ST CMEA 3972-83 (ST SEV 3972-83)

UDC 62-192:624.01/04:624.013.2.001.24 Series Zh02

# CMEA STANDARD

# Building units and foundations reliability

# Steel construction units

# General provisions referring to the calculations

*To be implemented as a USSR national economy standard since 01/01/1985*

*as a legal regulation of cooperation contracts standard since 01/01/1985*

# GENERAL INFORMATION DATA

1. Drafted by the USSR delegation to the Standing Commission in the sphere of construction works.

2. Item - 22.200.18-81.

3. The CMEA standard has been ratified on the 53-th session of Standing Commission in the sphere of construction works.

4. Commencement of the CMEA standard implementation terms:

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| Countries - CMEA members | Commencement of the CMEA standard implementation terms | |
|  | as a legal regulation of economic and scientific and technical cooperation contracts standard | in the sphere of national economy |
| People's Republic of Bulgaria | July, 1985 | July, 1986 |
| Hungarian People's Republic | January, 1984 | - |
| The Socialistic Republic of Viet Nam |  |  |
| German Democratic Republic | January, 1984 | January, 1988 |
| The Republic of Cuba |  |  |
| Mongolian People's Republic | January, 1986 | January, 1987 |
| Poland People's Republic | July, 1986 | July, 1986 |
| The Socialistic Republic of Romania |  |  |
| The USSR | January, 1985 | January, 1985 |
| Chechoslovak Soviet Socialistic Republic | June, 1986 | June, 1986 |

5. The term of the earliest examination - 1988, the periodicity of examinations - 5 years.

RATIFIED by Resolution № 115 dated July, the 20th, 1984 approved by Construction Works State Committee of the USSR.

CONFIRMED by the Standing Commission in the sphere of standardization, July, 1983, Prague.

INSTEAD of RS 131-74 standard

The present CMEA standard is mandatory within the frameworks of CMEA standards implementation convention

The present standard regulations cover the sphere of steel construction units of residential, public, industrial, agricultural and other buildings and constructions and stipulates the general regulations referring to the ultimate conditions calculations of the above-mentioned buildings.

As applied to the steel construction units operated under the specific conditions (blast furnaces, different types of reservoirs, buildings and the constructions aimed to resist the seismic or temperature impact) as well as the special types of constructions (prestressed and pendulous), the additional requirements accounting the particular qualities of their operational peculiarities should be taken into account.

The present CMEA standard should not be applied to steel construction units of bridges and pipelines.

# 1. General provisions

1.1. Steel constructions must be rated in accordance with their ultimate conditions laid down by ST CMEA 384-76, at that, the destruction of these constructions should be comprehended as a fragile, viscous or fatigue destructions.

1.2. Steel construction units must be rated as indivisible spatial systems. There must be considered such factors as strained and malformed conditions, geometrical and physical nonlinearity, materials and coats plastic and rheological properties in accordance with the present CMEA standard as well as CMEA calculation methods standards.

1.3. In case of absence of accurate theoretical calculations methods or absence of the approved solutions put to practice before, it is allowed to apply the approximate calculations method grounded upon the splitting of indivisible spatial systems on the separate two dimensional subsystems and elements. These approximate methods must guarantee the total level of constructions units reliability as required by the ultimate conditions method. Meanwhile, it is obligatory to consider the particular qualities elements of steel construction units interaction as well as their interaction with a foundation.

1.4. Bar structures division on the separate elements are to be effected on the grounds of the effective (estimated) bar lengths to be defined on the basis of Euler's method.

1.5. In case of absence of statically indeterminate construction units calculation methods regarding physical nonlinearity, it is allowed to effect the assumed load calculations through the undistorted pattern with the elastic strains of steel assumptions. However, the calculation of the separate elements ability to resist the above-mentioned forces should be implemented within the frameworks of strained pattern considering the physical nonlinearity of plastic strain of steel effect.

1.6. Stable frameworks, post-and-beam and plated structures calculations, as well as their components calculations must be performed on the grounds of linear dependance between malformations and displacements with consideration of plastic strain of steel effect. It is also possible to employ the theory of minor elastoplastic strain at the periods of simple loading.

1.7. Steel construction units computations must provide the simultaneous accomplishing the structural strength (stability) as well as its components.

1.8. While performing a steel construction unit calculation of the single load increase up to its maximum, the applicable types of steel should be regarded as nonlinearly elastic material.

In cases of the possible loads diminution as well as in cases of recurring alternating loading of the steel, the steel should be regarded as elastic-plastic material.

1.9. The following geometrical hypotheses are to be applied while performing steel construction units and their components resistance the outer stresses calculations: strip theory, sectorial areas and direct normals.

1.10. The calculations of steel construction units and there components in the complicated state of stress should be performed by defining intensity of stresses taking into consideration strength-energy theory.

1.11. The calculations of steel construction units and their components holding their own residual stresses (as a consequence of welding, rolling, cold truing) requires application the algebraic summation of conditional deformations hypothesis considering the deformations caused by outer stress. Refer to the following

 (1)

*E* represents coefficient of elasticity

Note. Own residual stresses might be excluded from calculations.

1.12. The selection of steel construction unit components should be determined by minimal section satisfying the provisions of the CMEA standard as well as CMEA calculation methods standards considering the assortment in sight and technical and economic feasibility study.

1.13. Steel construction units reliability must be secured by simultaneous compliance with the requirements concerning the material selection, calculations and design and engineering processes.

1.14. Standard values of stresses, reliability stresses coefficients and combinations defining estimated values of stresses should be comprehended as per ST SMEA 1407-78.

# 2. Materials

2.1. The applicable types of steel should be selected depending on operational conditions, estimated temperatures, level of impact of dynamic or vibration stresses, technologies of manufacture and assembling steel construction units. Meanwhile, it is necessary to take into account mechanical properties of steel types, ductility properties, impact elasticity, fatigue failure, fracture failure, weldability, hardness, anticorrosion durability.

2.2. Welded connections should be made of the materials which properties match the types of the steels to be welded; these materials should guarantee all the necessary properties of the weld seams in case the complying technology of working process is observed.

2.3. Bolts applicable for the bolted connections of steel construction units should be defined according to ST CMEA 759-77 and ST CMEA 2651-80.

2.4. It is necessary to apply guy ropes made of steel, bundles and strands made of high-strength wire or rolled steel for construction of stretching wires and flexible elements of covers, pole guys of poles and towers, as well as for construction of stressed elements of prestressed structures.

2.5. The specifications of types of steel, welding materials, screws and rivets, the shipment conditions of the above-mentioned stuff (if necessary) should be indicated on the drawings of steel constructions units as required by CMEA ESKD standards.

2.6. It is recommended that steels applied in the construction units conform to the following values of physical parameters:

1) coefficient of elasticity (*E*)-2,06⋅105MPa

2) modulus of rigidity (*G*)-0,79⋅105 MPa;

3) coefficient of lateral deformation (ν)-0,3;

4) coefficient of linear expansion (α)-0,12α10-4 αC-1;

5) density (ρ)-7850 kg/m3.

# 3.Calculated resistance of materials and compounds.

3.1. Calculated strengths of rolled steel and pipes must be found as per the following formulae:

1) tensile strength, compression strength, flexural strength:

yield strength limitation

 (2)

time strength limitation

 (3)

2) slip resistance

 (4)

3) collapse resistance of the end surface (in the presence of a fitting)

 (5)

*Ryn* and *Run* represent normative strengths of steel equal to the minimal values of yield strength and time strength defined by CMEA standards for steel;

*Ym* is reliability coefficient of a material.

In order to calculate the 1st group ultimate conditions of the constructions, the following indicators should be accepted *Ym*≥1,0.

3.2. It is possible to define calculated strengths values not according to the normative strengths indicated in p. 3.1., but according to the conditional normative strengths, which values should match the standards introduced be CMEA for steel.

3.3. Calculated strengths values of welded junctions should be accepted to be equal or of less values than calculated strengths values of the essential metal in dependance of the type of state of stress, welding technology and applicable methods of weld seams control.

Calculated strengths values of welded junctions originated in types of steel with different normative strengths should be accepted according to the least value of normative strength.

3.4. Calculated strengths values of metal weld seam cut and metal of flash-off coverage of the welded connections with corner weld seams should be accepted according to the normative breaking strengths values of the weld seam and the welded metals considering the reliability coefficients of the material.

3.5. Calculated the one-bolted connections tensile strengths values and shearing of the bolts as well as collaps resistance of the joined elements (considering the accuracy rating of the bolts) should be stipulated according to the normative strengths values of the joined bolts and steel considering the reliability coefficients of the material.

Multi-bolted connections require that working conditions of the connections coefficients which depend on the accuracy rates of the bolts and the towards efforts between centers of bores and from the nearest bore center's edge should be taken into account.

3.6. Calculated strengths values of riveted joints should be stipulated according to the requirements as per p. 3.5 considering technologies of assemblage and formation of borings.

3.7. Calculated tensile strengths of high-strength bolts and foundation bolts should be accepted as equal the same values of time breaking strength of the bolts, stipulated by CMEA standards for bolts divided on the reliability coefficient of high-strength bolts and foundation bolts respectively.

3.8. Calculated tensile strength of high-strength wire applied in the form of bundles and strands should be accepted as equal the same values of time breaking strength divided on the reliability coefficient.

3.9. Rated force value of guy rope tensile strength should be accepted as equal the value of breaking strength of the guy rope as a whole divided on the reliability coefficient.

3.10. It is necessary to consider the reliability coefficients and the working conditions coefficients stipulated by ST CMEA 384-76, the present CMEA standard and CMEA calculation methods standards while calculating ultimate conditions of steel construction units and joint constructions.

# 4. The 1st group ultimate conditions of the construction units

4.1. General provisions

4.1.1. While calculating bearing capacity of construction components, rated forces of efforts and impacts should not exceed the efforts which might be born by sections or components of these strengths of steel. Ultimate efforts born by the sections or components should be defined considering the immanent irregularities of the material.

4.1.2. While calculating the constructions in reference to the ultimate conditions of total exhaust, it is to be considered that the residual displacements (malformations) corresponding the calculated stresses as well as impacts, should not exceed the displacements (malformations) limiting values, defined by CMEA calculation methods standards.

The substantiation within the frameworks of CMEA calculation methods standards of the ultimate conditions of total exhaust calculation can be presented in the form of the efforts verification (alike while calculating the bearing capacity) to be defined taking into account physical nonlinearity.

4.1.3. The calculations concerning the 1st group ultimate conditions of the constructions ought to be performed in the form of comparison of the element force or in the form of computational stresses with calculated stresses.

4.1.4. Structural strength calculation in terms of conditions of elastic failure, fracture failure and fatigue failure ought to be performed with the usage of calculated strength *Ru* and "net" properties of the section.

Structural strength calculation in terms of conditions of displacements or malformations limitations (conditional strength) ought to be performed with the usage of calculated strength *Ry* and "gross" properties of the section (applicable if depression of the section up to 15%) and "net" properties (applicable if depression of the section is more than 15%).

4.1.5. General and local rigidity of the constructions calculations ought to be performed with the usage of calculated strength *Ry*, "gross" properties the compressed components effective lengths.

4.1.6. Calculation of resistance of the components which are not depressed by the bores for bolts or rivets made of the types of steel with ratio *Ru*/*Yu*>*Ry* ought to be performed on the basis of the calculated impact resistance *Ry*; the same calculation referring to the types of steel with ratio *Ru*/*Yu*<*Ry* ought to be performed on the basis of the calculated resistance *Ru*.

Calculation of resistance of the components which are depressed by the bores for bolts or rivets made of the types of steel with ratio *Ru*/*Yu*>*Ry* ought to be performed on the basis of the calculated strengths *Ry* and *Ru*. In reference to the steels with ratio *Ru*/*Yu*<*Ry* on the basis of the calculated strength *Ru*.

4.1.7. While performing the strength calculations on the basis of calculated strength *Ru* according to the pp.4.1.4, 4.1.6 and 4.2.2 there should be considered the reliability coefficient *Yu*>1.

4.2. Axially stretched construction elements

4.2.1. The stability of the axially stretched construction elements calculation ought to be performed on the basis of the calculated strengths *Ry* and *Ru* according to the requirements laid down by pp. 4.1.4, 4.1.6 and 4.2.2.

4.2.2. The stability of the stretched construction elements calculation made of the types of steel with the ratio *Ru*/*Yu*>*Ry* which can be under operations even if the yield point has been achieved ought to be performed on the basis of the calculated strength *Ru* only.

4.3. Axially loaded construction elements

4.3.1. The stability of the axially loaded construction elements calculation ought to be performed on the basis of the calculated strengths *Ry* and *Ru* considering the requirements laid down by pp. 4.1.4, 4.1.6 and 4.1.7.

It is allowed to perform the axially loaded construction elements resistance calculation equipped with riveted or bolted junctions as it being performed for the fade-resistant construction elements.

4.3.2. The axially loaded construction units rigidity calculation must be performed as it is being performed for eccentrically loaded units considering the following:

1) the section shape of the element;

2) initial axis bend and accidental eccentricity of the compression force accepted in accordance with the fluctuations admitted by CMEA steel constructions units manufacture and their assemblage standards or in accordance with the outcomes of the statistical analysis of their working values.

3) from the own residual stresses according to p. 1.11;

4) the impact of the junction plates or lacings on the total hardness of the element (for the through elements).

The calculation of the element ought to be performed on the basis of the malformed scheme considering the ductility malformations. The value of the calculated bearing resistance should be accepted as the equal to the compression force maximal value which can be taken by the element.

In case the component contains the pivoting bearings, the shape of the axis bend can be accepted as half-wavelength of sinusoid.

4.3.3. The effective length of arbitrary fastening of the elements' ends should be established as the maximal distance between the two points of the axis change to be defined on the grounds of the calculation of the element on the basis of the Euler's method.

4.3.4. While calculating of the axially loaded elements, it is necessary to accept the reliability coefficient equal to *Ye*>1,0 in reference to the critical stress defined on the basis of the Euler's method.

4.3.5. Cover plates and cord plates of axially loaded elements should pass the rigidity check according to pp. 4.8.3 - 4.8.5.

4.3.6. Axially loaded elements of open slender section (besides the calculations effected according to pp. 4.3.2 - 4.3.5) should pass the additional rigidity check at the bending-torsion form of rigidity loss, in case the above-mentioned process stipulated by CMEA calculation standards.

4.3.7. It is necessary to check the rigidity of separate sectors of the branches, located between the nods of the through axially loaded elements (besides the calculation of the element as a whole).

4.3.8. The calculation of the junction plates or lacings of the through axially loaded elements should be performed considering conditional lateral force.

4.4. Curved elements

4.4.1. The curved elements resistance calculation, depending on the allocations of these elements and conditions under which they are to be operated must be performed within the scope of the elasticity or out of this scope, which ultimate strength limitations depending on the following groups of construction units:

1) the construction units for which the plastic malformations are not allowed;

2) the construction units for which the plastic malformations development is limited by the condition of plastic adaptation. The calculation of these constructions should be performed within the scope of elastic malformations;

3) the construction units for which the plastic malformations development is not accompanied by the yield hinges formation. These calculation should be performed without consideration of the moment of deflection repartition;

4) the construction units for which the plastic malformations development is accompanied by the yield hinges formation. These calculation should be performed considering the moment of deflection repartition.

4.4.2. The resistance calculation of the 1st group curved elements should be performed after the check of the normative stresses net section σ*x* and σ*y*, parallel and perpendicular to the axis of the element, tangential stresses τ*xy*, as well as the intensity of stresses of the plate defined according to the p. 1.10.

It is possible to calculate the curved elements under the conditions of the local rigidity losses of the flakes shaping the section of the element.

It is necessary to calculate the rigidity of the elements curved in the flat surface of the maximal rigidity by the bending-torsion malformation considering the stresses properties, the place of its section height application, presence or absence of the anchoring of the element in the panel and the shape of the section. The calculation ought to be performed on the basis of the thin-walled bars stability theory considering the constrained torsion and free torsion.

It is allowed to substitute the rigidity of elements calculation effected under the conditions of the bending-torsion malformation by check the compression chord rigidity according to pp. 4.3.2 - 4.3.5.

The walls and the chord plates of the curved elements should pass the rigidity check according to the pp. 4.8.6 - 4.8.10.

Note. In case the chord plate of the curved element is fixed to prevent the transverse displacement, the rigidity calculation is not required.

4.4.3. The resistance calculation of the 2nd group curved elements should be performed according to the requirements laid down by p. 4.4.2 on conditions of multiplication of the geometric properties of the net section and plastic adaptation coefficients. The last values should be accepted as the ones exceeding 1 and to be defined on the basis of maximal malformations strength value defined for this group.

4.4.4. The resistance calculation of the 3d and the 4th group of the curved elements is allowed to be performed for the construction units under the static stresses.

The following requirements should be observed while calculating the above-mentioned elements:

1) it is recommended that the steel is characterized the square of the reciprocal viscosity at least 6*Ry/E* and ratio of the normative stresses *Run/Ryn*>1,3;

2) if the tangential stresses are τ>0,5RS, it is necessary to consider the impact of the lateral force on the ultimate value of the moment of deflection;

3) in case the area of the pure bending is presented, it is necessary to limit the total displacements of the element;

4) as for the 3rd and the 4th group of construction units, the distances between the junction points of the compression chord of the element from the lateral displacements, as well as the ratio of the wall height and the overhanging width of the chord to their thicknesses must have the values providing their rigidity for the maximal value of the malformation stresses defined for the 3rd group respectively and in case of the yield hinges formation - as for the 4th group.

4.5. The components subject to the torsion effects

4.5.1. The components subject to the torsion effects resistance calculations ought to be performed under the conditions of the constrained torsion and free torsion.within the scope of the elastic strains or taking into account plastic strains depending upon its purpose or presumed conditions of their operations.

4.5.2. While calculating the components subject to the free torsion effects resistance, it is necessary to apply the check of the tangential stresses only.

While calculating the components subject to the constrained torsion effects resistance, it is necessary to apply the only check of the tangential stresses, but also normal stress defined by the sectoral square rule.

4.6. The elements subject to the bending axis force

4.6.1. The elements subject to the bending axis force depending on the allocations of these elements and conditions under which they are to be operated must be performed according to the groups of construction units laid down by the p. 4.4.1 considering the maximal malformations strength value.

Calculation of resistance of the components belonged to the 1st and the 2nd groups should be performed according to the requirements laid dow by the pp. 4.4.2 - 4.4.3.

Calculation of resistance of the components belonged to the 3rd and the 4th groups should be performed with the usage of efforts values corresponding with the interaction surfaces and according to the requirements laid down the p. 4.4.4.

Note. In case the section is not weakened, the resistance of elements subject to the contractive force impact calculation should not be performed; it also should not be performed in case the resistance and rigidity calculations operate the same moments of deflection values.

4.6.2. The eccentrically loaded construction units and bending-compressed construction units rigidity calculation while they are being bended within one of the main flat surfaces must be performed within the momentum action plane surface (the plane instability form) as well as out momentum action plane surface (bending torsion instability form).

4.6.3. The eccentrically loaded construction units and bending-compressed construction units rigidity calculation bending within the momentum action plane surface, as a rule, should be performed according to the pp. 1.4 and 4.3.2.; meanwhile, accidental eccentricity should be accepted as the additional one to the calculated eccentricity *e=M/N* where *M* is the moment of deflection; *N* is the axial force) considering the likelihood of their calculated values coincidence.

In order to calculate the eccentricity, the calculated values of the momentum of deflection and the axial force of the element are to be defined as per the strain-free scheme with the assumptions of the elastic strains. They also should be accepted at the same combination of forces considering alterations of the moment of deflection according to the length of the elements and conditions of the ends of the element junctions.

It is possible to accept other methods providing the defining of the buckling load and crippling load in accordance with the general requirements of marginal states methods.

4.6.4. The rigidity elements calculation out of the flat surface by the bending-torsion malformation ought to be performed in the bending conditions in the flat surface of maximal firmness (*Ix*>*Iy*) coincides with the plane of symmetry considering the constrained torsion and free torsion, spatial motions of the element's sections at the moment of the rigidity liss and plastic strains of steel.

4.6.5. What concerns the eccentrically loaded construction units and bending-compressed construction units in the same flat surface, it is necessary to check up the rigidity of separate branches, besides the whole element calculation, considering the additional effort caused by the moment of deflection.

4.6.6. The junction plates or lacings calculation of eccentrically loaded construction units and bending-compressed construction units in the same flat surface should be performed at the actual and conditional lateral forces considering the likelihood of their simultaneous impact on the element.

4.6.7. The solid wall eccentrically loaded construction units and bending-compressed construction units rigidity calculation if being bended in two main flat surfaces should be performed in a way of diminishing the buckling load to be calculated for the each bended element in flat surface of minimal firmness due to spacial motion of the elements' sections and plastic malformations being bended in the maximal firmness flat surface.

It is also possible to employ other methods which guarantee the buckling load defining as well as the moments in accordance with the general requirements of marginal states methods.

4.6.8. The eccentrically loaded construction units and bending-compressed construction units rigidity calculation if being bended in two main flat surfaces should be performed for the whole element as well as for its separate branches.

The calculation of the whole element on the flat surface which is parallel to the surfaces of lacings can be performed accepting the zero equal moment acting on the surface perpendicular to the surfaces of lacings.

The rigidity verification of separate branches ought to be performed as for the eccentrically loaded construction units bended on the surface of the maximal firmness; meanwhile, the axial force of the each branch should be defined with consideration of the additional force of the momentum acting which is parallel to the surfaces of the lacings, but the momentum acting on the surface which is perpendicular to the surfaces of the lacings can be alloted proportionally according to their firmnesses.

4.6.9. The calculation of the junction plates or lacings of the eccentrically loaded construction units and bending-compressed construction units if being bended in two main flat surfaces should be performed according to p. 4.6.6. Meanwhile, the actual lateral force should be accepted on the surface which is parallel to the surfaces of the junction lacings.

4.6.10. The verification of the plates rigidity and rigidity of the cord plates of the eccentrically loaded units and bending-compressed construction units should be performed according to the requirements laid down by p. 4.8.11.

4.7. Effective lengths of the elements.

4.7.1. The effective lengths of the compressed eccentrically loaded construction units and bending-compressed construction units of the framed structure ought to be defined when it is impossible to calculate the construction units as a single malformed scheme system considering the plastic strains of steel.

4.7.2. The effective length of the element *Ief* ought to be defined as per the following formula



where μ is the coefficient of length reduction depending upon the condition of the ends of the element junctions and the type of compressive load application;

*I* is the length of the element.

4.7.3. The effective lengths of the compressed elements of the plane frame systems should be defined within the flat surface as well as out of the flat surface.

4.7.4. The effective lengths of the compressed elements of the frames' elements should be defined in accordance with the section of the elements shapes and their nod connections. Meanwhile, the connections of the elements against displacements from the flat surface of the frame should also be taken into account.

4.7.5. While calculating the effective lengths of the compressed elements of the plane frame systems of the angle irons, it is necessary to define the flat surface loosing the structural rigidity (within the flat surface of the minimal firmness or within the flat surface parallel to the flange of the angle iron).

4.7.6. While calculating the effective lengths of the uprights, it is possible to implement the approximate calculation schemes, which must be equal to the effective loading conditions of the columns and the connections of their ends. Meanwhile, it is obligatory to consider the irregularity of the vertical loading distributions between the uprights, the differences between the rigidities of the uprights, the presence of the firm construction elements which guarantees the three-dimensional rigidity of the building or the construction.

4.7.7. The effective lengths of the stepped frame columns of the one-storied industrial buildings can be calculated of the combinations of the loadings, providing the maximal values of the longitudinal strengths of the separate parts of the uprights. The values found *Ief* are to be applied while calculating other combinations of the loadings.

4.7.8. The effective lengths of the uprights in the along-track direction (out of the flat surfaces of the frames) must be accepted as equal to the distances between the points connected against the displacements out of the frame flay surface. The values of the effective lengths of the uprights out of the flat surfaces of the framed might be specified through the rigidity calculation based upon the calculated schemes considering the effective conditions of the connections of the ends of the columns.

4.7.9. The effective lengths of the stretched elements should be defined as the distances between the points connected against the displacement.

4.8. The plates rigidity and rigidity of the cord plates of the elements

4.8.1. As for the elements, calculated according to the pp. 4.3, 4,4, 4.5 and 4.6, the plates rigidity and rigidity of the cord plates, as a rule, must be provided in accordance with the values of the ultimate strengths of the elements on the whole.

In case the section of the elements is defined according to the ultimate values of the displacements or the flexibilities as well as in other cases defined by the technical and economic calculations the plates rigidity and rigidity of the cord plates might be guaranteed according to the less values of the efforts in the elements.

4.8.2. The verification of the plates rigidity and rigidity of the cord plates should be performed through calculations.

Meanwhile, it is necessary to set up the maximal values of the ratios of the wall height and the overhanging width of the chord to their thicknesses considering the transverse and longitudinal firmness ribs.

Note. In case there are less values of these ratios the verification of the walls and the overhanging of the chord is not required.

4.8.3. The verification of the plates rigidity and rigidity of the cord plates of the axially-loaded elements should be performed for the most tensed section of the element considering the requirements laid down by the p. 1.6; meanwhile, it is recommended to consider the impact of the interaction of the chords and wall on their rigidity.

4.8.4. As for the axially-loaded elements, in case the rigidity of the wall as per pp. 4.8.2. and 4.8.3. has not been secured, the calculation can include the sectors defined out of the calculation of the element considering the overcritical phase the wall operation on the grounds of the nonlinear theory of the thin plates malformations considering the plastic strains of steel.

4.8.5. The edges intended for strengthening the of the axially loaded must have the sufficient firmness in accordance with the walls calculation method; meanwhile, longitudinal edges ought to be include as a part of the calculated area of the element.

4.8.6. The verification of the plates rigidity and rigidity of the cord plates of the curved elements calculated according to the p. 4.4.2 should be performed considering all the components of the tensed condition (σ*x*,σ*y* and σ*xy*).

4.8.7. The rigidity of the beam web calculation ought to be performed applying the values of the components ratios of the tensed condition of the web and their critical values corresponding the interacting flat surfaces between them. Meanwhile, the critical tensions values must be defined on the basis of the geometrically linear theory of the rigidity of the plates considering the elastic strains of steel assumptions. It is allowed to consider the elastic fixing of the wall in the chords.

4.8.8. The chord of a beam rigidity calculation, as a rule, should be performed as the calculation of the free-ended on the long side plate on the basis of the geometrically linear theory of the rigidity of the plates considering the elastic strains of steel assumptions.

It is allowed to consider the impact of the wall firmness on the rigidity of the chord of a beam.

4.8.9. The beams which rigidity is not secured in accordance with pp. 4.8.2., 4.8.6. and 4.8.7. can be calculated considering the considering the overcritical phase the wall operation.  The ultimate bearing capacity of beam with a flexible wall should be defined applying the calculations schemes corresponding the fracture mechanism of the beam with the wall which lost the rigidity As for the axially-loaded elements, in case the rigidity of the wall as per pp. 4.8.2. and 4.8.3. has not been secured, the calculation can include the sectors defined out of the calculation of the element considering the overcritical phase the wall operation on the grounds of the nonlinear theory of the thin plates malformations considering the plastic strains of steel.

4.8.10. The edges intended for the strengthening of the beam walls should be manufactured according to p.4.8.5. requirements.

The part of the beam wall situated above the bearer if being strengthened by the rigidity edges should be calculated on the longitudinal curve out of the flat surface of the wall as an axially loaded construction element the impact of end reaction according to the requirements laid down by p. 4.3.2.

4.8.11. The verification of the plates rigidity and rigidity of the cord plates of the eccentrically loaded units and bending-compressed construction units performed according to the requirements laid down by pp. 4.6.3. - 4.6.9. should be performed according to the requirements laid down by pp. 4.8.3 - 4.8.5. It is necessary to consider the impact of tangential stresses.

4.9. Persistence and reliability with consideration of the fracture failure.

4.9.1. The construction units subject to iterative immediate effects of movable, vibrational stresses or any other types of stresses which might evoke the fatigue effects should be verified by the persistence calculation considering the steel selection requirements and the applicable engineering solutions should be applied.

4.9.2. The ability of steel constructions to resist the fracture failure should be secured by the accomplishing of the the steel selection requirements and the applicable engineering solutions should be applied.

It is allowed to verify it by the persistence calculation considering the fracture failure.

4.9.3. The tensions in the construction elements should be calculated on the basis of the formulas of the reliability calculations and the net section with the elastic strains of steel assumptions defined by CMEA for stresses.

4.9.4. While performing the persistence and reliability calculations considering the fracture failure within the construction elements it is necessary to consider that they should not exceed the calculated fatigue strength and fracture failure strength.

4.9.5. The calculated fatigue strength and fracture failure strength should be defined according to the types os steel applied, the type of the stressed state, node structural scheme or junction, technology of parts finishing and borings formation. It is necessary to consider types of stresses, the quantity of loading cycles, maximal and minimal values of stresses for the calculated fatigue stress; for the calculated fracture failure strengths there should be considered the thickness of the element, the assemblage temperature and the operational temperature.

4.9.6. The reliability calculation considering the fracture failure should be performed for axially stretched and eccentric-stretched elements as well as the curved elements stretching areas.

4.10. The junction of the elements calculation.

4.10.1. Welded junctions.

4.10.1.1. In case the welded junction is effected by the longitudinal strength, the tension distribution along the weld seam should be accepted as the uniform one.

4.10.1.2. In case the welded connection is effected by the curving momentum, the distribution of tensions along the weld seam is to be accepted as the distance proportional from the centre of gravity of the connection to the regarded section of the seam.

4.10.1.3. The weld seams calculation being simultaneously effected by the longitudinal axis and the momentum should be performed on the load line, calculated separately from the longitudinal strength and the momentum.

4.10.1.4. It is allowed not to take into account the eccentricities emerging in the connected elements and depending upon their thickness while calculating the weld seams.

4.10.1.5. The butt joints reliability calculation should be performed in the scope of elastic malformations on the basis on the formulae for the basic section upon the calculated strengths for the welded butt joints.

The intensity of the tensions within the butt joints being simultaneously effected by the normal and cutting tensions should be verified according to the p. 1.10. It is allowed to apply other methods considering the connections between components of the tensed condition of the seam.

The butt joints calculation should not be performed in case the calculated resistance of the basic metal and the metal of the joints are the same and welding is accomplished by the total welding method and the ends of the seams are placed out of the surface of the joint.

4.10.1.6. The angle seams calculation must be performed on the conditional shearing upon the calculated sections of the seam metal and the welded verge metal considering the properties of the types of steel welded, welding materials, welding technology and the state of the seam.

In order to reduce the volume of the welded metal, it is allowed to apply the welding materials providing higher reliability of the seam metal in comparison with the basic metal.

The welded joints with angle seams calculation being simultaneously effected by the cutting tensions in two directions should be, as a rule, performed upon the load line of these tensions.

It is also possible to employ other methods considering the connection between components of the tensed condition of the seam being stressed in two directions.

4.10.2. Bolted connections and rivet connections.

4.10.2.1. Bolted connections and rivet connections should be subject to tensile strength and cutting strength calculations as well as collapse resistance of the jointed elements.

The tensile strength calculations of the bolts should be performed upon the net section of a bolt.

4.10.2.2. In case a bolted connection or a rivet connection is a subject to the axial force effect, the distribution of this force between bolts or rivets should be accepted as the even one.

4.10.2.3. In case a bolted connection or a riveted connection is a subject to the momentum of deflection effect the distribution of strengths on the bolts or rivets must be accepted as the distance proportional from the centre of gravity of the connection to the regarded bolt or rivet.

While the momentum is acting on the surface of the connection the calculation must be performed on the cutting edge of bolts or rivets as well as collapse resistance of the jointed elements. While the momentum is acting on the surface which is perpendicular to the surface of the connection the tensile strength calculation of the bolts must be performed.

4.10.2.4. Bolts or rivets calculation being under the effect of the axial force and the momentum should be performed according to the load line strength.

4.10.2.5. Reliability sections calculations of the connected elements and butt strips weakened by bolts or rivet borings ought to be performed according to the requirements laid down by p. 4.1.6.

4.10.3. High-strength bolts connections

4.10.3.1. Axial stretching efforts of high-strength bolts ought to be accepted depending upon the mechanical properties of bolts and net section ares of the bolt.

4.10.3.2. High-strength bolts connections calculation, as a rule, ought to be performed with the presumption of efforts transference through the abutting flat surfaces of the connecting elements.

It is allowed to perform the calculation with the presumption of efforts transference through the cutting edge or through the collapse of the elements considering the influence of the ultimate condition attrition of the connection.

Allotment of the the axial force effecting the connection between the bolts should be accepted as the uniform one.

4.10.3.3. The calculated effort which might be taken by the each flat surface attrition of the connected elements shrunk by a single high-strength bolts should be defined depending upon the axial stretching efforts, attrition coefficient of the connected elements and the looading properties (the statical or the dynamical ones).

4.10.3.4. Reliability sections calculations of the connected elements subject to the attrition stresses and weakened by high-strength bolts borings ought to be performed according to the requirements laid down by p. 4.1.6. considering the part of the effort distributed on the each bolt in the section regarded transfers by the forces of attrition.

4.10.4. While calculating the welded, bolted or riveted connections according to pp. 4.10.1.1, 4.10.1.2, 4.10.2.2, 4.10.2.3 and 4.10.3.2, it is allowed to consider the actual distribution of tensions along the welded seam and efforts between the bolts or rivets, defined through the more precise theoretical method or the experimental method and approved by the operational process.

# 5. The 2nd group ultimate conditions steel construction units calculation

5.1. While calculating the ultimate conditions of the 2nd group of displacement, malformation and fluctuation parameters caused by stresses defined by the CMEA ST SEV 140-78 standard cannot exceed the ultimate values.

5.2. The ultimate values of displacement, malformation and fluctuation parameters  should be defined on the basis of normal operational conditions considering the personnel safety engineering, operational conditions of the industrial equipment, safety of the filler structures.

The ultimate values of deflections are allowed to augment by the height of the camber unless it contradicts other requirements of the present CMEA standard.

5.3. Displacement, malformation and fluctuation parameters calculation should be performed with the elastic strains of steel assumptions without consideration of the weakening of sections by the borings for bolts and rivets as well as without consideration of the dynamical coefficient.

5.4. The column aberration calculation in lateral and axial directions as well as deflections of the crane brake constructions should be performed on the horizontal stresses actions caused be cranes laid down by ST SEV 1407-78 standard.

5.5. Displacements and deflections of the bolted constructions calculations should consider the influence of slip in connections in case it is stipulated by CMEA calculation methods standards.

5.6. The maximal values of flexibilities of the compressed and stretched elements should not exceed their ultimate values defined in dependance the designation of the element and the type of its loading.

Informational addendum 1.

# Terms and definitions

|  |  |
| --- | --- |
| The term | The definition |
| 1. Elastic strain | The type of malformation disappearing after the removal of the outer stresses and impacts caused the malformation. |
| Elastic residual strain | The type of malformation not disappearing after the removal of the outer stresses and impacts caused the malformation. |
| 3. Plastic adaptation (versability) | The property of physical entities manifesting in plastic strains appearing on the 1st stage of loading; all the following loadings cause the elastic strains. |
| 4. Deplanation of the lateral section. | Displacement of the lateral section points transforming the section to the nonlinear surface or to the ensemble of the surfaces. |
| Effective (calculated) length | The conditional length of a single-slope shaft which critical load under the conditions of articulated connection is the same as for the given shaft. |
| Effective length out of the flat surface of the frame | Effective length in the flat surface which is perpendicular to the flat surface of the system (frame). |
| 7. Intensity of strains (malformations) | Integrated stress (strain) in the physical entity during the complicated stressed state equivalent to the stress (the strain) during the simple stretching according to the condition of transition of this entity to plastic state in the point. |
| 8. Free torsion | The torsion during which all the lateral sections of the thin-walled bars have the same deplanations and tangential stresses only emerge in the section. |
| 9. Constrained torsion | The torsion during which all the lateral sections of the thin-walled bars have different deplanations and tangential and normal stresses emerge in the section. |
| 10. Nonlinear elastic material | A tentative material characterized by the same nonlinear or partial-linear dependance between the strains and stresses while being loaded and unloaded. |
| 11. Elastic-plastic material | A tentative material characterized by the nonlinear or partial-linear dependance between the strains and stresses while being loaded and by linear dependance while being unloaded. |
| 12. Own residual stresses | The stresses existing within the construction which is not being effected by any outer impacts. |
| 13. Complicated stress state | The stress state characterized by at least two components of stresses effectink in the points of an entity. |
| 14. Geometrical non-linearity | Nonlinear or partial-linear dependance between the strains and stresses between the stress and displacements of a system. |
| 15. Physical non-linearity | Nonlinear or partial-linear dependance between the strains and stresses of a material |
| 16. Displacement | Alteration of the location of point, system of points or an entity |
| 17. Flat surface of interaction | The flat surface in the space of tensions or efforts, which points define the ultimate of the critical state of the section, the element or the system. |
| 18. Conditional lateral force | The lateral force caused by bending of a compressed or a eccentrically loaded shaft and equal the projection of the compression force applied to the direction which is perpendicular the bended axis of the shaft. |
| 19. Viscous destruction | The destruction appearing along with the plastic strain. |
| 20. Fatigue destruction | The destruction appearing along with cracking as a result of iterative force impacts. |
| 21. Fracture failure | The destruction appearing along with the minor malformation which can be neglected. |
| 22. Malformed (non-malformed) scheme | The calculated scheme which considers (does not consider) the displacements from the initial unloaded state and alterations of the loadings location in consequence of the system malformations. |
| 23. The Euler method | The method intended for the straight shaft (or the system of the straight shafts) rigidity calculating under the conditions of axial compressing (when the loads are applied to the nods of the system) within the scope of elastic malformations. |
| 24. Immanent irregularities | The array of geometrical aberrations of shapes, dimensions and factors affecting the properties of steel and deviation from the accepted calculated scheme arousing while manufacturing, transporting and assembling of the steel construction units. |
| 25. The rigidity loss out of the flat surface of momentum (the flexural flat surface). | The rigidity loss in the direction perpendicular to the flat surface of momentum (the flexural flat surface). |

Informational addendum 2

# Axially loaded construction elements calculation.

Axially loaded construction elements calculation can be performed applying the longitudinal curve coefficients to be calculated according to the following formula



where  

Coefficients α and β must be defined considering the influence of the section form and the immanent irregularities according to p. 4.3.2.

Informational addendum 3

# The effective lenght coefficient of the compressed elements with the constant sections

|  |  |
| --- | --- |
| The layout of strengthening and loading | The effective lenght coefficient |
|  | 1,0 |
|  | 2,0 |
|  | 0,7 |
|  | 0,5 |
|  | 1,0 |
|  | 2,0 |
|  | 0,725 |
|  | 1,12 |