UDC 693.547.4

NORMATIVE SUPPORT OF DEVELOPMENT OF TECHNOLOGICAL CHARTS FOR CONCRETING OF MASSIVE CONSTRUCTIONS

NATALIA SHPILEVSKAYA, KHRYSTSINA PALETAI, ALEXANDER SHVEDAU
Polotsk State University, Belarus

When concreting large-sized overall constructions there is not always the possibility of uninterrupted laying of the concrete mix. In the production of concrete work, breaks in concreting are caused both by technological and organizational factors. But in the organizational and technological documentation there are no specific parameters and technologies for the device of cold joint. Also there are no normative documents concerning the design of the work for the construction of these joints.

Construction of massive concrete and reinforced concrete designs, such as base plates, fortification and engineering constructions (causeway, air-raid shelters, dams, etc.), as a rule, is made by separate sections.

When the structures are divided into sections (charts) of concreting, joints are formed, which if possible should be arranged at the same time performing several functions at once. The construction of work joints is caused by the inevitable pause of concreting due to all sorts of organizational (the end of the work shift, the breakdown of equipment, the lack of materials, etc.) and technological reasons (the need for mounting overlying reinforcement, repositioning of scaffolding and formwork, limiting loads on support structures, etc.).

Recommendations on the size of the allowed interval of overlapping concrete layers before the formation of the working joints are very vague and contradictory. According to various sources [1, 2] this interval should not exceed the time of "beginning of setting of cement", "beginning of setting of concrete", "beginning of setting cement in concrete", just "setting time of concrete", etc. But none of these terms isn't standard, and this makes it difficult to analyze their validity. In some sources [3] the recommended approximate values of allowable intervals are in the range of 2 - 4.5 hours. Almost in all standards [4–6], the choice of the allowable interval is assigned to the construction laboratory, and there is no methodology and criteria for its determination. The break in concreting affects the strength of the joining of the concrete layers.

For example, in the article [7] it is noted that during breaks in concreting the quality of the top (contact) concrete layer worsens because of water separation process. It takes place most intensively during the first 1-1.5 hours. The author explains the reduction in the strength of the joint with the age of "old" concrete in the first hours after its packing by the reduction in cohesion. However, according to [1-3], the strength of the butt joint, even with a break in concreting of 5 hours or more, is significantly higher than the strength of the joint with fully cured concrete, even with careful preparation of its surface. These results obtained in the laboratory do not take into account at the same time the most important production factor - the possibility of damaging the emerging crystallization structure of "old" concrete when it transfers loads to it from the unloaded material, the movement of workers and machinery.

In practice the critical duration of a break in mix laying corresponding to the beginning of formation of crystallization structure is defined by the ability of "old" concrete to be diluted at vibration. When at immersion of the vibrator in it not swimming away cracks are formed, it is necessary to arrange a working joint. At breaks more than the determined time further laying of mix can be spent only after set by earlier poured concrete of durability not less than 1,5 MPa. Otherwise its structure can be broken.

When laying a concrete mixture in massive thickly-reinforced plates of a large area (foundation plates, bottoms of tanks and sedimentation tanks, etc.) according to standard technological chart, [8-10], the main technological requirement is the continuous laying on the entire height of the slabs. Existing methods [11] determining the timing of setting cement systems have drawbacks, they do not uniquely define the term beginning and end of setting.

Let's consider some typical technological chart s for concreting slab foundations. In 7351 TC "Technological chart for the construction of a monolithic reinforced concrete foundation plate" is a schedule of work on the installation of foundation slabs using a concrete pump [8]. The technological chart is designed for concreting a base plate with a size of 44m x 20m x1m, V_b = 880 m^3. The labor costs of workers will amount to 193,6 people-hours. According to the schedule of work, the duration of laying the concrete mix is 6,5 days, when working in 1 shift. Hence, a working joints arrangement is required.

Table 1. – Schedule of work on the foundation of the slab using an concrete pump /8/

Point No	Name of technological processes	Measuring unit	Scope	Labor costs		Membership	Process time, days	Working days												
				of workers, man-h.	of machine operator man-hours(duty of machine, mach.-h.)			1	2	3	4	5	6	7	8	9	10	11	12	13
1	2	3	4	5	6	7	8	9												
1.	Fitting and steel lashing	t	55	230,89		Steelfixers: 3grade-3 man 2 grade-1 man	7,0													
2.	Welding of node point of reinforcement joints	t	16,94	108		Ark welder 3grade-1 man Steelfixer 2grade-1 man	6,6													
3.	Fittings by truck crane	t	55	7,15	3,52 (3,52)	Crane operator 5grade-1 man Scaffolders: 2grade-2 man	0,4													
4.	Setting forms	m^2	128	57,6		Building joiners: 4grade-1 man 2grade-1 man	3,5													
5.	Feeding of concrete mix by concrete pump	m^2	880	158,4	53,68 (53,68)	Crane operator 4grade-1 man Metal worker 4grade-1 man Concreter 2grade-1 man	6,5													
6.	Concrete placement	m^2	880	193,6		Concreters 4grade-2 man 2grade-2 man	6,1													
7.	Servicing of concrete surface	m^2	880	5,46		Concreter 2grade-1 man	0,67													
8.	Formwork disassembling	m^2	128	33,28		Building joiners: 4grade-1 man 2grade-1 man	2,0													
				794,38	57,20 (57,20)															

In TC 6306031077/31077 /9 / "Arrangement of flat monolithic reinforced concrete foundation slabs in civil buildings" the schedule of works on the foundation of the slab with a concrete pump is presented.

Table 2. – Schedule of work on the foundation of the slab using an concrete pump /9/

Name of processes	Measuring unit	Scope	Labor costs		Adopted membership	Process time, relays	Working relays							
			of workers, man-h.	of machine operator man-hours (mach.-h.)			1	2	3	4	5	6	7	8
Feeding and installation of reinforcement, including mounting clamps, fixing corners	t	0,86	43,44	0,40 (0,40)	Crane operator5gr.-1 Steelfixers: 4gr. - 1 3gr. - 1 Ark welder 3gr. - 1	1,77								
Feeding and installation of formwork boards, including dobors;	t	2,99	18,52	8,75 (8,75)	Crane operator 5gr.-1 Metal workers: 4gr. - 1, 3gr. - 1	1,13								
Reception, feeding and laying of concrete mix	m^3	143	45,36	9,15 (9,15)	Operator by concrete pump 4 gr. - 1 Concreters: 4gr. -1, 2gr. - 1	1,38								
Dismantling of formwork panels	m^2	44,19	8,84	2,65 (2,65)	Crane operator5gr.-1 Metal workers: 4gr. - 1, 3gr. - 1	0,54								

The technological chart is designed for concreting a foundation slab under a building in the form of a monolithic reinforced concrete slab of a 20-storey building. The technological chart provides the installation of a monolithic reinforced concrete slab 1 m high, in the section between the axes 1-2 and the rows of GE in a height of 0,7 m from concrete M200 with the use of large-panel formwork, V_b = 143 m^3. The duration of receiving, feeding and laying of the concrete mix is 1,38 shifts according to the schedule of works. Therefore, a work joints arrangement is required.

In TC 4.01.01.63 [10] "The technological chart for the construction of flat monolithic reinforced concrete foundation slabs in general purpose buildings and structures with a slab thickness of up to 1200 mm" presents the schedule of works for the foundation plate using a concrete pump.

Table 3. – Schedule of work on the foundation of the slab using an concrete pump /10 /

Name of processes	Measuring unit	Scope	Labor costs of workers, man-h.	Labor costs of machine operator man-hours (mach.-h.)	Adopted membership	Process time, relays	Working relays 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Unloading, sorting of materials and mechanized shuttering works (items 1,2,4 by calculation)	100m3 by slab	19,8	322,6	151,98	Team №1 Ironworkers: 4 gr. - 1 3 gr. - 1 2 gr. - 1 Crane operator 5gr. - 1	161,98	
Manual shuttering work (items 3.5 by calculation)	"	19,8	59,76		Team №2 Metal workers: 4 gr. - 1 3 gr. - 1	59,76	
Reinforcement work and installation of grids for BH1 (items 6,7,8,10 for calculation)	"	19,8	716,2	176,62	Team №3 Steelfixers: 4 gr. - 1 2 gr. - 3 Ark welder 5 gr. - 1	179,04	
Welding (item 9)	"	19,8	28,29		Crane operator 5gr. - 1		
Concrete work (items 11, 12, 13 by calculation)	"	19,8	356,4	247,5	Team №4 Concreters: 3 gr. - 1 2 gr. - 2 Operator 5gr. - 1 Crane worker 5gr. - 1	118,8	
Servicing of concrete (item 14)	"	19,8	31,0				
Demolition of formwork and loading of materials (paragraphs 15,16,17 by calculation)	"	19,8	21,02	6,82	Team №1 Ironworkers: 4 gr. - 1 3 gr. - 1 2 gr. - 1 Crane operator 5gr. - 1	7,01	
Total:			1536	582,92			

The technological chart is designed for concreting a foundation slab measuring 37,2 m x 44,35 mx 1,2 m, V_b = 1980 m^3. Here the duration of concrete works is 118,8 hours, 7 days according to the schedule of works. There are breaks in the concreting - a device of working joints is required.

Analysis of organizational and technological documentation (technological charts) for concreting large-sized overall structures allows us to conclude that they are missing, and the issue of working joints has not been resolved. In the graphical part, the working joint looks like a dashed line with the "working joints of concreting" callout. But the technological charts do not take into account the main factor - the time for the construction of working joints.

The norms do not provide specific guidance and recommendations for this work. The composition of works for laying a concrete mixture in a construction, according to NZT, Sat.4 [12] includes: 1. Reception of a concrete mixture. 2. Laying the concrete mixture directly into place. 3. Leveling of concrete mix with partial overturning. 4. Vibrating with vibrators. 5. Smoothing of the exposed surface of concrete. 6. Rearrange the vibrators. That is, the issue of working seams remains unresolved.

The issue of working joints remains undeveloped. The working seam in the drawings is shown in the following way: the usual dashed line with the "working joints of concreting" callout. There are no specific instructions on its design. Consequently, it remains unclear how to practically organize the work on concreting the structures on the construction site in the presence of working joints.

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