EXAMPLE OF CALCULATION OF REINFORCED CONCRETE BEAM SPANS FOR TEMPORARY (A-14 AND NK-100) AND PERMANENT

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ABSTRACT
An example of the computation of reinforced concrete beam spans for calculated temporary (A-14 and NK-100) and permanent loads was given in the article. Bridges are built to withstand a variety of loads, each of which consists of a mix of permanent and live loads.

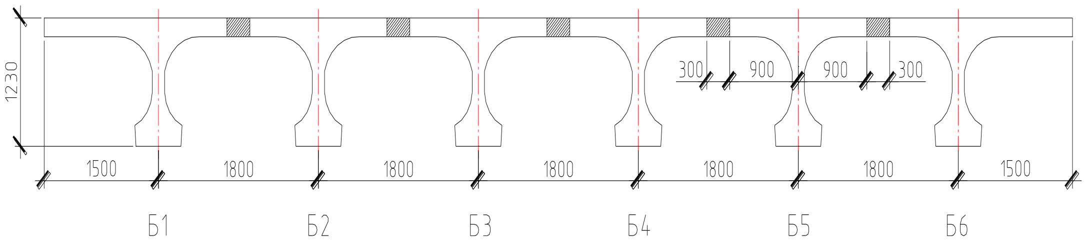
Keywords: superstructures, unified, assembled, in bundles, end beams, protective layer, waterproofing, concrete protective layer, crowd.

LOADS

There are currently two methods for calculating forces in spans due to the impacts of permanent and temporary loads.
Bridges are built to withstand a variety of loads, each of which consists of a mix of permanent and live loads.
Loads are divided into permanent and temporary.
1) Permanent loads - the own weight of the beams of the superstructure and the joints between them, the own weight of sidewalk blocks and railings, the own weight of the clothes of the driving deck and sidewalks.
2) Live loads - impact from rolling stock, pedestrians, and wind loads.
When roads cross natural or man-made impediments, structures should be designed to withstand the following live loads:
AK – Normative load from automobiles.
NK – A specific mode was used to pass the normative load from non-standard vehicles.
The bridge dimension is D-8+2x1.0. Design loads A-14 and NK-100. The span beams, support elements and other reinforced concrete structures are adopted unified according to the current standard designs.

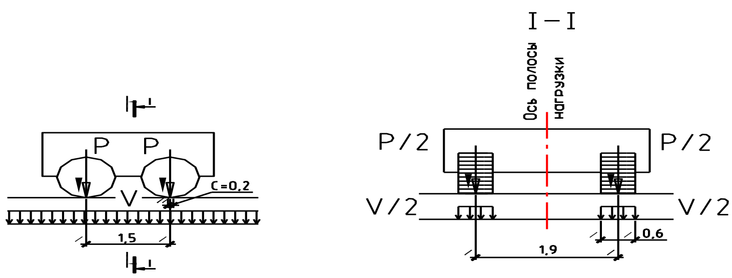
- The reinforced concrete bridge is designed according to the monitor 18+24m+24m+24 +18m.
- Total bridge length is 108,76 m.
- The accepted dimension of the bridge is D-8+2×1. The bridge dimension is designed in accordance with the requirements of SRDC 2.05.03-12.
- Roadway width is 6 m

- Safety lane width is 1,0 m
- Width of sidewalks is 1 m
- The 1.23m high cross section is made up of 6 T-beams with prestressed reinforcing. Superstructure of reinforced concrete integrally carried beams 24 and 18 meters long, strengthened with horizontal beams. Concrete of B35 class, longitudinal prestressing reinforcement of B-1400 class, and non-prestressing reinforcement of A-540 class.



Cross section of the bridge spans structure.

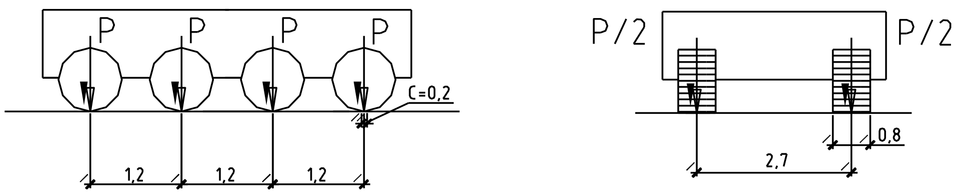
For individual beams, the designation B1, B2 ... B6 is accepted. Formwork dimensions of the beams of the superstructure in relation to the standard project of the series 3.503.1-81.
The span's beams are joined by embedding the 30cm wide longitudinal seams of the loop joint, which links the flanges of contiguous beams along the whole span. The intermediate beams have reinforcing ports on both sides on the side surfaces of the top shelf's overhangs to accomplish this. For their connection with the intermediate beams, the end beams feature strengthening protrusions on one side. Barriers and railings are installed on the superstructure's extreme beams.
The bridge deck is dressed as follows: a 3cm thick leveling layer of class B25 concrete reinforced with a wire mesh with a diameter of 2.5mm is applied to the upper surface of the superstructure beams, followed by a 7cm thick two-layer asphalt concrete coating.
Load class A14 in accordance with point 4.1 [2]
P=14 thou; V=1,4 thou



Load diagram A14

Load class NK100.8 in accordance with point 4.1 [2]

P=25 thousand



Load diagram of NK-100.

Reliability factors for load in accordance with the table 14[1]

a. Load A14
b. $\gamma^{тел}$=1,5; γ_f=1,2
c. Load NK-100,8.
d. $\gamma^{тел}$=1,0

Dynamic coefficients applied to the load from the rolling stock in accordance with paragraph.
For load A14

$$1+\mu = 1+\frac{45-\lambda}{135}$$, where λ is loading length

$$1+\mu = 1+\frac{45-\lambda}{135} = 1{,}16$$

For load NK-100,8
1+ μ=1,10 at λ≥5,0 m;
For NK100 moving string, a reduction factor is applied $\gamma_{кол}$=0,75
The standard live load for pedestrian sidewalks (from the crowd) according to point 2.12 [1] is calculated by the formula:
p=400-2 λ ≥200 kgf/m^2
λ – distance between the axes of the supporting parts of the beam.
p=400-2×23,4=353,2 kgf/m^2
Calculation of intermediate support:
We accept a support in the form of a frame pinched at the level of the top of the base (line of local erosion). The calculation scheme of the frame is divided into finite rod elements. Calculation of the own weight of the sidewalks of the carriageway and sidewalks
The bridge deck consists of:

- Leveling layer of concrete B25
- Waterproofing
- Protective layer of concrete
- Asphalt concrete sidewalks

$S_{п. м}$=13,5m×23,4m=315,9 m^2 (total surface area of the bridge)
1) Leveling layer of concrete:
h_b=0,03 м; ρ=2,5 t/m^3
q= ρ h_b $S_{п. м}$=2,5×0,03×315,9=22,27 t
2) Waterproofing:
h_b=0,04 м; ρ=1,5 t/m^3
q= ρ h_b $S_{п. м}$=1,5×0,04×315,9=18,95 t
3) Protective layer of concrete:
h_b=0,04 м; ρ=2,35 t/m^3
q= ρ h_b $S_{п. м}$=2,35×0,04×315,9=29,69 t
4) Asphalt concrete sidewalks:
h_b=0,07 м;ρ=2,3 t/m^3
q= ρ h_b $S_{п. м}$=2,3×0,07×315,9=50,86 t
5) Metal fence:
q= 0,042×23,4=0,91 t
on both sides =1,96t

Table 1. Normative and calculated constant loads from the weight of the bridge span coating.

Layers	Regulatory loads	Reliability factor	Design loads
Leveling layer of concrete	$q^{н} = \frac{22,27}{315,9} = 0,07$ t/m^2	γ=1,3	q^{p}=0,07×1,3=0,0916 t/m^2
Waterproofing	$q^{н} = \frac{18,95}{315,9} = 0,06$ t/m^2	γ=1,3	q^{p}=0,06×1,3=0,078 t/m^2
Protective layer of concrete	$q^{н} = \frac{29,69}{315,9} = 0,094$ t/m^2	γ=1,3	q^{p}=0,094×1,3=0,122 t/m^2
Asphalt concrete sidewalks	$q^{н} = \frac{50,86}{315,9} = 0,161$ t/m^2	γ=1,5	q^{p}=0,161×1,5=0,2415 t/m^2
Metal fence	$q^{н} = \frac{1,96}{315,9} = 0,0062$ t/m^2	γ=1,1	q^{p}=0,0062×1,1=0,0068 t/m^2
∑q	$\sum q^{н}$=0,391 t/m^2		$\sum q^{p}$=0,54 t/m^2

Temporary (normative and design) loads

Load A14 according to point 4.1 [2]

Axle load is 14 thousand (P)

Uniformly distributed load from the track is 0,1×14=1,4 thousand (V)

Table 2.

Type of load	Normative for per wheel	Estimated per wheel
Spot from per wheel	P/2=7 thou	P/2=7×1,5×1,16=12,18 thou
distributed along the span	V/2=0,7 thou	V/2=0,7×1,5×1,16=1,218 thou

CROWD LOAD (A14)

p=400-2×23,4=0,3532 thousand/m^2

$q^{н}$=0,3532 тс/ м^2 γ_f=1,2 q^{p}=0,3532×1,2=0,42384 thousand/m^2

Load NK-100.8 according to point 4.1

Axle load is 25,2 thousand (P)

Table 3.

Type of load	Normative for per wheel	Estimated per wheel
from per wheel	P/2=12,6 thou	P/2=12,6×1,1=13,86 thou

ESTIMATED CONSTANT LOAD ON THE SUPPORT ELEMENTS

The calculation of loads is carried out taking into account the requirements of design standards [4].

1. Uniformly distributed load from the weight of the support:

$q_{оп}=y_f×π×R^2×ν$=1,1×3,14×0,75^2×2,5=4,86 thousand/m.

R – support radius;

y_f – load safety factor;

ν – bulk density of reinforced concrete.

UNIFORMLY DISTRIBUTED LOAD FROM THE WEIGHT OF THE CROSSBAR

q_p=b×h× y_f ×ν=1,25×0,7×1,1×2,5=2,4 thousand/m.

b, h – cross section.

3. Self-weight of the extreme beams of the superstructure:

$F_к$= ($F_{бк}$+ $F_{мк}$) y_f = (39,4+1,48) ×1,1=44,97 thousand.

$F_{мк}$ – weight of the monolithic section of the extreme beam;

$F_{бк}$ – the weight of the edge beam without a monolithic section.

4. Dead weight of intermediate beams:

$F_п$= ($F_{бп}$+ $F_{мп}$) y_f = (37,23+2,96) ×1,1=44,21 thousand.

$F_{мп}$ – weight of the monolithic section of the intermediate beam

5. Sidewalks and metal railing load:

$F_{тр}$=$q_{тр}$×L× y_f =0,57×24×1,1=15,1 thousand.

L – span length (beams).

$F_п$=$q_п$×L× y_f =0,042×24×1,1=1,1 thousand.

$q_{тр}$, $q_п$ – the weight of one linear meter of the sidewalk and railings.

6. Base load:

$P_{осн}$=p_o×L× y_f =0,28×24×1,3=8,74 thousand.

7. Load from asphalt concrete sidewalk:

$P_{асф}$=p_a×L× y_f =0,25×24×1,5=9 thousand.

The total load transmitted from the extreme beams to the crossbar:

F=$F_п$+$P_{осн}$+$P_{асф}$=44,97+8,74+9=62,71 thousand.

For intermediate beams:

F=$F_п$+$P_{осн}$+$P_{асф}$=44,21+8,74+9=61,95 thousand.

Estimated wind load

According to SRDC 2.05.03-11 “Bridges and pipes”, the normative intensity of the horizontal transverse wind load should be taken at least 180 kgf/m^2 (w=0,18 thousand/m^2).

The wind load is applied to the bridge support in the form of a concentrated force W collected from the cargo area:

W=w×L× y_f =0,18×24×1,5=6,48 thousand.

The normative horizontal transverse load from impacts of the wheels of vehicles is taken as a concentrated force applied at the level of the top of the carriageway.

P=0,6×K=0,6×14=8,4 thousand.

The design load is:

P=P×y_f=8,4×1,2=10,1 thousand.

2.2.7 Estimated braking load

The normative longitudinal braking force from vehicles is assumed to be 2.5K.

Estimated force from vehicle braking:

T=2,5×K×y_f=2,5×14×1,2=42 thousand.

$\frac{T}{3} = \frac{42}{3} = 14$ thousand

The load is applied at the level of the top of the support.

Estimated load on the sidewalks from the "crowd"

The load from the sidewalks on the intermediate support is determined in accordance with point 2.21 of the norms [4].

The design load is:

$R_{тр}=q^n \times b \times L \times y_f=0,4 \times 1 \times 24 \times 1,2=11,52$ thousand.

q^n – normative temporary load on the sidewalk;

b – sidewalk width;

y_f – load safety factor.

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