary building construction According to data dating back to 2006, the total global concrete production was around 6 billion cubic meters, which represents around 1 cubic kilometer per resident of the planet (www.sr.wikipedia.org). Due to the specific characteristics of this building material and various influences (interruptions, downtime, irregularities, etc.) which occur during concreting, it is very important to pay a special attention to planning and execution of such works.

Concreting works constitute a major part of construction works, both of infrastructural and high-rise buildings. In case of the housing structures, in the skeletal construction system, the share of concreting works is considerable, from the aspect of quantities and costs. For instance, an average amount of concrete placed into a housing buildings having a basement, ground floor, 5 floors and an attic (P_0+P+5+$P_{k)}$, and gross surface area of 400 m^2 per floor, in the skeletal construction system, is around 1 250 m^3, of which around 860 m^3 is placed in the slabs (75 800 €), 220 m^3 into the vertical elements – columns, walls, lift shafts (22 200 €) and 170 m^3 into other smaller elements – window and door lintels, sidewalks, parapets, floors, etc. (17 350 €). The total cost of concreting works of 115 350 € represents around 38 % of the total cost of basic building works. For such structures, concrete works represent critical activities in the dynamical plan of works execution. For this reason, it is important to perform a realistic planning of execution of these works by coordinating all influences and by providing the required productivity. It can be accomplished using the software package for net dynamic planning.

One of the most important developmental projects of the Republic of Serbia is the constructing of housing space which is an existential need across the entire territory of Serbia. Necessity to build housing space is an evident consequence of population migrations, formation of new, young households, and replacement of dilapidated and low quality (environmentally inappropriate and energy inefficient) housing stock. According to the analyses of the real estate market and other indicators, the number of required houses a year in Serbia is over 25 000, and currently there is over 300 000 households without the proper housing. (www.pks.rs/PrivredaSrbije).

4. Concreting Process Technology

Nowadays, production of fresh concrete, in the conditions of contemporary technologies and increasing work division, is progressively performed in concrete plants. Concrete plants usually service a large number of constructions sites, if they are stationary, or only a specific construction site, which means that they are semi-stationary or mobile.

A technological system of a concrete plant consists of a silo for aggregate, silo for cement, water and admixture weighing systems. Optionally, such plant can have the additional silo which can store filler, micro-silicone or some other concrete admixtures. The weighing procedure depends on the manufacturer of a concrete plant, and considerably differs from one to another manufacturer.

The quality of concrete is specified based on the structural design, or technical conditions for concreting. The structural design defines the required concrete class (MB) as well as other concrete properties which determine the durability of the structures (frost and frost and salt resistance, water tightness, etc.) and concrete placing technology. In the design documents, the concrete class for a certain part of the building is specified, or the work item describes the required concrete class and other properties.

The quality control consists of the production control and control of compliance with the conditions of the conditions of structural and concrete designs. By controlling the concrete quality, it is verified that the required concrete class and other requisite properties have been achieved for a specific concrete batch. Acceptance criteria determine whether a specific batch will be accepted or rejected.

Quality control of the produced concrete is performed during concrete production and at the construction site (at the location where concrete is placed) in accordance with the regulations and provisions of PBAB (Code for Concrete Works). In addition to compressive strength, the concrete plant also performs control of particle size distribution and water content in the aggregate, fresh concrete consistency, start and completion of setting, and of cement and admixtures (Technical conditions for transported concrete SRPS U.M1.045).

On the constructions site, concrete consistency and workability ought to be tested (Technical conditions for transported concrete SRPS U.M1.045).

A special attention must be paid to the concrete transport and good coordination between a concrete plant and a construction site, to avoid unwanted changes in the fresh concrete properties. Finished concrete must be transported to a construction site in suitable (workable) condition, considering that it has a limited placing time, so it is necessary to plan and organize its transport well. The most often and most appropriate way of fresh concrete transport from a concrete plant to a construction site is in mixer trucks, whose constant drum rotation during transport keeps concrete fresh. Since mixer trucks have different capacities (5 – 12 m^3), it is necessary to well coordinate the required number of vehicles with the transport needs in terms of quantity and time. Fresh concrete transport represents a very delicate operation in the framework of entire concreting works execution technology, for the following reasons: potential for segregation, leaking of cement paste from the vehicles, evaporation of water during prolonged transport (especially in summer time), time of transport in the function of the start of setting of cement in concrete and of consistency retention (especially in the summer period) – usage of retardant admixtures, change of consistency over time when plasticizers and suerplasticizers are used. During concrete transport, care must be taken that: concrete temperature during transport does not exceed permissible limits, coarse fractions do not crush the fine fractions because particle size distribution is changed, concrete does not become segregated, etc. In essence, transport should be organized so that there are no delays and interruptions during pouring into formwork. According to SRPS U.M1.045/87 concrete mixture must be poured out of a transport vehicle no later than 2 hours after water was added in a concrete plant, if the transporting vehicle has a truck mixer device, or alternately, 1 hour if the transporting vehicle does not have a truck mixer device. In case of cold and damp weather, and when setting retardant is used as admixture, the proper time can be longer. When weather is hot and when concrete is made with a larger share of cement, or when concrete hardening accelerator is used, the proper time can be shorter.

Transport of any quantity of concrete loaded in the transport vehicle is documented by a shipping note issued by a worker in the concrete plant. The shipping note – bill of lading consists of two copies, one staying at the constructions site, and the other, signed by a construction site representative is returned to the concrete plant. Data which need to be written on the shipping note are: name of the concrete manufacturer, date of delivery, name of the purchasing customer, name of the construction site, name of the structure, type and class of concrete, special properties of concrete, delivered quantity, type of used aggregate and cement, time of completion of a transport vehicle filling up, concrete consistency, concrete temperature, time of arrival of a transport vehicle to the construction site, starting and ending time of off loading of concrete.

There are several ways of transport and placement of concrete at a construction site, but one of the most often implemented is by using the concrete pumps, especially the truck mounted ones (concrete pump trucks). Concrete pump trucks have extendable booms which allow flexible placing of concrete at various points of a structure, horizontally, at a height or at a depth. Nowadays, the pumped concrete became an important link in the chain of contemporary civil engineering, and concrete pumps are the most developed special machines, and one quarter of total concrete is placed using them. Work with the pumps is simple and engages a small number of workers, and concrete placed by a pump must have appropriate characteristics such as the quality of fine particles, aggregate grain shape, consistency, quantity of entrained air, etc. Concrete placing using pumps is quick, has a good quality and provides high profit. A record was set in 2008 in terms of the height where concrete was pumped – 606 m, at the Burj Khalifa skyscraper in Dubai (www.wikipedia.org/wiki/Burj_Khalifa).

Concrete placement comprises spreading of fresh concrete or filling the formwork using the concrete pump, compacting of concrete using vibrators and finishing of top surfaces of elements. Prior to placing concrete, it is necessary to control the installed formwork and reinforcement. The formwork must be well engineered and secured to prevent its failing and concrete leaking. The basic principle of placing is that concrete placement must be finished before cement starts to set. Setting time depends on the type and quantity of cement, as well as of admixtures, so it necessary to place concrete in the formwork and compact it with vibrators in that time. The most favorable time for placing concrete is at the air temperature from +14^{o}C to +20^{o}C. Placing of concrete at external temperatures below +5^{o}C and above +30^{o}C is considered concreting under special conditions when it is necessary to implement special concrete protecting measures. Placing of concrete is as important as the proper transport and production. This procedure ensures a homogeneous compacted structure without cavities in concrete, which contributes to its water tightness and durability, and to obtaining of a required class of concrete. Concrete ought to be installed and compacted so that all the reinforcement is well encased in concrete within prescribed tolerances for concrete protective layer. A special attention must be paid to placing and compacting of concrete at locations where cross-section dimension change (e.g. where they are narrowed) next to apertures, where reinforcement bars are densely laid and where there are concreting breaks. Normal layer thickness should not exceed the height of the immersed vibrator, and vibration should be performed by immersing the vibrator vertically, so that the surface of the lower layer is re-vibrated. In case of the thicker layers, re-vibration of the surface layer is recommended in order to avoid plastic precipitation of concrete below the upper reinforcement bars. Rate of placing and compacting of concrete must be sufficiently high to avoid cold joints and sufficiently low to avoid excess precipitation or overloading of formwork and scaffolds.

Concreting procedures depend on the type of structure, type of concreting elements, type of concrete etc. Concreting of columns (figure 2) must be performed without breaks to the specified height. Free fall of poured concrete must not exceed 1.5 m to prevent concrete segregation.

Fig. 2 Concreting of reinforced concrete columns (photo by the author of the paper)

Concreting of walls is performed in layers 30 – 50 cm thick, with uniform placing of concrete along the entire length (figure 3). Very thin elements (less than 15 cm thick) and in the case of very dense reinforcement, loading must be performed through the openings in the formwork which are made from the sides.

Fig. 3 Concreting of reinforced concrete walls
(photo by the author of the paper)

Fig. 4 Concreting of reinforced concrete slab
(photo by the author of the paper)

Solid slabs are concreted in strips having a specified width (figure 4), and in case of „fert“ structure slabs with girders and ring beams, one must first concrete girders and ring beams, and the slab afterwards (figure 5).

Concreting process is finished by curing concrete, which can vary, depending on the type of concrete and weather conditions. The concrete curing process comprises protection of concrete from weather conditions (high and low temperature, strong wind, aggressive impacts, mechanical damage etc). In practice, usually the curing of concrete is not paid sufficient care which can cause very negative effects, especially in terms of the durability of surface layer of concrete. Preventing of rapid loss of water from the surface layer can be provided by wetting the concrete with water or by covering it using various materials, or coating or sprinkling in order to create membranes.

Fig. 5 Concreting of "fert" ceiling (photo by the author of the paper)

At the end of the concreting process, a final evaluation of concrete quality is give based on the documents of taking over of concrete, visual inspection and by reviewing the construction site documents. The final concrete quality evaluation proves safety and durability of the structure.

In figure 6 are provided concreting process phases, from concrete production to placing in a structure.

The technology of execution of the concreting works considered in this paper comprises making of concrete in a concrete plant, transport to the construction sited using truck mixer trucks, transport and placing using pump trucks and compacting using vibrators.

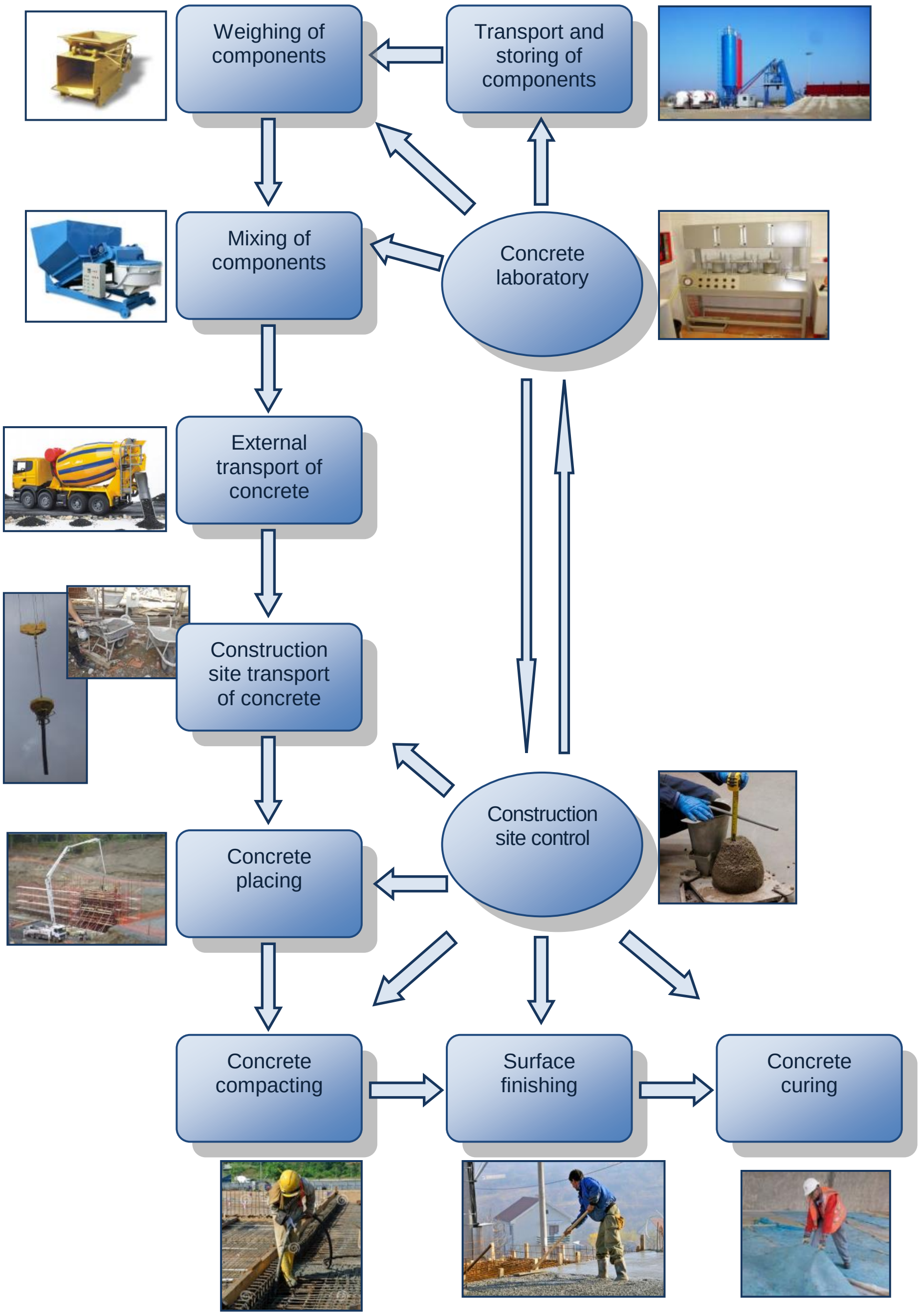

Fig. 6 The stages from production to concreting

5. Concreting Process Productivity

There is a large number of factors which have a varying importance and impact in studying the concreting process productivity. Based on the previous considerations, it can be concluded that the concreting process productivity expressed as a ratio between the placed amount of concrete and time required for obtaining a unit of measure depends on the following factors:

- Concrete supply (truck mixer at the construction site, concrete factory, concrete plant, capacity, distance, ...);
- The structure (dimensions of the structure, accessibility for placing – position of the construction site, elements of the structure where concrete is installed: foundations, slabs, beams, columns, walls, ...);
- Concreting technology (truck pump, stationary pump, crane, hoist, carts, directly from the truck mixer,… vibrators, etc.);
- Machinery to be used (condition, capacity, availability, ...);
- Characteristics of the work crew engaged on placing concrete (number of workers, ability, skill, coordination of work crew, motivation, training level, working experience, ...);
- Weather conditions (time of year, air temperature, precipitations, ...);
- Construction site management etc.

5.1. Concrete supply

Concrete is produced in the concrete facilities of various capacities with automatic or semi-automatic control. For the classes of concrete lower than MB 25, for the first category concretes (B.I) and small quantities of concrete, it is permitted to use manual or machine making of concrete without previous tests. Therefore, the method of making and practical performance of concrete plant/truck mixer have a direct impact on the productivity of construction site concreting. Concrete factory position in respect to the construction site (distance, transport conditions: urban, extra-urban traffic, etc.) available number of truck mixers and their capacity have an impact on synchronization with the construction site demands which is directly related to the required time and productivity. Also, simultaneous supplying of several constructions site from the same concrete plant inexorably leads interruptions and reduction of productivity.

5.2. Structure

Concreting of various elements of the structure entails variations in productivity. Concreting the massive structures, with great thickness and a higher amount of concrete per unit of measure is not the same as concreting thinner elements such as, for instance, walls or slabs or placing concrete in some complex cross-section elements, etc. In figure 7 is presented average achieved productivity depending on the type of concreted element, based on the collected data from the construction site. The lowest productivity was achieved during concreting of columns and walls, and the highest during concreting of solid slabs.

Table 1 The average achieved productivity depending on the type of element

Type of element	Average achieved productivity (m^3/h)	Number of concreting
Slabs	24,27	40
Slabs and beams	19,12	38
Columns and walls	7,88	58

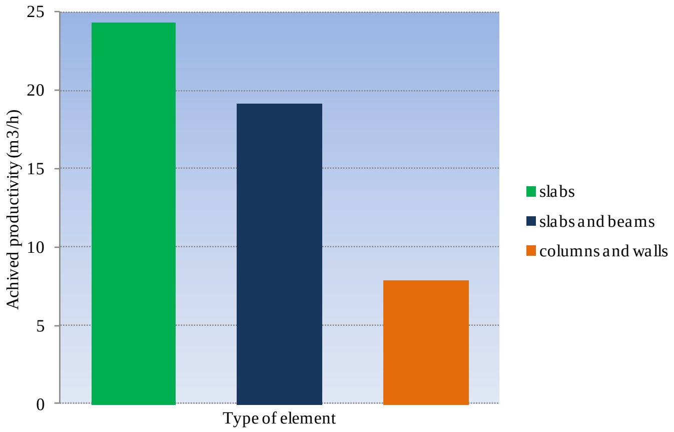

Fig. 7 The average achieved productivity depending on the type of element

The type of concrete element (reinforced or non-reinforced) also has an effect, as well as the type and class of concrete, composition of concrete, quantity of concrete, quantity of reinforcement and method of reinforcing, type of formwork etc. Figure 8 presents the increase of achieved productivity with an increase of the quantity of concrete to be placed. If the element is densely reinforced, the placing of concrete into the formwork and compaction will be more difficult. Height of the structure being concreted (reach of the pump pipeline, extensions, crane radius etc.) as well as the position of the construction site (accessibility of concrete pump approach, confined city conditions, ...) have a great impact on productivity.

Table 2 The average achieved productivity depending on the amount of concrete

Amount of concrete	Average achieved productivity (m^3/h)	Number of concreting
Less than 10 m^3	7,53	9
10-30 m^3	7,95	49
30-100 m^3	18,83	46
100-200 m^3	24,69	20
More than 200 m^3	28,13	12

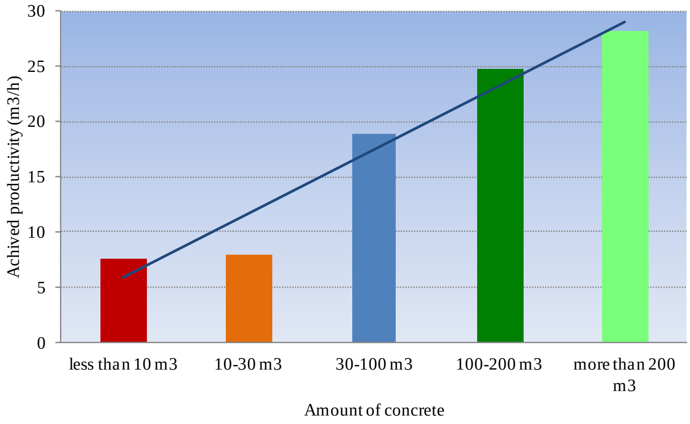

Fig. 8 The average achieved productivity depending on the amount of concrete

5.3. Concreting technology

Depending on the applied concreting technology, achieved productivity mostly varies. Different time is needed for placing a unit of measure of concrete if concrete is transported using a truck pump instead of, for instance, stationary pump. Concreting will last even longer if it takes a crane to transport concrete, some other hoist or carts, and it will require a considerably higher number of workers. The method of concrete compaction has an impact on the process duration. Placing using vibrators, formwork vibrators or vibrating rods and plates will affect engaging of different number of workers and achieving different productivity.

5.4. Machinery

Machinery affects the concreting process productivity to a great extent, considering that a larger share of concreting entails usage of machinery. It is comprised that a higher performance of machinery can largely increase productivity of the entire process. The age of the machinery, as well as its condition, regarding maintenance, contribute to a higher or lower efficiency (malfunctions, repairs, downtime, etc.). Availability of machinery also has an impact on the continuous flow of the works, that is, on avoiding interruptions and delays. In case of malfunctions, there should always be spare machinery at disposal. The availability can also refer to the occupancy of machine engaged at some other process which results in waiting for it to become available (for instance, concrete plant makes concrete for several construction site simultaneously, or a crane is engaged lifting some other materials apart from concrete, etc.).

5.5. Concreting work crew characteristics

Productivity can be increased by planning a sufficient number of workers, of appropriate qualifications and training level. It is clear that abilities, motivation and adequate skills possessed by the workers have a direct impact on the quality of works and achieved productivity. It is necessary that the workers have sufficient working experience and motivation for execution of the considered works. A formed work crew, if it is well coordinated and with a sense of team work will enable the works to be executed very quickly, without delays due to misunderstanding or discrepancy between the skill level of the workers. Coordination level of a work crew is evaluated using marks from 1 (poorly coordinated and organized group) to 3 (excellent coordination) on the construction sites, and in figure 9 is presented the increased productivity resulting from the better coordination of a work crew. All these characteristics have an impact on productivity and relate both to manual laborers and machinery operators.

Table 3 The average achieved productivity depending on the crew organization

Evaluation of the crew organization	Average achieved productivity (m^3/h)	Number of concreting
1	6,03	7
2	7,52	33
3	9,44	18

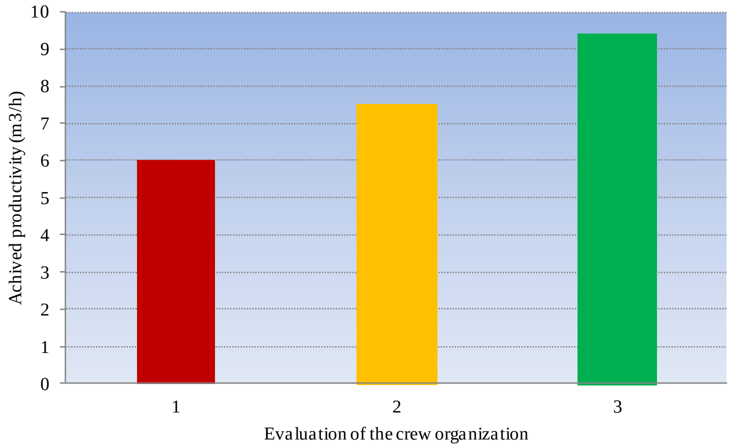

Fig. 9 The average achieved productivity depending on the crew organization

5.6. Weather conditions

Since the concreting works are executed mostly in the open air, as most of the works in civil engineering, weather conditions can exert a considerable impact to productivity. Concreting, as rule is executed at temperatures 5-30^{o}C. However, after adding various admixtures, it is possible to execute the works at lower or higher temperatures than these without consequences on the concrete quality. In those case high or low temperatures can have a negative impact on the working ability of the crew, and thus on the achievable productivity. Diagram in figure 10 displays the achieved productivity in comparison to three temperature ranges. The highest productivity was achieved at air temperatures 5-15^{o}C. Precipitations also affect the process, in a way that concreting has to be interrupted in case of heavy rain or showers, while working in drizzle is possible, but it affects the productivity. It is clear what effects the seasons in a year have, regarding the temperature but also shorter daylight time in late autumn and winter months. Periods within a day, i.e.

shifts in which the works are executed, as well as the shift length, have an impact on the realized productivity. Night work and longer duration of the shifts, as well as the work on Sundays and during holidays have a negative impact on the workers due to fatigue and lower motivation, and in case of machinery malfunction, repairs are more difficult to perform, etc.

Table 4 The average achieved productivity depending on the temperature range

Temperature range (^{o} C)	Average achieved productivity (m^3/h)	Number of concreting
5-15	22,93	30
15-25	20,74	25
25-35	21,35	23

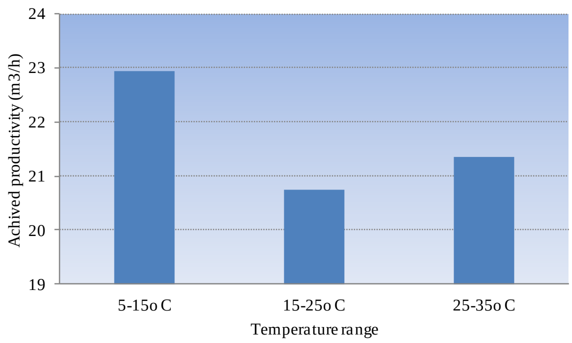

Fig. 10 The average achieved productivity depending on the temperature range

5.7. Construction site management

Concreting process productivity is also affected by the relations and of the participants in the process and the atmosphere among them. A professional, correct relationship and trust between managers on a construction site and workers is a very important factor for a good and timely achieving of goals. The experience and experience of the heads in managing a construction site and execution of works on the similar structures is significant, as well as motivation, influence, responsibility, etc. However, the most important for productivity of the concreting process is the construction site management model, i.e. management of the concrete works execution process.

6. Conclusion

The paper provides an analysis of concreting works productivity and describes the most influential factors on the concreting process itself. For reasons of specific character and importance of concreting works, it is necessary to pay a special attention to them during construction of any civil engineering structure. In order to finish the works in the planned deadline, required productivity of concreting works as critical activities in the dynamic work execution plan must be ensured. However, owing to a large number of various influential factors, it is not always simple and easy to ensure uninterrupted and continuous works. Because of the limited time for placing of concrete, it is necessary to well synchronize concrete producer and the constructions site, in order to provide the continuity of concreting works. Concreting of various elements results in different productivity levels. Placing of large quantities of concrete, as well as a better organization and coordination of the crew result in higher productivity.

REFERENCES

1. A. Flašar, Proučavanje tehnoloških procesa u građevinarstvu, Fakultet Tehničkih nauka, Novi Sad, 1985.
2. A. M. Jarkas, "Analysis and measurement of buildability factors affecting edge formwork labour productivity", Journal of Engineering Science and Technology Review, vol. 3 (2010) 1, pp. 142-150
3. A. M. Jarkas, "Buildability Factors Influencing Concreting Labor Productivity", Journal of Construction Engineering and Management, 138 (2012) 1, pp. 89–97
4. B. Matejević, Model za prognoziranje produktivnosti procesa betoniranja, doktorska disertacija, Građevinsko-arhitektonski fakultet, Niš, 2016.
5. P. G. Prabhu, D. Ambika, "Study on behaviour of workers in construction industry to improve production efficiency", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD), 5 (2013), pp. 59-66
6. Pravilnik o tehničkim normativima za beton i armirani beton – BAB 87
7. M. E. Shehata, K. M. El-Gohary, "Towards improving construction labor productivity and projects' performance", Alexandria Engineering Journal, 50 (2011) 4, pp. 321-330
8. M. Soham, B. Rajiv, "Critical factors affecting labour productivity in construction projects: case study of south gujarat region of India", International Journal of Engineering and Advanced Technology, 2 (2013) 4, pp. 583-591
9. A. Soekiman, K. S. Pribadi, B.W. Soemardi, R. D. Wirahadikusumah, "Factors relating to labor productivity affecting the project schedule performance in Indonesia", Procedia Engineering, 14 (2001), pp. 865-873
10. Softconsulting (www.savjetnik.ba/šta-je-produktivnost/)
11. Tehnički uslovi za transportovani beton SRPS U.M1.045
12. H. R. Thomas, D. R. Riley, V. E. Sanvido, "Loss of labor productivity due to delivery methods and weather", Journal of Construction Engineering and Management, 125 (1999) 1, pp. 39-46.
13. H. R. Thomas, I. Zavrski, "Construction baseline productivity: Theory and practice", Journal of Construction Engineering and Management, 125 (1999) 5, pp. 295-303
14. www.sr.wikipedia.org
15. www.pks.rs/PrivredaSrbije
16. www.wikipedia.org/wiki/Burj_Khalifa

ANALIZA PRODUKTIVNOSTI PROCESA BETONIRANJA

Tokom izvođenja radova na izgradnji bilo kog objekta, javlja se veliki broj faktora koji imaju uticaj na ukupne performanse gradilišta. Jedan od veoma značajnih faktora je produktivnost. Zbog specifičnosti i značaja betonskih radova pri izgradnji građevinskog objekta potrebno je obratiti posebnu pažnju na izvođenje ovih radova. U ovom radu analizira se produktivnost: u opštem smislu, kao i produktivnost u građevinarstvu, sa posebnim osvrtom na produktivnost pri izvođenju betonskih radova. Ukazano je na značaj betonskih radova i opisana tehnologija izvođenja betonskih radova. Dat je pregled i opis faktora koji imaju uticaj na produktivnost procesa betoniranja. Izvršena je analiza produktivnosti na konkretnim gradilištima na osnovu podataka dobijenih snimanjem procesa betoniranja i dati su neki od rezultata.

Ključne reči: *građevinarstvo, produktivnost, proces betoniranja, tehnologija betoniranja, uticajni faktori.*