Metal Structures II

Design project II

Crane supporting structures

PROJECT OBJECTIVE’S

Analysis of dynamic action from crane;

Calculation of beam in case out-of-range Saint-Venant Principle;

Analysis of global and local effects in cran run-beam;

Calculatiom of build-up members (bi-chord column);

Photo: zksgrzelak.eu

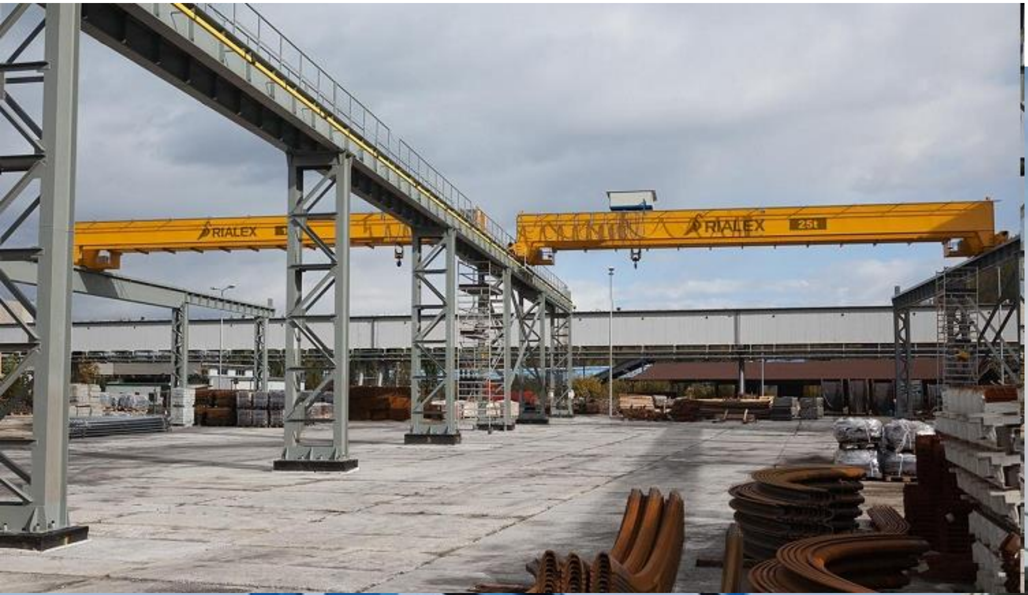


Photo: dzwigar.info.pl

Photo: obrieninstall.com

Topic:

Design of crane supporting structure:

Crane ....

Hoist load Q_h ....

Working area P_1 x P_2 .... x ....

High H_p ....

Steel ....

Location ....

Additional information for calculations, the same for everybody:

- One crane only
- Assembly crane, HC1, S0
- Steady hoisting speed v_h = 0,08 m / s
- Hook → φ_3 = 0,0
- φ_4 = 1,0
- φ_5 = 1,5
- η = 0
- Single wheel drive, m_w = 2
- Friction coefficent μ = 0,2
- Wheel flanges, a_{ext} = R
- Fixing of wheel IFF
- Longitudinal velocity of crane v = 0,7 m / s
- Spring constant of the buffer S_B = 65 kN / m
- ξ_b = 0,5
- Rail supported on an elastomeric bearing pad

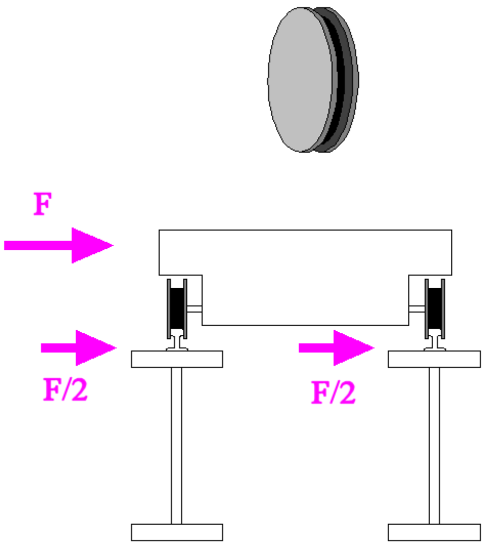
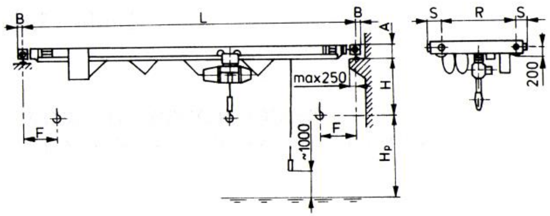


Photo: Author



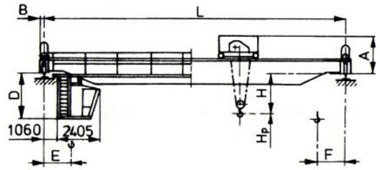
Udźwig *Q* kN	Rozpiętość *L* m	Masa t	Nacisk koła kN	*R* mm	*S*
20	4–7	1,68	13,8	1600	286
	7–10	1,90	14,8		
	10–12	2,43	16,5	2000	
	12–13				326
	13–16	2,71	17,4	2500	
	16–19	3,51	19,7	3000	
	19–21	4,85	23,3	3500	
	21–22				378
	22–25	5,27	24,5	4000	
32	4–7	1,74	19,0	1600	286
	7–9	2,01	20,5		
	9–10				326
	10–13	2,80	23,0	2000	
	13–16	3,16	24,2	2500	
	16–19	4,49	28,0	3000	378
	19–22	5,53	30,4	3500	
	22–25	5,80	31,7	4000	
50	4–7	2,34	28,3	1600	326
	7–10	2,64	32,1		
	10–11	3,77	34,0	2000	
	11–13				378
	13–16	4,70	36,9	2500	
	16–19	5,35	39,0	3000	
	19–22	5,88	40,6	3500	
	22–25	7,07	47,6	4000	

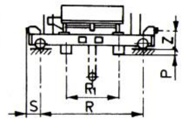
Suwnice należą do grupy natężenia pracy A4
Wymiar F, F_1 H_{max} może ulec zmianie zależnie od zastosowanego elektrowciągu.
Suwnice produkuje Fabryka Urządzeń Dźwigowych w Mińsku Mazowieckim.

SUWNICE JEDNODŹWIGAROWE NATOROWE ELEKTRYCZNE JNe

Wymiary					
H_p	H_{max}	*F*	F_1	*A*	*B*
9000	1444	1090	900	360	98
				385	103
				470	125
9000	1650	1120	940	360	98
				385	103
				470	125
9000	2054	1190	1000	385	103
				470	125

W. Bogucki, M. Żyburtowicz, Tablice do projektowania konstrukcji metalowych, Arkady, Warszawa 1996, pp. 518-519





SUWNICE POMOSTOWE DWUDŹWIGAROWE 1-HAKOWE SPe1H

Udźwig *Q*	Rozpiętość *L*	Masa suwnicy	Nacisk koła N_{max}	$H_{p\,max}$	A_{max}	A_{min}	B
kN	m	t	kN	m			
80	8–11	13,2	89	16,1	2215	1780	195
	11–14	14,5	93				
	14-17	16,0	96				
	17–20	17,2	99				
	20–23	20,2	108				
	23–26	22,0	114				
	26–29	25,8	124				
	29–32	27,3	129				
	32–35	30,3	136				
80	8–11	14,4	93	16,1	2215	1780	195
	11–14	16,2	99				
	14–17	17,4	103				
	17–20	20,2	110				
	20–23	21,6	114				
	23–26	24,0	120				
	26–29	28,4	133		2315	1880	210
	29–32	31,3	141				
	32–35	35,0	151				
125	8–11	13,7	111	16,1	2215	1780	195
	11–14	15,5	117				
	14–17	16,7	121				
	17–20	19,5	130				
	20–23	20,9	134				
	23–26	23,3	141				
	26–29	27,4	152		2315	1880	210
	29–32	30,3	161				
	32–35	34,0	172				

D	E	F	H	R	R_1	Z	S	P	GNP
			mm						
2520	850	1090	10	3300	1800	900	730	60	A4
2635				4000			630	310	
2805								560	
3055	790	1030		5000				810	
2760	1000	1100	15	3800	2300	900	900	60	A5
2635			110	4500			800	310	
2805								560	
2960			15	5000			700	710	
3210								960	
2760	1000	1100	15	3800	2300	900	730	60	A4
2635			110	4500			630	560	
2805									
2960			15	5000				710	
3210								960	

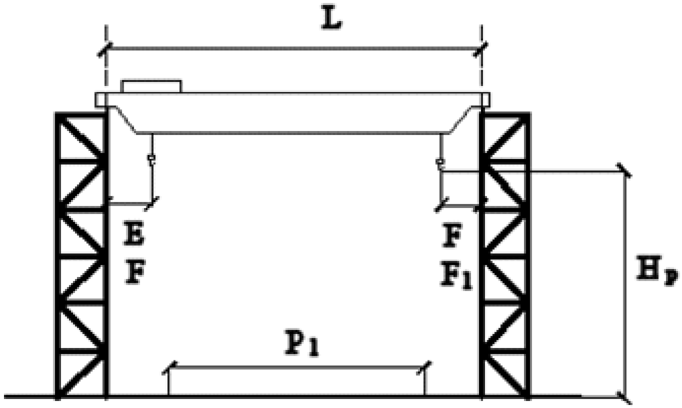
W. Bogucki, M. Żyburtowicz, Tablice do projektowania konstrukcji metalowych, Arkady, Warszawa 1996, pp. 522-523

Algorithm

- Initial drawing
- Loads
- Beam
    - Resistance
    - Stability
    - Fatiuge
    - Bumper
- Column
- Bracing
- Drawing and list of materials

Crane's hook must reach the each point of working area - this means, that span of crane bridge L must be longer than width of working area P_1 plus „dead zone” E + F. The same for length of crane supporting structure: length of structure ($n \cdot L_b$) must be longer than length of working area P_2 plus „dead zone” two times (R/2 +S).

In case of problems with geometry, part of crane could be on overhang, but not greater than S + R/2.



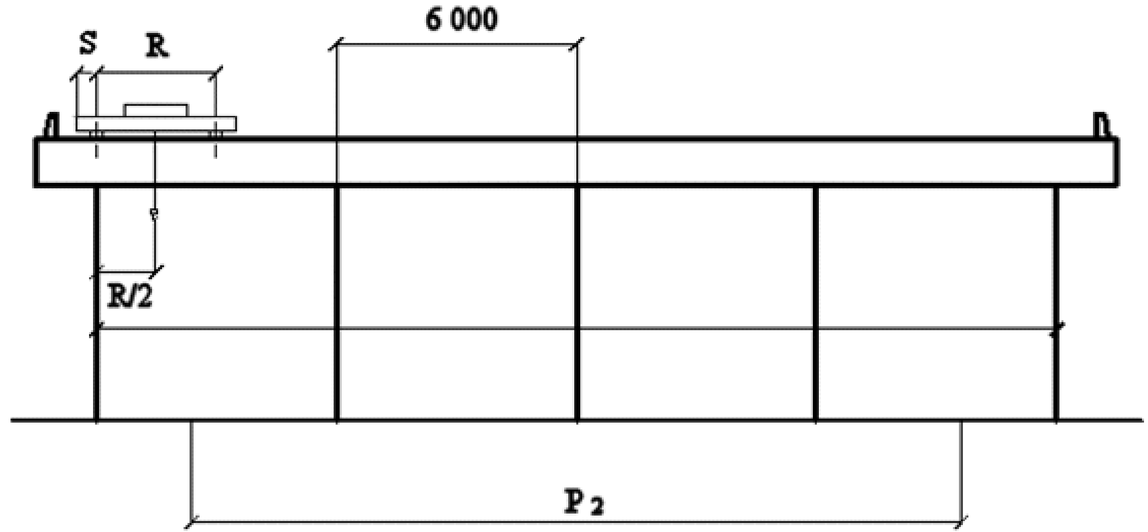


Photo: Author

$$L_b = 6{,}000 \text{ m}$$

$$P_1 + E + F \leq L \rightarrow \text{mass of crane}$$

$$n \cdot L_b \geq P_2 + R/2 + R/2 + S + S$$

Initial drawing
1:200

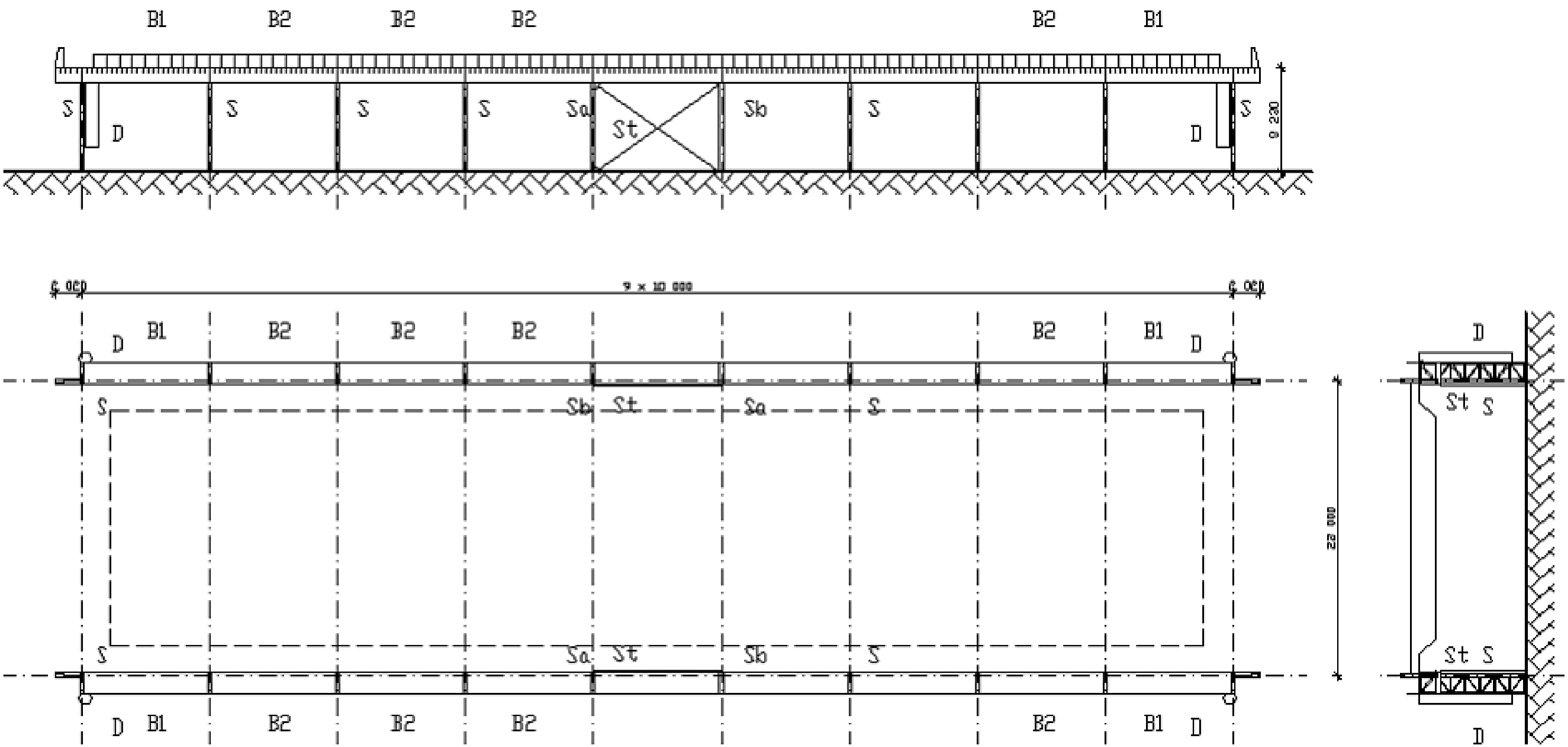
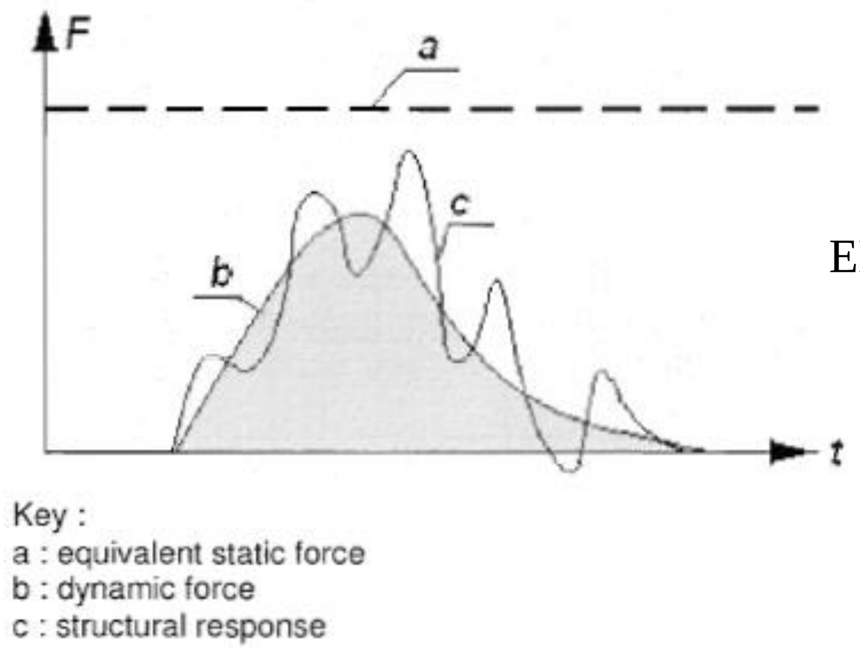


Photo: Author

Loads and safety factors

Type	γ
Dead weight of steel structure	1,35
Dead weight of crane	1,50
Weight of hoist load	
Acceleration of crane bridge	
Skewing of crane bridge	
Test load	
Buffer forces	
Loads on walkways	
Fatigue loads	
Wind	
Snow	
Tilting forces	
Guard rails	
Thermal action	
Actions during execution	
Accidental action	

Many types of crane actions have dynamic character. There are special calculation for this case:



EN 1991-1-7 fig. 1.1

$F_{\varphi,k} = \varphi_i F_k$

F_k – equivalent dynamic force; φ_i – dynamic coefficient, $F_{\varphi,k}$ – equivalent static force

Dynamic factors	Effect to be considered	To be applied to
φ_1	Excitation of the crane structure due to lifting the hoist load off the ground	Self-weight of the crane
φ_2 or φ_3	Dynamic effects of transvering the hoist load from the ground to the crane Dynamic effects of sudden release the payload if for examle grabs or magnet are used	Hoist load
φ_4	Dynamic effects induced when the crane is travelling on rail tracks or runways	Self-weight of the crane and hoist load
φ_5	Dynamic effects caused by drive forces	Drive forces
φ_6	Dynamic effects of a test load moved by the drivers in the way the crane is used	Test load
φ_7	Dynamic elastic effect of impact on buffers	Buffer loads

EN 1991-1-3 tab. 2.1

		Symbol	Section	Groups of load									
				ULS							Test load	Accidental loads	
				1	2	3	4	5	6	7	8	9	10
1	Self-weight of crane	Q_c	2.6	φ_1	φ_1	1	φ_4	φ_4	φ_4	1	φ_1	1	1
2	Hoist load	Q_h	2.6	φ_2	φ_3	0	φ_4	φ_4	φ_4	η	0	0	0
3	Acceleration of crane bridge	H_L H_T	2.7	φ_5	φ_5	φ_5	φ_5	0	0	0	φ_5	0	0
4	Skewing of crane bridge	H_S	2.7	0	0	0	0	1	0	0	0	0	0
5	Acceleration of barking of crab or hoist block	H_{T3}	2.7	0	0	0	0	0	1	0	0	0	0
6	In-service wind	F_W^*	Annex A	1	1	1	1	1	0	0	1	0	0
7	Test load	Q_T	2.10	0	0	0	0	0	0	0	φ_6	0	0
8	Buffer force	H_B	2.11	0	0	0	0	0	0	0	0	φ_7	0
9	Tilting force	H_{TA}	2.11	0	0	0	0	0	0	0	0	0	1
For out of service wind, see Annex A													
η is the proportion of the hoist load that remains when payload is removed, but is not included in the self-weight of the crane													

EN 1991-1-3 tab. 2.2

It is a very complicated project. Only introductory information is provided here. The following points will be shown as calculation examples during the next meetings:

- Calculation of loads acting on runbeam;
- Adoption of initial geometry of runbeam section;
- Checking resistance of runbeam;
- Checking stability od runbeam;
- Checking fatigue of runbeam;
- Checking resistance of column;

Thank you for attention

tmichal@pk.edu.pl