ENGINEER

international scientific journal

SPECIAL ISSUE

E-ISSN
3030-3893

ISSN
3060-5172

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A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

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E-ISSN: 3030-3893

ISSN: 3060-5172

SPECIAL ISSUE

16-iyun, 2025

engineer.tstu.uz

“QURILISHDA YASHIL IQTISODIYOT, SUV VA ATROF-MUHITNI ASRASH TENDENSIYALARI, EKOLOGIK MUAMMOLAR VA INNOVATSION YECHIMLAR” MAVZUSIDAGI RESPUBLIKA MIQYOSIDAGI ILMIY-AMALIY KONFERENSIYA TASHKILIY QO‘MITASI

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Determination of the displacements of the conjugated ends of the span structures of bridge structures and recommendations for selecting modern designs of deformation joints

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Abstract: The article examines the deformation joints of bridge structures that overlap gaps between span structures and other parts of the bridge (supports, supports) to ensure smooth and safe traffic flow, designed to compensate for deformations caused by temperature changes, dynamic loads, and other factors. Also, the types of stresses on deformation joints, determining the calculated temperature range, and determining the displacements of the ends of span structures from various types of stresses are described. Recommendations for choosing a deformation seam are given depending on the calculated values of displacements of the ends of the span structures.
The article also examines determining the installation size of the deformation seam.
Keywords: deformation seam, longitudinal movements, span structure, transverse movements, horizontal movements, concrete shrinkage, temperature effects, concrete creep, elasticity model, transport braking.

1. Introduction

Deformation joints on bridges are special structural elements that close the gaps between the span structures and other parts of the bridge (supports, supports) to ensure smooth and safe movement of vehicles. They are designed to compensate for deformations caused by temperature changes, dynamic loads, and other factors

The main purpose of deformation joints is: *to allow span structures to move* without overvoltage and damage to joint elements during temperature changes, soil settlement, and other influences;

ensure smooth driving of vehicles, excluding knocks and vibrations, creating safe and comfortable driving;

prevent premature bridge destruction, as deformation joints help distribute loads and prevent stress accumulation.

Initially, steel sheets were used for deformation joint structures, covering the gap between span structures. With the increase in the length of the span structures of bridges, the use of these sheets was insufficient, therefore, comb joints and steel sliding sheets began to be used. All these types of deformation joints were not waterproof, so the water freely penetrated the gap and fell on the ends of the span structures, supporting parts, and supports. The first waterproof deformation joints were constructed using rubber tubes that seal the joint of the span structures and perceive longitudinal movements of the ends of the span structures due to the elastic deformation of the rubber. Thus, another task was added to the tasks facing the deformation joints - ensuring the tightness of the gap between the span structures.

This design principle led to the emergence of a large number of different deformation joint designs. Nevertheless, despite the continuous change in the design of deformation joints, they still remained among the most vulnerable elements of the road bridge pavement, subject to rapid wear, especially in bridges with intensive transport loads.

When determining the displacements of the ends of span structures for the purpose of selecting a deformation joint structure for use, errors are most often made, which are caused by both the designer's subjective approach and the lack of knowledge of the true operation of the structures. The result of these errors is the use of deformation joint structures of an incorrect type (size), which, in turn, leads to early destruction of joint structures, deterioration of movement conditions on the bridge, and damage to load-bearing structures.

Methods. The construction of deformation joints is influenced by natural and climatic factors; vehicles directly in contact with the elements of deformation joints; operational factors (conditions and level of maintenance of bridge structures); and the movement of the ends of span structures in joints between themselves and with supports.

Based on this, we can list the methods for calculating deformation joint structures based on the factors of influence.

The method of calculation based on the natural climatic impact factor includes calculations of air temperature, the number of days in a year with negative temperature, the number of temperature transitions through "zero," environmental pollution, precipitation, and solar radiation exposure.

Calculation method based on the factor of operational impacts: abrasive impact of vehicle wheel tires, repeated load from the wheels, the possibility of foreign materials entering the structure and the duration of their impact, ice on the roadway in the zone of deformation joints, water impact, contamination of deformation joints.

Calculation method by the displacement factor of the ends of span structures: linear horizontal longitudinal and transverse relative displacements, linear vertical relative displacements, angular displacements in the longitudinal vertical plane, angular displacements in the transverse vertical plane, angular displacements in the horizontal plane.

Each influence according to the indicated characteristics is reflected in specific prerequisites for design and calculation, requirements for materials, and application conditions. The effect of displacements on the ends of span structures is taken into account when choosing the type or variety of deformation seam and when calculating the units and parts of its structure.

2. Results and Discussion

The foundations for calculating the displacements of the deformation joint are the values *of the maximum and minimum temperatures of the bridge structure span structures.* These temperature values determine the range of change in the value *of the deformation seam gap (calculated* *range of temperature change* Δt), which is necessary for the correct and rational choice of the seam type (and its type size). When calculating for simplification purposes, the corresponding values of the maximum and minimum air temperatures (T_{max} and T_{min}) in the construction area are taken as the maximum and minimum temperatures. The calculated temperature range is calculated as the sum of the maximum and minimum air temperature modules (T_{max} and T_{min}):

$$\Delta t = |T_{max}| + |T_{min}|, \qquad (1)$$

In addition, it is necessary to know the temperature of the bridge structure structures at the moment of installing the deformation seam (*the temperature of installing the deformation seam* T_{ins}).

The calculation method based on the "movement of the ends of span structures" factor (or *"calculated movements")* involves dividing the movements into the following types (Figure 1)

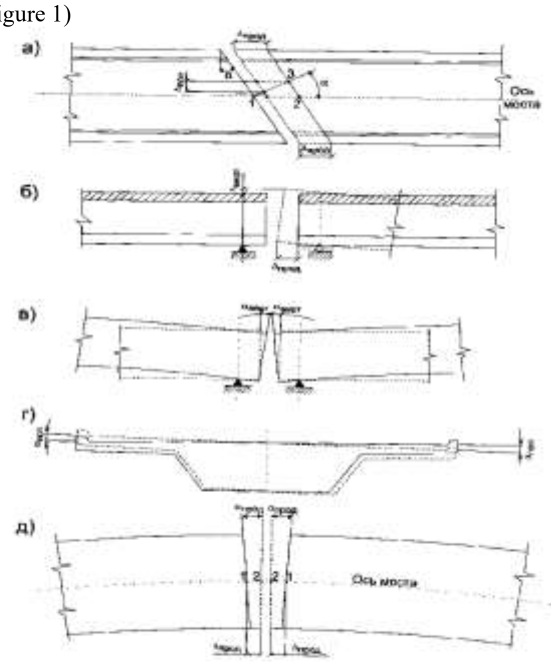

Fig. 1. Types of displacements of the ends of span structures

Linear horizontal longitudinal and transverse displacements of the mating ends of span structures, uniform along the length of the seam Δ_{long} and Δ_{trans}. Such movements occur due to the uniform change in ambient temperature, creep, and shrinkage of concrete.

1) Temperature effects.

The influence of temperature on the steel and reinforced concrete span structures of bridges can be taken into account using the known formula (2):

$$\Delta l = 1{,}2 \cdot \alpha \cdot \Delta t \cdot l \qquad (2)$$

where: 1,2 - reliability coefficient for temperature effects;

α – temperature expansion coefficient, equal for concrete: on granite coarse aggregate $\alpha = 9{,}5 \cdot 10^{-6}$ K^{-1}, on limestone coarse aggregate $\alpha = 6{,}8 \cdot 10^{-6}$ K^{-1}; for steel: $\alpha = 1 \ldots 1{,}1 \cdot 10^{-6}$ K^{-1}

Δt is the calculated range of temperature change for a given area, formula (1);

l the calculated length of the "chain" from which the movements are assembled

The calculated length of the "chain" from which the displacements from temperature effects are collected is called the length of the part of the bridge taken between adjacent fixed supporting parts, provided that the given deformation joint is located in this section (fig. 2):

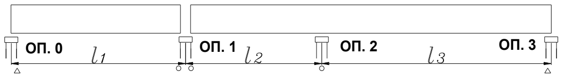

Fig. 2. Diagram for determining the calculated length of the chain for collecting displacements

In Figure 2, the deformation seam is located on support 1, and the fixed supporting parts are on supports 0 and 3. Then the calculated length of the "chain" *l* will be the length equal to $l = l_1 + l_2 + l_3$.

2) Creep of concrete.

When calculating the displacements of the ends of span structures, it can be assumed that the creep deformation of concrete occurs for 10 years (or more, if periodic additional loading of beams occurs).

The influence of creep on the displacement of the ends of span structures can be simplified by further reducing the lower limit of the calculated temperature range by 15 ºC.

3) Concrete shrinkage.

When calculating concrete shrinkage deformations, the data in Table.2.

Table 2

	Measurements of normative shrinkage deformations $_{sn}$ for concrete of compressive strength classes										
	B20	B22.5	B25	B27.5	B30	B35	B40	B45	B50	B55	B60
ε_{sn} 10^6	400	400	400	400	400	400	400	365*	330*.	315**	300**

When the cone settles 1-2 cm.

At a mixture hardness of 35-30 s.

Table. 2 contains the values of *limit relative deformations of concrete shrinkage*, which in our case show a relative increase in the length of the span structure due to concrete shrinkage. That is, for example, it can be assumed that the maximum change in the length of the span structure *l* = 100 m from concrete of the compressive strength class B30 will not exceed $_{sn}$ = 100 m ·400·10⁶ = 0.04 m = 4 cm.

If the deformation joints are installed some time after the bridge construction (as is most often the case), it is necessary to take into account the shrinkage deformation time, which can be conventionally taken as 5 years when the bridge is located in regions with a temperate climate, after which the shrinkage deformation can be considered conventionally terminated. In this case, the residual shrinkage deformation, and consequently, the displacement size, is taken taking into account the age of the concrete at the time of constructing the deformation joints according to Table. 3.

Table 3

Normative shrinkage deformations, %, depending on the age of the concrete, month.									
Climatic regions	1	3	6	12	18	24	36	48	60
Regions with temperate and cold climates	30	50	60	70	77	84	92	96	100
Southern regions	40	55	67	80	90	95	100	-	-

Table. 3 shows what percentage of shrinkage deformations from the limiting relative shrinkage deformations of concrete $_{sn}$ has already occurred by this time. That is, for the above-considered span structure of the bridge with *l* = 100 m, assuming it is located in the southern region, and the deformation joints are made one year after the completion of concreting, it is necessary to expect another 100% - 80% = 20% of all unfavorable shrinkage deformations, which will be 0.2·4 cm = 0.8 cm at the limiting value of concrete shrinkage deformations equal to 4 cm.

The shrinkage of reinforced concrete span structures causes horizontal displacements, while the shrinkage of the reinforced concrete slab of steel-reinforced concrete span structures causes horizontal and vertical displacements.

The calculated values of displacements of the ends of span structures from shrinkage and creep are determined by multiplying the normative values by the reliability coefficient $\gamma=1.1$.

4) Acceleration and braking of transport.

Horizontal displacements of deformation joints can also be caused by vertical displacements of supports (settlements), forces from acceleration and braking of transport. We will not consider the subsidence of supports for simplification when performing laboratory work, although in practice it must be taken into account. Additionally, the settlement of supports is not fully considered in the case of continuous bridge structures, as support settlement is not permissible for them.

As for the forces from the braking and acceleration of vehicles, the displacements from their action can be approximately taken into account using Hooke's law (3):

$$\Delta_{прод}^{m,уск} = \frac{S^{m,уск} \cdot l}{E \cdot F} \qquad (3)$$

where:

l - total length of the span structure;

E - modulus of elasticity of the span structure material;

F - cross-sectional area of the span structure;

$S^{m,уск}$ - force from braking and vehicle traction force.

The force is $S^{m,уск}$applied to each of the adjacent spans, between which the deformation seam is provided (the calculation is carried out accordingly by substituting the values of l , E and F for each of these spans separately).

So, when the main displacements of the span structures are determined, it is necessary to sum them in three main directions: vertical displacements Δ_{vert}, horizontal longitudinal displacements Δ_{long}, and horizontal transverse displacements Δ_{tran}.

The types and designs of deformation joints are selected based on the total calculated displacements of the ends of the span structures in three directions, taking into account their signs "+" or "-" (the sign "+" is conventionally accepted if the displacement is aimed at stretching the span structure and closing the deformation joint, the sign - "-" in the opposite case). Summed displacements with their recommended designations are given in the table. 4.

Summed displacements along directions and influences

Table 4

Directions	Loads and impacts				
	constants	temperatu re	shrinkage and creep of concrete	temporary mobile	
				vertical	horizontal
Longitudinal	$\Delta_{c.long}$	$\Delta_{t.long}$	$\Delta_{c.long}$	$\Delta^{v}_{tm.long}$	$\Delta^{h}_{tm.long}$
Vertical	$\Delta_{c.vert}$	$\Delta_{t.vert}$	$\Delta_{c.vert}$	$\Delta^{v}_{tm.vert}$	-
Transverse	$\Delta_{c.trans}$	$\Delta_{t.trans}$	$\Delta_{c.trans}$	-	-

It is necessary to remember that the perception of all the indicated displacements (Δ_{long}, Δ_{trans}, Δ_{vert}) must be ensured by the seam design. If the deformation joint design is not suitable for at least one Δ indicator, its application is not permitted.

Based on the obtained displacement values, a specific type of deformation seam is selected (types differ by the seam design, grade, manufacturer, etc.), as well as the type and size of this seam type (different within the same type and grade by the magnitude of perceived displacements), after which the installation size of the selected deformation seam is determined.

3. Conclusion

Based on the above calculations, recommendations can be given for selecting the deformation seam type, depending on the seam's installation size.

The installation size of the seam is the width of the deformation seam gap, which the deformation seam has when it is installed in the bridge structure. The weld's installation size must be strictly defined and dependent on the temperature of the span structures at the time of installation, otherwise the calculated range of displacements of the span structures may not coincide with the permissible range of displacements of the deformation weld and may exceed it at the minimum or maximum temperature of the bridge structure. In practice, the installation size is determined using special tables (attached to this type of seam), in which the dependence of the installation size of the seam on the temperature of the span structures is given (for which, as a rule, the ambient air temperature is taken).

When a specific deformation seam for a given bridge structure is already selected, its installation size should be determined based on the fact that the middle of the calculated range of displacements of the span structure should, if possible, correspond to the middle of the permissible range of displacements of the deformation seam. In practice, we can take the deformation seam gap value, corresponding to the ambient air temperature, for which the deformation seam gap is approximately equal to half the calculated maximum gap, as the setting size.

Foydalanilgan adabiyotlar / References

[1] Шестериков В. И. Ремонт конструкций деформационных швов с металлическим окаймлением. – М., 2001. – (Автомоб. дороги: Обзорн. информ./Информавтодор; Вып. 7)

[2] Современные конструкции дефор-мационных швов автодорожных мостов часть 1. Деформационные швы WABO. Мет. указ. для студ. спец. 2910, 2911. Составлены: Раткиным В.В., Овчинниковым И.Г., Макаровым В.Н. Саратов: Сарат. гос. техн. ун-т, 2000

[3] Современные конструкции дефор-мационных швов автодорожных мостов часть 2. Деформационные швы MAURER. Мет. указ. для студ. спец. 2910, 2911. Составлены: Раткиным В.В., Овчинниковым И.Г., Макаровым В.Н. Саратов: Сарат. гос. техн. ун-т, 2000

[4] Günter Ramberger. Structural bearings and expansion joints for bridges. Structural Engineering Documents 6. Zurich, Switzerland, IABSE, 2002. – p. 51-89

[5] Шермухамедов У.З., Хикматова И.Ф. Анализ существующих конструкций де-формационных швов в мостостроении. Problems of architecture and construction. 2024, №2

[6] I.F. Khikmatova. Features work and scope of application of crushed stone-mastic expansion joints of bridges structures. Nazariy va amaliy fanlardagi ustuvor islohotlar va zamonaviy ta'limning innovatsion yo'nalishlari. Vol.1 №5 (2024). may

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