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BUILDING CODES AND REGULATIONS. PART II. SECTION C. CHAPTER I. CONCRETE AND REINFORCED-CONCRETE STRUCTURES, DESIGN CODES SNiP II-C.1-62*

Foreign Technology Division
Wright-Patterson Air Force Base, Ohio

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BUILDING CODES AND REGULATIONS
PART II, SECTION C

CHAPTER I

CONCRETE AND REINFORCED-CONCRETE
STRUCTURES, DESIGN CODES
SNiP II-C.1-62*

by

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13. ABSTRACT

The present chapter SNiP II-C.1-62, "Concrete and Reinforced-concrete Structures, Design Codes", was worked out in the development of chapter SNiP II-A.10-62 "Building Structures and Foundations. Basic Design Aspects". When chapter SNiP II-C.1-62 came into effect on 1 January 1963 the following were superseded: "Codes and Specifications in the Designing of Concrete and Reinforced-concrete Structures" (NiTU 123-55); "Instructions on the Designing of pre-stressed Reinforced-concrete Structures" (SN 10-57); "Instructions for the Building Elements of Reinforced-concrete Structures" (SN 15-57); "Instructions on the Application of Welded Frameworks and Welded Grids in Reinforced-concrete Structures" (I 122-56 MSPMKhP). Chapter II-C.1-62 was worked out by the Concrete and Reinforced-concrete Scientific Research Institute of the Academy of Construction and Architecture in conjunction with the Design Institute of Standard and Experimental Designing (Gipotis) of Glavstroyproekt at the Gosstroy of the USSR. Chapter SNiP II-C.1-62, "Concrete and Reinforced-concrete Structures. Designing Codes" considers the following: The earlier introduced additions and corrections published in the "Collections of Changes, Corrections, and Additions, introduced into the Building Codes and Regulations (SNiP)", as of 1 July 1966 (Stroyizdat, 1966), 1 July 1967 (Stroyizdat, 1968) and 1 July 1970 (Stroyizdat, 1970).

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

The present chapter of the Construction Codes and Regulations [SNiP] (СНиП) II-V.1-62* "Concrete and reinforced-concrete structures. Design Codes" was worked out in the development of Chapter SNiP II-A.10-62 "Construction structures and foundations. The basic aspects of design."

With the implementation of Chapter SNiP II-B.1-62 on 1 January 1963 the following are superseded:

The "codes and specifications of the design of concrete and reinforced-concrete structures" ([NiTU] (НиТУ) 123-55);

"Regulations on the design of prestressed reinforced-concrete structures" ([SN] (СН) 10-57);

"Regulations on the building of the elements of reinforced-concrete structures" (SN 15-57);

"Regulations on the use of welded framework and welded grids in reinforced-concrete structures" ([I] (И) 122-56/Ministry of Construction of Enterprises of the Metallurgical and Chemical Industry [MSPMKhP] (МСПМХП)).

"Regulations on the calculation of cross sections of the elements of reinforced-concrete structures" (I 123-55/MSPMKhP).

The Chapter SNiP II-V.1-62 was worked out by the Scientific Research Institute of Concrete and Reinforced Concrete of the Academy of Construction and Architecture of the USSR together with the Design Institute of Standard and Experimental Planning and Technical Investigations (Giprotis) of the Glavstroyproekt of the Gosstroy of the USSR.

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*[Translator's note: SNiP II-V.1-62 - Russian character B has been stranliterated as V; probably should have been rendered as C - for alphabetical ordering.]

In Chapter SNiP II-V.1-62* "Concrete and reinforced-concrete structures. Design codes" are taken into account:

the earlier introduced additions and corrections published in Collections of changes, corrections and additions, introduced into the construction codes and regulations (SNiP)," as of 1 July 1966 (Stroyizdat, 1966), 1 July 1967 (Stroyizdat, 1968) and 1 July 1970 (Stroyizdat, 1970.);

the data on new effective types of reinforcing steel contained in the "Instructions on the use of reinforcing rods in reinforced-concrete structures" (SN 390-69), on the welding of reinforcing rods, which are contained in the "Instructions on the welding of reinforcing rods connections and concrete laying components" (SN 393-69), on the protection of structures from corrosion, contained in the "Instructions on the anticorrosive protection of construction structures" (SN 262-67) and others;

requirements of state standards and specifications for reinforcing steels and articles, introduced into practice in recent years.

The number of points and tables of Chapter SNiP II-V.1-62*, into which separate corrections and editorial changes have been introduced, are noted by asterisks (*).

Chapter SNiP II-V.1-62* was prepared by the Scientific and Research Institute of concrete and reinforced concrete and the TsNII Promzdaniy of the Gosstroy of the USSR.

The State Committee of the Council of Ministers of the USSR on Matters of Building (Gosstroy USSR)	Construction Codes and Regulations. Concrete and Reinforced-Concrete Structures. Design Codes	SNiP II-V.1-62* To replace: NiTU 123-55, SN 10-57, SN 15-57 and 122-56/MSPMKhP, and 123-55/MSPMKhP
Introduced by the Academy of Construction and Architecture of the Glavstroyproekt of the Gosstroy of the USSR	Approved by the State Committee of the Council of Ministers on Matters of Construction 31 Jul 1962	Implemenation Date 1 January 1963.

1. GENERAL ASPECTS

1.1*. The present codes are extended to the design of concrete and reinforced-concrete carrying structures of buildings and structures of heavy-aggregate and lightweight-aggregate concrete based on a cement binder and inorganic fillers.

Note. The present Codes do not extend to the design of concrete and reinforced-concrete structuresof hydraulic construction, bridges, transport tunnels, culverts, highway and airport surfaces, or armored-cement and self-prestressed structures and structures of cellular, expanding-cement and special concretes.

1.2. When designing concrete and reinforced-concrete carrying structures it is necessary to observe the requirements of the present Chapter of SNiP II-A.10-62 "Constructional structures and foundation. The basic design aspects."

*The new edition with the changes accepted in July 1970.

For certain special types of constructions or structures (thin-walled spatial structures, reservoirs, silos for the storage of free-flowing bulk goods, supports for electric transmission lines and others.) it is necessary, moreover, to be guided by the appropriate standard documentation.

1.3*. The design of concrete and reinforced-concrete structures of buildings and other construction intended to be built in seismic regions, in zones of predominant permafrost soils and zones where the soil is settling and in areas being reworked, and also to withstand the conditions of the systematic effect of elevated and high temperatures (higher than plus 50°C), and negative temperatures from minus 70°C and lower, and aggressive environment and increased humidity, should be carried out taking into account the additional requirements, imposed on the construction of building and structures and their construction under the conditions enumerated by the appropriate chapters of SNiP or by other standard documentation.

1.4*. The rated ambient winter temperatures are established from the coldest five-day period depending on the region of construction in accordance with Chapter SNIP II-A.6-62 "Construction climatology and geophysics. Basic design aspects." The rated technological temperatures are established by the design requirements.

1.5. The selection of design solutions should be carried out in accordance with the accepted methods for the preparation, and the erection of structures, and also taking into account:

a) the use conditions of the structures;

b) the necessity for the broad application of precast structures, predominantly of standardized or off-the-shelf standard elements of factory manufacture;

c) the observance of requirements for economical expenditure of metal, lumber and cement and for the maximum reduction in the laborinput going into the preparation and erection of structures.

Note. The use of the complex design solutions or structures of complex shapes should be based on technical and economical advisability.

1.6. In the design process it is necessary to ensure the use of those reinforced-concrete structures which make it possible to most effectively make use of high-grade concretes and high-strength reinforcing steel(for example prestressed structures, spated thin-walled and hollow large-scale structural elements, spatial thin-walled structures, including precast and precast monolithic, etc.,) and lend themselves to the conditions of mechanized manufacture at specialized enterprises. It is recommended that the elements of precast reinforced-concrete structures be enlarged to the extent permitted by the load-lifting capacity of the assembling mechanisms, by clearance, and also by the conditions of element transportation and manufacture.

1.7. When designing reinforced-concrete structures for the purpose of mechanizing the reinforcing operations it is necessary to specify unstressed reinforcement predominantly of flat standardized welded elements (frameworks and grids) with as few as possible typical dimensions made preferably using multi-point and other highly productive electric welding machines; in doing this it is recommended that the three-dimensional reinforcing frameworks are specified of flat elements joined by electric welding.

It is necessary to try to see that the number of types and diameters of reinforcement rod used in one structure or in one element be minimum.

1.8. The use of the prestressed elements with reinforcement rods, not having adhesion with the concrete, is permitted only in the case of special justification.

1.9. Reinforced elements, which do not satisfy the requirements for the minimum percentages of reinforcement accepted for reinforced-concrete structures (see 12.13), should be rated and designed as concrete structures.

1.10. It is recommend: that concrete (unreinforced) elements, as a rule be used in structures which operate predominantly in compression, and also when insignificant tensile stresses exist. It is permissible to employ flexural concrete elements only when they rest on the ground or on a specially prepared surface or setup.

1.11. When designing buildings and structures with reinforced-concrete and concrete load-carrying structures it is necessary to employ specific design setups which ensure the necessary strength, overall stability, and also three-dimensional immutability of the building or structure.

The necessary strength, rigidity and stability of a building or structure on the whole, and also of its individual elements and their connections at all stages of use and erection should be determined by calculation; and these rated setups should correspond to the accepted design setup.

1.12. All the necessary measures ensuring the strength, stability and immutability of buildings and structure being designed at all stages of their use and erection (in this case special attention should be focused on buildings and structures, the basic carrying elements of which are specified to be precast and precast-monolithic), and also the basic instructions concerning the order of their erection should be given in the design.

Note. The basic instructions concerning the order of erection of buildings or structures and their main load-carrying elements should be subsequently taken into account when work out the design for carrying out construction and assembly operations.

1.13. In testing the strength and stability of elements of buildings and structures when they are being erected the values of the load factors for all the loads being considered, except the weight of the elements, products and materials, are reduced by 20%.

The required strength and stability of the elements during their erection can be, when necessary, ensured by setting up temporary bracings (couplings, stay rods, guy wires, struts, etc.), and for buildings with external self-supporting walls also by securing the elements during assembly to the longitudinal and transverse external walls. The enumerated measures should be specified in the design of the elements.

1.14*. In precast elements special attention should be focused on the strength, rigidity and service life of the couplings.

In skeleton-frame building of the semirigid type, it is necessary to specify the type of frame element connections which ensure the necessary three-dimensional rigidity and stability of the structures in all stages of their erection and after completion of construction. In skeleton-frame buildings of the rigid type and in frame-less buildings, the three-dimensional rigidity and stability of which are ensured by longitudinal and transverse walls, staircases, etc., together with the ceilings and floors, it is necessary to check these elements for the effect of horizontal loads.

The connections of the elements of precast structures made by welding the projecting part of reinforcing rods or the steel insert components, should be accomplished in accordance with the requirements for "Instructions for welding of reinforcing rod connections and insert components of reinforced-concrete structures" (SN 393-69). In structures employed at rated ambient temperatures of minus 40°C and below (see 1.4), these types of joints should be designed, as a rule, monolithized.

1.15. In joints of precast reinforced-concrete elements, and also in precast, monolithic structures the reliable connection of additionally laid monolithic concrete with concrete of precast structures should be accomplished by employing reinforcing bars projecting from the precast reinforced-concrete elements, by installing concrete keys or grooves on the surfaces of elements being joined or by employing other reliable tested measures. Also in the design, instructions should be given concerning the fact that the surfaces of prestressed structural elements, which are to be subjected to concreting, should be thoroughly cleaned and washed.

1.16. The elements of junctions and joints and of steel insert components should ensure reliable transmission of forces to the element by anchors which have been rated and which are secured in a reliable manner, and in possible cases - by welding steel insert components to the working reinforcement rods of the element. In this case the strength of the element itself should be ensured in the zone of the transmission of the forces to it from the joint.

1.17. The units of the joint elements of precast structures are assumed rigid in the calculation, if they are monolithized with concrete of the required strength which is connected with the concrete of the precast elements with the necessary reinforcement. Element joints made on a weld before they are made monolithic, are assumed hinged in the calculation, if their required rigidity is not confirmed by calculation.

1.18. The rigidity of the joints of precast reinforced-concrete elements made to create continuity of a structure by welding reinforcing rods and insert components with subsequent concreting, is evaluated from the rigidity of the element in the section next to the joint. In doing this the concreting of the joints should be carried out according to the instructions of 1.15 and 2.5 of the present codes.

1.19. Vertical and horizontal diaphragms made from precast reinforced-concrete elements, can be examined as monolithic, if the coupling joints both between the individual elements of the diaphragms and the adjacent element are monolithized.

The making of monolithic joints can be accomplished:

a) by butt-jointing of the projecting ends of the reinforcing rods with each other with subsequent filling of the joints with concrete;

b) by welding steel insert components with each other; these components are reliably anchored in the elements being joined.

The reinforcement area at the sites of the joining of elements, the dimensions of the welded seams and the structure of the steel insert components and the connecting butt straps should be tested for stress analysis of the stresses which appear in the corresponding sections of the diaphragms. When transverse stone walls serve, as vertical diaphragms and monolithized reinforced-concrete spanning structures serve as horizontal diaphragms the sealing of the reinforced-concrete diaphragms should be ensured in the walls, and the strength of the walls should also be tested.

1.20. Joints of any type designated for structural reasons, should not change the nature of the operation of a building or the structure of any of its individual elements. Otherwise such joints must be taken into account in the calculations.

1.21*. In the working drawings of structures or in explanatory notes to them the following should be indicated:

a) the grade of concrete to be used on the job and its compressive strength, and also in the cases, specified in 2.2 of the present Codes, - the grades of concrete to be used on the job and their tensile strength, frost resistance and watertightness;

for prestressed reinforced-concrete structures, moreover, the grades to be used on the job and the strength in compression of the concrete and of the mortar to be used to form the protective layers and for filling channels, and also the volumetric strength of the concrete in compression accepted for the job (including during repeated compression);

b) the type and the volumetric weight of lightweight concrete;

c) the type of reinforcement (rod and wire) and its shape; the class of the rod reinforcement, and when necessary (for example for structures operating at low temperatures or rated for durability) and the grade of steel; the All-Union State Standard [GOST] (ГОСТ) number and when this is not known - the number of the specifications for a given type of reinforcement; the methods of [illegible] and anchoring the reinforcement and the sites of its anc[illegible], (in prestressed structures all the data are given separately for prestressed and unprestressed reinforcement);

d) the magnitude of the tensile force (stress), the sequence of the tension in the bundles of rods; the condition and the order of the release of the tension from the reinforcement; with repeated tensioning of the reinforcement on the hardened concrete - the magnitude of the force of the repeated tension and the holding time between the first and repeated tensions; the pattern of the sequence of winding continuous reinforcement and the sites where the ends are fastened;

e) the impermissibility of transmitting a constant or temporary load directly to the reinforcement (by means of suspending formwork, auxiliary equipment on it, etc.,), if this load has not been taken into account in the calculations;

f) the radii of the curvature of prestressed reinforcement with a curvilinear contour, the sites of the transition from one curvature to another, and also the structure and the locations of the auxiliary devices which reduce the friction of the reinforcement against the walls of the channels and protect the concrete from local crumbling;

g) the locations of the tops (T-pieces) for forcing the cement or cement-sand mortar and the sequence for filling the channels, and also the requirement for the necessity of filling the channels and for constructing the protective concrete layer immediately after the termination of tensioning of the entire reinforcement located in the channels, grooves or on the surface of structures;

h) anticorrosion measures and measures for protecting against the effect of high temperatures, if these are necessary;

i) the thickness of the protective concrete layer for working reinforcement, and also the necessity for installing appropriate diaphragms, supports, pins and similar devices which ensure the designed position of the reinforcement; the distances between the reinforcing rods in the main sections of the elements;

j) when necessary - the calculated layouts and loads.

1.22*. In the working drawings of the elements of precast and precast, one-piece structures or in an explanatory note to them, besides the data, enumerated in 1.21 of the present Codes, there should be indicated:

a) the minimum sizes of the supporting sections, the degree (the quality) of their finishing and the support methods; when necessary for prestressed reinforced-concrete elements - the requirement for the compression of the concrete with transverse reinforcement installed near the end of an element; before its compression with the longitudinal reinforcement, for the purpose of eliminating the onset of cracks in the face sections;

b) sites for gripping the elements when lifting and assembling, sites for resting them when they are being transported and stored;

c) sites for cutting off the stressed reinforcement rods of a manufactured element and methods for protecting against corrosion and high temperature when welding these reinforcing rods, and also steel anchor devices and insert components protruding on the surface of the structures; for structures with continuous stressed reinforcement wound on pintles or insert components being removed from the concrete, it is also necessary to indicate the requirements for filling the hollows or recesses with concrete or with mortar ;

d) requirements for making joints and junctions (the nature of the processing of butting surfaces, welding technique, the type or the brand of electrode, anticorrosion measures for protecting steel insert components, connecting butt straps and connections, if such is necessary, and also data on the concreting of joints and junctions); when necessary in prestressed reinforced-concrete elements - indicate the material, the type of construction and the locations of tubes or packing isolating channel cavities against the penetration of concrete or mortar being packed in a joint, and when making a joint "dry" - packing preventing the leakage of mortar from the channel when it is being injected;

e) requirements for the application of manufacturer's marks (alignment marks), necessary for ensuring the qualitative sequential assembly of structures, and for elements with a top or ends which are difficult to differentiate (for example a rectangular cross-section with single or unsymmetrical double reinforcement) - requirements for the application of manufacturer's markings (labels) ensuring the correct positioning of such elements when they are being lifted, transported or put in place;

f) basic instructions concerning the order and sequence of assembly of structural elements, and also the measures ensuring their strength during assembly and the general stability of a building (structure) at all stages of erection and in use (see 1.12-1.14 of the present codes);

j) for elements, specimens of which in accordance with the requirements of GOST 8829-66 "Precast reinforced - concrete articles. Methods of testing and evaluating the strength, rigidity and crack resistance" or those of other standard documents, are tested to destruction, the test procedures, the magnitudes of the control loads and control deflections, and for prestressed elements - also the magnitude of the control load which corresponds to the formation of cracks in the concrete, should be indicated.

h) for structures, whose assembly can be carried out under the effect of rated temperatures of minus 40°C and lower, - the requirements concerning the impermissibility of subjecting a structure in the assembly process to dynamic loads, and also to a static load exceeding 70% of the standard load.

Note. In designating a control load corresponding to the formation of cracks in concrete (see 1.22 "g"), the rating with respect to crack formation should be carried out taking into account the appearance of prestressing losses (see 5.12 of the present Codes).

2. MATERIALS FOR CONCRETE AND REINFORCED-CONCRETE STRUCTURES

CONCRETE

2.1*. Concrete for concrete and reinforced-concrete structures of the following job-grades with respect to strength in compression[1] is employed:

a) heavy-aggregate - 100, 150, 200, 300, 400, 500 and 600;

b) lightweight-aggregate - 35, 50, 75, 100, 150, 200, 250, 300, 350 and 400.

For reinforced-concrete structures the use of heavy-aggregate concrete of a job-grade below 150, as a rule, is not permitted. Prestressed reinforced-concrete elements or their parts, in which stressed reinforcement is installed, should be made from a concrete of a job-grade not lower than: heavy-aggregate - 200 and light-aggregate - 150.

In structures which are rated for durability (see 4.1 "a"), use of concrete of a job-grade above 200 is not recommended.

For concrete structures one should not use a concrete of a job-grade above 300.

Note. 1. When it is justified the use of concrete of higher grades, than those indicated in 2.1 is permitted; in doing this their rated resistances and other characteristics should be taken from the appropriate standard documents.

2. The use of heavy-aggregate concrete of job-grade 100 in massive reinforced-concrete structures with structural reinforcement is permitted under the condition of the observance of the requirements imposed on the concrete which ensure the protection of the reinforcement against corrosion.

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[1]In connection with the fact that in reinforced-concrete and concrete building construction and other structures, to which the present design codes extend, the *job-grade concrete with respect to strength in compression* is the basic characteristic considered in designing, and henceforth, in the text of the present Codes. For brevity's sake the following shortened designation - *job-grade concrete* - is used. In structure drawings the full name should be used.

3. The use of heavy-aggregate concrete of job-grade 150 is permitted in the walls of round one-piece prestressed reservoirs and pipes, with stressing only of the circular (or spiral) reinforcement.

4. For definitions of the concepts "heavy-aggregate" and "light-aggregate" concretes see Chapter SNiP I-V.3-62.

5. For the definition of the concept "Job-grade concrete" see Chapter SNiP II-A.10-62.

2.2*. For structures operating predominantly in tension, with special justification it is permissible to additionally establish a job-grade concrete with respect to tensile strength (see 3.3 "b") in accordance with Chapter SNiP II-A.10-62.

For structures which are subjected to repeated freezing and thawing (water-cooling towers, open structures in localities with frequent alternation of frosts and thaws), the concrete job-grade should be established with respect to the frost resistance in accordance with Chapter SNiP II-A.10-62. For external wall panels, bases and foundations of buildings and structures the concrete job-grade with respect to frost resistance is established in accordance with the requirements of Chapter SNIP II-V.2-62.

For concrete and reinforced-concrete structures which are subjected to rated temperatures (see 1.4.) minus 40°C and below, it is necessary to establish concrete job-grades with respect to frost resistance, and when necessary with respect to watertightness also not lower than those given Tables 39 and 40 of Appendix IV of the present Codes.

2.3. The period of hardening (age) of a concrete corresponding to its job-grade with respect to strength, is taken: for monolithic structures, as a rule, to be 28 days, and for precast structures - in accordance with the period, specified in the state standards for products, and in their absence - in the specifications for the manufacture of a given type of product.

With special justification it is permitted to establish the concrete job-grade monolithic structures in age which is different from 28 days (for example 60 or 90 days), depending on the periods of the actual loading of the structures, the methods of their erection, the conditions of concrete hardening, and also the type of cement used; in this case in the designs along with the concrete job-grade the appropriate periods of concrete hardening should be indicated.

The age of the concrete of monolithic structures, in which its job-grade is established, should not be taken to be more than 28 days for structures being erected in sliding and adjustable formwork, and also for non-massive structures and of those of average massiveness (see note 2 to 4.26), with the exception of those laid directly on the ground or on a base of crushed stone or lean concrete; in this case the conditions of the erection of structures during the winter period should be considered.

Note. The form-removal strength of the concrete of precast reinforced-concrete and concrete products in the absence for these products of state standards is established in the specifications for the manufacture of given types of products depending on the purpose of the structures, the season, the assembly conditions and the loading period, but not less than 70% of the concrete job-grade with respect to strength in compression. In this case the magnitude of the form-removal strength of the concrete of products should be agreed to by the design organization, and when necessary also by the assembly (construction) organization.

2.4. For centrally and eccentrically compressed reinforced-concrete elements of heavy-aggregate concrete, the cross-sectional dimensions of which are determined by stress analysis, it is recommended that a job-grade concrete of not less than 200 be accepted. For highly loaded constructions, for example for the columns of the lower floors of multi-storey buildings, and also the columns of single-storey buildings receiving considerable crane load, it is recommended that a job-grade of concrete of not less than 300 be accepted.

For thin-walled reinforced-concrete structures of heavy-aggregate concrete, and also for walls of buildings and structures being constructed in sliding and adjustable formwork, it is necessary to select a job-grade concrete of not less than 200.

2.5*. A job-grade concrete for filling the joints of precast elements, with a joint thickness of more than 1/5 the smallest dimension of the element cross section and more than 10 cm, should not be less than the job-grade concrete of the elements being joined; in the case of a lesser joint thickness it is permissible to use for filling the joints a job-grade concrete and mortar one grade lower than the job-grade concrete of the elements being joined; in doing this, the reduction in the strength of the concrete in the joint cannot be taken into account in the calculation, with the exception of the calculation of key joints.

Moreover, in making joinable elements from heavy-aggregate concrete for filling the joints a concrete of a job-grade not lower than 150 or a mortar- not lower than 100, and in making joinable elements from light-aggregate concrete - a concrete or mortarof a job-grade not lower than 50 should be used.

In precast concrete and reinforced concrete structures which during use or assembly can be subjected to the effect of rated temperatures of minus 40°C and lower, the job-grade concretes used for monolithizing the joints, with the respect to frost.

resistance and watertightness should correspond to the job-grade concretes of the elements being joined.

Note. For the definition of job-grade mortar see Chapter SNiP I-V.11-62.

2.6. For prestressed structures the concrete job-grade and its ultimate compressive strength (cube strength) when being crushed are taken to be not lower than those indicated in Table 1. And, in the case of the use for reinforcement of smooth wires, at the ends of the individual wires, and also of bundles and multi-strand wires (cables) the placing of anchors is mandatory, the design structure of the anchors should be tested by practical application or by special tests.

The job-grade of a mortar for the protection layer over the reinforcement of prestressed structures should not be selected lower than 150, and of a mortar for injection into channels - not lower than 300.

REINFORCEMENT

2.7*. For the reinforcement of reinforced-concrete structures the following types of reinforcing steels are used:

a) rod hot-rolled round (smooth) steel of class A-I - with a diameter of from 6 to 40 mm;

b) rod hot-rolled deformed steel:

class A-II - with a diameter of from 10 to 90 mm;

class A-III - with a diameter of from 6 to 40 mm;

class A-IV - with a diameter of from 10 to 32mm;

class A-V - with a diameter of from 10 to 18 mm;

Table 1*. Job-grades of concrete for prestressed reinforced-concrete structures and the compressive strength of concrete (cube strength) during crushing.

Type of structures, concrete and reinforcement	Job-grade of concrete, not lower than	Cube strength of concrete during crushing R_0 in kg/cm^2, not lower than
1. long-span structures, dead load of which constitutes a considerable part of the design load, of concrete:		
a) heavy-aggregate	400	Depending on the type of reinforcement being stressed, in accordance with instructions 2 and 3 of the present tables
b) light-aggregate	200	
2. Structures of heavy-aggregate concrete, with wire reinforcement in the form of:		
a) high-strength smooth reinforcing wire (of class B-II) with anchors	300	200
b) High-strength reinforcing deformed wire (of class Br-II) without anchors with a wire size of up to 5 mm	300	200
c) the same, with a diameter of 6 mm and more	400	300
d) wire twisted from two smooth high-strength wires with a diameter of up to 3 mm without anchors	400	250
e) reinforcing strands of class P-7 without anchors with strand diameters of up to 15 mm	400	250
3. Structures of heavy-aggregate or light-aggregate concrete with deformed reinforcing rod without anchors with a diameter of:		
from 10 to 18 mm (inclusively of classes:		
a) A-III, A-IIv and A-IIIv	200	140
b) A-IV and At-IV	200	140
c) A-V and At-V	300	200
d) At-VI	400	300
from 20 mm and more of classes:		
e) A-IIv and A-IIIv	300	200
f) A-IV and At-IV	300	200
g) A-V and At-V	400	300
h) At-VI	500	350
4. Reinforced-concrete end washers under the anchors; concrete of the anchor sleeves, in which the ends of the wires bent into hooks are embedded	600	500
5. Walls of monolithic round reservoirs and pipes with stressing of only the circular (or spiral) reinforcement	150	100

Table 1* Continued

Type of structures, concrete and reinforcement	Job-grade of concrete, not lower than	Cube strength of concrete during crushing R_0 in kg/cm^2, not lower than
6. Concrete in which there is no working reinforcement (for example the additionally laid concrete of precast monolithic structures; concrete of precast structures of armored prestressed elements, etc.,):		
a) heavy-aggregate..............................	100	-
b) light-aggregate..............................	50	-
7. Structures of light-aggregate concrete, in which there is no working reinforcement in the case when this reinforcement is protected from it by a layer of heavy-aggregate concrete or motar with a thickness of not less than 15 mm	35	25

Note. 1. The cube strength of concrete during its crushing corresponds to the strength of concrete cubes with a side of 200 mm.

2. For structures rated for durability (see . 4.1 "a"), the maximum values of the concrete job-grade and the strength of of the concrete when it is being crushed, specified in 2 "a" - "c," 3 "a," "b" and the "e" of Table 1, should be increased by 20-25%.

3. When designing the structures indicated in 2 "a" - "e," 3 "c" - "i" of Table 1, when experimentally justified a reduction in the concrete job-grade by one grade is permissible; in this case value R_0 should constitute not less than 70% of the job-grade. Such a reduction in the grade of a heavy-aggregate concrete and in the strength concrete when it is being crushed for the structures indicated in 3 "c" - "i" of Table 1, can be carried out without experimental justification when the coarse filler content is not less than 820 l per 1 m^3 of concrete, if this condition is specified in the design, but the possibility of decreasing the concrete strength is confirmed by the calculation.

4. In prestressed hollow flooring with a length of up to 6.5 m with reinforcement of classes A-V and At-V with a diameter of up to 18 mm inclusive, intended for residential and public buildings, it is possible to use the concrete grade and the cube crushing strength, specified in 3 "b" of Table 1.

5. For the structures of light-aggregate concrete indicated in 3 "a" Table 1, with prestressed reinforcement of class A-III, being stressed to a tension of not more than 3500 kg/cm^2, it is possible to use concrete of grade 150; in this case the crushing strength of the concrete should be not less than 120 kg/cm^2.

6. For structures with wire reinforcement when they are manufactured from light-aggregate concrete the minimum concrete grade is reduced by one grade with respect to that indicated in 2 "a" - "e" of Table 1; in this case the cube crushing strength of the concrete should be not less than that specified in 2 "a" - the "e" of Table 1.

c) heat-hardened deformed rod reinforcement:

of class At-IV - with a diameter of from 10 to 25 mm;

of class At-V - with a diameter of from 10 to 25 mm;

of class At-VI - with a diameter of from 10 to 25 mm;

d) draw-hardened deformed reinforcing rod:

of class A-IIv - with a diameter of from 10 to 40 mm,

of class A-IIIv - with a diameter of from 6 to 40 mm,

e) smooth reinforcing wire;

of class V-I - the usual diameter is from 3 to 8 mm,

of class V-II - high-strength with a diameter of from 3 to 8 mm,

f) deformed reinforcing wire of class Vr-II - high-strength with a diameter of from 3 to 8 mm;

g) seven-wire reinforcing strands (cables) of class P-7 - with a diameter of from 4.5 to 15 mm;

h) multi-strand cables without an organic core.

For reinforcing structures of light-aggregate concrete of grades 100 and lower it is necessary to use only reinforcing steel of classes A-I, A-II and A-III.

For insert components and butt straps hot-rolled band, angular and shaped steel of group "steel 3" grades according to GOST 380-60* are used.

Note. The assortment and the quality of reinforcing steel and steel for insert components and butt straps, and also the methods of testing them should satisfy the requirements of Chapter SNiP I-V.4-62 and of the existing state standards or specifications for a corresponding type of steel (see Appendix III, Table 35).

2. Reinforcement hardened by drawing, and also reinforcement in the form of welded grids and frameworks should satisfy the requirements of the appropriate specifications or state standards.

3. It is permissible to use twisted reinforcement from high-strength wire obtained by twisting two wires made according to the appropriate specifications.

4. The use of cables made from wire with a diameter of less than 1 mm for reinforcement is not permitted.

5. Using multi-strand cables their pre-stretching for a period of not less than 30 min by a force exceeding by 5-10% the control force during tensioning (see 5.6) should be specified.

6. It is permissible to use other types of steel, not specified in 2.7 as reinforcement; in doing this the special types of reinforcing steel (nineteen-wire strands, two-and-three-strand cables, heat-hardened cable) developed by industry should satisfy the requirements of the appropriate specifications and be used according to the appropriate instructions; the use of steel, not specified by the present codes, is permitted only when the possibility and advisability of the use of such steel are justified in reinforced-concrete structures; in this case the non-grade steels should be pre-tested to destruction with determination of the yield point, tensile strength and relative elongation at rupture, and also for flexure or reverse flexure in the cold state; when necessary, moreover, testing of the chemical composition and weldability of the steel should be carried out, and also the endurance limit of the reinforcement. The rated characteristics of such steel should be specially substantiated.

2.8. In designing reinforced-concrete structures it is necessary to consider the following properties of the reinforcing steel:

a) the basic mechanical characteristics, the strength (the yield point or tensile strength) and plastic (elongation per unit length at rupture, bend angle or the number of reverse bends in the cold state); the mechanical characteristics of reinforcing steel are established depending on its class and type in accordance with chapters SNiP I-V.4.62 and II-A.10.62 and are guaranteed by the appropriate state standards or specifications.

b) the tendency toward cold brittleness - when designing structures intended for use at temperatures below the freezing point; the cold brittleness of rod reinforcement is determined by the class of reinforcement, and also by the steel grade and the method of its smelting (which when necessary should be specified in the designs);

c) the weldability of the steel - in selecting the type of weld joints which conform to the requirements for the appropriate state standard or specifications for the welded reinforcement of reinforced-concrete structures; the weldability of reinforcing steel depends upon their type and class (the grade and smelting method), the rod diameter, the structure of the weld connection and technology of its execution;

d) the stress relaxation - in determining the prestressing loss; the effect of stress relaxation is considered in accordance with the instructions of 5.11 of the present Codes, and also of other standard documents on the designing of prestressed reinforced-concrete structures;

e) the reduced strength of reinforcing steel under the effect on a structure of a multiply repeated load (the limit of endurance) in comparison with its strength in the case of a static load (the yield point or tensile strength); the corresponding variations in the rated strength of reinforcing steel are established depending on the characteristics of the stress cycle in the reinforcement in accordance with the instructions of 3.7 and 3.8 of the present Codes.

2.9. The selection of reinforcing steel when designing reinforced-concrete structures should be carried out taking into account their properties indicated in 2.8, depending on:

a) the purpose of the reinforcement in accordance with the instructions of 2.10, 2.12, 2.13, 2.15 and 2.18 of the present Codes;

b) the grade and type of concrete in accordance with the instructions of 2.6 of the present Codes, and also of other standard documents on design;

c) the weldability of reinforcing steel in accordance with the instructions of 12.35-12.41 of the present Codes, and also the requirements of standard documents on welded reinforcement;

d) the production conditions of the reinforcement and the structures, and also of their assembly in accordance with the requirements of the appropriate standard documents.

Furthermore, for structures, on which special requirements are imposed, or for structures operating under special conditions, when selecting reinforcing steel the additional instructions of 2.11, 2.14 and 2.16-2.18 of the present Codes should be considered.

2.10*. As the unstressed reinforcement of reinforced-concrete structures it is necessary to mainly use:

a) hot-rolled reinforcing steel of class A-III;

b) standard reinf rcing wire with a diameter of 3-5.5 mm only in welded grids and frameworks;

it is also permissible to use;

c) hot-rolled reinforcing steel of classes A-II and A-I mainly for the transverse reinforcement of linear elements, for structural and assembly reinforcement, and also as the longitudinal working reinforcement in cases when other types of unstressed reinforcement cannot be used;

d) draw-hardened reinforcing steel of class A-IIv - for longitudinal stressed working reinforcement;

e) standard reinforcing wire: with a diameter of 3-5.5 mm for the tie clamps of beams with a height of up to 400 mm and columns; with a diameter of 6-8 mm - only in welded frameworks and grids;

f) hot-rolled reinforcing steel of classes A-IV and A-V and heat-hardened reinforcing steel of classes At-IV and At-V, draw-hardened reinforcing steel of class A-IIIv - only for longitudinal stressed working reinforcement of the frameworks and grids; in this case measures should be taken which ensure the anchoring of the ends of the rods for stressed reinforcement in accordance with the instructions of 12.5, 13.16 and 13.17 "d" of the present Codes, and the requirements should also be observed with respect to the categories of resistance to cracks and with respect to the width of crack opening in the case of the use of structures in an aggressive medium (see Appendix III, Table 36);

it is not permissible to use:

g) high-strength reinforcing wire;

h) reinforcing strands and cables;

i) heat-hardened reinforcement of class At-VI.

It is recommended that unstressed reinforcement of hot-rolled steel of classes A-III, A-II and A-I be used in the form of welded frameworks and welded grids.

2.11 In structures with unstressed reinforcement, on which the requirements for watertightness is imposed:

it is necessary to use, as a rule, hot-rolled reinforcement steel of classes A-II and A-I;

it is permissible to use with appropriate justification hot-rolled reinforcing steel of class A-III and standard reinforcing wire with a diameter of not less than 5 mm (in welded frameworks and grids);

it is not permissible to use other types of reinforcing steel as unstressed reinforcement in the indicated structures.

2.12*. For prestressed structures of the 1st category of resistance to cracks (see 4.3) as the stressed reinforcement it is necessary to mainly use:

a) high-strength reinforcing wire;

b) reinforcing strands;

c) heat-hardened reinforcing steel of classes At-VI and At-V;

d) hot-rolled reinforcing steel of class A-V;

it is also permissible to use:

e) hot-rolled reinforcing steel of class A-IV;

f) heat-hardened reinforcing steel of class At-IV;

g) reinforcing steel of class A-IIIv, draw-hardened with monitoring of the stresses and elongations.

The use of other types of reinforcing steel as stressed reinforcement in structures of the 1st category of crack resistance is not recommended.

2.13*. As the stressed reinforcement of prestressed structures of the 2nd category of crack resistance (see 4.3):

it is necessary to mainly use:

a) high-strength reinforcing wire;

b) reinforcing strands and cables;

c) heat-hardened reinforcing steel of classes At-VI and At-V;

d) hot-rolled reinforcing steel of classes A-V and A-IV;

e) reinforcing steel of class A-IIIv, draw-hardened with monitoring of the stresses and elongations;

it is also permissible to use:

f) heat-hardened reinforcing steel of class At-IV;

g) reinforcing steel of class A-IIIv, draw-hardened with monitoring of only the elongations:

h) reinforcing steel of class A-IIv, draw-hardened with monitoring of the stresses and elongations;

i) hot-rolled reinforcing steel of class A-III.

2.14*. When selecting reinforcing steel for the stressed reinforcement of prestressed structures of the 2nd category of crack resistance which is subject to the effect of a multiply repeated load and is subject to rating for durability, it is necessary to mainly use high-strength smooth and deformed wire; it is permissible to use hot-rolled reinforcing steel of classes A-IV and A-III and reinforcing strands, and with appropriate experimental justification - draw-hardened reinforcing steel of classes A-IIIv and A-IIv.

2.15*. For prestressed structures of the 3rd category of crack resistance (see 4.3) as the stressed reinforcement it is necessary to mainly use:

a) hot-rolled reinforcing steel of classes A-IV and A-V;

b) heat-hardened reinforcing steel of class At-V;

c) reinforcing steel of class A-IIIv, draw-hardened with monitoring of the stresses and elongations;

it is also permissible to use:

d) reinforcing steel of class A-IIIv, draw-hardened with monitoring of only the elongations;

e) heat-hardened reinforcing steel of class At-IV;

f) reinforcing steel of class A-IIv, draw-hardened with monitoring of the stresses and elongations;

g) hot-rolled reinforcing steel of class A-III;

h) standard reinforcing wire;

it is not permissible to use in these types of structures heat-hardened reinforcing steel of class At-VI, high-strength reinforcing wire, reinforcing strands and cables.

2.16*. For structures operating under the conditions of an aggressive medium, the selection of the type, classes and grades of reinforcing steel should be carried out according to the appropriate standard documents depending on the degree of agressiveness of the medium, the type of concrete, width of the crack openings, the category of the crack resistance of the structures and the measures for protecting them (see Appendix III, Table 36).

In structures situated under conditions of an aggressive medium, in which the appearance of cracks is allowed, the diameter of the standard reinforcing wire should be not less than 4 mm.

In prestressed structures which are located under conditions of an aggressive medium, the reinforcing strands and cables should consist of wires with a diameter of not less than 2.5 mm.

2.17*. The selection of the type and grades of reinforcing steel for reinforcement ascertained by calculation, should be carried out depending on the temperature conditions and the character of the loading in accordance with Table 37 of Appendix III.

For structures intended for use at positive temperatures, but during construction being under conditions of negative temperatures of from minus 40°C and below, it is necessary in the case of the use of reinforcements in them, whose use at temperature lower than 40°C is not permitted, to specify in the design a tentative restriction on their loading before the turning over of the structure or building for normal use in accordance with the requirements of 1.22 "i" of the present Codes.

2.18*. For assembly (lifting) loops of percast reinforced-concrete and concrete elements only hot-rolled reinforcing steel of class A-I of grades VMSt.3sp, VMSt.3ps, VKSt.3sp and VKSt.3ps should be used.

Note. 1. When the assembly of a structure at a temperature of minus 40°C and below is possible, one should not use for the assembly loops steel of grades VMSt.3ps and VKSt.3ps.

2. It is permissible instead of steel of class A-I of grades VMSt.3sp and VKSt.3sp to use reinforcing steel of class A-II of grade 10GT with appropriate extrapolation of the area of the rod cross sections.

3. RATED CHARACTERISTICS OF MATERIALS

3.1. The rated strengths of concrete and reinforcement are determined (with rounding off) as the product of the standard strengths and the appropriate degrees of uniformity and the basic coefficients of the operating conditions (see 3.2 and 3.5). Furthermore, when necessary additional coefficients of the operating conditions of concrete and reinforcement (see 3.3 and 3.6) are taken into account. The values of the standard strengths of concrete and reinforcement, their degrees of uniformity and elastic moduli are obtained from chapter SNiP II-A.10-62 or from the data of Appendix I to the present Codes.

CONCRETE

3.2. In the rated strengths of concrete given in Table 2, there are included the following values of the basic coefficients of the operating conditions of concrete $m_б$:

a) for concrete with a stress analysis of concrete structures of $m_б = 0.9$;

Table 2. Rated strengths of concrete when designing structures for strength and with respect to the formation and opening of cracks.

Type of stressed state	Designation of rated strength	Type of structures	Rated strengths of a concrete in kg/cm^2 with compressive strength job grade									
			35	50	75	100	150	200	300	400	500	600
			Tensile strength job-grade concrete									
			—	—	—	P11	P15	P18	P23	P27	P31	P35
Axial compression (prismatic strength)	R_{np}	Reinforced-concrete	14	20	30	44	65	80	130	170	200	230
		Concrete	12,5	18	27	40	60	70	115	—	—	—
Flexural compression	R_{u}	Reinforced concrete	17,5	25	37	55	80	100	160	210	250	280
		Concrete	16	22	33	50	70	90	140	—	—	—
Axial tension	R_{p}	Reinforced-concrete	2,3	2,7	3,6	4,5	5,8	7,2	10,5	12,5	14	15
		Concrete	2	2,4	3,2	4	5,2	6,4	9,5	—	—	—
Tension in calculating for crack formation	R_{T}	Prestressed reinforced-concrete	3,2	3,8	5	6,3	8	10	14,5	17,5	19,5	21
Tension when testing for the necessity of calculating for crack opening.		Reinforced-concrete										

Notes. 1. For individual small monolithic reinforced-concrete structures with a total concrete volume of up to 10 m^3 the values of the rated strengths of the concrete should be taken as for concrete structures.

2. For light-aggregate concretes of job-grades 250 and 350 the values of the rated strengths are determined by interpolation.

3. If it is necessary to test by rating the structures, in which the strength of a concrete did not reach the job-grade (for example at the moment of formwork removal), the values of the rated strengths of a concrete should be determined by taking into account the actual strength of the concrete by interpolating for Table 2.

b) for compressed concrete of job-grade 500 with a stress analysis of the reinforced-concrete structures of $m_б$ = 0.95, the same, of job-grade 600 $m_б$ = 0.9;

c) for stressed concrete in rating the crack formation of prestressed structures, and also in checking the necessity for rating the crack openings of reinforced-concrete structures $m_б$ = = 1.4.

3.3*. The rated strengths of concrete in rating concrete and reinforced-concrete structures for strength, and also with respect to the formation or the opening of cracks should be taken from Table 2 with multiplication in the cases indicated below by additional coefficients of the operating conditions $m_б$ considered independently of one another:

a) in checking the strength of concrete in the preliminary crushing stage for precast prestressed elements it is necessary to multiply the values of the rated compressive strengths of concrete ($R_{пр}$ and $R_и$) by the coefficient $m_б$ = 1.2;

b) for concretes being prepared at concrete plants or concrete centers with the use of automatic or semi-automatic batching components, the values of the rated compressive strengths of concrete ($R_{пр}$ and $R_и$) can be multiplied by coefficient $m_б$ = 1.1 under the condition, that systematic checking of the degree of uniformity of the concrete to compression confirms its corresponding increase in comparison with the values indicated in Table 4 of chapter SNiP II-A.10-62 or in Table 30 of Appendix I to the present Codes;

c) in analyzing the strength of concrete and reinforced-concrete centrally and eccentrically compressed elements being concreted in the vertical position (monolithic columns and walls, precast panels manufactured by the cassette method, etc.,), the values of the rated compressive strengths of concrete ($R_{пр}$ and $R_и$)

should be multiplied by the coefficient $m_б = 0.85$;

d) in rating the strength of monolithic concrete columns with a cross section of less than 35 × 35 cm, and also monolithic reinforced-concrete columns with the larger side of the cross section less than 30 cm the values of the rated compressive strengths of concrete ($R_{пр}$ and $R_и$) should be multiplied by the coefficient $m_б = 0.85$;

e) in rating the strength of wall panels for partions with a cross section area of less than 0.1 m^2 the values of the rated compressive strengths of the concrete ($R_{пр}$ and $R_и$) should be multiplied by the coefficient $m_б = 0.8$;

f) in rating the strength of concrete and reinforced-concrete centrally and eccentrically compressed elements of all types of light-aggregate concrete the rated compressive strengths of the concrete ($R_и$ and $R_{пр}$) should be multiplied by the coefficient $m_б$ determined experimentally, and in the absence of experimental substantiation this coefficient can be assumed equal to:

for concretes based on artificial porous fillers $m_б = 0.8$;

for concretes based on natural porous fillers $m_б = 0.6$;

g) in rating the bearing capacity of elements of concrete and reinforced-concrete structures used at rated temperatures of minus 40°C and below, the rated compressive strengths of the concrete ($R_и$ and $R_{пр}$), given in Table 2, should be multiplied by the coefficient $m_б$, whose values are given in Table 39 of Appendix IV to the present Codes;

h) in ascertaining the job-grade of a concrete in tension (see 2.2) and in satisfying the requirements pertaining to the selection of the composition and to hydrotechnical-concrete tests, it is possible to multiply the values of the rated tensile strengths of a concrete (R_p and R_T) by the coefficient $m_б = 1.1$;

i) for concretes based on high alumina cement the values of the rated tensile strengths (R_p and R_T) should be multiplied by the coefficient $m_б = 0.7$;

j) for light-aggregate concrete of job-grades 200 and above, prepared on a base of natural porous fillers of volcanic origin, the values of the rated tensile strengths of a concrete R_p and R_T should be multiplied by the coefficient:

for concretes of job-grades 200 and 250 - $m_б = 0.8$;

for concretes of job-grades 300 and 350 - $m_б = 0.7$;

for concretes of job-grades 400 - $m_б = 0.65$;

l) for porous light-aggregate concrete, and also for concrete prepared with the use of expanded perlite sand, the values of the rated tensile strengths of a concrete (R_p and R_T) are multiplied by coefficient $m_б = 0.8$;

3.4*. The rated strengths of concrete in designing structures for durability and also for crack formation in the case of a multiply repeated load $R'_{пр}$, $R'_{и}$ and $R'_{т}$ are computed by multiplying the appropriate rated concrete strengths $R_{пр}$, $R_{и}$ and R_T defined by 3.2 and 3.3 by coefficient $k_{\rho б}$,taken from Table 3 depending on the characteristics of the stress cycle in the concrete

$$\rho_б = \frac{\sigma_{б\,мин}}{\sigma_{б.\,макс}},$$

where $\sigma_{б.мин}$ and $\sigma_{б.макс}$ are respectively the least and greatest values of stresses in the concrete (compressive or tensile) arising under standard loads (see 11.5).

Table 3. Coefficients $k_{\rho б}$ for determining the rated strengths of a concrete in designing reinforced-concrete structures for durability and for cracking with multiply repeated loads.

$\rho_б$	<0.1	0.2	0.3	0.4	0.5	0.6
$k_{\rho б}$	0.75	0.8	0.85	0.9	0.95	1

Note. Coefficients $k_{\rho б}$ have been designated taking into account the increase in strength of a concrete at the time when the number of repetitions (cycles) of load is so great, that testing of the durability of the structures will be required. This increase in strength is assumed to be;

for concrete of job-grade 150 - 40%;
for concrete of job-grade 600 - 20%;
for concrete of intermediate grades - linear interpolation is used.

If the conditions, under which a structure is employed, or the technology of its construction, do not ensure the indicated increase in strength, then the values of coefficients $k_{\rho б}$ should be accordingly reduced.

REINFORCEMENT

3.5*. Included in the rated strengths of the reinforcement[1] cited in Table 4 are the following values of the basic coefficients of the conditions of reinforcement use m_a:

a) for the reinforcement indicated in 2, 3 and 4 Table 5, m_a = 0.8;

[1]The rated strengths of the steel given in 1 Table 4, also extended to the steels used for insert components and butt straps.

Table 4*. Rated strengths of rod reinforcements in stress analysis.

Tensile stressed	Rated strengths of reinforcements in kg/cm². Type of reinforcements: a) longitudinal; b) transverse and bent back in flexure rating along inclined section R_a	transverse and bent back in rating transverse force $R_{a.x}$	compressed (having adhesion with the concrete) $R_{a.c}$
1. hot-rolled round (smooth) steel of class A-1, and also strip angular and shaped groups of "steel 3" grade........	2100	1700	2100
2. hot-rolled deformed steel of class A-II.....	2700	2250	2700
3. The same, of class A-III..................................	3400	2700	3400
4. The same, of class A-IV..................................	5100	4100	3600
5. The same, of class A-V..................................	6400	5100	3600
6. Heat-hardened deformed steel of class At-IV...............	5100	4100	3600
7. The same, of class At-V..................................	6400	5100	3600
8. The same, of class At-VI..................................	7600	6100	3600
9. Draw-hardened steel of class A-IIv: a) with monitoring of the stresses and elongations.........	3700	3000	2700
b) with monitoring of only the elongations, without monitoring of the stresses..............................	3250	2600	2700
10. The same, of class A-IIIv; a) with monitoring of the stressed and elongations.........	4500	3600	3400
b) with monitoring of only the elongations, without monitoring of the stresses..............................	4000	3200	3400

Note: 1. For compressed reinforcement , which does not have adhesion with the concrete, it is assumed that $R_{a.c} = 0$.

2. For heat-hardened reinforcement (6, 7 and 8 Table 4) and hot-rolled reinforcement of class A-IV of grade 80S (4 Table 4) the rated strength $R_{a.x}$ pertains only to the bent back rods in rating for transverse force.

3. In rating flexure for an inclined section the rated strength is assumed to be equal to $R_{a.x}$ for bent back reinforcement of classes A-IV, A-V, At-IV, At-V, and At-VI (3-8 Table 4) at the bend sites, if the bending [illegible] accomplished along a circular arc of a radius of not less than 15 diameters of the stressed reinforcement , and the angle of inclination of the backbends does not exceed 30°.

Table 5*. Rated strengths of wire reinforcement: in stress analysis.

Type of reinforcement	Wire gauge in mm	Rated strengths of the reinforcement in kg/cm². Type of reinforcement: a) longitudinal; b) transverse and bent back in flexure rating for inclined section R_a	Type of reinforcement: transverse and bent back in rating for transverse force $R_{a.x}$	compressed (having adhesion with the concrete) $R_{a.c}$
1. Standard reinforcing wire of class V-I	3-5.5	3 150	2200	3150
	6-8	2 500	1750	2500
2. High-strength smooth reinforcing wire of class V-II.	3	12 200	9700	3600
	4	11 500	9200	
	5	10 800	8600	
	6	10 200	8100	
	7	9 600	7600	
	8	8 900	7100	
3. High-strength deformed reinforcing wire of class Vr-II	3	11 500	9200	3600
	4	10 800	8600	
	5	10 200	8100	
	6	9 600	7600	
	7	8 600	7100	
	8	8 300	6700	
4. Seven-wire reinforcing strands (cables) of class P-7	1.5	12 200	9700	3600
	2	11 500	9200	
	2.5	11 500	9200	
	3	10 800	8600	
	4	10 200	8100	
	5	9 600	7600	
5. Multistrand steel cables: according to GOST 3066-66	1-3	9 500	7600	3600
GOST 3067-66	1-3	9 000	7200	
GOST 3068-66	1-3	8 700	7000	

Note. 1. When employing standard reinforcing wire (1 Table 5) for the stirrups of tied framework the rated strength of the wire is assumed to be the same as for hot-rolled steel of class A-I (see 1 Table 4).

2. For compressed reinforcements, which does not have adhesion with the concrete, it is assumed to be $R_{a.c} = 0$.

3. The rated strengths of the steel-strand cables, cited in Table 5, correspond to the values of the standard strengths (the smallest tensile strengths) of the wires in the cables 190 kg/mm²; with the use in the cables of wires with other values of the lowest tensile strength in rated strengths of the cables should be accordingly changed.

4. For high-strength wire, strands and cables bent back at an angle of more than 30° around a pin with a diameter of less than 8d, the rated strength of the stressed bent back reinforcement at the bend sites during rating flexure along inclined section R_a should be assumed to be the same as in rating transverse force, i.e., equal to $R_{a.x}$; in this case the weakening due to bending is considered in the sections with a length of 30d at each side of the bend (where d - the gauge of the wire, strand or cable).

b) for the reinforcement indicated in 1 Table 5 (employed in welded frameworks and grids) and in 5 Table 5, $m_a = 0.7$;

c) for the draw-hardened stressed reinforcement indicated in 9 and 10 Table 4 $m_a = 0.9$;

d) for the heat-hardened reinforcement indicated in 8 Table 4, $m_a = 0.95$;

e) in rating elements for transverse force, for transverse and bent back reinforcement , from standard reinforcing wire used in welded frameworks, $m_a = 0.7$; from other types of reinforcements $m_a = 0.8$.

Notes. 1. The basic coefficients of the conditions of employment the reinforcement , specified in 3.5, are taken into account independently of one another.

2. For structures of light-aggregate concrete of grades 100 and lower it is necessary to introduce the additional coefficients for the employment conditions of the reinforcement , whose values are taken from special standard documents.

3.6*. The rated strengths of reinforcement in rating reinforced-concrete structures for strength should be taken from Tables 4 and 5 with multiplication in the cases indicated below by the additional coefficients of the employment conditions m_a taken into account independently of one another:

a) for the elements of precast structures manufactured at plants and specially equipped sites, with systematic testing of the reinforcement in accordance with GOST 5781-61 and 12004-67 the values of the rated strengths of the reinforcement (tension stressed, and also compressed, having adhesion with the concrete, when $R_{a.c}$ is less than 3600 kg/cm^2) under the conditions, that in all tested samples of hot-rolled reinforcing steel (see 1-3 Table 4) and 1 Table 5, can be multiplied by coefficient m_a = 1.1 (assuming $R_{a.c}$ to be not more than 3600 kg/cm^2) under the condition, that in all tested samples of hot-rolled reinforcing steel (see 1-3 Table 4) the yield point does not by less than 10% exceed its standard value, and in all tested samples of reinforcing wire (see 1 Table 5) the tensile strength is not lower than its smallest standard value.

b) for reinforcements, twisted from two high-strength wires (see 2 and 3 Table 5 and Note 3 to 2.7), the values of the rated strengths indicated in Table 5 for the wire before twisting, should be multiplied by the coefficient m_a = 0.95;

c) in structures with reinforcement of high-strength wire (2 and 3 Table 5) located close in two and more rows without clearance and without twisting, when the mortar of concrete does not envelope the whole wire surface (for example with the use of bundles; bundles consisting of four and more wires, not filled inside with mortar; in continuous reinforcement), the rated strengths of the reinforcement should be multiplied by coefficient m_a = 0.85;

d) for tensile stressed rod reinforcement (see 4-7 Table 4) of bent reinforced-concrete elements the rated strengths indicated in Table 4, depending on the magnitude of the relative height of the compressed zone of cross section ξ should be multiplied by an additional coefficient of the employment conditions m'_a, equal to:

when $\xi \leqslant 0{,}1$ $m'_a = 1{,}1$;
when $\xi = 0{,}3$ $m'_a = 1$;
when $\xi = 0{,}4$ $m'_a = 0{,}9$;

here the values of ξ are calculated from the rated strengths presented in Table 4; for intermediate values of ξ (in the interval from 0.1 to 0.3 and from 0.3 to 0.4) magnitude m'_a is determined by interpolation; the additional coefficient of the employment conditions $m'_a > 1$ is not considered for the reinforcement of structures used in an aggressive medium or rated for durability;

for the reinforcement of elements which have the relationship $h/l < 1/30$, coefficient $m_a' > 1$ can be taken into account only when experimentally justified.

3.7. The rated strengths of stressed rod and wire reinforcement in rating reinforced-concrete structures for durability (R_a') should be calculated by multiplying the rated strength of the stressed reinforcement R_a determined in accordance with 3.6, by coefficient $k_{\rho a}$ taken from Table 6 depending on the characteristic of the stress cycle in the reinforcement $\rho_a = \frac{\sigma_{a.\text{мин}}}{\sigma_{a.\text{макс}}}$ where $\sigma_{a.\text{мин}}$ are respectively the smallest and greatest values of the stresses in the stressed reinforcement arising under standard loads (see 11.5).

Table 6*. Coefficients $k_{\rho a}$ for determining the rated strengths of reinforcement in rating reinforced-concrete structures for durability.

Type of reinforcement	Values of coefficient $k_{\rho a}$ when ρ_a is equal to								
	-1	-0.2	0	0.2	0.4	0.7	0.8	0.9	1
1. Hot-rolled reinforcement of class A-1..................	0.45	0.7	0.8	0.85	1	1	1	1	1
2. The same, of class A-II.	0.4	0.58	0.65	0.72	0.84	1	1	1	1
3. The same, of class A-III	0.31	0.47	0.52	0.57	0.67	0.83	1	1	1
4. The same, of class A-IV.	-	-	-	-	0.37	0.72	0.9	1	1
5. High-strength reinforcing smooth wire of class V-II.	-	-	-	-	-	0.8	1	1	1
6. The same, deformed of class Vr-II..................	-	-	-	-	-	0.7	0.85	0.95	1

Notes: 1. Coefficients $k_{\rho a}$ with intermediate values ρ_a are determined by interpolation.

2. When $\rho_a < 0.7$ the use of the prestressed structures with reinforcement of high-strength wire, which are subject to rating for durability (see 4.1 "a"), is permitted with special justification.

3. The data of Table 6 does not extend to reinforcement of strands and cables, for which the values of coefficients $k_{\rho a}$ should be specially justified.

3.8. The coefficients $k_{\rho a}$ presented in Table 6 for rod reinforcement pertain only to reinforcement which does not have welded rods(stirrups)or welded joints of various types, with the exception of joints made by resistance butt [Thomson] welding (fusing) with longitudinal mechanical dressing of the joint flush with the surface of the reinforcement (without ribs).

In welding rod reinforcement or in welding rods, anchors, steel insert components, etc., to it the rated strength of stressed rod reinforcement in rating for durability R_a' should be calculated by multiplying values R_a' determined in accordance with 3.7, by coefficient k_c taken from Table 7.

Table 7. Coefficients k_c, for determining the rated strengths of rod reinforcement with welded connections in rating reinforced-concrete structures for durability.

Type of welded connection	Values of coefficient k_c for hot-rolled steel.	
	Of class A-I of the group of "steel 3" grades	Of class A-II of grade St.5 and of class A-III of grades 25G2S and 35GS
1. Welding by the resistance method (without dressing) or by the bath method on elongated straps............	0.9	0.8
2. Electric arc welding with paired straps.............	0.8	0.65
3. Resistance spot welding of intersected rods (in welded frameworks and grids)...	0.75	0.75

<u>Note</u>. With other grades of steel and types of welded connections the values k_c should be obtained on the basis of experimental data.

3.9*. In rating reinforced-concrete structures for durability for determining the stresses in reinforcement the ratio of the elastic modulus of the reinforcement to the conditional elastic modulus of the concrete with multiply repeated loading (the reduction factor) $n' = \frac{E_a}{E_б'}$ should be taken from Table 8.

Table 8*. Reduction factors n' for rating of reinforced-concrete structures for durability.

Type of concrete	Values of factor n' with a job-grade concrete of						
	150	120	250	300	350	400	500 and above
Heavy-aggregate	30	25	-	20	-	15	10
Light-aggregate	55	50	45	40	35	30	-

Note. 1. In computing the cited geometric characteristics of the cross section of prestressed elements the reduction factor can be assumed equal to $n = E_a/E_б$.

2. The use of reinforced-concrete structures of slag-pumice concrete rated for durability, is permitted only when sufficient experimental data is available.

3. The use of perlite concrete on a quartz sand base, and also of light-aggregate concretes with expanded perlite sands and porous light-aggregate concretes for reinforced-concrete structures rated for durability, is not permitted.

4. For light-aggregate concrete on a base of natural porous fillers, and also on a base of artificial coarse and fine fillers the values of the reduction factor n' are taken from experimental data.

4. BASIC RATED ASPECTS

GENERAL INSTRUCTIONS

4.1. The rating of concrete structures should be carried out with respect to bearing capacity (the 1st limiting condition): for strength taking into account when necessary longitudinal flexure and with testing of the stability of the structure shape.

The rating of reinforced-concrete structures should be carried out:

a) with respect to bearing capacity (the 1st limiting condition): for strength (taking into account when necessary longitudinal flexure and with the testing of the stability of the structure shape) and for durability - for structures, under the effect of a multiply repeated mobile or pulsating load causing a considerable drop in the stresses in the concrete or in the stressed reinforcement (crane beams and gantries, ties, frame foundations and spanning structures for certain unbalanced machines, etc.,);

b) with respect to deformations (displacements) (the 2nd limiting condition) - for structures, the magnitude of the deformations (displacements) of which can limit the possibility of their operation;

c) with respect to the formation or the opening of cracks (the 3rd limiting condition) - for structures, in which with respect to use conditions the formation of cracks is not permitted or their opening should be limited.

Furthermore, when necessary the stability of the structure position should be tested by rating for tilting and slipping (retaining walls, eccentrically loaded high foundations, etc.,) or for surfacing (sunken or subterranian reservoirs, pumping stations, etc.,).

The rating of the strength of concrete and reinforced-concrete structures, the makeup of the limiting conditions of which has still not been established or for which the onset conditions of a limiting condition cannot be expressed by forces in the cross section (some types of coverings, wall beams etc.,), it can be carried out in the same way as for an elastic body, in doing this:

for concrete structures the stresses with the designed loads should not exceed the corresponding rated strengths of the concrete;

for reinforced-concrete structures the compressive stresses in the concrete at design loads should not exceed the rated strengths of the concrete in compression, and all tensile forces in the cross section should be completely received by the reinforcement with the stresses in it, not exceeding its rated strength.

Notes: 1. In the text of the present Codes (in the points concerning the rating of reinforced-concrete elements) the concepts "compressed" or "tensile stressed" zone in concrete designate the zone which is respectively compressed or tensile stressed in the limiting state in question.

2. Centrally compressed reinforced-concrete elements with indirect reinforcement in the form of spirals, grids or rings, and also sections of elements operating in local compression undergoing a multiply repeated load, are not rated for durability.

3. Crane beams being rated for strength with the simultaneous operation of two cranes, in testing for durability should be rated for the load on one crane; with the cranes in a light operating regime the crane beams are not rated for durability.

4.2. The rating of concrete structures, and also the rating of reinforced-concrete structures with respect to the 1st and 3rd limiting conditions should be carried out for all those stages of production, transportation, assembly and use, in which the danger of the achievement by the structure of one of the indicated limiting conditions can arise: the rating of reinforced-concrete structures with respect to the 2nd limiting condition is carried out for the use stage, and precast monolithic structures, furthermore, for the assembly stage (see 4.10); in doing this the residual strains in the elements which can accumulate during the transportation, storage and assembly period should be considered.

Note. The rating of reinforced-concrete structures for deformations and for crack opening can not be carried out, if on the basis of practical application or of experimental testing of a structure made in accordance with special instructions, it is established, that its rigidity in the use stage is sufficient (see 4.14) and the magnitude of crack openings in it (in all stages enumerated in 4.2) does not exceed the permissible (see 4.16).

4.3. The rating for crack formation is carried out for prestressed reinforced-concrete structures which with respect to the requirements for crack resistance imposed on them are subdivided into three categories in accordance with Table 9. In this table instructions are given concerning the necessity of rating for crack formation in the structures of each category of crack resistance.

4.4*. In prestressed reinforced-concrete structures intended for use under conditions of the effect of rated temperatures of minus 40°C and below, in their rating with respect to the use stage the appearance of tensile stresses in the concrete of cross sections, normal to the axis of the elements is not permitted:

- being rated for durability;

- the first category of crack resistance;

- the 2nd category of crack resistance taking into account half of the horizontal forces caused by the wind load and by the braking of moving transport equipment.

The rating for the appearance in these cross sections of tensile stresses is carried out according to the instructions of Section 5 of the present Codes.

4.5. The rating of structures reinforced with prestressed elements, for crack formation is carried out separately:

Table 9*. The categories of prestressed reinforced-concrete structures with respect to the requirements of crack resistance imposed on them and instructions concerning the necessity of rating them for cracking.

The categories of structures with respect to the requirements for crack resistance imposed on them		The necessity of rating structures with respect to cracking
1st category	Structures on which requirements for water-impenetrability are imposed (for example pressure pipes [penstocks], reservoirs, etc.,)	The rating of structures for crack formation is always necessary
2nd category	Structures on which requirements for water impenetrability are not imposed, but which: a) are located under the effect of a multiply repeated load and are subject to rating for durability (see 4.1. "a"), or b) are designed with stressed reinforcement which has a standard strength of more than 10,000 kg/cm², or c) are exposed to the elements and operate under an alternating load	The rating of structures for crack formation is required; however if these structures are not subject to the effect of an aggressive medium and are not subjected to rating for durability, then for their individual zones rating for crack formation can not be carried out in the following cases: a) in inclined sections of bent elements made with transverse and bent back reinforcements of hot-rolled steel of classes A-III and lower or of standard reinforcing wire; b) in normal element sections, in zones of structures which experience compression during use, and under the effect of preliminary crushing - tension, if the longitudinal reinforcement in these zones is made from hot-rolled steel, and with welded framework and of standard reinforcing wire; in this case the cross-sectional area of the reinforcement in the zone in question should constitute not less than 0.1% entire cross-sectional area of the element and the requirements of 8.9 and 8.12 of the present Codes should be taken into account. In structures with stressed reinforcement of wire, bundles or strands without anchors rating for crack formation for the end sections of element over the length of the anchoring zone (see 7.28 of the present Codes) is in all cases mandatory, with the exception of individual sections with the removal of stress (see 8.12 of the present Codes)
3rd category	All structures, except those pertaining to the 1st and 2nd categories of crack resistance	The rating of structures for crack formation is not required

Note. 1. For structures used in aggressive media, the category of crack resistance is established depending on the degree of the aggressiveness of the medium, the type of reinforcing steel and its diameter in accordance with the requirements of Table 36 of Appendix III.

2. For the structures indicated in paragraph "C" of the 2nd category of crack resistance with the stressed rod reinforcing steel under the short-term effect of standard infrequently repeated loads (electric power line poles, etc.,) with special justification short-term opening of cracks with a width of not more than 0.1 mm is permissible; in this case with the effect of the steady load the magnitude of the compressive stresses on the cross-sectional face with a crack should be not less than 20 kg/cm².

a) for additionally laid concrete surrounding the prestressed elements;

b) for the concrete of the prestressed elements.

Such structures in rating for crack formation in the prestressed elements and in the concrete surrounding the elements, can pertain to various categories of crack resistance.

4.6. For elements of reinforced-concrete structures, not subjected to prestressing, and also for prestressed elements of the 3rd category of crack resistance the determining of the forces which cause the appearance of cracks, is carried out by computing the deformations, in the rating of the crack openings, or in the case, provided in 12.13. In these cases the instructions of 8.2-8.13 are used.

4.7. The rating of crack openings should be carried out:

a) for reinforced-concrete elements, not subjected to prestressing;

b) for prestressed elements of the 3rd category of crack resistance;

c) for cross sections and zones of prestressed elements of the 2nd category of crack resistance, for which rating of crack formation is not carried out (see Table 9).

It is permissible to not carry out testing of the width of crack openings, normal to the longitudinal axis of elements, in structures of concrete of grade 150 and above, not located under conditions of an aggressive medium or under the pressure of free-flowing bulk goods or fluids and not subject to rating for durability, in which as the longitudinal reinforcement hot-rolled steel of classes A-I or A-II is used.

The width of the openings of inclined cracks in the elements and zones enumerated in the present point, should be checked in all cases independent of the use conditions of the structure and the type of reinforcement employed.

Note. It is permissible not to carry out rating for crack openings in the case, specified in the note to 4.2 of the present Codes.

4.8*. The order of considering the loads and effects in rating concrete and reinforced-concrete structures for various limiting conditions both in the use stage and in the stages of manufacture, storage, transportation and assembly, is given in Table 10. The magnitudes of the standard and rated loads are taken in accordance with Chapters SNiP II-A.10-62 and II-A.11-62.

In checking for the presence of tensile stresses in concrete in cross sections, normal to the longitudinal axis of an element (see 4.4), rating is carried out:

for design loads - for structures of the 1st category of crack resistance;

for standard loads - in the remaining cases.

4.9. The magnitude of the impact factor for loads from crane should be taken in accordance with the instructions of Chapter SNiP II-A.11-62.

The effect of dynamic loading on the structural elements can be considered in accordance with the recommendations of the existing standard documents on planning and rating the carrying structures of buildings for machines with dynamic loading.

In rating precast structures for the effect of forces arising during lifting, transportation and assembly, the dead load of the

Table 10. The order of considering loads and effects in rating concrete and reinforced-concrete structures: A - in the use stage; B - in the production, storage, transportation and assembly stages (the loads and the effects, possible in the stage, for which the rating is being conducted should be considered in the calculations).

Type of structures	Rating of structures in stage	1st limiting condition (bearing capacity)		2nd limiting condition	3rd limiting condition	
		For strength	For durability	For deformations	For crack formation	For crack opening
Concrete	A	For the effect of rated loads	–	–	–	–
	B		–	–	–	–
Reinforced-concrete without pre-stressing	A	For the effect of rated loads when necessary (taking impact factor into account)	For the effect of standard loads when necessary (taking impact factor into account)			For the effect of standard loads when necessary (taking impact factor into account)
	B		–	For the effect of standard loads (when taking residual strains into account in accordance with 4.2)	–	
Reinforced-concrete pre-stressed	A	The same, in conjunction with prestressing of the reinforcement of the compressed zone (see 7.5-7.9 of the present Codes)	For the effect of standard loads in conjunction with the prestressing when necessary (taking impact factor into account)		For structures with respect to the category of crack resistance: 1st – For the effect of rated loads; 2nd – For the effect of standard loads. In conjunction with the prestressing when necessary (taking impact factor into account)	For the effect of standard loads in conjunction with the prestressing when necessary (taking impact factor into account)
			–	In this case flexure due to preliminary crushing of the concrete can be taken into account, with the exception of cases where there is a limit on the total deflection of the element with respect to use conditions (for example for structures, on which crane or railway rails are imposed		

Table 10. Continued

Type of structures	Rating of structures in stage	1st limiting condition (bearing capacity)		2nd limiting condition	3rd limiting condition	
		For strength	For durability	For deformations	For crack formation	For crack opening
Concrete	A	For the effect of rated loads	–	–	–	–
	B		–	–	–	–
	B	For the effect of the prestressing when necessary taking the dead load of the structures and other loads into account acting in the B stages introduced into the calculation with the load impact factors (the effect of concrete crushing is taken into account in accordance with the instructions of 7.5-7.9 of the present Codes)		Rating is carried out only for precast monolithic structures for the effect of standard loads; in this case the flexure due to preliminary crushing of the concrete can be taken into account	For the effect of prestressing taking the load of the element and other loads acting in the B stages introduced into the calculation with the load or impact factor into account	For the effect of prestressing taking the dead load of the element and other loads acting in the B stages introduced into the calculation without the load and impact factors into account

Note. 1. For explanations of the concepts "design load" and "standard load" see Chapter SNIP II-A.10-62

2. In rating prestressed structures with reinforcement, which does not have adhesion with the concrete (for example in the use stage of a structure before filling of the channels), the tension in the stressed reinforcement is examined as an external force.

3. Crane beams rated for strength with the simultaneous operation of two cranes, are rated for crack formation for the load of these two cranes, but the impact factor is not taken into account.

element should be introduced into the calculation with impact factor 1.5; but the ratio of the load factor to the dead load of the element is not introduced.

Note. The ratio of the impact factor to the dead load of precast structures in rating them for the effects of the forces arising during lifting, transporting and assembling, can be assumed less than 1.5, if this is confirmed by many years of use experience of such structures, but in any case not less than 1.25.

4.10. The rating of precast monolithic structures and their elements for bearing capacity, for deformations, and also for crack formation and opening should be carried out for the following two stages of structure use:

a) before the acquisition of the assigned strength by additionally laid concrete - for the effect of transport and assembling loads, of freshly laid concrete and other loads arising during erection, and

b) after the acquisition by additionally laid concrete of the assigned strength, i.e., in the case of its joint use with precast elements under conditions of structure use (in accordance with the directions of the appropriate instructions).

4.11. The rating of centrally and eccentrically compressed concrete and reinforced-concrete elements for strength taking longitudinal flexure into account, and also the rating of reinforced-concrete elements for deformations and for crack openings should be carried out taking the adverse influence of the prolonged effect of the entire dead load and part of the live load into account, and when necessary - the effect of preliminary crushing.

The separating of live load into a long-term and short-term load is done in accordance with the instructions of Chapters SNiP II-A.10-62 and II-A.11-62.

4.12. In determining the deformations of a floor or spanning structures the weight of the partitions situated on it is taken into account in the following manner:

a) the load from the weight of rigid partitions, (for example precast reinforced-concrete partitions made from horizontal elements, reinforced-concrete and concrete monolithic partitions, stone partitions, etc.,) is assumed concentrated at the ends of a partition, and when apertures exist - also near the edges of the apertures;

b) for other partitions - 60% of their weight is assumed distributed along the length of the partition (on the sections between the apertures), and 40% - concentrated on the ends of the partition and near the edges of the apertures.

4.13. The distribution of local load between the elements of precast spanning structures made from flexicore or solid slabs, under the condition that high-quality filling of the joints between the slabs is performed, can be carried out taking the following instructions into account:

a) in rating both for strength and deformation the following load distribution due to the weight of the partitions arranged along slab spans is assumed:

if a partition is situated within the limits of one slab, then 50% of the weight of the partition is imparted to this slab, and 25% of its weight is imparted to each of the two adjacent slabs;

if a partition rests on two adjacent slabs, then the weight of the partition is distributed equally between them;

b) in rating for deformations the local concentrated loads situated within the limits of the middle third of a slab span, are distributed along its width, which does not exceed the length of this span; in rating for strength such a distribution of concentrated loads can be allowed only under the condition that the adjacent slabs are joined along the length by keys checked by calculation (see 7.66).

Note. The extension of the recommendations of the present point to ribbed panels is permitted only with appropriate justification when these are transverse ribs of sufficient rigidity.

4.14*. The sagging of reinforced-concrete elements under standard loads, determined by taking into account (when necessary) the long-term effect of the whole dead load and part of the live load, should not exceed the values indicated in Table 11. For cases, not specified in Table 11, or when with respect to the use conditions of buildings or structures (for example in connection with technological specification) the deflections indicated in this table cannot be permitted, the maximum deflection values should be established by the appropriate standard documents for the designing of the given type of structures or by the design specifications.

In building reinforced-concrete structures with camber the values of the maximum deflections can be increased by the magnitude of the camber; for prestressed elements the correction for the flexure due to concrete crushing can also be taken into account, with the excepti . of the cases indicated in Table 10.

If in underlying premises with a smooth ceiling there are situated across element span l permanent partitions (which are not supports) with a distance between them of l_1, then the deflection of the element within the limits of distance l_1 (reckoned for the line connecting the upper points of the partitions axes), can be permitted up to 1/200 l_1, however in this case the maximum deflection of the entire element should not be more than 1/150 l.

Table 11*. The maximum deflections of reinforced-concrete elements.

Designation of the elements	Maximum deflections in fractions of the element span l
1. Crane beams with cranes:	
a) manual............................	1/500
b) electrical........................	1/600
2. Spanning elements with flat ceilings and covering elements in span:	
a) $l < 7$ m..........................	1/200
b) $l \geq 7$ m..........................	1/300
3. Spanning elements with ribbed ceilings and staircase elements in span:	
a) $l < 5$ m..........................	1/200
b) $5 \text{ m} \leq l < 7$ m....................	1/300
c) $l \geq 7$ m..........................	1/400
4. Suspendable wall panels in rating them from the span plane:	
a) $l \leq 6$ m..........................	1/200
b) $l > 6$ m..........................	1/250

The maximum deflections for cantilevers in fractions of their span l are assumed to be two times greater than the corresponding values indicated in Table 11.

4.15. For spanning structures, stairways and platforms and also similar elements unjoined with the adjacent elements of reinforced-concrete slabs, besides the rating of static deflections, testing for fluctuation should also be carried out. In doing this the rated deflection of such elements due to the short-term effect of a concentrated load with a weight of 100 kg, in addition to the full standard load, should not be more than 0.7 mm.

4.16*. The width of crack openings (normal and inclined to the axis of the element) in reinforced-concrete structures should be not more than:

a) for elements which are under the pressure of a fluid and which operate in central or eccentric tension, if the whole cross section of the element is tensile stressed (in the absence of special shielding measures) - 0.1 mm;

b) for elements which are under the pressure of a fluid and which operate in flexure and eccentric compression, and also in eccentric tension, if part of the cross·section of the element is compressed, and for elements which are under the pressure of free-flowing bulk materials, and also for all elements reinforced with steel of classes A-V, At-IV and At-V, - 0.2 mm;

c) in the remaining cases - 0.3 mm.

Notes: 1. In rating an element for loads acting in the transportation and assembly stages, the maximum width of cracks openings can be 30% more than that indicated in the present point.

2. The maximum width of crack openings in reinforced-concrete elements with special shielding measures, and also under the conditions of an aggressive medium should be established in accordance with the appropriate standard documents (see Appendix III, Table 36).

4.17*. The distance between expansion-contraction joints in concrete and reinforced-concrete structures of buildings and other structures should be established by calculation (see 4.23-4.25 of the present Codes) with consideration when necessary of crack formation and the appearance of rheological properties of concrete.

If the distances between expansion-contraction joints do not exceed the magnitudes given in Table 12, and the rated negative temperature is higher than minus 40°C, then for structures made without prestressing, and also for prestressed structures of the 3rd category of crack resistance it is not permissible to carry out calculations for expansion and contraction.

Table 12. The greatest distances between expansion-contraction joints in concrete and reinforced-concrete structures permitted without calculation at a rated temperature of more than minus 40°C.

Structure designations	The greatest distances between expansion-contraction joints in m, permitted without calculation	
	inside heated buildings or in soil	in open constructions and in unheated buildings
1. Concrete structures		
a) precast..............	40	30
b) monolithic with structural reinforcement..................	30	20
c) monolithic without structural reinforcement..................	20	10
2. Reinforced-concrete structures (with unstressed reinforcement or prestressed structures of the 3rd category of crack resistance):		
a) precast skeleton-frame structures, including mixed metallic or wooden coverings............	60	40
b) solid precast.........	50	30
c) monolithic and precast-monolithic skelton-frame of heavy-aggregate concrete.............	50	30
d) the same, of light-aggregate concrete....	40	25
e) solid monolithic and precast-monolithic of heavy-aggregate concrete.............	40	25
f) the same, of light-aggregate concrete....	30	20

Note. For reinforced-concrete structures of single-storey industrial and agricultural buildings it is permissible without calculation to increase the distance between expansion-contraction joints by 10% above the values indicated in Table 12.

For prestressed structures of the 1st and 2nd categories of crack resistance (see Table 9), and also for all structures employed at rated temperatures of minus 40°C and below, the distances between the expansion-contraction joints should be established by calculation.

For reducing the temperature forces in statically undefined systems it is recommended that their separation be carried out (during the building period) with temporary joints with subsequent monolithization (closing) at the ambient temperature, which is as close as possible to the value of the average annual temperature of the given construction region defined by the graph of Table 14 Chapter 1 of SNiP II-A.6-62 "Construction climatology and geophysics. The basic aspects."

4.18. The volumetric weight of concrete in the rating of structures is taken in accordance with the instruction of Chapter SNiP I-V.3-62. The volumetric weight of reinforced concrete with a reinforcement content of 3% should be defined as the sum of the weights of the concrete and the reinforcement per unit volume of reinforced-concrete structure.

DETERMINING FORCES IN THE ELEMENTS OF STATICALLY UNDEFINED STRUCTURES

4.19*. The forces acting in the elements statically undefined reinforced-concrete structures; it is recommended that they be determined by taking the inelastic deformation into account in accordance with the appropriate instructions for rating statically undefined constructions by taking the redistribution of forces into account.

To obtain a more favorable combination of forces in statically undefined systems artificial regulation of the forces can be employed taking their relaxation with time due to concrete creep into account.

The forces in statically undefined concrete structures, and also in reinforced-concrete structures, for which calculation procedures taking inelastic deformations into account, have still not been developed, can be determined by assuming of their elastic operation.

4.20*. In determining the forces arising due to a variation in the temperature and humidity of an element, and also the forces acting in elements of statically undefined structures, for which the magnitude of the load and the nature of its distribution depend upon the rigidity of the elements (for example the distribution of soil pressure on slab foundations), should take their deformations (displacements) into account in accordance with the instructions of 9.1-9.9 of the present Codes, and also in accordance with other standard documents.

4.21. In determining the forces in the elements of statically undefined structures for rating them both for bearing capacity and for deformations it is recommended that the three-dimensional operation of the structures be considered.

4.22. For slabs bordered along their whole contour with beams monolithically joined with them, designed without taking thrust into account arising under a limiting condition (with the exception of slabs of girderless spanning structures), the values of the bending moments should be reduced in comparison with those determined by calculation:

a) in cross sections of intermediate spans and near intermediate supports - by 20%;

b) in cross sections of extreme spans and in supports which are second from the edge of the spanning structure:

when $\frac{l_H}{l} < 1.5$ - to 20%;

when $1.5 \leq \frac{l_H}{l} \leq 2$ - to 10%, where l - the rated span of a slab in the direction, perpendicular to the edge of the spanning structure;

l_H - the rated span of a slab in the direction, parallel to the edge of the spanning structure (Fig. 1).

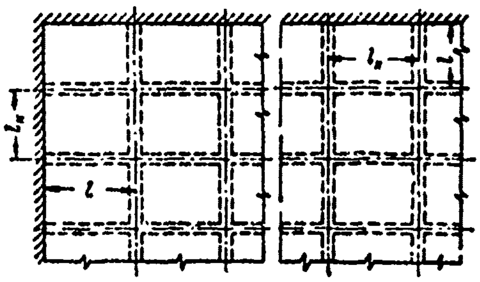

Fig. 1. Designations of rated spans of slabs of monolithic ribbed spanning structures.

4.23. Temperature-moisture effects on concrete and reinforced-concrete structures should be considered in establishing the distances between expansion-contraction joints (4.17), and also in special cases of rating structures subjected to considerable temperature or moisture variations, for example:

a) with an abruptly non-uniform temperature or moisture distribution with respect to the cross section of elements;

b) with the periodic effect on a structure of industrial-technological heat releases;

c) with stable low environment humidity.

It is permissible not to consider the shrinkage of concrete in elements of precast reinforced-concrete structures, or in structures, protected from an early age from desiccation by soil or by paint and varnish coats.

4.24. The determining of forces due to temperature or humidity effects in the elements of concrete structures, and also in the elements of reinforced-concrete structures, in which in accordance with the use conditions crack formation is not permitted, can be carried out in the same way as for uniform elastic systems; in this case the rigidities of their elements are determined in accordance with the instructions of 9.3 of the present Codes. Reinforced-concrete constructions, in which crack formation is permitted under standard loads, are designed taking inelastic deformations into account by the method of successive approximations, taking into account the duration of the effect in question; crane loads in determining the deformations of an element in these cases are not considered.

4.25. In determining the forces arising in the elements of statically undefined concrete and reinforced-concrete structures due to temperature or moisture effects, it is necessary to consider the variation in the mean rated temperature of the elements and the rated temperature differential on the thickness of the cross sections of the elements or with respect to the mean rated moisture and the rated moisture differential on the thickness of the cross sections of the elements. The data necessary for this with respect to the temperature or moisture distribution on the cross sections of structural elements are determined by construction physics methods, and the physical characteristics of heavy-aggregate concrete can be assumed to be the following:

the coefficient of linear expansion during heating from 0 to 100° -

$$\alpha = 1 \cdot 10^{-5} \text{ degree}^{-1};$$

the coefficient of linear shrinkage -

$$\beta = 3 \cdot 10^{-2} \frac{\text{mm/mm}}{\text{g/g}};$$

the coefficient of linear swelling -

$$\eta = 5 \cdot 10^{-3} \frac{\text{mm/mm}}{\text{g/g}}.$$

The coefficient of thermal conductivity of concrete and reinforced concrete, and also the specific heat and the coefficient of heat transfer are taken from the existing Codes on structural heat engineering.

When experimental data for concrete manufactured from the same materials, of the same composition and by the same methods are available, as the concrete being used in the construction, it is permissible to take the values of its physical characteristics from the experimental data.

The mean rated temperature (or moisture) of an element, whose variations cause axial deformations in it, is assumed equal to the area of the actual diagram of the temperature distribution (or effective moisture) with respect to the thickness of the transverse cross section of the element divided by the thickness of the element in the direction in question.

For determining the rated temperature (or humidity) differential in the direction in question, whose variations cause bending of the element axis, the actual diagram of the temperature (or effective moisture) distribution with respect to the thickness of the transverse cross section of the element is replaced by a conditional trapezoidal diagram equivalent to it (with respect to area and the static moment of the area) with boundary ordinates t_1 and t_2 (u_1 and u_2) (Fig. 2), after which the rated temperature differential is assumed equal to (see Fig. 2, a)

$$\operatorname{tg} \alpha_t = \frac{t_2 - t_1}{h}, \tag{1}$$

and the rated moisture differential is assumed equal to (see Fig. 2, b)

$$\operatorname{tg} \alpha_u = \frac{u_2 - u_1}{h}. \tag{2}$$

Note: 1. The coefficients of linear shrinkage and linear swelling are relative deformations of concrete (in mm/mm), caused by the variation per unit of its relative weight moisture (in g/g) respectively during uniform desiccation and moistening.

2. The effective moisture of concrete is that part of its total moisture which represents the adsorptively bound water of gel, the removal of which from concrete is accompanied by its shrinkage.

3. Using the instructions of 4.25 the necessary physical characteristics for light-aggregate concrete should be established by individual standard documents and be taken from the experimental data.

4.26. In considering the variation in the mean rated drop in moisture with respect to the thickness of an element cross section only those factors are taken into consideration which are connected with the variations in the effective moisture of concrete.

The diagram of the effective moisture distribution with respect to the cross section of an element is found in the actual

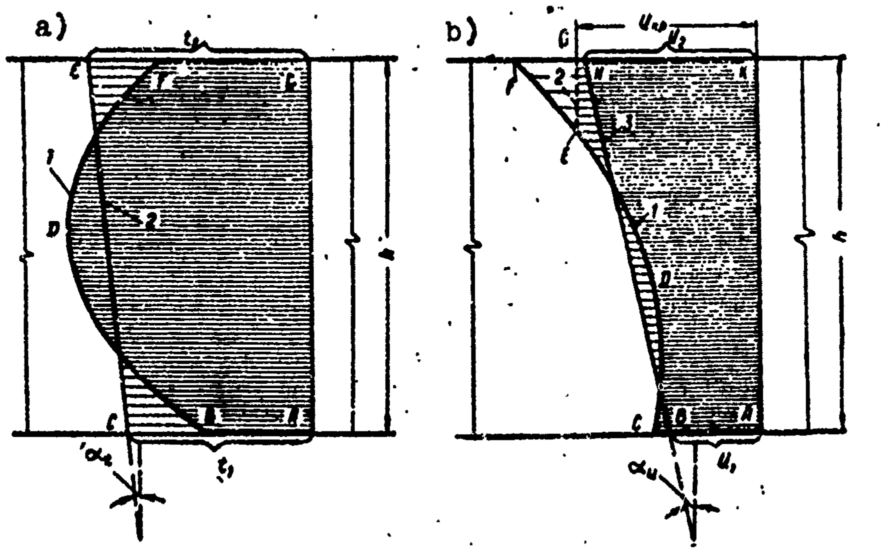

Fig. 2. Diagrams of the temperature and moisture distribution over the cross section of an element; a) - temperature distribution diagram: 1 - actual (ABDFG); 2 - hypothetical trapezoidal, considered in calculation (ACEG); b) - moisture distribution diagrams: 1 - actual (ACDFK); 2 - effective moisture diagram (ACDEGK): 3 - hypothetical trapezoidal, considered in calculation (ABHK).

diagram of the moisture distribution of concrete with respect to the thickness of an element cross section by cutting off and rejecting its parts which lie above the critical moisture of concrete $u_{\text{кр}}$ (see Fig. 2, b), determined for heavy-aggregate concrete by using the following formula

$$u_{\text{кр}} = W + \dot{u}_{\text{кр}} K, \tag{3}$$

where W - the rated equilibrium moisture of concrete in a structure, which corresponds to a relative atmospheric humidity of 75%, equal to: 0.0125 g/g - for non-massive structures and to 0.00625 g/g - for massive structures;

$u_{\text{кр}}$ - the rated excess (above equilibrium moisture) critical moisture of concrete, is equal to: 0.01 g/g - for non-massive structures and 0.005 g/g - for massive structures;

K - the coefficient taken from Table 13 depending on the job-grade of the concrete.

Table 13. Values of coefficient K.

Job-grade of the concrete	100	150	200	300	400	500	600
K	1.6	1.5	1.4	1.3	1.2	1.1	1

For structures of mean massiveness (see Note 2) values W and $u^*_{кр}$ are determined by interpolation depending on the modulus of the element surface.

Note. 1. The critical moisture of concrete is the maximum value of its effective moisture.

2. Depending on the modulus of a structural element surface m in m^{-1} (the ratio of an element surface, open to desiccation in m^2 to its volume in m^3) concrete and reinforced-concrete structures are subdivided into:

massive - when $m \leq 2$;
average massiveness - when $2 < m < 15$;
non-massive - when $m \geq 15$.

5. DETERMINING THE STRESSES IN PRESTRESSED ELEMENTS

5.1*. The stresses in concrete and reinforcement of prestressed reinforced-concrete elements must be determined by calculating:

a) the losses due to concrete creep and the effect of multiply repeated load;

b) the forces in the reinforcement tensile stressed by the concrete;

c) the cross sections, normal and inclined to the axis of the element, for the effect of multiply repeated load;

d) the formation of cracks in cross sections, inclined toward the axis of the element;

e) deformations in elements of the 3rd category of crack resistance;

f) the beginning of joint openings in butt-joined cross sections of sectional and modular structures;

g) cross sections, normal to the axis of the element, for the appearance of tensile stresses in concrete (see 4.4).

5.2. Stresses in cross sections, normal to the axis of an element, are determined from their given area, by introducing into the calculation the total cross-section of concrete taking into account the weakening due to its channels, grooves, etc., and also the area of the cross section of the entire longitudinal stressed and unstressed reinforcement (if it is more than 0.008F) multiplied by the ratio of the elastic moduli of the reinforcement and the concrete; in this case if parts of a concrete cross section are made from concrete of different job-grades, they are treated as a single grade of concrete, on the basis of the ratio of their elastic moduli.

Stresses in concrete σ_6 are determined by the elastic stage regardless of the fact of whether stressing is carried out on chocks or on hardened concrete, and in doing this the resultant of the forces in the entire stressed and unstressed upper and lower reinforcement N_0 (Fig. 3) is examined as the external force

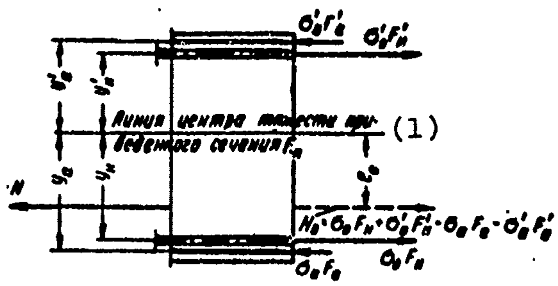

Fig. 3. Diagram of the distribution of forces in the transverse cross section of a prestressed element when determining stresses in concrete and reinforcement .
KEY: (1) Center of gravity line of the cited cross section.

compressing (in general, eccentrically) the given element, cross section, taking the stressed and unstressed reinforcement into account, and they are determined by the formula

$$N_0 = \sigma_0 F_н + \sigma_0' F_н' - \sigma_а F_а - \sigma_а' F_а'. \quad (4)$$

The eccentricity of force N_0 relative to the center of gravity of the given cross section is found in the formula

$$e_0 = \frac{\sigma_0 F_н y_н + \sigma_а' F_а' y_а' - \sigma_0' F_н' y_н' - \sigma_а F_а y_а}{N_0}, \quad (5)$$

where F_H and F_a - are the cross-sectional areas of the stressed and unstressed longitudinal reinforcement respectively; in the elements being bent, eccentrically compressed and eccentrically tensile stressed - or reinforcement A_H and A, situated in the more compressed zone of the concrete; in centrally compressed and centrally tensile stressed, and also in all elements of annular cross-section (with the reinforcement situated around the circumference - all;

F_H' and F_a' - are the cross-sectional areas of the stressed and unstressed longitudinal reinforcement A_H' and A' respecitvely, situated in a lesser compressed zone of the concrete of the elements being flexured, eccentrically compressed and eccentrically tensile stressed;

σ_0 and σ'_0 - are respectively the stress in stressed reinforcement A_H and A'_H before compression of the concrete (with tensioning of the reinforcement on chocks) or at the moment of the reduction in the magnitude of concrete prestressing down to zero with the effect on the element of external actual or hypothetical forces; σ_0 and σ'_0 are assumed in considering the tension quality factor of m_T (see 5.3) and in considering the losses of stresses determined for the stage of element use in question (see 5.4);

σ_a and σ'_a - are stresses respectively in unstressed reinforcement A and A', caused by shrinkage and creep of the concrete, at the moment of the reduction of the stresses in the concrete down to zero by the effect on the element of external actual or hypothetical forces;

y_H, y'_H; y_a and y'_a - are the distances from the axis, normal to the bending plane and passing through the center of gravity of the given cross section respectively up to the points of the application of the resultant forces in the stressed and unstressed reinforcement (Fig. 3).

Note. With curvilinear positioning of the stressed reinforcement values σ_0 and σ'_0 in formulas (4) and (5) are multiplied respectively by cos α and cos α', where α and α' are the angles of inclination of the stressed reinforcement to the longitudinal axis of the element (for the cross section in question).

5.3. The prestressing quality coefficient of reinforcement m_T is assumed to be:

a) for all longitudinal reinforcement :

in rating for crack formation in a pre-compressed cross-section zone[1] $m_T = 0.9$;

in rating for crack formation in prestressed or in a less compressed zone of a cross section (with the exception of the cases of rating by the approximation formulas given in 8.3-8.5) $m_T = 1.1$;

b) in rating for strength in the use stage - for reinforcement A'_H, and in the concrete compression stage - for all longitudinal reinforcement stressed in concrete, $m_T = 1.1$;

c) in the remaining cases $m_T = 1$.

Note. In prestressing reinforcement by the electrothermal method the tension quality factor is taken from special standard documents.

5.4. In rating prestressed structures and in designating the controlled stressing for them it is necessary to consider the loss of prestressing in reinforcement.

In stressing reinforcement with chocks the losses which occur are considered:

before the termination of concrete compression - due to the relaxation of stresses in the steel, the deformation of the anchors and temperature differential;

after concrete compressing - due to the shrinkage and creep of the concrete and the effect of the multiply repeated load.

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[1]And also in the cases, specified in 9.7 and 10.2 of the present Codes.

In stressing reinforcement in concrete the losses which occur are considered:

before the termination concrete compressing - due the deformation of the anchors and the friction of the reinforcement against the channel walls or the structure surface;

after concrete compressing - due to the shrinkage and creep of the concrete, the relaxation of the stresses in the steel, the warping of the concrete during turning of the reinforcement and due to the effect of a multiply repeated load.

The values of the losses in reinforcement prestressing are determined in accordance with the instructions of 5.11-5.17 of the present Codes, and when special experimental data are available, from the experimental results. The total value of the losses when designing structures should be taken in all cases to be not less than 1000 kg/cm^2.

5.5. With the use in an element of several reinforcement bundles or rods not simultaneously stressed in the concrete, it is necessary to consider the variation (reduction or increase) in the stresses in reinforcement stressed earlier, as a result of the elastic compressing of the concrete by the forces of bundles or rods stressed later (see 5.17 of the present Codes).

5.6*. The values of the stresses in reinforcement σ_0 and σ_0' neglecting the losses, taken into account in the calculations (see 5.2), as a rule, should be: for wire reinforcement - not more than $0.7R_a^H$, but not less than $0.4R_a^H$; for rod reinforcement - not more than $0.9R_a^H$, but not less than $0.4R_a^H$.

The magnitude of the greatest stress in reinforcement σ_0 and σ_0' can be raised for wire reinforcement up to $0.8R_a^H$ and for rod reinforcement - up to R_a^H in the following cases:

a) in reinforcement of the compressed zone for the purpose of increasing crack resistance during compression of the element, during transport;

b) in the annular reinforcement of penstocks;

c) during the temporary redrawing of reinforcement for the purpose of increasing its limit of proportionality or decreasing the losses due to stress relaxation;

d) in compensating for losses due to the relaxation of stresses or nonsimultaneous stressing of the reinforcement due to the friction of the reinforcement against the channel walls and concrete surface, and also due to the temperature differential between the stressed reinforcement and the devices receiving the forces of its stressing.

Note. The magnitude of the greatest stressing of rod reinforcement σ_0 with the electrothermal method of stressing should be determined taking the maximum permissible deviations in prestressing (p) into account, on the basis of the fact that $\sigma_0 + p \leq R_\alpha^H$.

5.7. In stressing reinforcement by the thermal method the maximum temperature of its heating, as a rule, should not exceed 350°C for rod reinforcement, and for wire reinforcement 300°C; when confirmed by experiment and in observing the heating modes specified by individual standard documents, the heating temperature of the reinforcement can be raised.

5.8. The stress level in reinforcement, being monitored during its stressing on chocks, is taken in accordance with the instruction of 5.6.

The magnitude of stressing in stressed reinforcement A_H and A'_H, checked during stressing of reinforcement in hardened concrete are determined for the cross section, designated by σ_0 and σ'_0, using formulas

$$\sigma_н = \sigma_0 - n\sigma_б = \sigma_0 - n\left(\frac{N_0}{F_п} + \frac{N_0 e_0 y_н}{J_п}\right); \qquad (6)$$

$$\sigma'_н = \sigma'_0 - n\sigma'_б = \sigma'_0 - n\left(\frac{N_0}{F_п} - \frac{N_0 e_0 y'_н}{J_п}\right), \qquad (7)$$

where $n = \frac{E_a}{E_б}$.

In formulas (6) and (7) σ_0 and σ'_0 are assumed before the appearance of losses; N_0 is determined after the appearance of losses which occur before the termination of concrete compression.

5.9*. The magnitudes of stresses established in concrete $\sigma_б$ after the appearance of losses used in computing the main stresses in concrete, in testing the durability of an element and in calculating the losses in prestressing due to the effect of a multiply repeated load, are determined by the formula

$$\sigma_б = \frac{N_0}{F_п} \pm \frac{N_0 e_0}{J_п} y, \qquad (8)$$

where values N_0 and e_0 are determined respectively using formulas (4) and (5); y - is the distance from the center of gravity of the given cross section to the filament, in which stress is determined.

The magnitudes of the stresses established in reinforcement $\sigma_н$ after the appearance of losses in testing the durability of an element are determined formula (6).

5.10. In determining stresses and rating cross sections of prestressed structures for cracking it is necessary to consider the stresses in stressed and unstressed reinforcement.

In this case the stress values in stressed reinforcement σ_0 and σ'_0 are taken:

a) directly after compressing of the concrete - taking into account the losses which occur before the termination of the concrete compression;

b) in the use stage of an element - taking all losses into account (see 5.4).

The values of the compressive stresses in unstressed reinforcement σ_a and σ'_a are taken to be numerically equal to:

a) in the concrete compression stage of an element - to the stress losses due to concrete shrinkage;

b) in the use stage of an element - to the sum of the stress losses due to the concrete shrinkage and creep.

Note: 1. For the precompression stage of concrete made not later than three days after the manufacture of an element, stresses σ_a and σ'_a are taken to be equal to zero.

2. With the positioning of resultant forces in stressed reinforcement N_0 (see 5.2) it is permissible to assume $\sigma'_a = 0$ on the face of the cross section core or near it.

5.11. The values of the prestressing losses of reinforcement in the rating prestressed structures are taken from Table 14.

5.12*. The value of the losses due to concrete shrinkage and creep with respect to 1 and 2 of Table 14 is determined for rating structures in the use stage.

For the intermediate working stages of a structure, for example, when they are subjected to production control tests, the value of the losses due to concrete shrinkage and creep, determined from 1 and 2 of Table 14, is multiplied by coefficient $\beta = \frac{4t}{100+3t}$, where t is the time in days, reckoned during determining the losses

Table 14. Losses of prestressing in reinforcement .

Name of the factors causing losses of prestressing	Value of losses in kg/cm² with stressing of the reinforcement: With chocks	In concrete
1. Shrinkage of heavy-aggregate concrete (see Note 1)	400	300
2. Creep of heavy-aggregate concrete (see Note 1)	$\frac{kE_aR}{E_bR_0}\left[\sigma_b + 3R_0\left(\frac{\sigma_b}{R_0} - 0.5\right)\right]$	$\frac{0.75kE_aR}{E_bR_0}\left[\sigma_b + 3R_0 \times \left(\frac{\sigma_b}{R_0} - 0.5\right)\right]$
	(see Note 2)	
3. Relaxation of stresses: a) for high-strength reinforcing wire and strands	$\left(0.27\frac{\sigma_0}{R_a^n} - 0.1\right)\sigma_0$	$\left(0.27\frac{\sigma_0'}{R_a^n} - 0.1\right)\sigma_0'$
	(see Note 3)	
b) for stressed rod reinforcement:	$0.1\sigma_0 - 200$	$0.1\sigma_0' - 200$
	(see Notes 3 and 4)	
4. Deformation of anchors (compression of washers or packing located between the anchors and the concrete of the element), is equal to λ_1 = 1 mm for each anchor, and the deformation of jacket-type anchors or of blocks with plugs for bundle reinforcement, or of anchor nuts and clamps.	$(\lambda_1 + \lambda_2)\frac{E_a}{l}$, where l - the length of a stressed bundle or rod in mm (see Note 5)	
5. Friction of bundles, strand or rods of reinforcement against the channel walls in rectilinear and curvilinear sections	—	$\sigma_0\left(1 - \frac{1}{e^{kx+\mu\theta}}\right)$ (see 5.15 of the present Codes)
6. Warping of the concrete under twisting of spiral or circular reinforcements with a construction diameter of up to 3 m	—	300
7. Variation in the temperature difference of stressed reinforcement and the device receiving the stress force (for example during steaming or preheating of the concrete, etc.)	20 Δt, where Δt in degrees - the difference between the temperature of the reinforcement and the chocks receiving the stress force	—
8. The effect of a multiple repeated load (it is considered only in rating for durability)	$600\frac{\sigma_b}{R_0}$ (see Note 6)	

Note. 1. The value of the losses of prestress due to shrinkage and creep of light-aggregate concrete should be taken from experimental data.

2. The magnitude of stress $\sigma_б$ is determined in accordance with 5.9 and 5.12 of the present Codes before the development of losses occurring after compression of the concrete; if in this case during the compressing of an element its dead load affects the stress distribution in the cross section, then it should be considered along with the other loads which act during compression of the concrete and remain during the use of the structure.

When $\sigma_б \leq 0.5\ R_0$ the values, in the parenthesis, are taken to be equal to zero.

Coefficient к is assumed to be; when using reinforcement of high-strength reinforcing wire and articles of it (strands, bundles, cables) k = 1, with the use of other types of reinforcement, k = 0.3;

R_0 - the cube strength of concrete when it is prestressed;

$E_б$ - the elastic modulus of concrete which corresponds to its job-grade.

The stresses in concrete $\sigma_б$, going into the formulas of 2 of Table 14, are determined at the level of the centers of gravity of longitudinal reinforcement $A_н$ and $A_н'$.

3. In determining the losses due to stress relaxation using the formulas of 3 of Table 14 the values σ_0 and σ_0' are taken from the instructions of 5.2 of the present Codes; if the calculated values of these losses are negative, then it is necessary to assume them equal to zero. The losses due to stress relaxation in structures operating at a temperature higher than 40°C, are taken from experimental data.

4. For hot-rolled reinforcing steel of classes A-III, A-II and A-I, and also for reinforcing steel of classes A-IIIv and A-IIv, draw-strengthened before stressing of the reinforcements, the losses due to stress relaxation are not considered (they are assumed equal to zero). With the electrothermal method of stressing and reinforcements of classes A-IV, A-V, At-IV, At-V and At-VI the losses of stress in the reinforcements due to stress relaxation can not be considered when stresses $\sigma_0 \leq 0.7R_a^н$, but when $\sigma_0 > 0.7R_a^н$ it is necessary to assume the stress losses equal to 0.03 σ_0.

5. With the use of anchors in the form of tightly screwed nuts or with the use of wedge washers mounted between the anchor and the element or between the clamp and the supporting device, the losses due to compression of the nuts and washers can not be considered, i.e., $\lambda_1 = 0$ and $\lambda_2 = 0$.

6. In the formula of 8 of Table 14 $\sigma_б$ - the ascertained stress in the concrete at the level of the center of gravity of the stressed reinforcements of the tensile stressed zone, defined by 5.9 of the present Codes before the development of losses due to a multiple repeated load; $R_б'$ - the rating strength of the concrete for durability, taken in accordance the instructions of 3.4 of the present Codes depending on the type of the stressed state.

due to concrete shrinkage from the day on which concreting of a structures is ended, and in determining the losses due to concrete creep - from the day of its precompressing.

If it is known in advance, that a prestressed structure will be subjected to the effect of dead load and external loads more than a 100 days after the compression of the concrete, then the value of the losses in the use stage is determined with value β, which corresponds to the actual period of structure loading.

5.13. In determining the losses due to concrete shrinkage and creep the following instructions should be taken into account:

a) in structures which are subjected to steam curing or to warming so as to accelerate concrete hardening, the losses due to concrete shrinkage and creep should in all cases be taken to be the same as for structures with stressing of the reinforcement in chocks;

b) for penstocks, reservoirs, piles and other structures which are under increased moisture conditions, the values of the losses due to concrete shrinkage and creep indicated in 1 and 2 of Table 14 can be reduced by 50%;

c) for structures intended for use in a hot dry climate (for example in the regions of Central Asia), the losses due to concrete shrinkage and creep should be increased by 20-30%;

d) in prestressed transverse reinforcement the losses of stresses due to concrete creep are not considered;

e) if when designing a structure the type of cement and the composition of the concrete which will used, and also the production and use are known of the structure and the type, the value and the time period of the load effects conditions, then it is recommended that the losses due to concrete shrinkage and creep be determined by more precise methods and be checked by experiments.

5.14. In determining the losses of prestresssing in structures consisting of modules, the compressive strain in each joint between the modules is taken to be:

a) for joints filled with concrete or mortar, - 1 mm;

b) in the joining of the modules in the dry state, whose faces during manufacture were adjacent and were separated by packing of constant thickness, - 0.5 mm; deviations from the indicated requirements are permitted when justified by experiments.

5.15. The value of the prestress losses of reinforcement $\sigma_{п.т} = \frac{N_H - N_a}{F_H}$ with friction of smooth and deformed bundles, strands or rods against the channel walls in rectilinear and curvilinear sections can be determined by taking the coefficient of friction of the reinforcement against the channel walls, the value of the arc angle of contact of the reinforcement in curvilinear sections and others data (Fig. 4) into account, using formula

$$\sigma_{п.т} = \sigma_H \left(1 - \frac{1}{e^{kx + \mu\theta}}\right), \quad (9)$$

where N_H - the force developed by the jack or the stressing device is taken to be equal to $N_H = N_a e^{kx+\mu\theta}$;

N_a - the force in the reinforcement taking the losses due to friction into account;

σ_H - the controlled prestressing of the reinforcement in the absence of losses; it is possible to assume value $\sigma_H = \sigma_0$;

e - base of natural logarithms;

x - the length of a channel section from the stressing device to the rated section in m; for linear elements it is permissible to assume value x equal to the length of the projection of the indicated channel section on the longitudinal axis of an element;

k - the coefficient which considers the deflection of a rectilinear channel section with respect to its designed position per 1 linear m of length defined by Table 15;

μ - the coefficient of friction of the reinforcement against the channel walls defined by Table 15;

θ - the central angle (in radians) of the arc formed by the reinforcement in a curvilinear channel section (see Fig. 4).

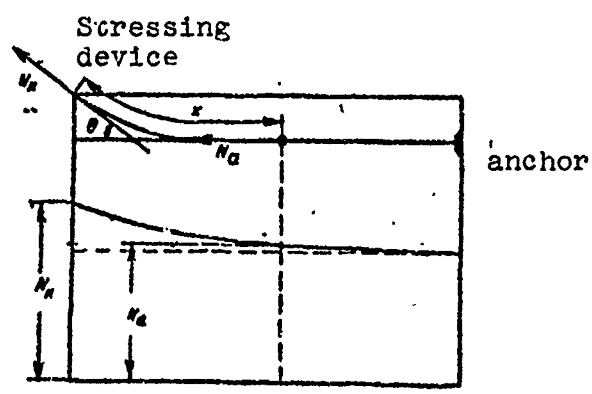


Fig. 4. Diagram of the variation in forces in stressed reinforcement of curvilinear shape for determining its losses of prestress with friction against the channel wall or the concrete surface of the structure.

Table 15. Values of coefficients k and μ.

Type of channel		Values of k	Values of μ with reinforcement of the type: Bundles, strands and smooth rods	Values of μ with reinforcement of the type: Deformed rods
Channel with a metal surface		0.003	0.35	0.4
Channel with a concrete surface	Formed by a rigid channel former	0	0.55	0.65
	Formed by a flexible channel former	0.0015		

Table 15a*. Ultimate compressive stress of concrete $\sigma_б$** in fractions of R_0.

Stressed state of the cross section	Method of stressing the reinforcements	Compressive stresses of concrete $\sigma_б$ in fractions of R_0, not more than, at a rated air temperature of: Above minus 40°C, in compression: Central	Above minus 40°C: Eccentric	Minus 40° and below, in compression: Central	Minus 40° and below: Eccentric
The precompressed zone of the cross section due to the effect of external loads is elongated and in the use stage can experience insignificant compression or tension	In abutments	0.7	0.8	0.5	0.6
	In concrete	0.6	0.7	0.4	0.5
The precompressed zone of the cross section due to the effect of external loads obtains additional shortening (compression).	In abutments	0.5	0.55	0.35	0.4
	In concrete	0.45	0.5	0.3	0.35

**Neglecting the losses occurring after the end of compression of the concrete.

5.16. With the use of repeated stressing of reinforcement in concrete, carried out during manufacture and aging of the structure for the purpose of compensating for losses of prestressing, it is permissible to reduce the latter by value $\Delta\sigma$, where $\Delta\sigma$ - the losses of stress in the reinforcement occurring during the period between the first and the second stressing; however this reduction should be not more than 50% of the losses assumed for elements in the absence of repeated stressing.

5.17. With use in a stressed element of several reinforcement bundles or rods nonsimultaneously stressed in concrete, the value of the variation (reductions or increases) in the stress in the reinforcement stressed earlier, due to elastic compression of the concrete by the forces in the reinforcement stressed later, can be assumed equal to $n\Delta\sigma_{б}$, where n - the ratio of the elastic modulus of the reinforcement to the elastic modulus of the concrete; $\Delta\sigma_{б}$ - the mean stress in the concrete (in the section of the length of the reinforcement group in question stressed earlier, at the level of its center of gravity) due to the stress force of the reinforcement group stressed later; in this case the stress in the reinforcement is taken after deducting the losses occurring during compression of the concrete.

Value $\Delta\sigma_{б}$ is determined for each group of reinforcement stressed after that group of reinforcement, for which the loss of stresses is determined; the reinforcement of the group stressed earlier, should be stressed more vigorously by the value of the variation in stress found by this method.

For determining the variation in prestress it is recommended that the whole reinforcement be subdivided into 2-3 groups.

Note. Other, more precise methods of taking the variation in stresses in reinforcement into account with its nonsimultaneous stressing are permitted.

5.18*. Compressive stresses of concrete $\sigma_б$ depending on the stressed state of the cross section and the method of stressing the reinforcement should not exceed the values (in fractions of the cubic strength of the concrete during its compression R_0) indicated in Table 15a.

Note. The values of $\frac{\sigma_б}{R_0}$ given in the last two columns of Table 15a pertain to concrete in the water-saturated state; with its moisture, corresponding to natural air-dry conditions it is necessary to assume these value 0.05 greater than those indicated in the table.

6. RATING THE ELEMENTS OF CONCRETE STRUCTURES FOR STRENGTH

GENERAL INSTRUCTIONS

6.1*. The strength rating of elements of concrete structures should be carried out for cross sections, normal to the axis of the element.

Supporting parts of elements should be tested by calculation for warping. In rating wall panels the random eccentricity taken to be equal to the following should be considered:

a) for panels of bearing walls - 2 cm;

b) for panels of self-bearing walls, and also for the individual layers of three-layered panels of bearing walls - 1 cm.

The indicated random eccentricity is totaled with the assigned eccentricity of longitudinal force.

Note. When it can be guaranteed, that when installing the panels the displacement of the axes with respect to the storeys is not more than 1 cm, it is permissible in rating the panels of bearing walls to consider the random eccentricity, equal to 1 cm.

6.2. The rated lengths l_0 for columns and concrete walls are taken from Table 16.

Table 16. Rated lengths l_0 of concrete elements (columns, walls).

The nature of the support of the columns and walls	Rated length l_0
1. For walls and columns supported at the top and bottom:	
a) for undisplaced supports in the form of spanning structures, in turn, resting on unsupported (rigid) transverse structures......................	H
b) for elastically displaced supports....	1.25H-1.5H
2. For free-standing walls and columns......	2H
3. For walls supported on four sides by undisplaced supports in the form of spanning structures and transverse walls, etc., when B:H $\leq$ 2...	0.9H
4. For walls supported on three sides by undisplaced supports when B:H $\leq$ 1.5...............	0.9H

where H - the height of the column or wall within the limits of the storey, after deducting the thickness of the spanning structure slab;

B - distance (length of the wall) between the vertical supports, and with support on three sides - the distance between the vertical support and the free face of the wall.

Note. If in rating panels their support in outline, is considered then a connection should be provided between the panel being rated and the transverse walls with respect to it, at least, by filling the grooves being left in the walls, or with the use of anchors located at the top, bottom and in the middle of the height of the storey.

CENTRALLY COMPRESSED MEMBERS

6.3*. The ratings of concrete elements in central compression taking buckling into account is carried out using the following formula

$$N_{\text{п}} \leqslant \varphi R_{\text{пр}} F. \qquad (10)$$

where $N_{\text{п}}$ - the given longitudinal force determined by the formula

$$N_{\text{п}} = \frac{N_{\text{дл}}}{m_{\text{дл}}} + N_{\text{к}}; \qquad (11)$$

ϕ - the coefficient of longitudinal flexure taken from Table 17;

$N_{\text{дл}}$ - a rated longitudinal force from a long-term acting part of the load;

$m_{\text{дл}}$ - the coefficient which considers the effect of prolonged action on the bearing capacity of a flexible element taken from Table 17.

FLEXURAL ELEMENTS

6.4. The rating of flexural concrete elements is carried out on the basis of the following aspects (Fig. 5):

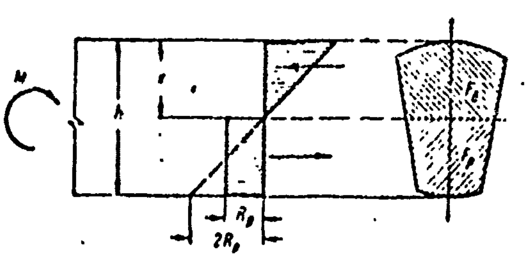


Fig. 5. Diagram of the distribution of forces and a diagram of the stresses in the transverse cross section of a flexural concrete element.

a) the cross sections are maintained plane (the plane cross section hypothesis);

b) the diagram of normal stresses in the compressed zone is triangular and has such a slope, that when it is extended into the tensile stressed zone it intercepts a segment on the stressed extreme fiber, equal to $2R_p$;

c) the diagram of the normal stresses in the stressed zone is rectangular with a stress value, equal to R_p.

With an arbitrary form of an element cross section then it is recommended that the calculation be carried out using formula

$$M \leqslant R_p W_T, \tag{12}$$

where W_T - the moment of resistance for the stressed face of a cross section, determined by taking the inelastic properties of the concrete into account (in accordance with Fig. 5), is equal to

$$W_T = \frac{2J_c}{h-x} + S_p, \tag{13}$$

where J_c - the moment of inertia of the compressed part of the cross section relative to the zero line;

S_p - the static moment of the stressed part of the cross section relative to the zero line.

The position of the cross-section zero line is determined from condition

$$S_c = \frac{(h-x)F_p}{2}, \tag{14}$$

where S_c - the static moment of the compressed part of the cross section relative to zero line;

F_p - the area of the stressed part of the cross section.

Table 17*. Values of coefficients ϕ and $m_{дл}$ for concrete elements.

$\frac{l_0}{b}$	$\frac{l_0}{r}$	Values of ϕ					Values of $m_{дл}$	
		for heavy-aggregate concrete	For light-aggregate concrete, with values of α				for heavy-aggregate concrete	for light-aggregate concrete
			1500	1000	750	500		
≤4	≤14	1	1	1	1	0,98	1	1
6	21	0,98	0,98	0,96	0,95	0,91	1	1
8	28	0,95	0,95	0,92	0,90	0,85	1	1
10	35	0,92	0,92	0,88	0,84	0,79	0,96	[illegible]
12	42	0,85	0,88	0,84	0,79	0,72	0,92	[illegible]
14	49	0,85	0,85	0,79	0,73	0,66	0,88	[illegible]
16	56	0,81	0,81	0,74	0,68	0,59	0,84	[illegible]
18	63	0,77	0,77	0,70	0,63	0,53	0,80	[illegible]
20	70	0,73	0,73	0,65	0,58	0,48	0,75	[illegible]
22	76	0,69	0,69	0,61	0,53	0,43	0,69	[illegible]
24	83	0,65	0,65	0,56	0,48	0,38	0,67	[illegible]

where l_0 - the rated length of the element (see 6.2);

b - the minimum size of a rectangular cross-section;

r - the smallest radius of gyration of a cross section;

α - the elasticity characteristic of light-aggregate concrete equal to the ratio $\frac{E_б}{R^н_{пр}}$; with intermediate values of α the values of ϕ are taken in accordance with the nearest least value of α.

The elements of a rectangular cross section can be calculated using formula

$$M \leq \frac{bh^2}{3.5} R_p. \tag{15}$$

ECCENTRICALLY COMPRESSED ELEMENTS

6.5*. The rating of eccentrically compressed concrete elements with small eccentricities satisfying the condition

$$S_б > 0{,}8S_с, \tag{16}$$

and with a rectangular cross-section - satisfying the condition

$$e_0 < 0{,}225h, \tag{17}$$

is carried out under a condition of constancy of the moment of maximum compressive force relative to the weakly stressed face of the cross section (Fig. 6) using formula

$$N_п \leqslant \varphi_1 R_{пр} \frac{S_о}{e}, \tag{18}$$

and with a rectangular cross section - using formula

$$N_п \leqslant 0{,}5\varphi_1 R_{пр} \frac{bh^2}{e}. \tag{19}$$

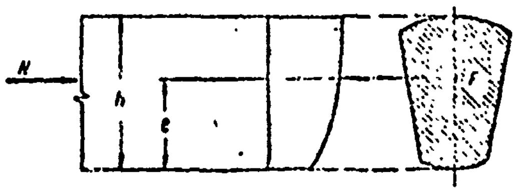


Fig. 6. Diagram of the distribution of forces and diagram of the stresses in a transverse cross section of an eccentrically compressed concrete element with a small eccentricity.

In formulas (16)-(19):

$S_б$ - the static moment of the cross-sectional area of the compressed zone of the concrete (the height of which is determined from the condition of the coincidence of its gravity center with the point of application of the longitudinal force) relative to the less stressed face of the cross section;

S_0 - the static moment of the entire cross-sectional area of an element relative to the less stressed face of the cross section;

$N_п$ - the cited longitudinal force determined with formula (11), in which coefficient $m_{дл}$ is found in Table 17, replacing the ratios l_0/b and l_0/r in it respectively with ratios l_0/h and $l_0/r_и$; cited force $N_п$ is applied with eccentricity $e_{о.п}$ calculated with formula (113a) - see 7.51;

$N_{дл}$ and $N_к$ - the same designations, as in formula (11);

e_0 - the distance from force $N_п$ to the center of gravity of the transverse cross section of the element;

e - the distance from froce $N_п$ to the less stressed face of the cross section;

ϕ_1 - the coefficient longitudinal flexure during eccentric compression

$$\phi_1 = k\phi; \qquad (20)$$

ϕ - the coefficient of longitudinal flexure taken from Table 17, in which values l_0/b and l_0/r are replaced respectively by l_0/h and $l_0/r_и$ - the radius of gyration of the cross section in the plane of flexure;

k - the coefficient which considers the effect of eccentric load application and is determined with formula

$$k = 1 - \frac{e_0}{h}\left(0{,}06\frac{l_0}{h_э} - 0{,}2\right); \quad (21)$$

$$h_э = 3{,}46\, r_и, \quad (22)$$

and for a rectangular cross section

$$h_э = h. \quad (23)$$

Note. In the case of the use of concrete of job-grade higher than 300 the values of coefficient k should be especially justified.

6.6. The rating of eccentrically compressed concrete elements with large eccentricities, which do not satisfy the conditions of (16) or (17), with the exception of the cases indicated in 6.7, is carried out on the basis of the positions cited in 6.4 (see Fig. 5); in this case it is recommended that the following formula be employed

$$M_я \leqslant \varphi_1 R_р W_т, \quad (24)$$

where $M_я$ - the moment of the external forces acting on one side of the cross section in question, relative to the core point, most distantly removed from the stressed face of the cross section; part of value $M_я$, depending on a long-term acting load, is increased by dividing by coefficient $m_{дл}$ in accordance with formula (11).

Value $W_т$ in formula (24) is determined with formula (13); in this case the position of the zero line in the cross section is determined as for flexural elements (i.e., assuming the absence of the longitudinal force) from condition (14).

Elements of a rectangular cross section can be rated using the following formula

$$N_п \leqslant 1{,}75\varphi_1 \frac{R_р bh}{6\frac{e_0}{h} - 1}, \quad (25)$$

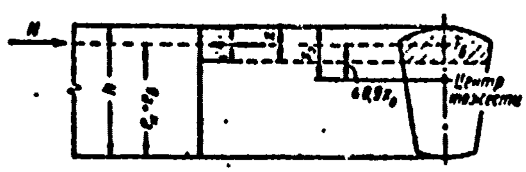
where value N_n is determined with formula (11).

6.7*. The rating of eccentrically compressed concrete elements, which are not subjected to the effect of an aggressive medium and are not located under the pressure of a fluid (with the exception of cornices and parapets), with large eccentricities, which do not satisfy the conditions of (16) or (17), can be carried out without considering the strength of the stressed zone of the concrete with a rectangular form the diagram of the stresses in the compressed zone (Fig. 7) using the following formula

$$N_n \leq \varphi_1 R_u F_6, \qquad (26)$$

where N_n - the cited longitudinal force determined using formula (11);

F_6 - the cross-sectional area of the compressed zone of concrete (determined not considering the strength of the stressed zone of the concrete).



(1)

Fig. 7. Diagram of the distribution of forces and a diagram of the stress in the transverse cross section of an eccentrically compressed with great eccentricity concrete element being rated without allowing for the strength of the stressed zone.
KEY: (1) Center of gravity.

In this case the height of the compressed zone is determined under the condition of the coincidence the center of gravity of the cross-sectional area of the compressed zone with the point of application of the resultant of the external forces.

Notes. 1. In the elements rated by formula (26), it is necessary to specify structural reinforcement in the stressed zone in accordance with the instructions of 12.61; when it is inexpedient or impossible to install this type of reinforcement the rating of the element must be carried out taking the strength of the stressed concrete into account (see 6.6).

2. In cases rated with formula (26), the value of the eccentricity of the rated force (including the random eccentricity) relative to the center of gravity of the section should not exceed 0.9y, where y - the distance from the center of gravity of the section to its most stressed face. In this case the distance from the point of application of the rated force to the most stressed face of the section should not be less than 2 cm. In rating cornices the value of the eccentricity of the rated force can not be more than 0.7y.

3. The rating of the strength of concrete wall panels can be carried out using formula (26) only when $e_0/h \leq 0.3$; when $e_0/h > 0.3$ the rating should be carried out taking the strength of the stressed zone into account in accordance with 6.6.

6.8. The rating of the support units of spanning structures on panel walls is carried out with the introduction to the bearing capacity of the element of coefficients which consider the effect of a mortar joint: 0.9 - with hardened mortar and 0.5 - with freshly mixed mortar.

6.9. In rating concrete elements having undisplaceable supports, the values of coefficients ϕ_1 and $m_{дл}$ are taken:

a) for sections in the middle third of the length of the element - from Table 17;

b) for sections within the limits of the extreme thirds of the length of the element - by linear interpolation, assuming in the support sections ϕ_1 and $m_{дл}$ to be equal to unity.

6.10. For elements operating in eccentric compression, besides taking the flexibility into account in the plane of the moment effect, testing of the sections should also be carried out taking the flexibility in the plane perpendicular to the flexural plane into account, is accomplished in the same way as for elements operating in axial compression (disregarding flexural moment).

RATING FOR LOCAL COMPRESSION

6.11. The rating of sections in local compression (warping) should be carried out using the following formula

$$N \leqslant \mu R_{см} F_{см}, \qquad (27)$$

where N - the rated load, applied to a part of the section in question (local load or the sum of local and base load);

$F_{см}$ - the bearing surface area;

μ - a coefficient taken equal to 1 with uniform load distribution on the bearing surface area and to 0.75 with non-uniform distribution of the local load under the ends of the beams, main beams and straight arches;

$R_{см}$ - the rated strength of the concrete with local compression, determined by the following formula

$$R_{см} = \gamma R_{пр}, \qquad (28)$$

$$\text{where } \gamma = \sqrt[3]{\frac{F}{F_{см}}}, \qquad (29)$$

but not more than the values of γ_1(depending on the site of the loading application, see Fig. 8), given in Table 18;

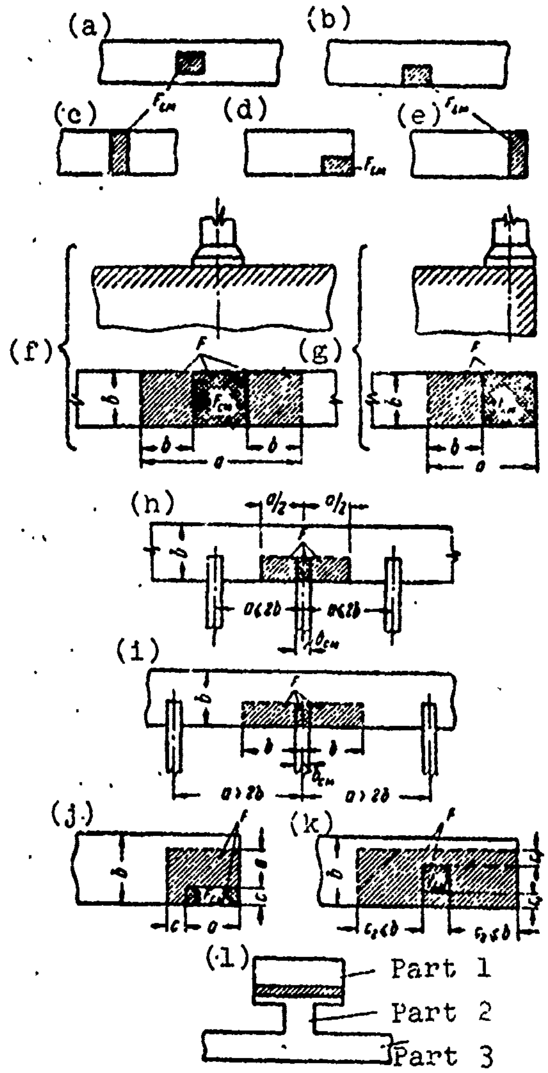


Fig. 8. Data for rating sections of elements in local compression (warping).
(a)-(e) - cases of the application of local load which determine the value of coefficient γ_1: (f)-(k) - cases of the distribution of local load and rated sectional areas F corresponding to them; (l) - is an example, when the individual parts of an element section are not included in rated sectional area F (parts 2 and 3 should not be considered when rating section 1 for warping); F_{CM} - the area of local compression (warping), to which the load is transferred; F - rated sectional area.

Table 18. Values of coefficient γ_1.

Type of load	Coefficient γ_1 in a local load application setup	
	From Fig. 8a, b, c	From Fig. 8d, e
In considering only local load	1.5	1.2
In considering local and base loads.........................	2	1.5

Notes: 1. In supporting the columns, of heavily loaded girders and beams, near the edge (the face) of a concrete wall it is assumed that $R_{см} = R_{пр}$.

2. If the local edge load $N_{см} > R_{пр}F_{см}$, then the section of the concrete element at the site of the application of this load should be reinforced with mesh reinforcement.

3. For light-aggregate concretes of job-grades of 100 and below given in Table 18 the coefficients of γ_1 are reduced by 20%.

F - the rated area of the section determined by the instructions of 6.12.

6.12. The rated sectional area F in formula (29) is taken in accordance with the following rules:

a) with the local load along the entire width of the section of element b parts with a length of not more than b in both directions from the edges of the local load (Fig. 8,f) are included in the rated area of the section;

b) with the local boundary load along the entire width of the section of element b the part adjacent to the edge of the local load, with a length of not more than b (Fig. 8,g) is included in the rated area of the section;

c) with the local load from the supporting of the ends of the main beams and girders a part with a width, equal to the length of the supporting part of the main beam or girder, and with a length in accordance with subparagraph of "b" but not more than the distance between the axes of the two adjacent spans between the girders (Fig. 8,i,j) is included in the rated sectional area;

d) with the edge local load on the corner of the section the part with a length of not more than dimension c in the direction of dimension a of the warping area and not more than a in the direction of dimension c of the warping area (Fig. 8, l) is included in the rated sectional area;

e) with the local load, applied to part of the length and width of the section, the rated area is assumed to be symmetrical with respect to the warping area, in accordance with Fig. 8,m. When several loads of the indicated type exists, the rated areas, moreover are limited by the lines, passing through the middle of the distances between the two adjacent loads.

Notes: 1. If a section has an intricate shape, it is not permitted to consider in the rated area the parts of the section, the proper connection of which with the loaded section is not provided for (for example in Fig. 8,n section parts 2 and 3 should not be considered in rating for local compression in part 1).

2. With the local load from the girders, main beams, straight arches and other elements operating in flexure, the depth of support l_{CM} considered in the rating in determining F_{CM} and F are assumed to be not more than 20 cm.

6.13. With the joint action on the section in question of the base and local loads the rating for warping is carried out in two variants:

a) for local load;

b) for the sum of local load and part of the base load being absorbed by warping area F_{CM}.

In these two variants of rating various values of coefficient γ_1 are taken in accordance with Table 18.

7. RATING OF ELEMENTS OF REINFORCED-CONCRETE STRUCTURES FOR STRENGTH

GENERAL INSTRUCTIONS

7.1. The rating of elements of reinforced-concrete structures for strength should be carried out for normal, and also for sections inclined (in the most dangerous direction) toward the axis of these elements.

When twisting moments are present it is also necessary to check the strength of an element in a three-dimensional section limited by a spiral crack in the most dangerous direction (see 7.58).

The supporting parts of elements should be tested by rating for warping; for prestressed structures, moreover, it is necessary to check the strength of the parts of an element under the effect of concentrated forces from stressed reinforcements.

It is also necessary to check the strength of elements in the zones of local loads concentrated in small areas.

7.2*. When stressed and unstressed reinforcement of various types and classes of steels are present in an element each type of reinforcement is introduced into the strength rating with its own rated strength. In this case the following products are in the rating formulas given below: R_aF_a and $R_{a.c}F'_a$ are replaced by the sum of the products of the rated strengths for the appropriate sectional areas, and products $R_{a.c}S_a$ and $R_aS'_a$ are replaced by the sum of products of the rated strengths of the reinforcement for the static moments of the appropriate sectional areas of the reinforcement.

When different grades of concrete are present in a section of an element the corresponding parts of the cross section are introduced into the strength rating with the rated strengths corresponding to these grades, but not exceeding triple the calculated strength of the concrete of the lowest grade.

In these types of elements the position of the center of gravity of the area of the entire concrete section or of its compressed zone, and also the static moments S_0 and $S_б$ should be determined, reducing the whole section to concrete of one grade in accordance with the accepted rated strengths.

7.3*. If longitudinal reinforcement A in flexural, eccentrically compressed in the first case (see 7.46) and in eccentrically stressed in the first case (see 7.54) reinforced-concrete elements is arranged in several rows within the limits of the height which exceeds half the height of the stressed zone of a section, then for rods arranged at a distance of more than 1/2(h - x) from the stressed face of the section, the rated strength of the reinforcement is introduced with coefficient 0.8.

Notes: 1. The instructions of 7.3 do not pertain to elements with the reinforcement arranged uniformly along the perimeter of the section (for example to elements of a ring cross section).

2. It is not permissible to introduce coefficient 0.8 specified by the present point with values of $S_б/S_0 \leq 0.45$, if reinforcement A is made from any type of reinforcing steel of the numbers specified by 2.7 of the present Codes, except steel of class A-1.

7.4. If in centrally compressed, flexural or eccentrically compressed reinforced-concrete elements the sectional area of the longitudinal reinforcement situated in the compressed zone, is more than 3% of the sectional area of this zone, then in the rating equations it is necessary to consider the decrease in the actual concrete area of the compressed zone by the value of the sectional area of the reinforcement located in it (for centrally compressed elements in accordance with the instructions of the note to 7.10, and for all other elements - in accordance with appropriate instructions).

7.5. The rated lengths l_0 in rating centrally and eccentrically compressed reinforced-concrete elements for strength taking longitudinal flexure into account can be determined in the same way for elements of semirigid frame construction (plane or space) under the assumption of nonsimultaneous loss of stability by them assuming that the design load is situated most disadvantageously for the element in question.

It is possible to assume the following value of rated lengths of reinforced-concrete elements:

a) for columns of single-storey industrial buildings with coverings, rigid in their plane (of reinforced-concrete, reinforced foamed concrete, etc., slabs), and also for trestles - in accordance with Table 19;

b) for columns of multistorey buildings with the number of spans not less than two and with a ratio of the width of the building to its height of not less than 1/3, and also for elements of reinforced-concrete girders and arches - in Table 20.

Table 19*. The rated lengths l_0 of columns of single-storey industrial buildings with rigid coverings (of reinforced-concrete, reinforced foamed concrete and similar slabs) and of trestle and pier columns.

Characteristics of columns			Rated length l_0 of columns in rating them in the plane: of bearing structures of coverings (structural girders, beams, etc.) perpendicular to the axis of piers or trestles	of the axis of a longitudinal row of columns or of the parallel axis of a pier or trestle: in the absence of connections in the plane of a longitudinal row of columns	of the axis of a longitudinal row of columns or of the parallel axis of a pier or trestle: in the presence of connections in the plane of a longitudinal row of columns
For buildings with travelling cranes	Sub-crane part of the columns	split	$1.5H_H$	$1.2H_H$	$0.8H_H$
		solid	$1.2H_H$	$0.8H_H$	
	Super-crane part of the columns with super-crane girders	split	$2.5H_B$	$2H_B$	$1.5H_B$
		solid	$2H_B$	$1.5H_B$	
For buildings without travelling cranes		single-span	1.5H	1.2H	H
		two and multi-span	1.2H		
For open crane gantries with sub-crane girders		split	$2H_H$	$1.5H_H$	H_H
		solid	$1.5H_H$	H_H	–
				in the absence of anchor supports	in the presence of anchor supports
For open trestles for conduits with connecting of the columns by a spanning structure.		hinged	2H	2H	H
		rigid	1.5H	1.5H	0.7H

where H – the total height of the column, beginning from the top of the foundation; H_H – the height of the sub-crane part of the column from the top of the foundation to the bottom of the sub-crane beam; H_B – the height of the super-crane part of the columns: in precast construction – from the bottom of the sub-crane girder to the top of the column; in monolithic construction – from the top of the sub-crane girder to the top of the column.

Notes: 1. The values of the rated lengths of columns of crane shops are given for the case of their rating taking crane load into account; if the rating is carried out without considering crane load, then the rated lengths of columns should be taken as for buildings without travelling cranes; in this case for stepped columns the rated length of the upper part is taken in the same way as when considering crane load.

2. If stepped columns (of the type used for buildings with travelling cranes) are used in buildings without travelling cranes, then the rated length of the upper part (with height H_B) is taken equal to $2.5H_B$.

3. It is permissible to take the values of the rated lengths given in Table 19 for double-branched columns (taking notes 1 and 2 to this table into account).

Table 20*. Rated lengths l_0 of multi-storey building columns and of compressed elements of girders and arches.

Name of elements			Rated length l_0
Columns of multi-storey buildings with the number of spans not less than two and the ratio of the width of the building to its height not less than 1/3, in spanning structures	precast		H
	monolithic		0.7H
Compression girders elements	top chord in rating in the plane and out of the plane of a girder		l
	diagonal and vertical struts in rating in the plane of a girder		$0.8l$
	the same, in rating out of the plane of a girder		l
Arches	in rating in the plane on an arch	three-hinged	0.58S
		double-hinged	0.54S
		hingeless	0.36S
	in rating out of the plane of an arch	any	S

where H - the height of a storey; l - for the upper chord of girders - the distance between the points of its attachment, and for vertical and diagonal struts - the length of the element between the centers of girder joints; S - the length of an arch along its geometric axis.

Notes: 1. The rated length of the elements of a girder framework in rating out of the plane of the girder can be taken less than l (but not less than $0.8\ l$), if the width of the girder chords is greater than the width of the framework elements and if there are powerful joint connections.

2. The effective length of the elements of the upper girder chords and supporting struts with their calculation in the plane of the girder can be taken as equal to $0.8\ l$ with the presence, on the element of the local load in question, of the component of a considerable fraction of the overall load on the girder.

3. The instructions in Table 20 extend to columns of multi-storey buildings when the number of storeys is not more than 8 and when the linear rigidity of cross girders is not less than the linear rigidity of the columns.

ADDITIONAL INSTRUCTIONS ON THE STRENGTH RATING OF PRESTRESSED ELEMENTS

7.6*. In flexural, centrally and eccentrically compressed, and also eccentrically stressed in the first case of prestressed reinforced-concrete elements the stressed reinforcement having adhesion with concrete and situated in a zone compressed (most compressed) due to the effect of external forces, is introduced into the rating not with rated strength $R_{a.c}$ but with stress σ'_c (in kg/cm^2), equal to

$$\sigma'_c = 3600 - m_T\sigma'_0, \qquad (30)$$

where σ'_0 - pre-tensile stressing (in kg/cm^2) in the reinforcement situated in the zone compressed (most compressed) due to the effect of external forces, taken depending on the stage of operation of the element in question, the stress conditions of the reinforcement and the magnitude of the losses in accordance with the instructions of 5.4 of the present Codes; m_T = 1.1 (see 5.3). Stress σ'_c can be compressive, zero or tensile. If stress σ'_c is compressive, then it should be assumed to be not more than $R_{a,c}$.

If the stressed reinforcement situated in a zone compressed due to the effect of external forces, is made of steel of various types or classes, each of them is introduced into the calculation with its value σ'_c.

7.7. In the strength rating of an element for the effect of central or eccentric precompression (taking the dead load or assembly loads into account in the necessary cases) the forces of the stressed reinforcement are introduced into the calculation as external loads; in this case the following instructions are considered:

a) for centrally compressed elements the compressive force is determined by taking the entire stressed reinforcement (N_{H}) into account;

b) for eccentrically stressed elements the compressive force is determined only from the stressed reinforcement situated in the most compressed zone (N'_{H});

c) in calculating compressive forces N_{H} and N'_{H} the stresses in the stressed reinforcement are assumed equal to:

in stressing reinforcement with abutments - $\sigma_0 - \sigma_{\Pi}$,

where σ_0 - the prestressing in the reinforcement after the appearance of losses occurring before the termination of concrete compressing; σ_{Π} - the magnitude of the reduction (loss) in prestressing in the reinforcement in bringing the concrete of the compressed zone up to the maximum state, equal to 3000 kg/cm^2, but not more than stress σ_0;

in simultaneously stressing of all the reinforcement in the concrete - σ_{H},

where σ_{H} - the controlled prestressing in the reinforcement at the end of the compressing of the concrete before the appearance of losses;

with stressing of the reinforcement in the concrete alternately in groups - $\sigma_0 - \sigma_{\Pi}$,

where σ_0 - the same value, as in stressing reinforcement in abutments; σ_{Π} the magnitude of the reduction (losses) in prestress in the reinforcement, equal to

$$\sigma_{\Pi} = \frac{F_1 F_{p.H}}{F_2 F_{H}} 3000 \text{ kg/cm}^2, \quad (31)$$

but not more than 2500 kg/cm^2; F_1 and F_2 - respectively the smallest and greatest transverse sectional areas of a compressed element; for elements with a constant transverse section it is assumed that

$$\frac{F_1}{F_2} = 1;$$

$F_{p.H}$ - the area of the stressed reinforcement of all groups of the compressed zone of an element, whose strength is being checked except the area of the latter group which is equal to $F_H - F_{p.H}$; F_H - for centrally compressed elements, - the sectional area of all the stressed reinforcement ; for eccentrically compressed elements, - the sectional area of the entire stressed reinforcement of the compressed zone of the element, whose strength is being checked.

The strength rating during the compressing of the concrete of a structure is carried out taking the rated strength of the concrete into account which corresponds to its strength at the moment of compression.

Notes: 1. In stressing reinforcement in concrete in elements which have sectional contraction in individual regions (for example due to the making of apertures), the strength rating of the sections in these regions should be carried out for the compressive force by the reinforcement, determined by taking the instructions of 7.7 into account but with the value of the reduction of prestress in the reinforcement $\sigma_n = 0$.

2. When stressed reinforcement is present, which is not parallel to the longitudinal axis of the element, there is introduced into the compressive strength rating a longitudinal component of the stress force of the reinforcement (see the note to 5.2).

7.8. The strength rating of a reinforced-concrete element during the compressing of the concrete by the reinforcement stressed in the concrete, is carried out taking the effect of the longitudinal flexure or deflection of the element into account when necessary; in these cases:

a) in reinforcement, not having adhesion with the concrete and capable of being displaced in the transverse section of an element situated in channels, grooves, recesses or outside the limits of the section, it is necessary to consider:

in axial compressing of an element - the effect of longitudinal flexure in accordance with instructions of 7.10 and 7.11;

in eccentric compressing of an element - the effect of element deflection in the plane of the action of the moment on the magnitude of eccentricity of the longitudinal force in accordance with the instructions of 7.51 and 7.52;

b) with reinforcement situated in closed channels and not displaced with respect to the longitudinal section of the element, the effect of longitudinal flexure or deflection of the element is disregarded.

The rating of the strength of a reinforced-concrete element during compressing of the concrete by the reinforcement stressed in abutments and having adhesion with the concrete, is carried out without considering the effect of longitudinal flexure or deflection of the element due to the compression.

In determining of the deflection of an element and in rating it for longitudinal flexure in the compression stage, besides the compressive force, when necessary one must consider the effect of the ·ad load of the element, its joint operation with the other structural elements, etc.

In rating the strength of elements with reinforcement, not having adhesion with the concrete, indicated in subparagraph "a" of the present point, for the precompressing effect the rated length of the element is assumed to be equal to the distance between the devices which fasten the reinforcement to the concrete along the length of the element.

7.9*. For prestressed elements of the 3rd category of crack resistance, whose strength is depleted with the formation of cracks in tensile stressed area as a result of the attainment of the rated strength by the stressed reinforcement , the forces received by the section of the element, should be assumed reduced by 15% in comparison with those determined by calculation.

CENTRALLY COMPRESSED ELEMENTS

7.10. The rating of the strength centrally compressed reinforced-concrete elements with transverse reinforcement in the form of individual clamps or welded to the longitudinal reinforcement rods (Fig. 9a), with the exception of the case, specified by 7.11, is carried out under the following condition

$$N_n \leqslant \varphi (R_{np}F + R_{a.c}F_a), \qquad (32)$$

where N_n - the given longitudinal force determined with formula (11) with the values of factor $m_{дл}$, taken from Table 21; φ - the coefficient of longitudinal flexure taken from Table 21.

Note. If the sectional area of longitudinal reinforcement F_a is more than 3% of the entire sectional area of element F, then in formula (32) the value of F is replaced by the value of $F - F_a$ (see 7.4).

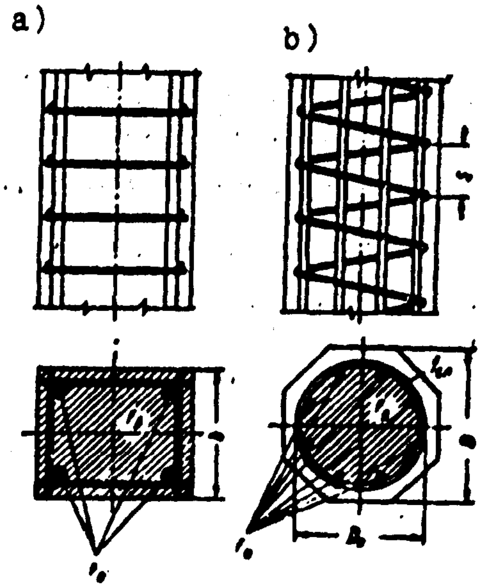


Fig. 9. The transverse reinforcement of centrally compressed reinforced-concrete elements a) reinforcement with the transverse rods welded to the longitudinal rods, b) reinforcement with a spiral.

Table 21*. The values of factors ϕ and $m_{дл}$ for reinforced-concrete elements.

	l_0/b	≤8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	l_0/D	≤7	8,5	10,5	12	14	15,5	17	19	21	22,5	24	26	28	29,5	31	33	34,5
	l_0/r	≤28	35	42	48	55	62	69	76	83	90	97	104	111	118	125	132	139
For heavy-aggregate concrete	φ	1	0,98	0,96	0,93	0,89	0,85	0,81	0,77	0,73	0,68	0,64	0,59	0,54	0,49	0,44	0,4	0,35
	$m_{дл}$	1	1	0,96	0,93	0,89	0,85	0,81	0,78	0,74	0,7	0,67	0,63	0,59	0,55	0,52	0,48	0,45
For light-aggregate concrete	φ	1	0,96	0,9	0,84	0,78	0,73	0,67	0,61	0,55	0,51	0,46	0,41	0,36	0,32	0,28	0,24	0,21
	$m_{дл}$	1	0,96	0,92	0,88	0,84	0,8	0,77	0,73	0,69	0,65	0,61	0,57	0,53	0,49	0,45	0,42	0,38

Here l_0 - the rated length of an element (see 7.5); b - the smallest dimension of the rectangular section; D - the diameter of the round section; r - the smallest radius of gyration of the section.

Note: 1. For structures of light-aggregate concrete, in which porous sand is the fine filler, value $m_{дл}$ should be reduced by 15%.

2. For structures of light-aggregate concrete based on natural fillers the values of ϕ and $m_{дл}$ can be taken on the basis of substantiated experimental data.

3. For structures of light-aggregate concrete of job-grades of 100 and lower the values of ϕ and $m_{дл}$ are taken from special standard documents or should be justified by experimental data.

7.11. The rating of the strength centrally compressed reinforced-concrete elements with stressed reinforcement, not having adhesion with the concrete and capable of being displaced in the longitudinal section of the element (see 7.8), is carried out for the two cases:

a) with the full rated length of the element and the given longitudinal force $N_{\text{п}}$;

b) with the rated length of an element, equal to the distance between the reinforcement attachment points and with given longitudinal force $N_{\text{п}}$, in which the resultant of the forces in the entire stressed reinforcement is considered after the compressing of concrete $N_{\text{н}}$; in this case in formula (11) it is necessary to replace rated longitudinal force $N_{\text{дл}}$ by the sum of forces $N_{\text{дл}} + N_{\text{н}}$.

7.12. In rating the strength of centrally compressed reinforced-concrete elements of a solid section with oblique stressed reinforcement in the form of spirals or welded rings (see Fig. 9b) the following condition should be satisfied

$$N \leqslant R_{\text{пр}} F_{\text{я}} + R_{\text{а. с}} F_{\text{а}} + 2 R_{\text{а}}^{\text{с}} F_{\text{сп}}, \qquad (33)$$

where $F_{\text{я}}$ - the area of the concrete section contained within the spiral contour or annular reinforcement; $R_{\text{а}}^{\text{с}}$ - the rated tensile strength of the spiral (annular) reinforcement; $F_{\text{сп}}$ - the given spiral section (the annular reinforcement), equal to $F_{\text{сп}} = \pi D_{\text{я}} f_{\text{сп}}/s$; $D_{\text{я}}$ - the diameter of the spiral (the rings); $f_{\text{сп}}$ - the sectional area of the spiral rod (the rings); s - the pitch of the spiral (the rings).

Calculation with formula (33) is carried out when the given spiral section is not less than 25% of the sectional area of the longitudinal reinforcement and when simultaneously $l_0/D \leq 10$; if one of these conditions is not observed, and also when calculating with formula (33) the bearing capacity of an element is less than with formula (32), the calculation is carried out without considering the oblique reinforcement in accordance with the instructions of 7.10 and 7.11 (in these cases the use of oblique reinforcement is not recommended).

The magnitude of breaking stress for an element with oblique reinforcement should not exceed one-and-one-half times the value of the breaking stress determined using formula (32).

7.13. In rating for local compression (warping) of reinforced-concrete elements with oblique reinforcement in the form of welded grids (for example under anchoring devices of stressed reinforcement ; under the centering inserts in column joints, etc.) the following conditions should be satisfied

$$N \leqslant \xi R_{пр} F_{см} + \mu_к R_а F_я, \qquad (34)$$

where ξ - the factor which considers the effect of the concrete casing on the increase in the bearing capacity of the concrete with warping, determined by the formula

$$\xi = 4 - 3\sqrt{\frac{F_{см}}{F}}, \qquad (35)$$

but taken to be not more than 3.5; it is necessary to use formula (34) when $\xi \geq 2$.

Here $F_{см}/F$ - the ratio of the warp area to the total rated area, to which the load is transferred; in this case rated area

F is taken in accordance with the instructions of 6.12 (see Fig. 8); R_a - the rated tensile strength of the grid rods in the oblique reinforcement; μ_K - the volumetric coefficient of the oblique reinforcement determined with the formula

$$\mu_K = \frac{n_1 f_{a1} l_1 + n_2 f_{a2} l_2}{l_1 l_2 s}, \qquad (36)$$

n_1, f_{a1}, l_1 - respectively, the number of rods, the sectional area of one rod and the length of a grid rod in one direction; n_2, f_{a2}, l_2 - respectively, the number of rods, the sectional area of one rod and the length of grid rod in the other direction, s - the distance between the grids; $F_{\text{я}}$ - the area of the concrete included within the grid contour, considering for their extreme rods. The sectional areas of the grid rods per unit length in one and the other direction should not differ by more than 1.5 times.

The welded grids of the oblique reinforcement should be installed near the face of an element in a quantity of not less than 4 pieces; when longitudinal reinforcement is present, it should pass within the contour of the welded grids which are arranged in a length (starting from the face of the element) of not less than 20d, if the longitudinal reinforcement is made from smooth rods, bundles or strands not less than 10d, if it is made from deformed rods (where d - the diameter of a rod, bundle or strand).

The rating for local contraction (warping) of reinforced-concrete elements in the absence of oblique reinforcement should be carried out in the same way as for concrete elements (see 6.11-6.13).

Note. Instead of welded grids with closed cells other equivalent types of oblique reinforcement (which intersect the grids in the form of ridge, spiral, etc.), can be used under the condition of ensuring its correct position in the concreting process.

CENTRALLY TENSILE STRESSED ELEMENTS

7.14. In rating centrally stressed reinforced-concrete elements for strength the following condition should be observed

$$N \leqslant R_a F_a. \qquad (37)$$

For prestressed elements reinforced with wire, bundles or strands without anchors, when testing the sections near the ends of an element within the limits of the length of the anchoring zone of the stressed reinforcement (see Table 23) the rated strength of this reinforcement in formula (37) should be assumed reduced in accordance with the instructions of 7.28

FLEXURAL ELEMENTS

7.15. The calculation of sections, normal to the longitudinal axis, of flexural reinforced-concrete elements (Fig. 10), with the exception of the case, specified in 7.17 "b," is carried out under the following condition

$$M \leqslant R_u S_б + R_{a.c} S_a; \qquad (38)$$

in this case the position of the neutral axis, and also the area and the shape of the section of the compressed zone of the concrete are determined by the following condition

$$R_a F_a - R_{a.c} F'_a = R_u F_б, \qquad (39)$$

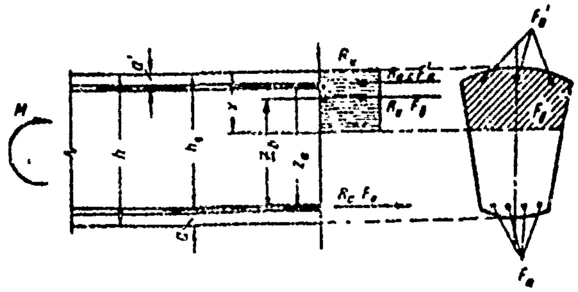


Fig. 10. Diagram of location of forces and stress diagram in the cross section of a bendable concrete element during its strength calculation.

and for unsymmetrical sections and for sections having at least one axis of symmetry and subject to flexure in a plane, not parallel to this axis (oblique flexure) (Fig. 11), moreover, by the condition of the parallelness of the planes of the effect of the external and internal moments, which for symmetrical sections is expressed by the formula

$$\mathrm{tg}\,\beta = \frac{M_y}{M_x}, \qquad (40)$$

where β – the angle included between the plane of effect of the internal pair of forces and the axis of symmetry of section x; M_x – the component of flexural moment which causes flexure in the plane of the x-axis; M_y – the component of flexural moment which causes flexure in the plane of the y-axis normal to the x-axis.

With the presence of stressed reinforcement situated in the compressed zone, this reinforcement is considered in the calculation in accordance with the instructions of 7.6.

If concrete or reinforcement of several types or grades (classes) is used, then it is necessary to consider the instructions of 7.2. With the positioning of longitudinal reinforcement in the stressed zone in several rows over the height of the section the requirement of 7.3 should be considered.

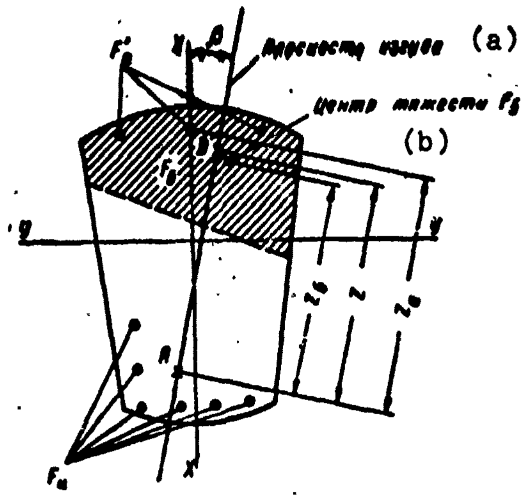


Fig. 11. Diagram of the arrangement of forces and the position of the neutral axis in the transverse section of a reinforced-concrete element subjected to oblique flexure A - the point of the application of the resultant of the forces in the whole stressed reinforcement; D - the point of the application of the resultant of all the compressive forces in the section (in the concrete and in the compressed reinforcement).
KEY: (a) Plane of flexure; (b) Center of gravity $F_б$.

7.16. For flexural elements of rectangular cross-sections in the plane of the axis of symmetry the rating of the sections, normal to the longitudinal axis of the element, is carried out under the following condition

$$M \leqslant R_u bx \left(h_0 - \frac{x}{2}\right) + R_{a.c} F'_a (h_0 - a'), \qquad (41)$$

in this case the position of the neutral axis is determined by the following formula

$$R_a F_a - R_{a.c} F'_a = R_u bx. \qquad (42)$$

7.17. The rating of symmetrical sections, normal to the longitudinal axis of flexural (in the plane of the axis of symmetry) elements having a flange in the compressed zone (T-shaped, double-T-shaped, etc.), is carried out in the following manner:

a) if the neutral axis terminates in the flange (Fig. 12a), i.e.,

$$R_a F_a \leq R_u b'_n h'_n + R_{a.c} F'_a \qquad (43)$$

then the calculation is carried out as for rectangular cross-sections with a width of b'_n;

b) if neutral axis terminates in the rib (Fig. 12b), then the calculation is carried out under the following condition

$$M \leq R_u b x \left(h_0 - \frac{x}{2}\right) + R_{np} (b'_n - b) \times \left(h_0 - \frac{h'_n}{2}\right) h'_n + R_{a.c} F'_a (h_0 - a'); \qquad (44)$$

in this case the position of the neutral axis is determined by the following formula

$$R_a F_a = R_u b x + R_{np} (b'_n - b) h'_n + R_{a.c} F'_a. \qquad (45)$$

In formulas (44) and (45) h'_n - the thickness of the compressed flange; b'_n - the rated width of the compressed flange.

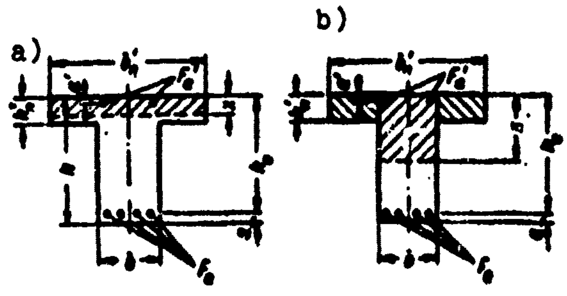


Fig. 12. Shape of the compressed zone in the transverse section of a T-shaped reinforced-concrete element; a) with positioning of the neutral axis in the flange; b) with positioning of the neutral axis in the rib.

7.18. In flexural reinforced-concrete elements with a flange in the compressed zone the width of the flange overhang in each direction from the rib introduced into the calculation should not exceed half of the distance inside the adjacent ribs and 1/6 of the span of the element being rated. Moreover, for elements, not having on the length of the span transverse ribs or having transverse ribs at distances greater than the distance between the longitudinal ribs, when $h'_п < 0.1h$ the width of flange overhang introduced into the calculation in each direction from the rib should not exceed magnitude $6h_п$.

For individual T-beams (with cantilever flange overhangs) the width of the flange introduced into the calculation in each direction from the rib should be:

when $h'_п \geq 0.1\ h$ - not more than $6h'_п$;

when $0.05\ h \leq h'_п < 0.1\ h$ - not more than $3h'_п$;

when $h'_п < 0.05h$ the cantilever flange overhangs are not introduced into the calculation and the element section is rated in the same way as a rectangular section with a width of b.

7.19. In flexural reinforced-concrete elements of symmetrical cross sections the position of the neutral axis which corresponds to the sufficient strength of the concrete in the compressed zone, with flexure in the plane of the axis of symmetry should satisfy the following condition

$$\frac{S_б}{S_0} \leqslant \xi. \qquad (46)$$

For elements which have a flange in the compressed zone, with positioning of the neutral axis in the rib the testing of condition (46) is carried out in the same way as for elements of rectangular cross-section, without considering flange overhangs. The overhangs of a flange, situated in a stressed area, in testing condition (46), are not considered in all cases.

For elements of rectangular cross-section subjected to oblique flexure, it is recommended that the testing of the sufficient strength of the concrete in the compressed zone be carried out, using the following condition

$$\frac{\frac{S_{\text{б}x}}{S_{0x}} + \frac{S_{\text{б}y}}{S_{0y}}\sqrt{tg\beta}}{\sqrt{1+tg\beta}} < \zeta \qquad (47)$$

where $S_{\text{б}x}$ and S_{0x} - static moments respectively of the compressed zone of the concrete and of the entire working section of the concrete relative to the axis, normal to the x-axis and passing through the point of application of the resultant of the forces in the reinforcement stressed due to the effect of moment M_x and situated near the face of the element, normal to the x-axis; $S_{\text{б}y}$ and S_{0y} - the same, relative to the axis, normal to the y-axis and passing through the point of application of the resultant of the forces in the reinforcement stressed due to the effect of moment M_y and situated near the face, normal to the y-axis.

The values of factor ζ depending on the job-grade of the concrete are taken from Table 22. The recommendations of present point do not extend to elements of circular or round cross-section with the longitudinal reinforcement distributed uniformly over the circumference (see 7.23).

Table 22*. The values of factor ζ.

Type of concrete	Factor ζ with a concrete job grade of				
	300 and below	350	400	500	600
Heavy-aggregate..........	0.8	-	0.8	0.7	0.65
Light-aggregate..........	0.8	0.7	0.65	-	-

7.20. If the quantity of reinforcement in the stressed zone of a section of a flexural element is taken to be greater than is necessary for observing conditions (38), (41) or (44) (for example under the condition of rating for crack formation), then when testing conditions (46) and (47) it is necessary to consider only that part of the reinforcement section in the stressed zone which is required from the rating for strength.

7.21. If the reinforcements situated in the compressed zone is considered in the calculation, then it is possible to use the instructions of 7.15-7.17 only upon the observance of the following condition

$$z_б \leqslant z_а, \qquad (48)$$

where $z_а$ - the distance between the resultants of the forces in the reinforcement of the compressed and tensile stressed zones; the stressed reinforcement of the compressed zone which is tensile stressed in the 1st limiting condition, is not considered in determining the value of $z_а$; $z_б$ - the distance between the resultants of the forces in the concrete of the compressed zone and in the reinforcement of the tensile stressed zone.

If condition (48) is not observed (which can occur when excess reinforcement with respect to that required by calculation) is placed in the compressed zone, then it is necessary, not using formulas (38)-(45), to determine the required sectional area of tensile stressed reinforcement from the following condition

$$M \leqslant R_a F_a z_a. \qquad (49)$$

7.22. The placing of special rated unstressed reinforcement in the compressed zone of flexural elements is permitted only when the height of the section is limited, when flexural moments of two signs are present, or in cases when there are any special requirements (for example to reduce creep in the compressed zone of the concrete for the purpose of increasing the rigidity of the element); the use of sections with double reinforcement not satisfying the following condition is not recommended

$$M \leqslant R_u S_0. \qquad (50)$$

Unstressed reinforcement situated in the compressed zone should not be considered in the calculation, if the observance of condition (49) leads to a decrease in the rated strength of the element in comparison with that obtained using formulas (38)-(45) neglecting the unstressed reinforcement of the compressed zone.

7.23*. Flexural reinforced-concrete elements of annular cross-section (tubular) with stressed and unstressed longitudinal reinforcement uniformly distributed along the length of the circumference (Fig. 13), should satisfy the following condition

$$M \leqslant \frac{1}{\pi}\left[R_{pr} F \frac{r_1 + r_2}{2} + (R_n + \sigma_0) F_n r_n + (R_a + R_{a.c}) F_a r_a\right] \sin \pi\alpha_k, \qquad (51)$$

where

$$\alpha_k = \frac{R_n F_n + R_a F_a}{(R_n + \sigma_0) F_n + (R_a + R_{a.c}) F_a + R_{pr} F}; \qquad (52)$$

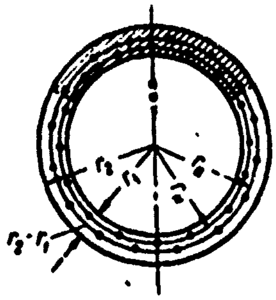


Fig. 13. The transverse section of a tubular reinforced-concrete element operating in flexure or in eccentric compression with large eccentricity (the accepted shape of the compressed zone is shaded).

in this case the values of $\alpha_{к}$ should satisfy the following conditions:

a) for elements with unstressed reinforcement (i.e., when $F_{н} = 0$), and also for elements with unstressed and stressed reinforcement when $\sigma_0 < 2000$ kg/cm^2

$$\alpha_{к} \leqslant \frac{\zeta}{2{,}7}; \qquad (53)$$

b) for elements only with stressed reinforcement (i.e., when $F_a = 0$)

$$\alpha_{к} \leqslant \frac{\zeta}{1{,}6}; \qquad (54)$$

c) for elements with unstressed and stressed reinforcement when $\sigma_0 \geq 2000$ kg/cm^2

$$\alpha_{к} \leqslant \frac{F_{н} + 0{,}9F_{а}}{2F_{н} + 3F_{а}} \cdot \frac{\zeta}{0{,}8}. \qquad (55)$$

In formulas (51) and (52) it is necessary to assume:

$$\sigma'_c = 3600 - m_1\sigma_0; \qquad (56)$$

stress σ'_c can be compressive, zero or tensile. If stress σ'_c is compressive, then it is necessary to observe the following condition:

$$\sigma'_c \leq R_{H.c}. \qquad (57)$$

In formulas (51)-(57) the following designations are accepted:

F - the area of the entire concrete section; F_a - the sectional area of the entire longitudinal unstressed reinforcement; F_H - the sectional area of the entire longitudinal stressed reinforcement ; r_1 and r_2 - respectively, the internal and external radii of the annular cross section; r_a and r_H - respectively, the radii of the circles, passing through the sectional centers of the longitudinal unstressed and stressed reinforcement rods; R_H and $R_{H.C}$ - the rated strengths of the longitudinal stressed reinforcement respectively in tension and in compression; m_T - the quality coefficient reinforcement prestressing, equal to $m_T = 1.1$ (see 5.3); σ_0 - the prestressing of the reinforcement taking the losses into account (see 5.2-5.6); ζ - the coefficient determined from Table 22.

Notes: 1. In rating elements, not subjected to prestressing, the value of F_H in formulas (51) and (52) is assumed equal to zero.

2. The recommendations of 7.23 extend to sections with the ratio $\frac{r_2 - r_1}{r_2} \leq 0.5$ when the number of longitudinal rods in the transverse section of an element is not less than 6.

7.24*. The rating of sections, inclined toward the longitudinal axis of a reinforced-concrete element, should be carried out both for the effect of flexural moment and also for the effect of transverse force.

As the rated value of moment in an inclined section there is taken the moment of all the external forces acting on one side from the inclined section in question, relative to the axis, normal to the plane of flexure and passing through the point of application of the resultant of the forces in the compressed zone of this section.

As the rated value of transverse force for inclined sections there is taken the transverse force in the section, normal to the longitudinal axis of the element, situated near the end of the section in the compressed zone, but in this case the part of the load situated within the limits of the length of the projection of the inclined section (decreasing the value of the transverse force), is considered only when this part of the load acts on the given portion constantly and cannot be mixed (see, for example, 7.33).

7.25. Elements of rectangular, T-shaped, double-T-shaped and box-shaped sections should be designed in such a way that the following condition is satisfied

$$Q \leqslant 0{,}25 R_n b h_0. \qquad (58)$$

7.26*. The rating of inclined sections of elements with respect to flexural moment (Fig. 14) should be carried out from the following condition

$$M \leqslant R_a F_a z + \sum R_a F_o z_o + \sum R_a F_x z_x, \qquad (59)$$

where F_o - the sectional area of all bent-up rods situated in one (inclined toward the axis of the element) plane intersecting the inclined section in question; F_x - the sectional area of all transverse rods (stirrup branches) situated parallel to the plane of flexure in one plane normal to the axis of the element intersecting the inclined section in question; when the transverse rods have an identical diameter F_x - $f_x n_x$; f_x - the sectional area of one transverse rod, parallel to the plane of flexure (one stirrup branch); n_x - the number of transverse rods (stirrup branches) arranged in one plane normal to the axis of the element; z_o and z_x - the distances from the center of gravity of the compressed zone of the concrete to the planes of the positioning respectively of the bends and the transverse rods which intersect the inclined section of the element in question.

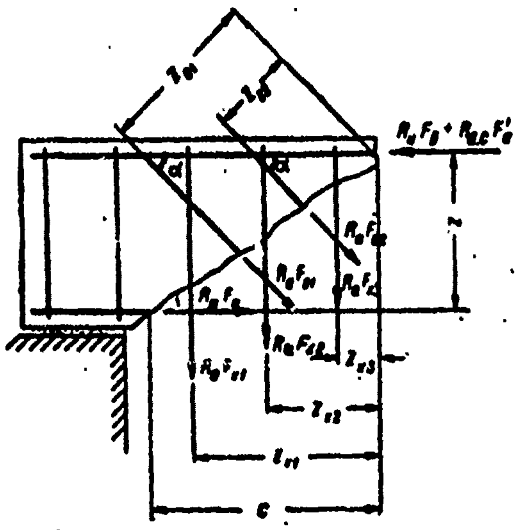


Fig. 14. Diagram of the forces acting in an inclined section of a bent reinforced-concrete element, when it is being rated for strength.

The direction of the most dangerous inclined section (with respect to flexural moment) for elements with a constant sectional height is determined from the following condition

$$Q = \sum R_a F_o \sin\alpha + \sum R_a F_x, \qquad (60)$$

where Q - the rated transverse force near the end of an inclined section in the compressed zone of an element; α - the angle of incline of bent-up rods to the longitudinal axis of an element in the section in question.

Note. In rating an inclined section the position of its neutral axis is determined from condition (39) in the same way as for a section, normal to the axis of the element and situated in such a way, so that the center of gravity of its compressed zone lies on the inclined section.

7.27*. The testing for flexure in inclined sections for beams with a constant or with a smoothly varied height (with the exception of the case, specified in 7.28) cannot be carried out, since the observance of the requirements of 7.36, 7.40, 12.9, 12.12, 12.33 and 12.34 ensures sufficient strength of inclined sections with respect to flexural moment.

For elements with a sharply varied cross-sectional height, for example for beams or cantilevers which have undercutting, calculation should be carried out for the effect of flexural moment in the inclined section, passing through the undercutting entry angle (Fig. 15).

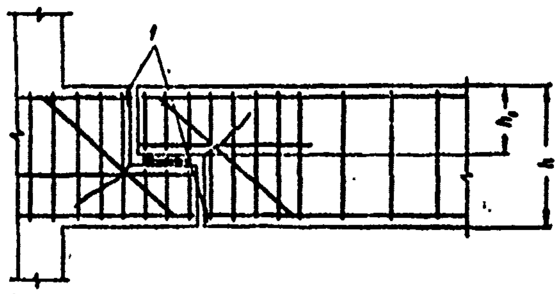


Fig. 15. The most probable sites of the formation of inclined cracks in reinforced-concrete beams with a sharply varied transverse sectional height. 1 - anchor washers.

7.28*. For prestressed elements reinforced with rod and wire reinforcement without anchors, the flexural strength should be tested with respect to inclined sections beginning near the support face, and also along the length of anchoring zone l_{aH} (see Fig. 37). In this case the strengths of the reinforcement is taken at the beginning of the anchoring zone to be equal to zero, and in the remaining points equal to $\sigma_0 \, l_x/l_{aH}$, but not more than R_a, where l_x - the distance from the beginning of the anchoring zone to the point in question. Value l_{aH} (in cm) is taken to be depending on the type and class of reinforcement:

Table 23*. Values of coefficient k_{aH} for determining the length of the anchoring zone l_{aH} of high-strength deformed reinforcing wire and seven-wire reinforcing strands, used without special anchors.

Type of reinforcement	Values of coefficient k_{aH} with the cube strength of the concrete at the moment of its compression R_0 in kg/cm^2			
	200	300	400	500
1. High-strength deformed wire	100	80	60	45
2. Seven-wire strands with a diameter of 4.5-9 mm	70	60	50	45
3. The same, with a diameter of 12 and 15 mm	50	40	35	30

Notes: 1. With instantaneous transmission of prestressing to the concrete the beginning of the reinforcement anchoring zone is taken to be at a distance of $0.25l_{aH}$ from the face of the element.

2. With the use of transverse stressed reinforcement without anchors (for example with continuous reinforcement) it is necessary to reduce the rated strengths of the transverse rods in the length of its anchoring zone $l_{aH.x}$ (see Fig. 37) extending the instructions of 7.28 also to transverse reinforcements.

3. In elements of light-aggregate concrete reinforced with high-strength deformed wire, the tabular values of coefficient k_{aH} are multiplied by 1.25. Moreover, for elements of light-aggregate concrete in which porous sand is the fine filler, in all types of wire reinforcement the values of k_{aH} are multiplied by 1.2.

4. In structural elements employed at a rated temperature of minus 40°C and below, the length of the anchoring zone of wire bundles and strands without anchors, calculated in accordance with the requirements of 7.28, should be increased by 1.7 times.

a) for wire reinforcement

when $\sigma_0 = 10{,}000$ kg/cm^2 $l_{aн} = k_{aн}d$;

when $\sigma_0 < 10{,}000$ kg/cm^2 $l_{aн} = k_{aн}d\sigma_0/10{,}000$

when $\sigma_0 > 10{,}000$ kg/cm^2 $l_{aн} = k_{aн}d + 3 \times \frac{\sigma_0 - 10{,}000}{R_0}$,

where d - the diameter of the wire or strand in cm; $k_{aн}$ - the coefficient taken from Table 23; σ_0 - the values of prestressing in reinforcement in kg/cm^2 taking the losses before the termination of concrete compression into account (see 5.10); R_0 - cube strength of the concrete during its compression in kg/cm^2 (see Table 1);

b) for rod reinforcement - in accordance with Table 23a.

The testing of flexural strength in inclined sections should be carried out taking the possibility of the breakdown of the adhesion of the reinforcement with the concrete into account (for example during the instantaneous transmission of prestressing to the concrete). In this case for wire reinforcement the flexural strength should also be tested in the section normal to the axis of element passing (the section) at a distance 0.25 $l_{aн}$ from the face of the element; in this case the strength of the prestressed reinforcement is not considered (in the case of the absence along the length of the anchoring zone of unstressed reinforcement the section is rated in the same way as a concrete section).

7.29. The rating of inclined sections of elements with respect to transverse force should be carried out at the following sites along the length of the element:

a) in sections, passing through the support face (Fig. 16 and Fig. 17);

Table 23a*. Length of the anchoring zone $l_{aн}$ of stressed rod reinforcement in concrete.

Class of reinforcement	Length of the anchoring zone $l_{aн}$ in diameters of the stressed rods with the cube strength of the concrete at the moment of its compression R_0 in kg/cm^2			
	140	200	300	400
A-IV and At-IV	20	15	15	15
A-V and At-V	25	20	15	15
At-VI	-	25	20	15

Notes: 1. In the case of the use as stressed rod reinforcement of deformed steel of classes A-IIIv, A-IIv, A-III the length of the anchoring zone is taken to be $l_{aн} = 15d$.

2. In the case of forced instantaneous transmission of compression force to the concrete it is necessary to specify for an increase in the length of the anchoring zone of the stressed rod reinforcement of all classes with a diameter of up to 18 mm by $0.25 l_{aн}$ in the calculation but with reinforcement diameters of more than 18 mm the instantaneous transmission of force is not permitted; an appropriate instruction should be given in the design.

3. In structural elements used at a rated temperature of minus 40°C and below, the length of the anchoring zone of the stressed rod reinforcement should be increased by 1.7 times.

b) in sections, passing through the beginning of bent sites situated in the tensile stressed zone (Fig. 16);

c) in sections, passing through points of variation in the intensity of the transverse reinforcement, situated (the points) in the tensile stressed zone (Fig. 17).

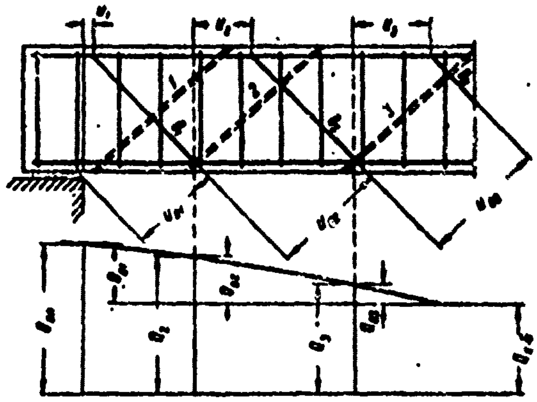


Fig. 16. Locations of the most dangerous inclined sections. 1 - section, passing through the support face; 2 and 3 - sections, passing through the beginning of bends in the tensile stressed zone.

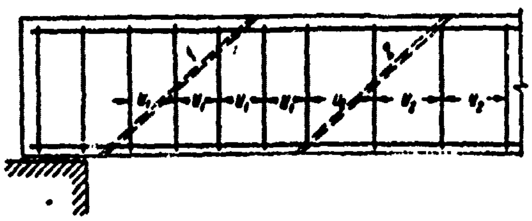


Fig. 17. Locations of the most dangerous inclined sections. 1 - section, passing through the support face; 2 - section, passing through the point of variation in intensity of the transverse reinforcement situated at the level of the tensile stressed reinforcement.

7.30. The rating of the strength of inclined sections of the elements enumerated in 7.25, for transverse force acting in the plane of the axis of symmetry of the section, can not be carried out, if the following condition is observed

$$Q \leq R_p b h_0. \qquad (61)$$

In this case for beams transverse reinforcement is designated for structural considerations in accordance with the instructions of 12.20-12.34.

7.31*. In elements of uniform cross section the rating of inclined sections for transverse force should be carried out under the following condition

$$Q \leq \sum R_{a.x} F_o \sin\alpha + \sum R_{a.x} F_x + Q_б \qquad (62)$$

where $Q_б$ - the projection of the breaking stress in the concrete of an inclined section on the normal to the axis of the element; F_o, F_x and α - the same designations, as in 7.26.

The value of the projection of breaking stress in the concrete of any inclined section on the normal to the longitudinal axis of the element of rectangular, T-shaped, double-T-shaped and box-shaped sections is determined with the following formula

$$Q_б = \frac{0{,}15 R_и b h_0^2}{c}, \qquad (63)$$

where c - the projection of the length of the inclined section on the axis of the element.

For structural elements of light-aggregate concrete prepared on a base of artificial and natural porous fillers, independent of the type of sand, with the exception of perlite sand, coefficient 0.15 in formula (63), and also in formula (67) and (90) of the following paragraphs is replaced by 0.12, and with the use of expanded perlite sand and light-aggregate concretes which have been made porous - by 0.10.

Note. In rating prestressed elements reinforced with wire, by bundles or strands without anchors (in 7.31 and in the following paragraphs), it is necessary to consider the reduction in the rated strengths of the stressed reinforcement (both bent-up and transverse) along the length of the anchor zone in accordance with the instructions of 7.28.

7.32*. In the absence of bent-up rods the rating of elements of uniform cross section for transverse force should be carried out under the following condition

$$Q \leqslant Q_{x.б}, \qquad (64)$$

where $Q_{x.б}$ - the maximum transverse force received by the concrete of the compressed zone and by the transverse rods (stirrups), in a very unfavorably inclined section.

For the elements enumerated in 7.25, reinforced by transverse rods (stirrups) located in planes, normal to the longitudinal axis of the element:

$$Q_{x.б} = \sqrt{0,6 R_u b h_0^2 q_x} - q_x u, \qquad (65)$$

where q_x - the breaking stress in transverse rods (stirrups) per unit length of an element determined by the following formula

$$q_x = \frac{R_{a.x} F_x}{u}; \qquad (66)$$

F_x - the same value, as in formula (59); u - the distance between the indicated transverse rods (stirrups), measured along the length of an element.

The length of the projection of a very unfavorably inclined section on the longitudinal axis of an element is equal to value c_0 increased up to the whole number of stirrup intervals, where

$$c_0 = \sqrt{\frac{0.15 R_u b h_0^2}{q_x}}. \quad (67)$$

For elements of light-aggregate concretes prepared on a base of artificial and natural porous fillers, independent of the type of sand, with the exception of perlite sand, the coefficient 0.6 in formula (65), and also in formuals (68), (72), (79), (80) and (208) of the following paragraphs is replaced by 0.48, and with the use of expanded perlite sand and light-aggregate concretes which have been made porous - by 0.4.

7.33*. In elements rated only in one load pattern for the effect of an actual continuous evenly distributed load p (for example, hydrostatic pressure, soil pressure, etc.), the rated value of the transverse force should be determined taking into account the part of the load, applied to the element within the limits of the length of the projection of the inclined section (decreasing the value of the transverse force), if this load is not applied within the limits of the height of the element and acts in its direction (for example, in a horizontal element a load acting from above downward, is applied to the upper face or a load acting from below upward, - to the lower face).

In order to take this part of the load into account in the radicands of formulas (65) and (67) instead of value q_x it is necessary to substitute value (q_x + p), where p - the rated continuous load, applied directly to the element in question or to a continuous beam slab resting on it. In this case the dead load of the element is introduced into value p with the coefficient 0.5.

7.34. In reinforcing the elements enumerated in 7.25, with transverse rods inclined at an angle of 45° to the longitudinal axis of an element and located at distances of u (measured along the length of the element) from one another, consisting of not more than $\frac{1}{2}h_0$ value $Q_{x.б}$ can be determined by the following formula

$$Q_{x.б} = \sqrt{0{,}6R_{и}bh_0^2q_{x1}} + q_{x1}(h_0 - u), \qquad (68)$$

where

$$q_{x1} = \frac{R_{a.x}F_x}{u\sqrt{2}}. \qquad (69)$$

7.35. In reinforcing an element with transverse rods (stirrups) situated normal to the axis of the element, and with bent-up rods the necessary cross section of the bends situated in one inclined plane, can be determined by the following formula

$$F_о = \frac{Q - Q_{x.б}}{R_{a.x}\sin\alpha}, \qquad (70)$$

where Q - the transverse force at the location of the given plane of the bends.

In this case the value of transverse force Q can be taken to be:

a) in rating the bends of the first plane - equal to the value of the rated transverse force near the support face;

b) for rating the bends in each of the subsequent planes - equal to the value of the transverse force near the lower point of the previous (with respect to the support) bend plane (see Fig. 16).

With a live load the rating of transverse rods and bends should be carried out for the flexural diagram of Q.

7.36. The distances between transverse rods (stirrups), and also between the end of the previous bend and the beginning of the subsequent bend (u_2 and u_3 in Fig. 16) in such cases when transverse rods and bends are required by the design, should be not more than value $u_{макс}$ determined by the formula

$$u_{макс} = \frac{0{,}1 R_p b h_0^2}{Q}. \qquad (71)$$

макс = max

Note. The positioning of the transverse rods and bends should also satisfy the requirements of 12.24, 12.33 and 12.34.

7.37. In slabs with transverse reinforcement only in the form of bends the cross section of the latter should be determined with formula (62) when $F_x = 0$; in this case the strength of the inclined sections should be tested beginning in the tensile stressed zone near the support and near the beginning of the bends of each plane and ending in the compressed zone at the end of the bends of each plane, and also at the site of the application of the concentrated force (Fig. 18).

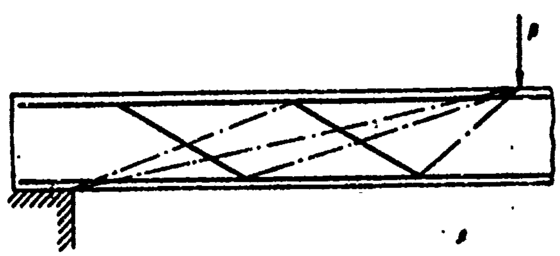


Fig. 18. The distribution of the most dangerous inclined sections in slabs reinforced with bent-up rods without vertical transverse rods.

In slabs rated only in one load pattern, for the effect of a continuous actual uniformly distributed load and with an intensity of p, applied exteriorly on a slab and acting in its direction (see 7.33), the cross section of the bends in the absence of stirrups (vertical transverse rods) can be determined with the formula

$$F_o = \frac{Q - \sqrt{0{,}6 R_{\text{н}} b h_0^2 p}}{R_{a.x} \sin \alpha}. \quad (72)$$

The magnitude of transverse force Q is taken in accordance with the instructions of 7.35.

7.38*. The rating of the strength of oblique sections with respect to transverse force for beams of variable height which increases with an increase in flexural moment, should be carried out under the following conditions:

a) for beams with inclined tensile stressed and horizontal compressed faces

$$Q \leqslant \sum R_{a.x} F_o \sin \alpha + \sum R_{a.x} F_x + Q_б + \frac{M - \sum R_{a.x} F_x z_x - \sum R_{a.x} F_o z_o}{z} \operatorname{tg} \beta, \quad (73)$$

where

$$\frac{M - \sum R_{a.x} F_x z_x - \sum R_{a.x} F_o z_o}{z} \operatorname{tg} \beta$$

- the projection on the normal to the compressed face of the force in longitudinal tensile stressed reinforcement situated parallel to an inclined face, equal to

$$\sigma_a F_a = \frac{M - \sum R_{a.x} F_x z_x - \sum R_{a.x} F_o z_o}{z \cos \beta}. \quad (74)$$

In prestressed elements when determining force $\sigma_a F_a$ the effect of the prestressing is not allowed to be taken into account.

In formulas (73) and (74) the following designations are accepted:

Q - the vertical transverse force acting in the oblique section in question; M and z - respectively, the flexural moment and the arm of the inner pair of forces in the vertical section, passing through the end of the oblique section in question in the compressed zone, determined without considering the precompression; F_o, F_x, z_o and z_x - the same designations, as in 7.26; α - the angle of inclination of the bent-up rods to the horizontal; β - the angle of inclination of the longitudinal tensile stressed reinforcement to the horizontal; $Q_б$ - is determined with formula (63) at working (rated) height of the beam, equal to its minimum value over the length of the oblique section;

b) for T-shaped (with the flange in the compressed zone) and rectangular beams with the inclined face compressed and the horizontal face tensile stressed

$$Q \leq \sum R_{a.x} F_o \sin\alpha + \sum R_{a.x} F_x + Q_б + D_{cв} \operatorname{tg}\beta, \qquad (75)$$

where $Q_б$ - is determined with formula (63) at a working (rated) height of the beam, equal to its mean value over the length of the oblique section; $D_{cв}$ tg β - the vertical projection of part of the resultant of the forces in the compressed zone received by the overhangs of the inclined flange; for rectangular ross-sections this term is equal to zero; α - the angle of inclination of the bent-up rods to the horizontal; β - the angle of inclination of the compressed face of the beam to the horizontal.

Value D_{cs} is determined in the vertical cross section, passing through the end of the oblique section in question in the compressed zone

$$D_{cs}=\frac{b_n'-b}{b_n'}D, \tag{76}$$

where

$$D=\frac{M-\sum R_{a.x}F_x z_x-\sum R_{a.x}F_0 z_0}{h_0-\frac{h_n'}{2}}+ + \sum R_{a.x}F_0\cos\alpha. \tag{77}$$

In determining force D_{cs} depending on the total value of the resultant of the forces in compressed zone D the width of the flange overhangs should be taken into account when considering the instructions of 7.18; in prestressed elements the effect of prestressing is not allowed to be considered.

7.39. The rating of strength with respect to the transverse force of elements of rectangular cross-sections subjected to flexure in plane, not par··llel to the axis of symmetry (see Fig. 10), is carried out under the following condition

$$\left[\frac{Q_x}{Q_{x.б(x)}}\right]^2+\left[\frac{Q_y}{Q_{x.б(y)}}\right]^2\leqslant 1, \tag{78}$$

where Q_x and Q_y - the components of the transverse force a· ·ing respectively in the x-plane and in the y-plane normal to i·; $Q_{x.б(x)}$ and $Q_{x.б(y)}$ - the maximum transverse forces which can be absorbed by an oblique section with their effect respectively only in the x-plane and only in the y-plane determined with formulas (79) and (80);

$$Q_{x.б(x)}=\sqrt{0{,}6R_p b_x h_{0x}^2 q_{x(x)}}-q_{x(x)}u_x; \tag{79}$$

$$Q_{x.б(y)} = \sqrt{0{,}6 R_{и} b_y h_{0y}^2 q_{x(y)}} - q_{x(y)} u_y, \qquad (80)$$

where b_x and b_y - the dimensions of the section in a direction, normal respectively to the x-axis and to the y-axis; h_{0x} and h_{0y} - the work (rated) heights of the section respectively in the direction of the x-axis and the y-axis; $q_{x(x)}$ and $q_{x(y)}$ - the breaking stresses in the transverse rods respectively in the direction parallel to the x-axis, and in the direction parallel to the y-axis, per unit length of the element; u_x and u_y - the distances between the transverse rods parallel respectively to the x-axis and the y-axis.

Notes. 1. Bent-up rods are not considered in rating for transverse force in oblique flexure.

2. The effect of torsion in rating for transverse force in oblique flexure should be considered in accordance with the appropriate instructions.

7.40. Longitudinal tensile stressed rods being broken in a span, should be established beyond the point of the theoretical break (i.e., for a cross section, normal to the axis of the element , in which these rods cease being required by the rating for flexural moment) by a length of not less than 20d and not less than value w which for elements of uniform cross section is determined by the following formula

$$w = \frac{Q - Q_0}{2 q_{xw}} + 5d; \qquad (81)$$

for beams of variable height with inclined compressed and horizontal tensile stressed faces

$$w = \frac{Q - Q_0 - R_a F_a \operatorname{tg} \beta}{2 q_{xw}} + 5d; \qquad (82)$$

for beams of variable height with inclined tensile stressed and horizontal compressed faces

$$w = \frac{Q - Q_0 - R_a F_a \sin\beta}{2q_{xw}} + 5d, \qquad (83)$$

where Q - the rated transverse force; in elements of constant height - in the section, normal to the axis of the element, and in beams of variable height - in the vertical cross section drawn through the point of theoretical breaking of the rod (corresponding to that case of loading, for which the point of the theoretical break was determined); Q_0 - the transverse force absorbed by the bends in the same cross section of the element; d - the rated diameter of the broken rod; β - the same designation as in formulas (73)-(75); q_{xw} - the breaking stress in transverse rods per unit length of the element for part w, determined by the following formula

$$q_{xw} = \frac{R_a F_x}{u}, \qquad (84)$$

F_x and u - the same designations, as in formulas (59), (65) and (66).

For the loading cases, specified in 7.33, in determining the breaking sites of the super-supporting rods from the direction of the application of a continuous load it is necessary to substitute value $2q_{xw} + p$ in formulas (81)-(83) instead of value $2q_{xw}$.

7.41*. The entry angles in the tensile stressed zone of elements, reinforced with intersecting longitudinal rods (Fig. 19), should have transverse reinforcements, sufficient for receiving:

a) a resultant of the forces in the longitudinal tensile stressed rods, not anchored in the compressed zone, equal to

$$P_1 = 2R_a F_{a1} \cos\frac{\gamma}{2}; \tag{85}$$

b) 35% of the resultant of the forces in all the longitudinal tensile stressed rods

$$P_2 = 0{,}7 R_a F_a \cos\frac{\gamma}{2}. \tag{86}$$

The transverse reinforcement necessary for rating under these conditions should be located along a length of

$$s = h \operatorname{tg}\frac{3}{8}\gamma. \tag{87}$$

The sum of the projections of the forces in the transverse rods (stirrups) situated along this length, to the bisector of angle γ should be not less than the sum of forces $P_1 + P_2$.

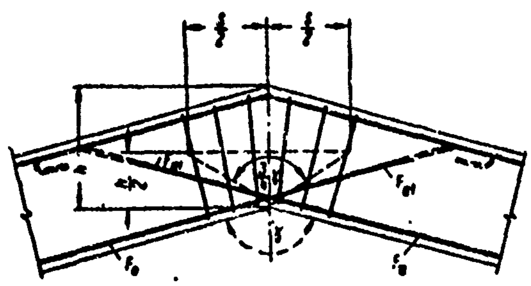


Fig. 19. The reinforcement of the entry angle in the tensile stressed zone of a reinforced-concrete element.

The following designations are adopted in formulas (85)-(87):

F_a - the sectional area of all the longitudinal tensile stressed rods; F_{a1} - the sectional area of the longitudinal tensile stressed rods, not anchored in the compressed zone; γ - the entry angle in the tensile stressed zone of an element.

7.42*. A distributed or concentrated load, suspended from a beam or applied within the limits of its cross-sectional height, to avoid breaking in the tensile stressed zone of the site of the transmission of the load should be completely received by additional transverse reinforcement without considering the strength of the concrete. The length of the beam section, within the limits of which this additional reinforcement is located receiving the concentrated load, is assumed to be not more than

$$s = 2h_1 + b_1, \qquad (88)$$

where h_1 - the distance from the bottom of the reinforcement of the rated element to the center of gravity of the compressed zone of the supporting section of the adjacent element, and with direct application of load - up to the lower level of its application (Fig. 20); b_1 - the width of the load distribution at the site of its application.

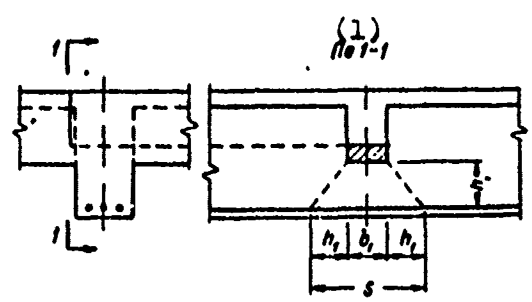


Fig. 20. Diagram of the determining of the length of the portion in which it is necessary to locate the additional transverse rods receiving the load, applied within the limits of the height of the beam cross section.
KEY: (1) According to.

A supporting reaction, applied above the level of the tensile stressed reinforcement , should be within the limits of the support completely received by transverse reinforcement F_x incompassing the tensile stressed longitudinal reinforcement or reinforcement welded to it (Fig. 21).

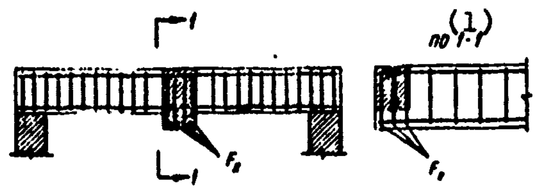


Fig. 21. The location of additional transverse rods receiving the support reaction, applied above the tensile stressed reinforcements.
KEY: (1) According to.

7.43. The dimensions of the cross sections of short cantilevers ($l \leq 0.9h_0$) supporting beams, girders, etc., (Fig. 22), are taken from the following condition

$$Q \leq mR_p bh_{01} + \frac{M}{z} \operatorname{tg} \gamma, \qquad (89)$$

where b, h_{01}, z and M - the width, height, arm of inner pair and the moment in vertical cross section I-I, passing through the edge nearest to the column of the area for transmitting the load to the cantilever; γ - the angle of inclination of the compressed face of the cantilever to the horizontal; m - the coefficient which considers the operating conditions of the cantilever.

For cantilevers supporting sub-crane beams for special heavy-duty cranes (with rigid suspension, magnetic, bucket, etc.), m = 1; for cantilevers supporting sub-crane beams in shops with standard heavy- and intermediate-duty travelling cranes, m - 1.6; for cantilevers supporting sub-crane beams in shops with light-duty cranes, and also for cantilevers, carrying a static load, m = 2.2

The buckling stress at the sites of the transmission of the load to a cantilever should not exceed $R_{пр}$.

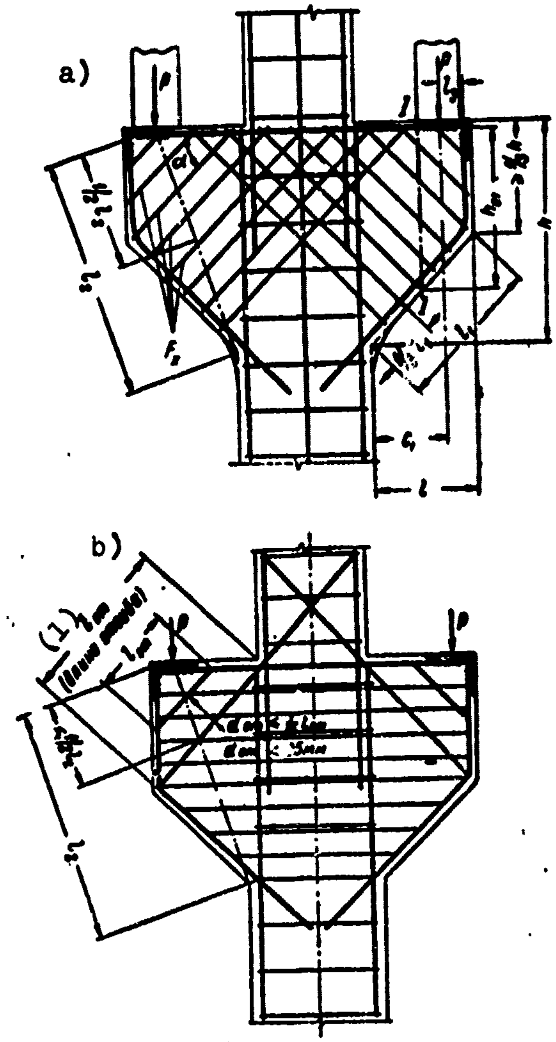


Fig. 22. Reinforcement in short cantilevers a) with inclined stirrups; b) with bent-up rods and horizontal stirrups.
KEY: (1) Length of bend.

For short cantilevers the angle γ of the compressed face with the horizontal should not be more than 45°. The height of a section near the free edge of a cantilever should not be less than 1/3 the height of the cantilever section at the site of its abutment with a column.

For short cantilevers supporting sub-crane beams, which carry special heavy-duty cranes, it is recommended that smooth abutment of the lower face of a cantilever with a column be executed in a curve for a portion of not less than 1/3 the length of the inclined face (see Fig. 22a) or that a haunch or bracket be set up.

Note. 1. An increase in the height of a cantilever section as a result of the making of curvature or a haunch or bracket is not considered.

2. In determining the minimum dimensions of a transverse section, and also the sectional area of reinforcements in the cantilevers, on which precast beams rest going along the overhang of a cantilever, in the absence of the special protruding insert components securing the support platform, it is assumed, that the beam rests on a platform with a length of $Q/bR_{пр}$, situated at the free end of the cantilever.

3. If the joints of the beams with the columns reliably monolithized and reinforcement placed in the joints, as in a frame with rigid joints, and the lower beam reinforcement welded through the insert components to the cantilever reinforcement , then the minimum dimension of a cantilever can be determined for the section, passing through the beam face, assuming its uniform support along the length from the end of the cantilever to the beam face. In this case the magnitude of bearing pressure

which is transferred to the cantilever from the load, applied after monolithization, can be reduced by 25%. The sectional area of the reinforcement in cantilevers in this case is also determined in accordance with note 2.

7.44. In short cantilevers abutting with columns or with other elements of greater height protruding beyond the compressed face of the cantilevers by not less than half the height of the cantilever h at the site of its abutment with column or with another element (see Fig. 22), the cross section of the longitudinal reinforcement is selected in accordance with the flexural moment acting on the face where the cantilever abuts with the element increased by 25%. In the remaining cases, and also if a short cantilever is an extension of a beam or slab freely lying on a support, the cross section of the longitudinal reinforcement is selected in accordance with the moment acting on the support axis increased by 25%. The longitudinal reinforcement of the corresponding cross section should reach to the end of the cantilever.

In cantilevers, for which coefficient m under condition (89) is greater than 1 and the distance l_3 from the center of the load to the edge of the reinforcements (see Fig. 22a) does not exceed:

a) with smooth round reinforcement - 15d;

b) with deformed reinforcement of classes A-III and A-II and with concrete of a job-grade below 300 - 15d;

c) with deformed reinforcement of classes A-III and A-II and with concrete of a job-grade of 300 and above - 10d, the longitudinal reinforcement should be equipped with anchors in the form of washers or angle irons; the rating of these anchors should be carried out in accordance with the appropriate instructions.

Note. The placing of anchors is not necessary in cantilevers, on which precast beams rest going along the overhang of cantilevers, if the joints of these beams are reliably monolithized and the reinforcement in them is placed in a frame with rigid joints, and the lower reinforcement of the beams is welded to the reinforcement of the cantilevers through the insert components.

7.45*. Short cantilevers are reinforced:

a) with inclined stirrups (Fig. 22a); this type of reinforcement is recommended when the height of a cantilever at the site of abutment with a column is $h \leq 2.5c_1$;

b) with bent-up rods and with horizontal stirrups (Fig. 22b); this method of reinforcement is recommended when $h > 2.5c_1$; when $h > 3.5c_1$ and $P \leq R_p bh_{01}$ (where P - the design load on a cantilever) bent-up rods cannot be used.

In both cases the stirrup interval should be not more than 150 mm and not more than h/4; the diameter of bent-up rods should be not more than 1/15 the length of a bend (see Fig. 22b) and not more than 25 mm.

The total cross section of bends and inclined stirrups intersecting the upper half of an inclined line (segment l_2 in Fig. 22) going from the load to the angle of abutment of the lower face of the cantilever to a column, should not be less than $0.002bh_0$ and not less than

$$f_0 = \frac{Q - \frac{0{,}15 R_p b h_0^2}{c_2}}{R_a \sin\alpha}, \qquad (90)$$

where $c_2 = c_1 + 0.3h_0$; if the cantilever is an extension of a beam or slab, then c_2 is taken as equal to the distance from the load axis to the support axis; c_1 - the distance from the load axis to the nearest column face at the bottom of the cantilever; α - the angle of inclination of the bent-up rods or inclined stirrups toward the horizontal; h_0 - the operational height of the cantilever in the section of its abutment with the column.

ECCENTRICALLY COMPRESSED
ELEMENTS

7.46. During rating eccentrically compressed elements for strength it is necessary to examine two possible cases of rating:

a) case 1, which corresponds to relatively large eccentricities, when the strength of an element is characterized by the tensile stressed reinforcement attaining its rated strengths;

b) case 2, which corresponds to relatively small eccentricities, when the strength of an element is characterized by the concrete of the compressed zone attaining its rated strength earlier than the tensile stressed (or slightly compressed) reinforcement attains of its rated strength.

The rating of eccentrically compressed reinforced-concrete elements when $e_0 \leq l_0/600$ is carried out as in axial compression in accordance with the instructions of 7.10 and 7.11 of the present Codes.

The rating of eccentrically compressed elements in the plane of the effect of the moment when $e_0 > l_0/600$ is carried out in accordance with the instructions of 7.47-7.50. When the ratio $l_0/r_и > 14$ it is necessary to consider the effect of the deflection of the element on the magnitude of eccentricity of the longitudinal force in accordance with the instructions of 7.51.

7.47. Eccentrically compressed reinforced-concrete elements, the transverse sections of which have at least one axis of symmetry, with the eccentricity only in the plane of this axis are rated in the following manner:

a) With "large" throws, if condition (46) is satisfied (case 1 of eccentric compression, Fig. 23) - *under condition*

$$N \leq R_и F_б + R_{а.с} F'_а - R_а F_а \tag{91}$$

or

$$Ne \leq R_и S_б + R_{а.с} S_а \text{ (see 7.15)} \tag{92}$$

In this case the position of the zero (neutral) axis can be determined using the following equation

$$R_и S_{бN} \pm R_{а.с} F'_а e' - R_а F_а e = 0, \tag{93}$$

where $S_{б N}$ - the static moment of the sectional area of the compressed zone of the concrete relative to the axis, normal to the plane of the effect of flexural moment and passing through the point of the application of longitudinal force N.

In formula (93) in front of the second term the sign is assumed: plus, if longitudinal force N is applied beyond the limits of the distance between the resultants of the forces in reinforcement A and A'; minus, if longitudinal force N is applied between the resultants of the forces in reinforcement A and A'.

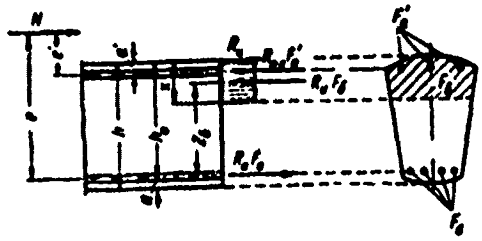


Fig. 23. Diagram of the distribution of forces and a diagram of the stresses in the transverse section of an eccentrically compressed reinforced-concrete element when it is being rated for strength in accordance with the first case.

If in the rating reinforcement A' is considered, then condition (48) must be satisfied; it is permissible to consider reinforcement A' in the rating and with the non-observance of condition (48) (see 7.21), but in this case it is necessary, not using formulas (91)÷(93), to carry out the rating under the following condition

$$N(e-z_a)\leqslant R_a F_a z_a. \qquad (94)$$

The unstressed reinforcement in the compressed zone should not be considered in the rating, if the fulfillment of condition (48) leads to a reduction in the rated strength of the element in comparison with a rating without considering this reinforcement.

With the positioning of tensile stressed reinforcement A in several rows in the height of the element cross section it is necessary to consider the requirement of 7.3.

b) With "small" eccentricities, when condition (46) is not satisfied (case 2 of eccentric compression, Fig. 24):

when $e > \bar{e}$ - *under the condition*

$$Ne\leqslant R_u\bar{S}_0 + R_{a.c}S_a, \qquad (95)$$

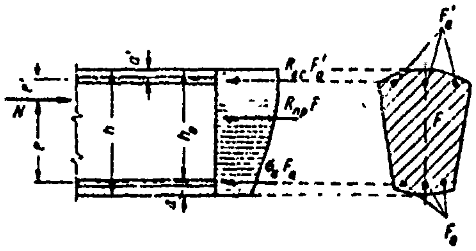


Fig. 24. Diagram of the distribution of forces and a diagram of the stresses in the transverse section of an eccentrically compressed reinforced-concrete element when it is being rated for strength in accordance with the second case.

where

$$\bar{e} = \frac{R_{и} \bar{S}_{б} + R_{а.с} S_{а}}{R_{и} \bar{F}_{б} + R_{а.с} F'_{а}}; \qquad (96)$$

$\bar{F}_{б}$ - the area of the compressed zone of the concrete which corresponds to the boundary between the 1st and 2nd cases of eccentric compression; $\bar{S}_{б}$ - the moment of force of area $\bar{F}_{б}$ relative to the axis, normal to the plane of the effect of flexural moment and passing through the point of application of the resultant of the forces in reinforcement A;

when e $\leq \bar{e}$ *under condition*

$$Ne \leq R_{пр} S_0 \frac{\bar{e} - 1{,}25 \frac{\bar{S}_{б}}{S_0} c - \left(1 - 1{,}25 \frac{\bar{S}_{б}}{S_0}\right) e}{\bar{e} - c} + R_{а.с} S_{а}, \qquad (97)$$

where c - the distance from the point of the application of the resultant of all internal forces in the concrete and in the reinforcement in an evenly compressed section to the resultant of the forces in reinforcement A;

$$c = \frac{R_{пр} S + R_{а.с} S_{а}}{R_{пр} F + R_{а.с} (F'_{а} + F_{а})}. \qquad (98)$$

S - the static moment of the entire cross section of the concrete relative to the axis, normal to the plane of the effect of flexural moment and passing through the point of the application of the resultant of the forces in reinforcement A.

In elements rated both by the 1st and by the 2nd case, the width of the compressed flange, introduced into the calculation, should not be more than the values determined in accordance with the instructions of 7.18.

If in the elements of a T-shaped cross section with a flange in the compressed zone the neutral axis intersects the rib, then the rating of the sections should be carried out in accordance with the instructions of 7.17 "b," i.e., in determining the values of $F_б$, $S_б$, $S_{б\,N}$, $\overline{F}_б$, and $\overline{S}_б$ the sectional area of the overhangs of the compressed flange $(b_п-b)h_п$ must be multiplied by the ratio

$$\frac{R_{пр}}{R_и}=0{,}8.$$

When stressed reinforcement is present in the zone compressed due to the effect of external forces, this reinforcement should be considered in the calculation in accordance with the instructions of 7.6. With the use of concrete and reinforcement of several types or classes it is necessary to be guided by the instructions of 7.2.

Note: 1. In rating T-shaped sections using formulas (91)-(93) the flange, located in the tensile stressed area, is not considered.

2. With a job-grade concrete of 400 and lower formulas (95) and (97) are reduced to the inequality

$$Ne\leqslant R_{пр}S_б+R_{а.с}S_а.$$

3. For T-shaped sections with a flange situated on the lesser compressed face, when $e < \bar{e}$ it is permissible to consider this flange in the calculation; in this case its greatest width, introduced into the calculation using formulas (95) and (97), is determined under the following condition.

$$S_0 \leqslant 0{,}55bh_0^2.$$

4. For eccentrically compressed 2nd-case elements when $e < \bar{e}$ the position of the least compressed side of the section (reinforcement A) and the most compressed side of the section (reinforcement A') is determined by condition $e > c$.

5. The recommendations of 7.47 do not extend to elements of annular cross-section (tubular) with the longitudinal reinforcement distributed uniformly as the circumference (see 7.49), and also to elements of round cross section with the same reinforcement.

7.48. The rating of eccentrically compressed reinforced-concrete elements of rectangular cross section can be carried out in the following manner:

a) With "large" eccentricities (case 1) using formulas

$$N \leqslant R_{\text{и}}bx + R_{\text{а.с}}F'_{\text{а}} - R_{\text{а}}F_{\text{а}} \tag{99}$$

or

$$Ne \leqslant R_{\text{и}}bx\left(h_0 - \frac{x}{2}\right) + R_{\text{а.с}}F'_{\text{а}}(h_0 - a'). \tag{100}$$

In this case the position of neutral axis is determined under the following condition

$$R_{\text{и}}bx\left(e - h_0 + \frac{x}{2}\right) \pm \pm R_{\text{а.с}}F'_{\text{а}}e' - R_{\text{а}}F_{\text{а}}e = 0. \tag{101}$$

The rule of the signs before the second term is taken in the same way as in formula (93) (see 7.47). The height of the compressed zone of the concrete, the reinforcement of the compressed zone is considered, should satisfy condition (48); it is permissible to consider the reinforcement of the compressed zone in the calculation also with the non-observance of this condition, but in this case the sectional area of the tensile stressed reinforcement should be determined using the formula

$$N\left(\frac{e}{h_0-a'}-1\right) \leq R_a F_a. \quad (102)$$

b) With "small" eccentricities (case 2):

when $e > \bar{e}$ *- under the following condition*

$$Ne \leq 0{,}5\zeta R_u b h_0^2 + R_{a.c} F'_a (h_0 - a'), \quad (103)$$

when $e \leq \bar{e}$ *- under the following condition*

$$Ne \leq 0{,}5 R_{np} b h_0^2 \frac{\bar{e} - 1{,}25\zeta c - (1 - 1{,}25\zeta) e}{\bar{e} - c} + R_{a.c} F'_a (h_0 - a'), \quad (104)$$

where $\bar{e}$ and c are determined in accordance with 7.47.

7.49. Eccentrically compressed reinforced-concrete elements of annular cross section (tubular) with stressed and unstressed reinforcement, uniformly distributed over the circumference (Fig. 13), are rated with the following formulas:

a) the 1st case, when $\alpha_K \leq \zeta/1.6$, where

$$\alpha_K = \frac{R_H F_H + R_a F_a + N}{(R_H + \sigma'_c) F_H + (R_a + R_{a.c}) F_a + R_u F}; \quad (105)$$

$$Ne_0 \leq \frac{1}{\pi}\left[R_{\text{н}}F\frac{r_1+r_2}{2} + (R_{\text{н}} + \sigma_c')F_{\text{н}}r_{\text{н}} + + (R_{\text{а}} + R_{\text{а.с}})F_{\text{а}}r_{\text{а}}\right]\sin \pi\alpha_{\text{н}}; \tag{106}$$

b) the 2nd case, when $\alpha_{\text{H}} > \zeta/1.6$

$$N(e_0 + r_{\text{н}}) \leq r_{\text{н}}[R_{\text{пр}}F + k_{\text{а}}(R_{\text{а.с}}F_{\text{а}} + + R_{\text{н.с}}F_{\text{н}}) - m_{\text{т}}\sigma_0 F_{\text{н}}], \tag{107}$$

where when $e_0 < r_{\text{H}}$ it is assumed that

$$k_{\text{а}} = 1 - \frac{e_0}{3r_{\text{н}}}, \tag{108}$$

and when $e_0 \geq r_{\text{H}}$ it is assumed that $k_a = 2/3$; e_0 – the eccentricity of longitudinal force N relative to the center of gravity of the given cross section; the remaining designations are the same, as in the formulas of 7.23.

With the use of formulas (106) and (107) it is necessary to consider conditions (56) and (57).

Notes: 1. In the absence of stressed reinforcement it is necessary to assume value F_{H} equal to zero and $r_{\text{H}} = r_a$.

2. The recommendations of 7.49 extend to cross sections with the ratio $\frac{r_2 - r_1}{r_2} \leq 0.5$ when the number of longitudinal rods in the transverse cross section is not less than 6.

7.50*. Elements having cross sections symmetrical relative to two mutually perpendicular axes and subject to the simultaneous effect of longitudinal force and flexural moments in the direction of both axes of symmetry (oblique eccentric compression, Fig. 25), are rated:

a) in the first case of oblique eccentric compression - under the conditions of (91) or (92).

In this case the position of the neutral axis which determines the shape of the compressed zone of the concrete, is found under condition (93), and also under the condition of the distribution on one straight line of points of the application of the resultant of the external forces, of the resultant of all the internal forces in the compressed zone of the section and of the resultant of the forces in the reinforcement situated in the tensile stressed zone. In this case all the requirements of 7.47 "a" should be observed;

b) in the second case of oblique eccentric compression - using formula

$$N \leqslant \frac{1}{\frac{1}{N_x} + \frac{1}{N_y} - \frac{1}{N_u}}, \qquad (109)$$

where N - the rated longitudinal force with the set of all effects; N_u - the rated longitudinal force which can be received by a section during central compression; N_x - the rated longitudinal force which acts in the plane of the x-axis with eccentricity e_x which can be received by the section; N_y - the same, in the plane of the y-axis with eccentricity e_y.

Values N_x and N_y are determined using the formulas of the second case of eccentric compression in accordance with 7.47 "b." The taking into account of the prolonged effect of a load during oblique eccentric compression is carried out in accordance with the "Instructions on the Design of Reinforced-Concrete Structures."

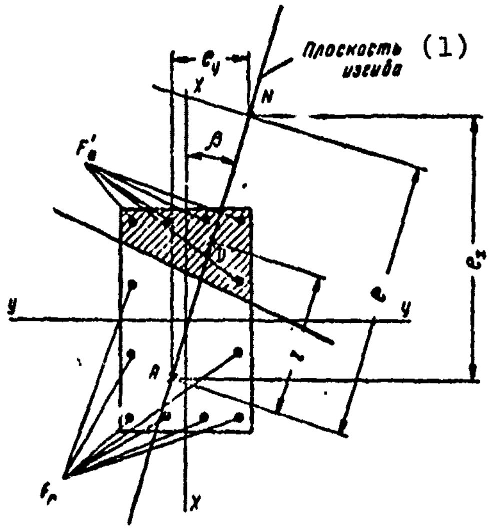


Fig. 25. Diagram of the distribution of forces and the position of the neutral axis in the transverse section of a reinforced-concrete element subjected to oblique eccentric compression, in rating by the first case; N - the point of application of the longitudinal force; A - the point of application of the resultant of the forces in whole tensile stressed reinforcement ; D - the point of application of the resultant of all the compressive stress in the section (in the concrete and in the compressed reinforcement).
KEY: (1) Flexural plane.

The carrying capacity of an element is taken to be equal to the smaller of its two values obtained in rating in accordance with 7.50 "a" and 7.50 "b."

Notes: 1. In determining N_x and N_y (as well as in determining $N_ц$) it is recommended that all the reinforcement existing in the section of the element be taken into account.

2. In determining N_x and N_y the flexibility of an element is considered in accordance with 7.51; in this case coefficient η is calculated in accordance with given rated longitudinal force N; in determining $N_ц$ flexibility is not considered.

7.51*. The effect of the deflection of an element is considered by multiplying value e_0 by coefficient η, determined using the following formulas:

a) for cross sections of the shape

$$\eta = \frac{1}{1 - \frac{N}{12cR_uF}\left(\frac{l_0}{r_u}\right)^2}; \quad (110)$$

b) for rectangular cross sections

$$\eta = \frac{1}{1 - \frac{N}{cR_uF}\left(\frac{l_0}{h}\right)^2}; \quad (111)$$

r_H - the radius of gyration of a transverse section in the flexural plane.

The values of coefficient c in the formulas of (110) and (111) are determined for heavy-aggregate concrete using formula (112), and for light-aggregate concrete - in accordance with a special standard document.

$$c = \frac{66\,000}{R + 350}\left(\frac{1}{\frac{e_0}{h} + 0{,}16} + 200\mu + 1\right), \quad (112)$$

where R - the job-grade concrete with the compressive strength in kg/cm^2;

$$\mu = \frac{F_a}{F};$$

F_a - the sectional area of reinforcement A.

If ratio e_0/h does not exceed the values given in Table 24, them in formula (112) instead of actual value e_0/h boundary values of these ratio are substituted in accordance with Table 24.

Table 24. Relative boundary eccentricities e_0/h for computing the coefficients of c.

Job-grade of the concrete	Relative boundary eccentricities e_0/h when					
	$l_0/r_н \leq 52$	69	86	104	122	139
	$l_0/h \leq 15$	20	25	30	35	40
150	0.60	0.45	0.30	0.20	0.15	0.07
200	0.55	0.40	0.30	0.20	0.10	-
300	0.50	0.35	0.25	0.15	0.06	-
400	0.40	0.30	0.20	0.10	-	-
500	0.35	0.25	0.15	0.05	-	-
600	0.30	0.20	0.10	-	-	-

When the flexibility of an element is $l_0/r_н > 35$ ($l_0/h > 10$) it is necessary to consider the prolonged effect of a load on the bearing capacity of the element. In these cases in formulas (110) and (111), and also in the formulas of 7.47-7.50 longitudinal force N is replaced by a given longitudinal force $N_п$ determined using the following formula

$$N_п = \frac{N_{дл}}{m_{э.дл}} + N_к \quad (113)$$

and applied with eccentricity $e_{о.п}$ computed using the formula

$$e_{о.п} = \frac{\frac{N_{дл} e_{о.дл}}{m_{э.дл}} + N_к e_{о.к}}{N_п}. \quad (113a)$$

Designations $N_{дл}$ and $N_к$ see 6.3.

$m_{э.дл}$ - the coefficient which considers the prolonged effect of a load on the bearing capacity of a flexible eccentrically compressed element determined using the formula

$$m_{э.дл} = \frac{m_{дл} + 2\frac{e_{о.дл}}{h}}{1 + 2\frac{e_{о.дл}}{h}}, \quad (114)$$

where $m_{дл}$ - the coefficient taken in accordance with Table 21, when replacing ratios l_0/b and l_0/r in it respectively with ratios l_0/h and $l_0/r_и$; $e_{о.дл}$ and $e_{о.н}$ - the distances from the point of application respectively of $N_{дл}$ and $N_н$ to the center of gravity of the transverse section of the element.

During rating the strength of eccentrically compressed reinforced-concrete elements, besides considering the flexibility in the plane of the action of the moment, it is also necessary to carry out testing for longitudinal flexure in the plane, perpendicular to the plane of flexure, as for elements operating in axial compression (disregarding flexural moment) in accordance with the instructions of 7.10 and 7.11.

Notes: 1. When $14 < l_0/r_и < 35$ consideration of the effect of deflection on the magnitude of eccentricity of the longitudinal force can be carried out with other, simplified methods.

2. The rated lengths l_0 of eccentrically compressed reinforced-concrete elements, with the exception of wall panels, should be taken in accordance with the instructions of 7.5.

3. For wall panels the rated lengths l_0 and the value of the random initial eccentricity should be taken in accordance with the instructions of 6.1 and 6.2.

4. If the value of coefficient η, determined in accordance with formulas (110) and (111), is equal to infinity or negative, then it is necessary to increase the dimensions of the section.

5. In rating reinforced-concrete elements having undisplaceable supports, the values of coefficients $m_{дл}$ and η are taken to be:

a) for sections in the middle third of the length of an element - in accordance with formulas (110) or (111);

b) for sections within the limits of the extreme thirds of the length of an element - by linear interpolation (taking in the supporting sections coefficients $m_{дл}$ and η to be equal to unity).

6. The rating of supporting joints of spanning structures for panel walls is carried out with the introduction to the bearing capacity of the element of coefficients which consider the effect of the mortar joint: 0.9 - with hardened mortar and 0.5 - with freshly poured mortar.

7.52. The strength rating of prestressed eccentrically compressed (by an external longitudinal force) reinforced-concrete elements with stressed reinforcement , not having adhesion with the concrete and capable of being displaced with respect to a transverse section of an element (see 7.8), is carried out for two cases:

a) with the total rated length of an element and with given longitudinal force $N_{п}$;

b) with the rated length of an element, equal to the distance between the attachment points of the reinforcement , and with given longitudinal force $N_{п}$, in which the resultant of forces $N_{н}$ is considered in the whole stressed reinforcement after compression of the concrete; in this case in formula (11) rated longitudinal force $N_{дл}$ must be replaced by the sum of forces $N_{дл} + N_{н}$.

If the compressed element can sag to the stressed reinforcement which prevents its further flexure, the the rated value of the additional eccentricity (the deflection) for force $N_{н}$ should not exceed the distance from the surface of the concrete to the surface of the stressed reinforcement measured in the plane of flexure, before compression of the element.

7.53. The testing of the strength of inclined sections of eccentrically compressed reinforced-concrete elements should be carried out in a manner analogous to the rating of flexural reinforced-concrete elements in accordance with the instructions of 7.24-7.42.

For prestressed elements reinforced with wire, bundles or strands without anchors, the strength of inclined sections and sections normal to the axis of element over the length of the anchoring zone of the stressed reinforcement should be tested taking into account the possibility of the breakdown of its adhesion with the concrete (see 7.28).

ECCENTRICALLY TENSILE-STRESSED ELEMENTS

7.54. The rating of eccentrically tensile-stressed reinforced-concrete elements of rectangular, T-shaped, double-T-shaped and box-like sections is carried out:

a) if force N is applied between the resultants of the forces in reinforcement A and A' (case 2, Fig. 26) - under the following conditions

$$N \leqslant \frac{R_a S_a}{e}; \quad (115)$$

$$N \leqslant \frac{R_a S'_a}{e'}; \quad (116)$$

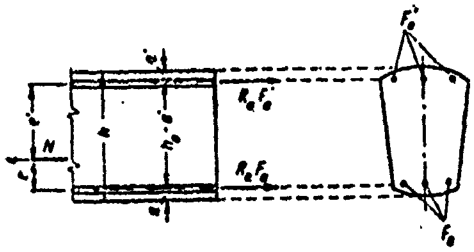


Fig. 26. Diagram of the distribution of forces in the transverse section of a tensile-stressed reinforced-concrete element in rating it for strength in accordance with the second case.

b) if force N is applied beyond the limits of the distance between the resultants of the forces in reinforcement A and A' (case 1, Fig. 27) - under the following conditions

$$N \leqslant R_a F_a - R_{a.c} F'_a - R_u F_6 \quad (117)$$

or

$$Ne \leqslant R_u S_6 + R_{a.c} S_a. \quad (118)$$

In this case the position of the zero (neutral) axis is determined using equation

$$R_u S_{6N} + R_{a.c} F'_a e' - R_a F_a e = 0. \quad (119)$$

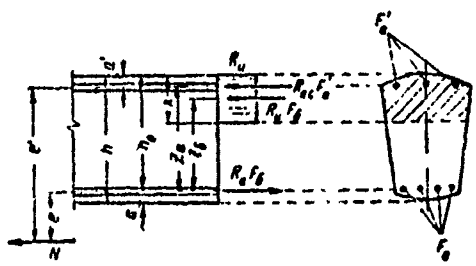


Fig. 27. Diagram of the distribution of forces and the diagram of the stresses in the transverse section of an eccentrically tensile-stressed reinforced-concrete element in rating it for strength in accordance with the first case.

The height of the compressed zone should satisfy condition (46), and with reinforcement A' present and being considered in the calculation, moreover, condition (48).

It is also permissible to consider reinforcement A' in the rating with non-observance of condition (48), but in this case it is necessary, without using formulas (117)-(119), to carry out the rating under the following condition

$$N (e + z_a) \leqslant R_a F_a z_a. \qquad (120)$$

Unstressed reinforcement A' should not be considered in the rating, if the observance of condition (48) leads to a decrease in the rated strength of the element in comparison with the rating without considering this reinforcement.

In positioning tensile-stressed reinforcement A in several rows over the height of an element section the requirement of 7.3 should be considered.

With the presence of a compressive zone in a stressed reinforcement section its consideration should be carried out in accordance with the recommendations of 7.6.

7.55. The rating of eccentrically tensile-stressed elements of rectangular cross section is carried out:

a) if force N is applied between the resultants of the forces in reinforcement A and A' - under the conditions of (115) and (116);

b) if force N is applied beyond limits of the distance between the resultants of the forces in reinforcement A and A' - under the following conditions

$$N \leq R_a F_a - R_{a.c} F'_a - R_u bx \tag{121}$$

or

$$Ne \leq R_u bx\left(h_0 - \frac{x}{2}\right) + R_{a.c} F'_a (h_0 - a'); \tag{122}$$

in this case the position of the zero (neutral) axis is determined using the equation

$$R_u bx\left(e + h_0 - \frac{x}{2}\right) + \\ + R_{a.c} F'_a e' - R_a F_a e = 0, \tag{123}$$

and the height of the compressed zone should satisfy condition (46); the considering of the compressed reinforcement should be carried out in accordance with the instructions of 7.54.

7.56. The strength of inclined sections of eccentrically tensile-stressed reinforced-concrete elements should be ensured by observance of the following requirements:

a) if longitudinal force N passes between the resultants of the forces in reinforcement A and A', the entire transverse force in any inclined section directed at an angle of 60° and less to the longitudinal axis of the element, should be received by the transverse reinforcement ; the testing of sections, composing with the longitudinal axis of an element an angle of more than 60°, can not be carried out;

b) if longitudinal force N is applied beyond the limits of the distance between the resultants of the forces in reinforcement A and A', the rating of the inclined sections should be carried out as for flexural elements, in accordance with the instructions of 7.24-7.42; in this case if the eccentricity of force N relative to the center of gravity of the entire concrete section is $e_0 \leq 1.5h_0$, then value $Q_б$ [see formula (63)] is multiplied by the coefficient

$$k = \frac{e_0}{h_0} - 0,5. \qquad (124)$$

The rating of the strength of inclined sections of eccentrically tensile-stressed elements cannot be carried out (the transverse reinforcement in this case is installed constructionwise in accordance with the instructions of 12.24), if only one of the following conditions is observed in case "b":

1) the magnitude of the main tensile stress $\sigma_{г.р}$ determined with rated loads, does not exceed the rated strength of the concrete to tension R_p;

2) $Q \leq kR_p bh_0$, and the first of these conditions is observed in case "a".

The magnitude of the main tensile stress $\sigma_{г.р}$ is determined in accordance with the rules on the strength of elastic materials; for prestressed elements magnitude $\sigma_{г.р}$ should be determined in accordance with the instructions of 8.10.

Note. For prestressed elements reinforced with wired, bundles or strands without anchors, it is necessary to check flexural strength of sections inclined and normal to the axis of the element along the length of reinforcement anchoring zone (see 7.28).

ELEMENTS OF HEAVY-AGGREGATE CONCRETE WITH UNSTRESSED REINFORCEMENT, WORKING IN TORSION WITH FLEXURE

7.57. For reinforced-concrete elements of rectangular cross-section working in torsion with flexure or in pure torsion, the dimensions of the section should be designated in such a way that the following condition is observed

$$M_к \leq 0{,}07\, R_и b^2 h, \tag{125}$$

where h and b - respectively the greater and smaller dimensions of the section.

7.58*. Elements of rectangular cross section which are subjected to torsion or to the simultaneous effect of torsion and flexure, are rated in accordance with the subsequent instructions.

a) The bearing capacity of an element is determined during the joint effect of torsional and flexure moments (in accordance with the 1st scheme, Fig. 28a) - under the following conditions

$$M_к \left(\frac{c_1}{b} + \frac{1}{\varkappa}\right) \leq \left[R_a F_{a1} + R_{a.x} \frac{f_{x1} c_1^2}{u_1 (2h+b)}\right] \times$$
$$\times \left(h_0 - \frac{x_1}{2}\right) + R_{a.c} F'_{a1} \left(\frac{x_1}{2} - a_1\right); \tag{126}$$

in this case the position of the neutral axis is determined by two parameters: by the length of the projection of the neutral axis on the longitudinal axis of element c_1 which is taken as equal to

$$c_1 = -\frac{b}{\varkappa} + \sqrt{\left(\frac{b}{\varkappa}\right)^2 + \frac{R_a F_{a1} u_1}{R_{a.x} f_{x1}} (2h + b)}, \tag{127}$$

but not more than

$$c_{1\,макс} = 2h + b, \tag{128}$$

and by the height of the compressed zone of the concrete x_1 which can be determined under the following condition:

$$R_a F_{a1} - R_{a.c} F'_{a1} = R_u b x_1. \tag{129}$$

Compressed reinforcement A' should be considered in formulas (126) and (129) only in the case when value x_1 determined under condition (129) disregarding the compressed reinforcement, is greater than $2a_1'$; if, in this case, magnitude x_1 determined from formula (129), taking the compressed reinforcement into account be less than $2a_1'$, then it is assumed that $x_1 = 2a_1'$.

When rating only for torsional moment (in the absence of bending moment in the section in question) magnitude κ in formulas (126) and (127) is taken to be equal to infinity.

b) The bearing capacity of an element is determined under the joint effect of torsional moment and transverse force (in accordance with the 2nd scheme, Fig. 28b) - under the following condition

$$M_\kappa \frac{c_2}{h}\left(1 + \frac{1}{\lambda}\right) \leqslant \left[R_a F_{a2} + R_{a.x} \frac{f_x c_2^2}{u_2 (2b + h)}\right] \times \left(b - a_2 - \frac{x_2}{2}\right); \tag{130}$$

in this case the position of the neutral axis is determined by magnitudes c_2 and x_2, where

$$c_2 = \sqrt{\frac{R_a F_{a2} u_2}{R_{a.x} f_{x2}} (2b + h)}, \tag{131}$$

but not more than

$$c_{2\,\text{макс}} = 2b + h, \tag{132}$$

and it is possible to determine x_2 under the following condition

$$R_a F_{a2} - R_{a.c} F'_{a2} = R_u h x_2; \qquad (133)$$

if, in this case, it turns out, that $x_2 < 2a_2$, then it is assumed that $x_2 = 2a_2$.

In rating only for torsional moment (in the absence of transverse force in the zone in question) λ in formula (130) is taken to be equal to infinity.

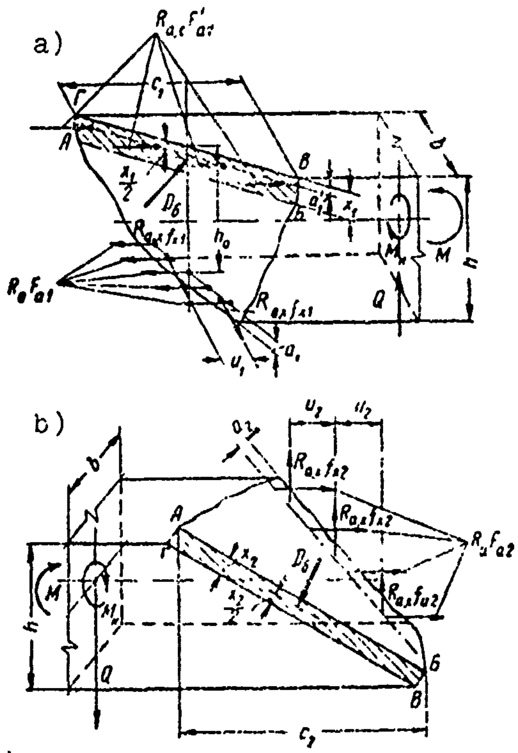


Fig. 28. Diagram of the formation of a plastic hinge in a reinforced-concrete element during the joint effect of flexure and torsion. a) 1st diagram; the neutral axis is situated at the face of the element with width b (compressed due to flexure); b) 2nd diagram; the neutral axis is situated at one of the faces of the element with width h (parallel to the plane of the effect of flexural moment); АБ - the neutral axis of the three-dimensional cross section of the element; АБВГ - compressed zone of the concrete.

The bearing capacity of an element is taken from the smaller of its two values obtained from formulas (126) and (130). Moreover, independent of the rating in accordance with the instructions of 7.58 a section of an element operating in flexture with torsion, should satisfy the conditions of 7.16 in the rating without considering torsional moment.

The following designations are accepted in formulas (126)-(133)

$$\varkappa = \frac{M_\kappa}{M};\ \lambda = \frac{2M_\kappa}{Qb};$$

M_κ, M and Q - respectively the torsional moment, flexural moment and transverse force, acting in one direction from (three-dimensional) section of the element in question shown in Fig. 28, bearing along the length of the element toward the center of gravity of the compressed zone of the concrete; F_{a1} - the sectional area of all the longitudinal rods situated at the face of an element with width b, tensile-stressed due to flexure; F'_{a1} - the same, at the face of an element of a width b compressed due to flexure; F_{a2} and F'_{a2} - the same, at each of the faces with width h (parallel to the plane of flexure); f_{x1} - the sectional area of one transverse rod from the number situated at the faces with width b (perpendicular to the plane of flexure); f_{x2} - the same, at faces with width h (parallel to the plane of flexure); u_1 and u_2 - the distances between the transverse rods (respectively at the faces with width b and width h); a_1 and a'_1 - the distances from the faces with width b (normal to the plane of the effect of flexural moment) respectively tensile-stressed and compressed due to flexure, up to the axis of the longitudinal rods, situated at the given face; a_2 - the distance from the lateral face of an element (with width h) to the axis of the longitudinal rods situated at this face.

When $\lambda < 1-2\frac{a_2}{b}$ the rating of an element in accordance with formulas (130)-(133) (with respect to the 2nd diagram) is not carried out, but is replaced by the rating for flexure for inclined sections, in accordance with the instructions of 7.24-7.27.

The sections introduced into the rating of the longitudinal and transverse reinforcement in elements operating in flexure with torsion or in pure torsion, should satisfy the following conditions:

a) for the faces of an element with width b (perpendicular to the plane of the effect of flexural moment)

$$0{,}5 \leqslant \frac{R_{a.x} f_{x1}}{R_a F_{a1}} \cdot \frac{b}{u_1}\left(1 + \frac{2}{\varkappa}\sqrt{\frac{b}{2h+b}}\right) \leqslant 1{,}5; \qquad (134)$$

b) for the faces of an element with width h (parallel to the plane of the effect of flexural moment)

$$0{,}5 \leqslant \frac{R_{a.x} F_{x2}}{R_a F_{a2}} \cdot \frac{h}{u_2} \leqslant 1{,}5. \qquad (135)$$

7.59*. When $\varkappa \leq 0.2$ it is necessary to observe the condition ensuring sufficient strength of the concrete in the compressed zone,

$$\frac{x_1}{h_0} \leqslant 1 - \sqrt{1-\zeta}, \qquad (136)$$

where ζ - the coefficient, characterizing the position of the neutral axis corresponding to the boundary of the over-reinforcement of the section, is determined in accordance with the instructions of 7.19.

If condition (136) is not observed, then it is necessary to increase the dimensions of the section or to raise the concrete grade. Sometimes when it is impossible or inexpedient to increase the dimensions of the section or to increase the concrete grade it is permissible to increase the section of the compressed reinforcement, if its inclusion makes it possible to satisfy condition (136).

7.60. If in an element operating in flexure with torsion, the dimensions of cross section are taken to be such, that the following condition is observed

$$M_\kappa < \frac{1}{6} R_p b^2 (3h - b) \qquad (138)^1$$

and in this case value $\kappa \leq 0.2$, then it is permissible not to place the rated transverse reinforcement at the face of an element with width b (perpendicular to the plane of flexure) compressed due to the flexure.

7.61. The magnitude of the transverse force in elements of rectangular cross section subjected simultaneously to torsion and flexure, in all cases should satisfy condition (58), and also the following condition

$$Q \leq \frac{Q_{x.б}}{1 - 1{,}5\lambda}, \qquad (139)$$

where $Q_{x.б}$ - the maximum transverse force received by the concrete and by the vertical transverse rods in simple flexure (see 7.32).

[1]Formula (137) is omitted.

RATING OF ELEMENTS OF HEAVY-AGGREGATE CONCRETE FOR PUNCHING SHEAR

7.62. The rating of centrally loaded square reinforced-concrete foundations, the capitals of girderless spanning structures, and also slabs under local loads for punching shear is carried out under the following condition

$$P \leqslant 0{,}75 R_p h_0 b_{cp}, \qquad (140)$$

where P - the rated punching-shear force; h_0 - the operational height of the cross section of a foundation (slab) in the part being tested; b_{cp} - the arithmetical mean between the perimeters of the upper and lower base of a pyramid which is formed with punching shear within the limits of the operational height of cross section h_0.

In determining values b_{cp} and P it is assumed, that punching shear occurs along the surface of the pyramid, the lateral sides of which are inclined at an angle of 45° to the vertical (Fig. 29a).

The magnitude of force P is assumed equal to the magnitude of the normal force acting in the column section at the top of the foundation or at the bottom of the capital of a girderless spanning structure minus the loads, applied to the larger base of the punching shear pyramid (considering up to the plane of the positioning of the tensile-stressed reinforcement).

7.63*. The rating of centrally loaded rectangular and also eccentrically loaded square and rectangular reinforced-concrete foundations for punching gear is carried out in accordance with 7.26; in this case values P and b_{cp} in formula (140) are taken to be equal to:

$$P = Fp_{гр};\qquad (141)$$

$$b_{ср} = \frac{b_о + b_н}{2},\qquad (142)$$

where F - the area of polygon ABCDEG (see Fig. 29b); $p_{гр}$ - the greatest boundary pressure on the ground from the rated load (taking moment into account); $b_о$ and $b_н$ - the dimensions respectively of the upper and lower (at the level of the tensile-stressed reinforcement) sides of the face of the punching shear pyramid:

parallel to the smaller side of a centrally loaded foundation or normal to the direction of the eccentricity of an eccentrically loaded foundation.

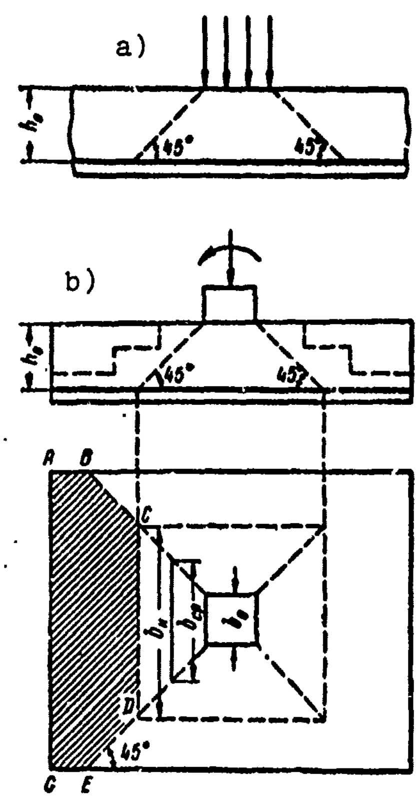


Fig. 29. Diagrams of the formation of punching shear pyramid in reinforced-concrete foundations a) for a square centrally loaded foundation; b) for a rectangular, and also an eccentrically loaded foundation.

THE RATING OF INSERT COMPONENTS AND ELEMENT JOINTS

7.64*. Anchors welded T-wise normal to the flat elements of steel insert components made in accordance with the instructions of 12.55 and 12.56, under the effect of flexure momen normal and shearing forces should be rated taking the joint effect of these force factors into account.

Bent-up anchors welded overlapped to the steel insert components also made in accordance with the instructions of 12.55 and 12.56, can be rated taking into account the principle of the independence of forces, and the anchors welded overlapped, are rated only for shear forces, and the anchors welded T-wise - only for flexural moments and normal forces.

The number, cross section, and length of the anchors should be determined in accordance with the "Instructions on Designing Reinforced-Concrete Structures."

The structure of the insert components with elements welded to them transmitting the load to the insert components, should possess sufficient rigidity to ensure uniform force distribution between the tensile-stressed anchors and the uniform transmission of compressive stresses to the concrete.

The thickness of the plates of the insert components $\delta_{п}$ with anchors welded T-wise, should satisfy condition (144), and also the technological requirements on welding.

$$\delta_{п} \geqslant 0,25d \frac{R_{a}}{R_{cp}}, \qquad (144)^{1}$$

[1]Formula (143) is omitted.

where d - the diameter of the anchors; R_a - the rated strength of the steel of the anchors to tension in kg/cm^2, R_{cp} - the rated strength of the steel of the plates to shear which can be assumed equal to 1300 kg/cm^2.

7.65. The rating of the indirect reinforcement of the ends of an element (in the cases, specified in 12.57) should be carried out using the following formula

$$N \leqslant (R_{пр} + 2\mu_к R_а) F_я, \qquad (145)$$

where $F_я$ - the sectional area of the concrete included within the contour of the welded grids, reckoning from the extreme outer rods; R_a - the rated strength of the grid rods; $\mu_к$ - the coefficient of the indirect reinforcement determined with formula (36).

In this case the reinforcement of the ends of the elements should be carried out in accordance with the instructions of 7.13.

7.66*. The dimensions of concrete keys transmitting shearing forces from one precast element to another (Fig. 30) or longitudinal shearing forces between precast elements and additionally laid concrete, should be determined with the following formulas:

$$\delta_ш \geq \frac{Q_{сд}}{R_{пр} l_ш n_ш}; \qquad (146)$$

$$h_ш \geq \frac{Q_{сд}}{2R_р l_ш n_ш}, \qquad (147)$$

where $Q_{сд}$ - the shearing force transmitted through the keys; $R_{пр}$ and $R_р$ - the rated strengths of the concrete to compression and to tension for concrete constructions; $\delta_ш$ - the depth of the key; $h_ш$ - the height of the key; $l_ш$ - the length of the key; $n_ш$ - the number of keys introduced into the calculation; in rating for shearing force $n_ш$ should not be more than three.

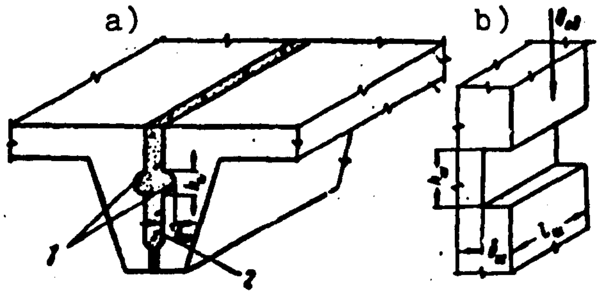


Fig. 30. The joining of precast elements using concrete keys; a) the joining of two slabs with a concrete key; b) diagram of the distribution of shear and the rated dimensions of the concrete key; 1 - concrete keys; 2 - the filling of a joint with concrete or mortar.

With the presence of reinforcement or compressive force, perpendicular to the planes of the joint, it is permissible to reduce the height of the keys rated for shearing force, in contrast to that determined by condition (147), but by not more than two times.

Notes: 1. When keying flooring elements the length of the key introduced into the calculation, should be not more than half of the span of the element; in this case the magnitude of shearing force $Q_{сд}$ is assumed to be equal to the sum of the shearing forces over the entire length of the element.

2. Magnitudes $R_{пр}$ and $R_р$ are taken for the lowest grade of concrete used in the key joint.

8. THE RATING OF PRESTRESSED ELEMENTS WITH RESPECT TO CRACKING

8.1. Prestressed structures of the 1st category of crack resistance, and also structures of the 2nd category of crack resistance, in which the formation of cracks is not permitted either in the use stage and in the stages of precompression, transportation and installation (see 4.2 and 4.4 of the present Codes) should be designed so that the resultant of the forces in the entire stressed longitudinal reinforcement after compression of the concrete does not go beyond thelimits of the core of the section. In this case the magnitude of the reinforcement prestressing should be assumed to be the greatest in accordance with the instructions of 5.6.

AXIAL TENSIONING OF CENTRALLY COMPRESSED ELEMENTS

8.2. Rating of prestressed centrally compressed reinforced-concrete elements for crack formation during their axial tensioning is carried out under the following condition

$$N \leqslant N_{т}, \tag{148}$$

where

$$N_{т} = R_{т}F + (300 - \sigma_{а}) F_{а} + + (300 + m_{т}\sigma_{0}) F_{н}; \tag{149}$$

N - the longitudinal force from the external loads (standard or rated, in accordance with the instructions given in Table 10); σ_0 - stress in the reinforcement taking losses into account (see 5.2; 5.4 and 5.10); σ_a - compressive stress in unstressed reinforcements, taken in accordance with the instructions of 5.10; 300 - the increase in stress in the reinforcement in kg/cm^2, corresponding to the maximum relative extensibility of the concrete taken to be equal to about 0.00015; F_a - the sectional area of the unstressed longitudinal reinforcement ; F_H - the sectional area of the prestressed longitudinal reinforcement ; m_T - the quality coefficient of the prestressing of reinforcement taken in accordance with the instructions of 5.3.

For elements, in which cracks can form before prestressing, and also for butt-joined sections of integral and modular structures when rating them for cracking (the beginning of the opening of joints) magnitude N_T is determined using the following formula

$$N_T = m_T \sigma_0 F_H. \qquad (150)$$

ELEMENTS OPERATING IN FLEXURE, ECCENTRIC COMPRESSION, ECCENTRIC TENSION, AXIAL TENSION WITH ECCENTRIC COMPRESSION AND TORSION

8.3. The rating of sections, normal to the axis of bent and eccentrically ecompressed prestressed reinforced-concrete elements for crack formation, with the exception of the cases indicated in 8.5, is carried out proceeding from the positions set forth in 6.4, with the replacement of R_p by R_T (Figs. 31-33). In this case it is recommended that the following approximation formula be used:

$$M_B^A \leqslant M_T, \qquad (151)$$

where M_B^A - the moment of the external forces located to one side of the section in question, relative to the axis, normal to the plane of flexure and passing through the core point, most distant from the zone of the section, whose crack formation is being checked.

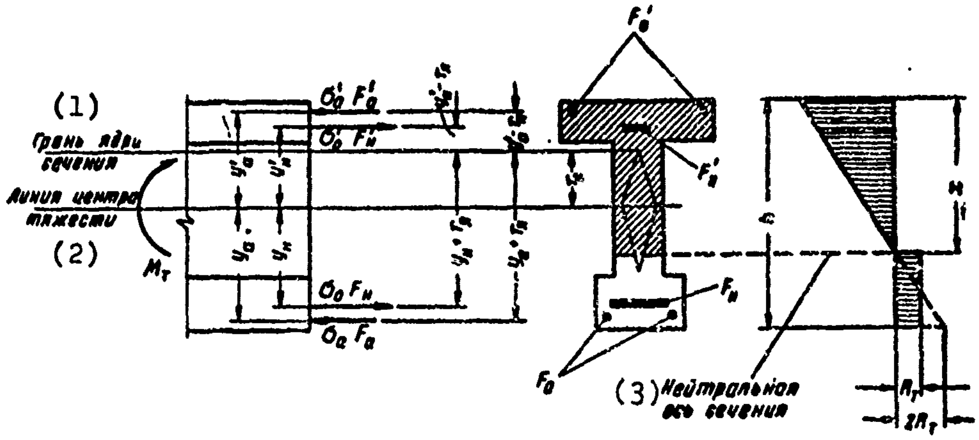


Fig. 31. Diagram of the distribution of forces and stress diagram in the transverse section of bent prestressed reinforced-concrete element during rating for crack formation in the zone tensile-stressed by an external load, in which stressed and unstressed reinforcement is contained.
KEY: (1) Section core face, (2) Center of gravity line; (3) Neutral axis of the section.

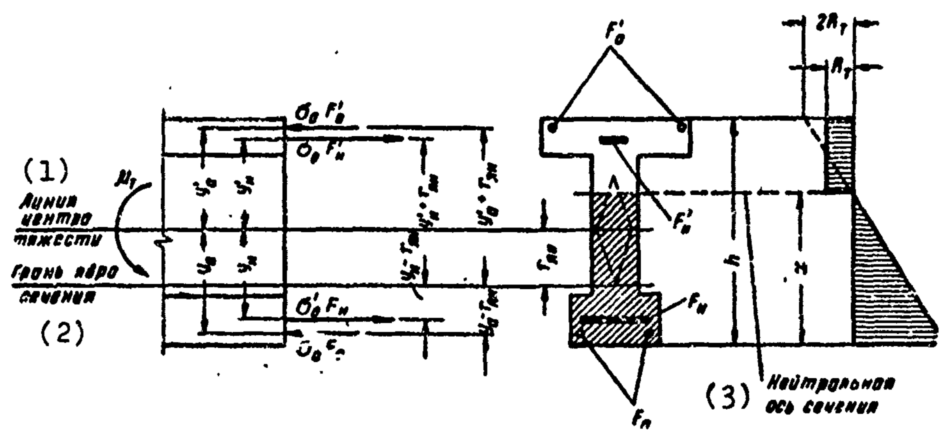


Fig. 32. Diagram of the distribution of forces and stress diagram in the transversed section of a bent prestressed reinforced-concrete element in rating the zone compressed by an external load for crack formation, in which stressed and unstressed reinforcements is contained.
KEY: (1) Center of gravity line; (2) Section core face; (3) Neutral axis of the section.

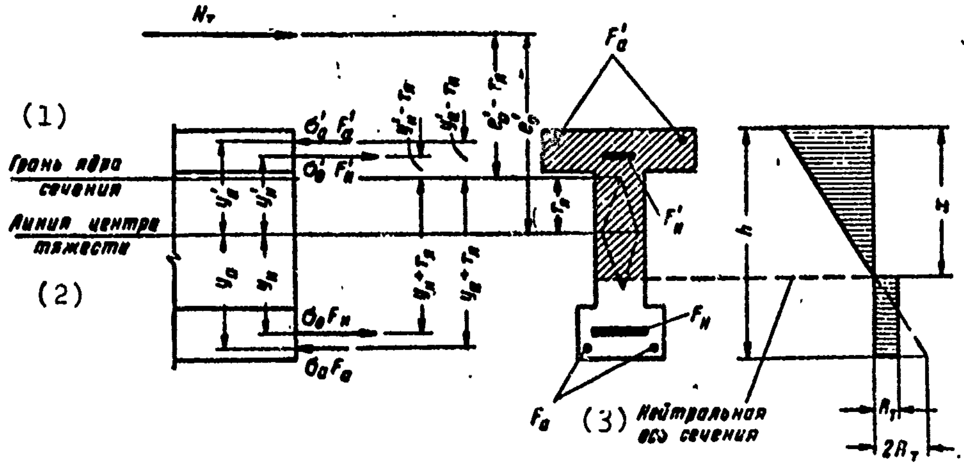


Fig. 33. Diagram of the distribution of forces and stress diagram in the transverse section of an eccentrically compressed prestressed reinforced-concrete element in rating the zone tensile-stressed by an external load for crack formation, in which stressed and unstressed reinforcement is contained.
KEY: (1) Section core face; (2) Center of gravity line; (3) Neutral axis of the section.

Value M_T for prestressed elements is determined using the following formula

$$M_{т} = R_{т} W_{т} \pm M^{я}_{об}, \qquad (152)$$

where $M^{Я}_{0б}$ - the moment of the resultant of forces N_0 in the stressed and unstressed reinforcement relative to the same axis, passing through the core point; in this case the resultant of forces N_0 is determined by considering the instructions of 5.2, 5.4 and 5.10; the sign of the moment is determined by the direction of rotation; W_T - the moment of resistance of the given section is determined by considering the inelastic deformations of the concrete, in accordance with the assumptions of 6.4; the given cross section is determined in accordance with the instructions of 5.2.

The moment of resistance for the tensile-stressed boundary fiber of given cross section W_T is determined, using formulas (13) and (14), in which values J_c, S_p, S_c and F_p are replaced by the appropriate characteristics of the given cross section (the position of the zero line in the cross section is determined under the assumption that longitudinal force is absent).

Value W_T can be determined from Table 34 of Appendix II.

8.4. The rating of sections, normal to the axis of prestressed reinforced-concrete elements for crack formation, subject to eccentric tension (and also to axial tension if with eccentric compression) (Fig. 34), with the exception of the cases indicated in 8.5 is carried out using formula (151), if in the ultimate state the tensile force does not exceed the compressive force, which is characterized by the following conditions:

a) compressive force N_0 and the core point, most distant from the zone of the sections, being checked for crack formation, are situated to one side of external force N (Fig. 35);

b) the distance between external force N and compressed force N_0 is

$$c - c_0 \geq \frac{W_T R_T}{N_0}. \qquad (153)$$

If even one of these conditions is not satisfied, therefore the tensile force in the ultimate state exceeds the compressive force, and the rating is carried out under the following condition

$$M_3^y \leqslant M_T, \qquad (154)$$

where

$$M_T = R_T W_T \pm M_{o6}^y; \qquad (155)$$

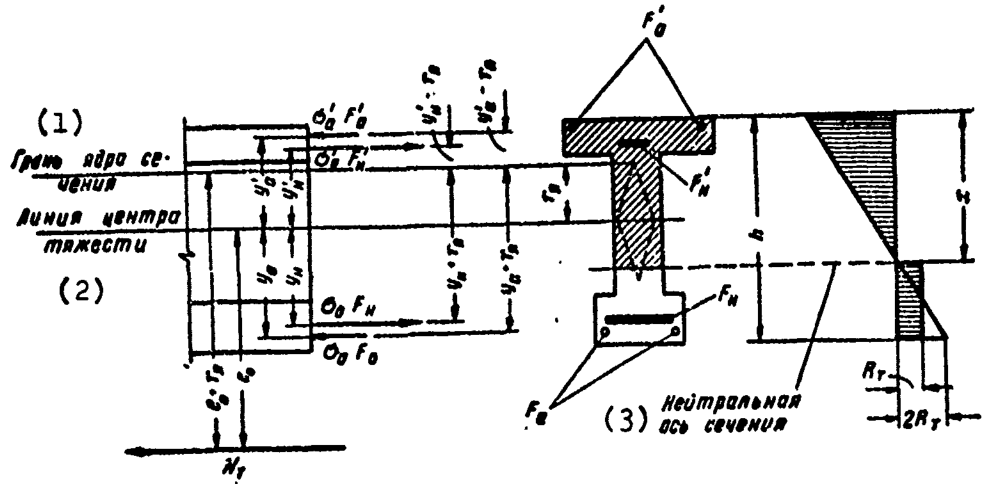


Fig. 34. Diagram of the distribution of forces and stress diagram in the transverse section of an eccentrically tensile-stressed prestressed reinforced-concrete element in rating the zone tensile-stressed by an external load for crack formation, in which stressed and unstressed reinforcement is contained.
KEY: (1) Section core face; (2) Center of gravity line; (3) Neutral axis of the section.

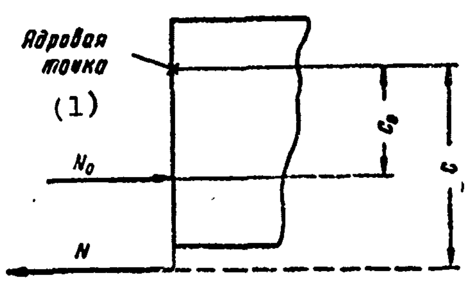


Fig. 35. Diagram of the distribution of forces in the transverse section of an eccentrically tensile-stressed prestressed reinforced-concrete element during its rating for crack formation.
KEY: (1) Core point.

M^y_B - the moment of external forces situated to one side of the section in question (Fig. 35), relative to the axis normal to the plane of flexure and passing through the conditional core point located from the center of gravity of the section a distance of

$$r_y = \frac{W_T}{F_n}; \tag{156}$$

M^y_{06} - the moment of the resultant of forces N_0 in the stressed and unstressed reinforcement relative to the same axis passing through the conditional core point most distant from the zone of the section, whose crack formation is being checked; in this case the resultant of the forces is determined taking the instructions of 5.2 into account; the sign of the moment is determined by the direction of rotation.

Note: In cases when inaccuracies in calculating value W_T can perceptibly affect the expenditure of materials or the evaluation of the crack resistance of an actual structure, it is recommended that this value be determined by using formula (13) and not by Table 34.

8.5. Prestressed reinforced-concrete eccentrically compressed elements, and also flexural elements of T-shaped cross section with a flange in the tensile-stressed zone (or other sections, close in shape to that indicated), when the following conditions is not observed

$$N + N_0 \leqslant \frac{bhR_u}{2} - F_n R_T, \tag{157}$$

should be rated for crack formation by taking the inelastic deformations into account (deviations in the compressed stressed diagrams from triangular) in accordance with the appropriate instructions.

8.6*. In rating precast monolithic prestressed reinforced-concrete ratings for crack formation in flexural and eccentrically compressed elements after attaining the assigned strength with additionally laid concrete, when value $M^{R}_{0б}$ in the cross section of a precast monolithic structure is greater than in the cross section of a precast element, for determining M_T it is permissible to use the following formula instead of formula (152)

$$M_{т} = R_{т}W_{т} + M^{я}_{об} - M_{1}\left(\frac{z_{я}}{z_{я1}} - 1\right), \qquad (158)$$

where M_1 - flexural moment due to an external load, acting in the cross section of an element, before the acquisition of the required strength by additionally laid concrete; z_{R1} and z_{R} - the distances from force N_0 to the core point, most distant from the zone of the cross section, in which crack formation is being checked, respectively for the cross section of the precast element and for the cross section of the precast monolithic element.

The instructions of the present paragraph extend only to the case of the placing of additionally laid concrete in the compressed zone of a cross section; in the remaining cases rating should be carried out in accordance with special standard documents.

8.7. In the crack-formation rating of articles and structures reinforced with prestressed elements, the position of the neutral axis at the moment of crack formation in prestressed elements is determined under the assumption that the area of the tensile-stressed zone of the concrete, not being subjected to prestressing, is equal to zero.

8.8. In rating butt-joined cross sections of integral [and] modular structures for seam opening value R_T in formulas 8.2-8.6 is assumed to be equal to zero.

8.9*. If in structures of the 2nd category of crack-resistance with respect to rating crack formation is permissible in the zones experiencing compression from external loads, then in the sections with these cracks values M_T determined using formulas (152) or (155) for the zones experiencing tension from external loads, are reduced by 10%.

8.10*. In rating prestressed elements for crack formation in sections, inclined to the axis of the elements, the following condition should be satisfied

$$\sigma_{г.р} \leq R_{т}; \tag{159}$$

in this case the main tensile stresses $\sigma_{г.р}$ should be determined at the most dangerous sites along the length of the span (depending on the type of transverse force, flexural and torsional diagrams and on the variation in the cross section of the element), and over the height of the cross section - only along the axis, passing through the center of gravity of the given cross section.

It is recommended that the value of the main tensile stresses $\sigma_{г.р}$ be determined using the following formula

$$\sigma_{г.р} = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2}, \tag{160}$$

where

$$\sigma_x = \frac{M}{J_n} y + \sigma_б; \tag{161}$$

$\sigma_б$ - the sustained prestressing in the concrete, determined by the instructions of 5.9; y - the distance from the fiber in question to the center of gravity of the given cross section.

It is necessary to substitute the tensile stresses in formula (160) and (161) with a "plus" sign, and the compressive stresses - with a "minus" sign.

σ_y - the compressive stress in concrete, acting in the direction, perpendicular to the longitudinal axis of an element, and caused by the effect of the prestressing of the transverse reinforcements (stirrups) or bends, and also of the local compressive stresses arising near supports or loads; absolute value σ_y due to prestressing of the transverse reinforcement (stirrups) or bends is determined using formula

$$\sigma_y = \frac{\sigma_{o.x} F_{н.x}}{u_x b} + \frac{\sigma_o F_{н.o}}{u_o b} \sin\alpha; \qquad (162)$$

here $F_{H.x}$ - the sectional area of all the stressed stirrups situated in one plane normal to the axis of the element in the section in question; $F_{H.O}$ - the sectional area of all the stressed bent-up reinforcement terminating in section u_0 with a length equal to h/2 situated symmetrically relative to section 0-0 in question (Fig. 36); $\sigma_{o.x}$ - the prestressing of the transverse reinforcement (stirrups) after the appearance of all the losses; u_x - the stirrup spacing; σ_o - the prestressing in the bent-up reinforcement after the appearance of all the losses.

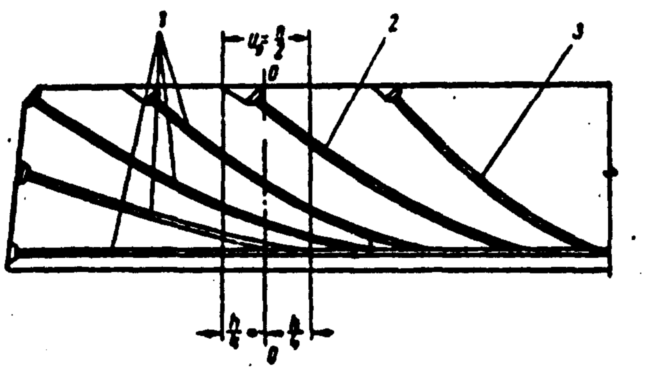


Fig. 36. Diagram of the distribution of the bundles of reinforcement taken into account in rating a flexural prestressed reinforced-concrete element for crack formation in the cross section. 1 - bundles of reinforcement taken into account in rating cross section 0-0 using formulas (164)-(166); 2 - bundle of reinforcement taken into account in rating cross section 0-0 using formula (162); 3 - bundle of reinforcement, not taken into account in rating cross section 0-0.

In formula (160)

τ - the shearing stress in concrete, determined using formula

$$\tau = \frac{QS_n}{J_n b}, \qquad (163)$$

where S_n - the given static moment of the part of the cross section situated after the fiber filament in question, relative to the axis passing through the center of gravity of the cross section; J_n - the moment of inertia of the given cross section determined by considering the instructions of 5.2; b - the width of ie element in the cross section in question.

In prestressed elements with a stressed inclined or curvilinear configuration with reinforcement the magnitude of transverse force Q, substituted in formula (163), is defined as the differenc. (or sum) of the transverse forces from external load Q_B and tensile stress Q_{np} using the following formula:

$$Q = Q_B - Q_{np}, \qquad (164)$$

where

$$Q_{np} = \sum N_0 \sin \alpha; \qquad (165)$$

N_0 - the force in the bundle or rod which terminates at a support or at a section between a support and a cross section situated at a distance of h/4 from cross section 0-0 in question (see Fig. 36) and determined using the following formula

$$N_0 = \sigma_0 f_H. \qquad (166)$$

σ_0 - the stress in the bent-up reinforcement after the appearance of all the losses; α - the angle included between the bent-up rod or bundle and the longitudinal axis of the element in the cross section in question; f_H - the sectional area of one rod or bundle of stressed bent-up reinforcement.

8.11*. For elements subjected to the joint effect of flexure and torsion, value τ, substituted in formula (160), is assumed to be equal to the sum of the shearing arising due to flexure [see formula (163)] and due to torsion τ_K.

Value τ_K can be determined using the formulas of plastic torsion, i.e., assuming, that at the moment of crack formation these stresses have an identical value over the whole cross section of the element; for elements of rectangular cross section the corresponding value τ_K is equal to

$$\tau_K = \frac{6M_K}{b^2(3h - b)}, \qquad (167)$$

where h and b - respectively the greater and lesser dimensions of the cross section.

8.12*. For prestressed elements (including centrally compressed elements rated for axial tension) reinforced with wire, bundles or strands, and also with stressed rod reinforcement without anchors, checking of the observance of the requirements of 8.3 and 8.10 in cross sections at the face of a support and over the length of the reinforcement anchoring zone l_{aH} determined in accordance with 7.28 is mandatory. In checking the observance of these conditions it is necessary to consider the possibility of incomplete compression of the concrete and the failure of the adhesion of the reinforcement with the concrete during the instantaneous transmission of the prestressing to the concrete (see note 3 to 7.28).

In determining $\sigma_{г.р}$ the prestressings in the reinforcement and in the concrete are assumed to be linearly increasing from zero at the beginning of the fixing site up to the values determined by formulas (6) and (8), at a distance $l_{ан}$ from the beginning of the fixing site (Fig. 37).

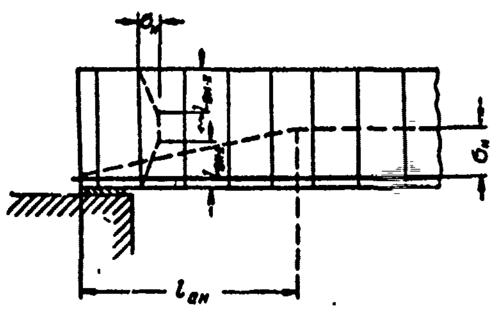


Fig. 37. Diagram of the distribution of prestressing along the length of reinforcement without anchors after compression of the concrete.

For the beams, not subject to rating for durability, in which the height of the cross section at support h_0 exceeds the length of the anchoring zone, it is permissible upon release of the tension not to carry out over this length checking of the observance of the requirements of 8.3 and 8.10. In this case in the tensile-stressed part during compression) of the circum-support zone of the beam over a length of not less than $1.5h_0$ from the beginning of the anchoring zone (see 7.28) it is necessary to install additional unstressed longitudinal reinforcement , placing it in the wall of the beam; the sectional area of this reinforcement should be not less than 0.2% of the area of the beam support section.

8.13. If in checking an inclined section condition (159) is not satisfied, it is necessary either to increase the dimensions of the transverse section of the element, or to employ prestressing of the transverse reinforcement, and if prestressing was already considered by the rating, then to increase it.

In these cases the required magnitude of prestressing of the transverse reinforcement $\sigma_{0.x}$ is determined using the following formula

$$\sigma_{0.x}=\frac{u_x}{F_{н.x}}\left[b\sigma_y-\frac{F_{н.0}}{u_0}\times\right.$$
$$\left.\times(\sigma_0+nR_т)\sin\alpha\right]-nR_т, \quad (168)$$

where σ_y - determined from formulas (160), assuming $\sigma_{r.p} = R_T$; σ_0 - the stress in the bent-up reinforcement taken into account in accordance with 8.10.

The prestressing of the transverse reinforcement (stirrups), checked during tensioning of the concrete $\sigma_{H.x}$, can be taken from the following condition

$$\sigma_{0.x}=\frac{\sigma_{н.x}+\sigma_п}{m_т}, \quad (169)$$

where m_T - the quality coefficient of the prestressing of the reinforcement taken in accordance with the instructions of 5.3.

9. RATING OF ELEMENTS OF REINFORCED-CONCRETE STRUCTURES FOR DEFORMATIONS

9.1. In rating reinforced-concrete structures for the second limiting condition, and also in the cases indicated in 4.20, the deformations (deflections and angles of rotation) of elements are calculated using the formulas of structural mechanics, determining their rigidity or curvature in accordance with the instructions of the present section of the codes.

Note. The instructions of the present section do not extend to structures of heating units (furnaces, flues, etc.) and their foundations being rated for temperature effects (see the instructions of 1.3 of the present Codes).

9.2. In determining deformations in necessary cases the effect of long-term loads should be considered, in accordance with the instructions of 9.4, 9.7 and 9.8.

9.3*. Deformations in elements of reinforced-concrete structures, during the use of which cracks in the tensile-stressed zone are not allowed or the appearance of cracks is highly improbable (for example prestressed elements of the 1st and 2nd categories of crack resistance, weakly reinforced elements), are determined in the same way as for a solid elastic body taking into account the operation of the concrete in the compressed and tensile-stressed zones; in this case the total cited cross section of the element is introduced into the rating (see 5.2).

In these cases the rigidity of the elements under the short-term effect of a load is determined using the following formula

$$B_{\kappa} = 0{,}85 E_{\delta} J_{s}. \quad (170)$$

In determining the deformations of T-shaped and double-T-shaped sectional grider elements of constant height with a ratio of the cross-sectional height to span of $\frac{1}{7}$ and more, are subjected to the effect of considerable concentrated loads (sub-crane beams, rafter and joint trussing beams, etc.), value $B_{н}$ should be assumed to be 10% less than that calculated using formula (170).

For prestressed elements of the 2nd category of crack resistance, in individual zones of which cracking is permissible during precompression (see Table 9), value $B_{н}$ should be taken to be 15% less than that determined using formula (170).

In determining the rigidity of structures made from light-aggregate concrete of grades 100 and below the coefficient 0.85 in formula (170) is replaced by 0.75.

9.4*. For the elements indicated in 9.3, the full value of the deformations in considering the long-term effect of part of the loads and flexure due to precompression of the concrete is determined using the following formula

$$f = f_{\kappa} + (f_{д} - f_{в}) c, \quad (171)$$

where $f^{*}_{н}$ - the deformation from a short-term acting load part; $f_{д}$ - the initial (short-term) deformation from a long-term acting load part; $f_{в}$ - the deformation due to the short-term effect of precompression of concrete (flexure); in computing $f_{в}$ the force in the stressed reinforcements is determined by taking all losses into account; values $f_к$, $f_д$ and $f_в$ are determined from rigidity $B_к$ calculated in accordance with the indications of 9.3; c - the coefficient which considers the increase in deformation resulting from concrete creep due to the prolonged effect of a load.

It is recommended that value c be taken equal to:

a) in the dry state c = 3;
b) in a normal state c = 2;
c) in the moist state c = 1.5.

Note. For structures of light-aggregate concrete prepared on a base of porous sand, and with a volumetric weight of the coarse filler of up to 700 kg/m^3 inclusive - and on a base of quartz sand, the value of coefficient c in formula (171) is taken in accordance with special standard documents.

9.5. The deformations of flexural elements, eccentrically tensile-stressed elements with eccentricties of $e_0 > 0.8h_0$ and eccentrically compressed elements, in which with loads corresponding to the stage of deformation determination, cracks can appear in the tensile-stressed zone (i.e., of elements made without prestressing, and also of prestressed elements of the 3rd category of crack resistance), are found in accordance with the instructions of 9.8 and 9.9, using the methods of structural mechanics for curvature values $1/\rho$, determined in accordance with the requirements of 9.6 and 9.7. For prestressed elements these curvature and deformation values are reckoned from the initial (before their precompressing) state of the elements.

Note. In 9.5 e_0 - the distance from the center of gravity of the given cross section to external tensile force N, and in the prestressed elements - to force N_c (see 9.7).

9.6. For elements of constant cross section having cracks in the concrete, in each portion, within the limits of which flexural moment does not change sign, curvature $1/\rho$ is calculated for the most stressed cross section. In the remaining cross sections of such a portion it is permissible to assume the curvature to be varying in proportion to the variation in the values of the flexural moment (Fig. 38).

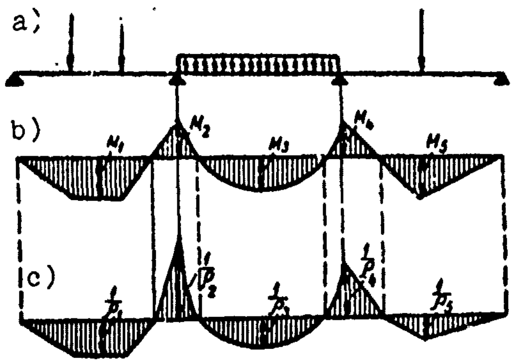


Fig. 38. Diagrams of the flexural moments and curvature in a reinforced-concrete element of constant cross section. a - diagram of the load distribution; b - diagram of the flexural moments, determined from a standard load; c - curvature diagram.

Deflections are determined in accordance with the found curvatures as moments due to a fictitious load, using the rules of structural mechanics.

9.7*. A curvature of $1/\rho$ in reinforced-concrete elements of rectangular, T-shaped and double-T-shaped cross sections (Fig. 39) indicated in 9.5, is determined using the following formulas:

a) for flexural elements made without prestressing,

$$\frac{1}{\rho} = \frac{M}{h_0 z_1}\left[\frac{\psi_a}{E_a F_a} + \frac{\psi_б}{(\gamma' + \xi)\, b h_0 E_б \nu}\right]; \qquad (172)$$

b) for prestressed flexural, eccentrically tensile-stressed elements with an eccentricity of $e_0 > 0.8h_0$, and also eccentrically compressed elements made both without prestressing as well as prestressed elements

$$\frac{1}{\rho}=\frac{M_з}{h_0 z_1}\left[\frac{\psi_a}{E_a F_a}+\frac{\psi_б}{(\gamma'+\xi)\, b h_0 E_б \nu}\right]-$$

$$-\frac{N_c}{h_0}\cdot\frac{\psi_a}{E_a F_a}. \qquad (173)$$

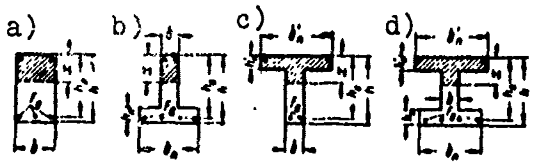


Fig. 39. Designations accepted in design equations for determining deformations (displacements) of elements of diverse transverse cross section; a - rectangular; b and c - T-shaped; d - double-T-shaped.

In formulas (172) and (173) the following designations are employed: $M_з$ - the substitution moment, i.e., moment relative to the axis, normal to the plane of flexure and passing through the center of gravity of the reinforcements of the tensile-stressed zone due to all the external forces, applied on one side of a cross section, and due to the force of precompression N_0 (determined by taking all losses into account, see 5.2); N_c - the total longitudinal force from external force N and from compressive force N_0; in eccentric tensioning force N is employed with a minus sign; F_a - the sectional area of the entire stressed and unstressed reinforcements of the tensile-stressed zone; z_1 - the distance from the center of gravity of the sectional area of the entire reinforcements situated in the tensile-stressed zone, up to the point of the application of the resultant of the forces in the compressed zone of the cross section (above a crack), determined using the following formula

$$z_1=h_0\left[1-\frac{\frac{h'_n}{h_0}\gamma'+\xi^2}{2(\gamma'+\xi)}\right], \qquad (174)$$

where

$$\gamma'=\frac{(b'_n-b)\,h'_n+\frac{n}{\nu}F'_a}{b h_0}. \qquad (175)$$

For rectangular cross sections having reinforcements A', instead of value h_n value 2a is substituted in formula (174); F'_a - the area of the entire stressed and unstressed reinforcements of the compressed zone (for designations of the dimensions of the cross section see Fig. 39), it is necessary to determine the design width of flange b'_n by taking the instructions of 7.18 into account; ψ_σ - the coefficient which takes into account the nonuniformity of the strain distribution of the extreme fiber of the compressed face of the cross section in the portion between the cracks taken to be equal to 0.9 both during the short-term and long-term effect of a load; ν - the ratio of the elastic part of the deformation of the extreme fiber of the cross-sectional compressed face to its total deformation which includes all types of non-elastic concrete deformation (creep, shrinkage, plastic deformations);

value ν during the short-term effect of a load is taken to be equal to:

a) for flexural elements made without prestressing, i.e., using formula (172), $\nu = 0.5$;

b) in the remaining cases, i.e., using formula (173), $\nu = 0.45$;

under the prolonged effect of a load value ν is taken to be equal both in formula (172) and in formula (173):

in the dry state $\nu = 0.10$;
in the normal state $\nu = 0.15$;
in the moist state $\nu = 0.20$.

For structures of light-aggregate concrete prepared on a base of porous sand, and with a volumetric weight of coarse filler of up to 700 kg/m^3 inclusive - and on a base of quartz sand, and also from light-weight concrete of grades 100 and below the value of coefficient ν is taken in accordance with special standard documents; ξ - the relative height of the compressed zone of the concrete in the cross section with the crack, equal to $\xi = \frac{x}{h_0}$, where x is the height of the compressed zone in the cross section with a crack; value ξ in formulas (172), (173) and (174) during the short-term effect of a load is assumed to be equal to

$$\xi = \frac{1}{1{,}8 + \frac{1 + 5(L + T)}{10\mu n}} \pm \frac{1{,}5 + \gamma'}{11{,}5\frac{e_1}{h_0} \mp 5}, \qquad (176)$$

but not more than 1,
where

$$L = \frac{M_3}{bh_0^2 R_u^н}; \qquad (177)$$

$$T = \gamma'\left(1 - \frac{h_п'}{2h_0}\right); \qquad (178)$$

$$\mu = \frac{F_a}{bh_0};$$

e_1 - the absolute value of the eccentricity of the longitudinal force (including the compressive force) relative to the center of gravity of the reinforcements of the tensile-stressed zone, which corresponds to flexural moment M_3.

For the latter term on the right side of formula (176) the upper signs are employed with compressive force N_c,,and the lower signs - with tensile force N_c.

If value x is less than the thickness of flange $h_п'$, situated in the compressed zone, then values x and z_1 should be determined both for a rectangular cross-section with width $b_п'$, assuming $\gamma' = 0$ and $\mu = \frac{F_a}{b_п' h_0}$.

Under the prolonged effect of a load it is permissible to employ value ξ in the same way as under the short-term effect of a load, - in accordance with formula (176).

ψ_a - the coefficient which considers the operation of tensile-stressed concrete between cracks, taken to be:

a) fcr flexural elements made without prestress.ng, i.e., in formula (172)

$$\psi_a = 1{,}3 - s\frac{M_{б.т}}{M}; \qquad (179)$$

b) for the remaining cases, i.e., in formula (173)

$$\psi_a = 1{,}3 - sm - \frac{1-m}{6-4{,}5m}; \qquad (180)$$

and in both cases coefficient ψ_a should be taken to be not more than 1.

In formula (179) the following designation is employed: $M_{б.т}$ - the moment relative to the axis normal to the flexural plane and passing through the point of application of the resultant of the forces in the compressed zone of the cross section, received by the cross section without considering the reinforcements of the tensile-stressed zone directly before the appearance of the cracks; value $M_{б.т}$ is determined using the following formula

$$M_{б.т} = 0{,}8W_{б.т}R^{н}_{р}, \qquad (181)$$

where $W_{б.т}$ - the moment of resistance of the given cross section, determined by taking the inelastic deformations of the concrete into account in accordance with the instructions of 6.4 and 8.3 with considering the reinforcements situated in the zone tensile-stressed by the external load.

In formula (180)

$$m = \frac{M_T'}{M_c}, \qquad (182)$$

but not more than 1.

Here: M_T' and M_C - the moments of all the forces situated on one side of the cross section in question (including force N_0) relative to the axis normal to the flexural plane and passing through the point of application of the resultant of the forces in the compressed zone of the cross section above the crack; M_C is determined in the same stage, for which the deformations are determined, while M_T' - in the stage is immediately after the cracking under flexural moment M_T.

Value M_T is determined when the resistance of the concrete to tension is equal to R_p^H; it is permissible to determine M_T using formula (152) replacing R_T in it with R_p^H; for eccentrically compressed elements, and also for flexural prestressed elements with a flange in the tensile-stressed zone, for which condition (157) is not observed (in replacing R_T in it with R_p^H), M_T should be determined taking the instructions of 8.5 into account; coefficient m_T in these cases is taken in accordance with 5.3 "a".

In formulas (179) and (180) the following designation is employed: s - the coefficient which characterizes the shape of the reinforcing rods and the load duration taken to be equal to:

for structures of concrete of grades above 100: under the short-term effect of a load for deformed rods s = 1.1, for smooth rods s = 1; under the prolonged effect of a load s = 0.8 irrespective of the shape of the reinforcing rods;

for structures of concrete grades of 100 and below: under the short-term effect of a load for deformed rods s = 0.8, for smooth rods s = 0.7; under the prolonged effect of a load s = 0.55 irrespective of the shape of the reinforcing rods.

9.8*. The total magnitude of the deformations of the elements enumerated in 9.5, including the deformations from the long-term effect of part of a load, is determined using the following formula

$$f = f_1 - f_2 + f_3, \qquad (183)^{1}$$

where f_1 - the deformation due to the short-term effect of the entire load; f_2 - the initial (short-term) deformation due to the long-term acting part of the load; f_3 - the total (prolonged) deformation due to the long-term acting part of the load.

Values f_1, f_2, and f_3 are found from the values of the curvatures determined in accordance with the instructions of 9.6 and 9.7; in this case values f_1 and f_2 are computed with values ψ_a and ν, corresponding to the short-term effect of a load, and value f_3 - with values ψ_a and ν corresponding to the prolonged effect of a load; f_2 and f_3 are always calculated under the assumption that cracks are present in the tensile-stressed zone of the element, taking value $\frac{M_{б.т}}{M}$ in formula (179) and value m in formula (182) to be not more than unity. For elements, in which cracks can arise during precompression, the values of the curvatures determined in accordance with formula (173), in the portion in which cracks due to precompression should be increased by 15%; it is permissible not to increase the rated values of the curvatures for prestressed elements of T-shaped cross section with a flange in the compressed zone.

In determining the deformations of hollow flooring for value f determined using formulas (171) and (183), it is necessary to introduce coefficient 0.8, with the exception of the cases, when

[1]Formula (184) is omitted.

the deformations of the hollow flooring are determined under the assumption that cracks are absent in the circum-support portions.

When the height of the cross section of reinforced-concrete elements is less than 16 cm the values of the deflections calculated using formula (183), are multiplied by coefficient $\frac{4}{\sqrt{h}}$, where h - the height of the cross section in cm.

9.9. For the elements indicated in 9.5, having T-shaped or double-T-shaped cross section with a constant height along the length of the span with a ratio of the height of the cross section to the span of 1/7 and more, and under the effect of considerable concentrated loads (sub-crane beams, joint and rafter supporting beams, etc.) the total value of the deformations should be increased by 20% with respect to that determined by calculation.

10. RATING THE ELEMENTS OF REINFORCED-CONCRETE STRUCTURES FOR CRACK OPENING

10.1. The rating of crack opening should be carried out for the elements (or their individual zones) indicated in 4.7; in this case:

a) checking the width of the opening of cracks, normal to the longitudinal axis of an element (both prestressed and made without prestressing), is not necessary, if the conditions of (148) and (151) are observed, in which values N_T and M_T are determined respectively using formulas (149) and (152);

b) checking of the width of the opening of inclined cracks is not necessary, if condition (159) is observed for prestressed, and for elements made without prestressing, - condition (61).

Note. For eccentrically compressed elements, and also for prestressed flexural elements with a flange in the tensile-stressed zone, for which condition (157) is not observed, in determining the values of the forces, up to which the rating of the opening of cracks normal to the longituidnal axis of the element is not necessary, one should be guided by the instructions of 8.5.

10.2. The width of the opening of cracks normal to the longitudinal axis of element a_T in centrally tensile-stressed, flexural eccentrically tensile-stressed when $e_0 > 0.8h_0$ and eccentrically compressed elements should be determined using the following formula

$$a_T = \psi_a \frac{\sigma_a}{E_a} l_T, \quad (185)$$

where l_T - the distance between the cracks; σ_a - the stress in the tensile-stressed reinforcements, taken when rating the width of crack openings;

a) for structures made without prestressing:

for centrally tensile-stressed elements

$$\sigma_a = \frac{N}{F_a}; \quad (186)$$

for flexural elements

$$\sigma_a = \frac{M}{z_1 F_a}; \quad (187)$$

for eccentrically tensile-stressed elements when $e_0 > 0.8h_0$ *and eccentrically compressed elements*

$$\sigma_a = \frac{N(e_1 \pm z_1)}{F_a z_1}; \quad (188)$$

b) for prestressed structures:

for centrally tensile-stressed elements

$$\sigma_a = \frac{N - N_0}{F_a}; \quad (189)$$

for flexural elements

$$\sigma_a = \frac{M + N_0 (e_x - z_1)}{F_a z_1}; \qquad (190)$$

for eccentrically tensile-stressed elements when $e_0 > 0.8h_0$ *and eccentrically compressed elements*

$$\sigma_a = \frac{N (e_1 \pm z_1) + N_0 (e_x - z_1)}{F_a z_1}. \qquad (191)$$

In formulas (188) and (191) the plus sign is employed with eccentric tensioning, and the minus sign - with eccentric compression.

In formulas (187) - (191): e_1 - the distance from the center of gravity of reinforcements sectional area A to the point of the application of external longitudinal force N; e_x - is the distance from the center of gravity of reinforcements sectional area A to force N_0; z_1 - see 9.7, formula (174).

In determining the width of crack openings in the stage of compressing an element with the force of stressed reinforcements values σ_a should be taken to be not more than R_a^H.

Values ψ_a in formula (185) are determined using the following formulas:

a) for centrally tensile-stressed elements made without prestressing, under the short-term effect of a load

$$\psi_a = 1 - 0{,}7 \frac{N_{б.т}}{N}; \qquad (192)$$

the same, under the prolonged effect of a load

$$\psi_a = 1 - 0{,}35 \frac{N_{б.т}}{N}, \qquad (193)$$

where

$$N_{б.т} = 0{,}8FR_p^н; \qquad (194)$$

in this case if the ratio $\frac{N_{б.т}}{N} > 1$, then it is necessary to employ it in formulas (192) (193) as being equal to 1;

b) for centrally tensile-stressed prestressed elements of the 3rd category of crack resistance under the short-term effect of a load

$$\psi_a = 1 - 0{,}7\frac{N_T - N_0}{N - N_0}, \qquad (195)$$

the same, under the prolonged effect of a load

$$\psi_a = 1 - 0{,}35\frac{N_T - N_0}{N - N_0}, \qquad (196)$$

where value N_T is determined using formula (149) replacing R_T with R_p^H;

in this case if ratio $\frac{N_T - N_0}{N - N_0} > 1$, then it is necessary to take it in formulas (195) and (196) to be equal to 1;

c) for flexural, eccentrically tensile-stressed elements when $e_0 > 0.8h_0$ and eccentrically compressed elements made both without prestressing and with prestressing of the reinforcements - using formulas (179) or (180), in which values $\frac{M_{б.т}}{M}$ and m are taken to be not more than 1.

Indetermining ψ_a for the prestressed elements coefficient m_T is taken in accordance with 5.3 "a".

10.3. The distance between cracks l_T, substituted in formula (185), is determined both under the short-term and under the prolonged effect of a load:

a) for centrally tensile-stressed elements - using formula

$$l_T = \frac{u}{\mu_1}\eta; \qquad (197)$$

b) for flexural, eccentrically tensile-stressed elements when $e_0 > 0.8h_0$ and eccentrically compressed elements - using formula

$$l_T = k_1 n u \eta. \qquad (198)$$

In formulas (197) and (198) the following designations are employed

$$u = \frac{F_a}{s}; \quad \mu_1 = \frac{F_a}{F};$$

s - the perimeter of the reinforcement cross section; k_1 - the coefficient determined using formula

$$k_1 = \frac{W_T}{F_a z_1 n} - 2; \qquad (199)$$

W_T - the moment of resistance of the given cross section determined using formula ('3) (see 6.4 and 8.3) taking the entire reinforcement into ; η - the coefficient depending on the type of longitudina ...-stressed reinforcement , taken to be equal to:

for deformed rods η = 0.7;

for smooth hot-rolled rods η = 1;

for standard reinforcing wire used in welded frameworks and grids, η = 1.25.

Notes. 1. For prestressed elements having in the zone, being checked for crack openings, stressed and unstressed reinforcements, in computing values F_a and z_1 the sectional area of the entire reinforcement is considered.

2. The perimeter of the cross section of deformed rods s is taken to be equal to the length of the circumference, which corresponds to the maximum diameter without considering the projections and ribs.

10.4. Under the joint effect of short-term and long-term acting loads the width of the opening of cracks, normal to the longitudinal axis of a reinforced-concrete element, is determined using the following formula

$$a_т = a_{т1} - a_{т2} + a_{т3}, \tag{200}$$

where $a_{т1}$ - the width of the crack openings due to the short-term effect of the entire load; $a_{т2}$ - the initial width of the crack openings due to a long-term acting load (under its short-term effect); $a_{т3}$ - the total width crack openings due to a long-term acting load.

Values $a_{т1}$, $a_{т2}$, and $a_{т3}$ are determined using formula (185), considering values $a_{т1}$ and $a_{т2}$ - under the short-term effect of a load, and value $a_{т3}$ - under the prolonged effect of a load.

10.5. The width of the opening of inclined cracks in flexural elements is determined using the following formula

$$a_т = 4 \frac{t^2}{(\mu_x + \mu_o) E_a R_и^н} l_т, \tag{201}$$

where

$$t = \frac{Q}{bh_o}; \tag{202}$$

$$l_т = \frac{1}{3\left(\frac{\mu_x}{\eta_x d_x} + \frac{\mu_o}{\eta_o d_o}\right)}, \tag{203}$$

but not more than $h_o + 30d_{макс}$; d_x and d_o - the rod diameters respectively of the transverse and bent-up rods; $d_{макс}$ - the greatest of these diameters; μ_x - the coefficient of saturation with transverse rods normal to the longitudinal axis of the element, determined using formula

$$\mu_x = \frac{F_x}{bu}; \tag{204}$$

μ_o - the coefficient of saturation with rods, inclined toward the longitudinal axis of the element (bends, inclined stirrups), determined using the following formula

$$\mu_0 = \frac{F_0}{bu_0}; \quad (205)$$

Q - transverse force from a standard load; η_x and η_0 - the coefficients which consider the shape of the reinforcing rods (respectively of those normal and inclined toward the longitudinal axis of the element), taken to be equal to: f r deformed rods - 0.7; for smooth hot-rolled rods - 1; for standard reinforcing wire used in welded frameworks and grids, - 1.25; F_x, F_0 and u - the same designations as is 7.26 and 7.32; u_0 - the distances between the planes of the bends (the inclined rods), measured along the normal to them; with different distances between the bends (see Fig. 16) value u_0 is defined as the half-sum of the distances between the plane of the bends in question and the two planes of the bends (adjacent to it) measured along the normal to the bends:

for the first from the support of the bend plane

$$u_0 = \frac{u_{01} + u_{02}}{2}; \quad (206)$$

for the second from the support of the bend plane

$$u_0 = \frac{u_{02} + u_{03}}{2}; \quad (207)$$

for the latter bend plane value u_0 is taken to be equal to the distance between it and previous bend plane, i.e., when $u_0 = u_{03}$.

Bends can be considered in a rating only in those portions, where the distances from the face of a support to the beginning of the first bend (u_1), and also the distances between the end of the previous and the beginning of the following bend (u_2, u_3) do not exceed 0.2h (see Fig. 16).

It is permissible to decrease value a_T by 1.5 times with respect to that determined using formula (201), if the beam is reinforced with transverse rods normal to the axis of the element, and with longitudinal rods of the same diameter with the distances over the height of the cross section equal to the spacing of the transverse rods.

11. RATING THE ELEMENTS OF REINFORCED-CONCRETE STRUCTURES WHICH ARE SUBJECTED TO MULTIPLY REPEATED LOADS

11.1. The rating of reinforced-concrete elements for durability, and also for crack formation in the case of a multiply repeated load is carried out on the basis of the plane cross-section hypothesis in this case a variation in the stresses in the concrete with respect to the height of the element cross section is taken in accordance with the linear law. In durability ratings of elements, not subjected to prestressing, the performance of tensile-stressed concrete is not considered.

During the durability rating of prestressed elements the determining of stresses in them is carried out assuming that they manifest elastic performance; in this case the values of the stresses ascertained in the concrete and in the reinforcements are considered in accordance with the instructions of 5.9.

The stresses in concrete and reinforcements in rating for durability are calculated in accordance with the reduction characteristics of a cross section; the reduction factors (n or n') are taken in accordance with the instructions of 3.9.

Note. Compressed reinforcement is not rated for durability.

11.2. In rating the elements of reinforced-concrete structures subject to a multiply repeated load, testing of the stresses due to the greatest standard load of the cycle should be carried out:

a) for all elements - in the cross sections, normal to their axis;

b) for flexural, eccentrically compressed elements and eccentrically tensile-stressed, elements, moreover, - in the direction of the main tensile stresses.

11.3*. In rating cross sections normal to the axis of an element for durability, greatest marginal compressive stress in the concrete should not exceed the rating strength of the concrete for compression $R'_{пр}$ or $R'_{и}$ taken in accordance with 3.4, and the greatest stresses in the longitudinal tensile-stressed reinforcements - the values of the rated strengths of reinforcement R'_{a}, taken in accordance with the instructions 3.7 and 3.8. Furthermore, in prestressed structures rated for durability, the greatest value of tensile stresses in the extreme fiber of tensile-stressed concrete should not exceed the rated resistance of the concrete to tension R'_{T}, taken in accordance with 3.4; for elements employed at rated temperatures of minus 40°C and below, tensile stresses are not allowed in concrete (see 4.4 of the present Codes).

11.4. The main tensile stresses in prestressed elements rated for durability, determined in accordance with the instructions of 8.10, should not exceed R'_{T}.

If in elements with unstressed reinforcement these stresses exceed R'_{T}, then the resultant of the main tensile stresses along the neutral axis should be completely received by the transverse and bent-up reinforcement with a rated resistance of this reinforcement , equal to R'_{a}.

11.5. For each of the cases (indicated in 11.3 and 11.4) of testing of stresses in elements subject to a multiply repeated load, stresses are calculated in the concrete and in the reinforcements under the least and under the greatest standard loads of the cycle, which determine the magnitude of the characteristics of the stress cycle respectively in the concrete $\rho_б = \frac{\sigma_{б.\ мин}}{\sigma_{б.\ макс}}$ and in the reinforcements $\rho_а = \frac{\sigma_{а.\ мин}}{\sigma_{а.\ макс}}$, dependent on which the rated resistances of the concrete and the reinforcements are being ascertained (see 3.4 and 3.7).

11.6. In determining the deformations of reinforced-concrete elements subject to the effect of multiply repeated loads, values ψ_a and $\psi_б$ in formulas (172) and (173) of 9.7 are taken to be equal to 1.

11.7. The testing of the width of crack openings in elements of reinforced-concrete structures with stressed reinforcement rated for durability should be carried out for those cross sections (normal or inclined to the axis of the elements), in which the greatest tensile stresses due to standard loads exceed R_T^1, in this case the value of coefficient ψ_a in formula (185) is assumed to be equal to 1, and the width of oblique crack openings a_T, determined in accordance with 10.5 of the present Codes, is increased by 1.5 times.

12. GENERAL STRUCTURAL REQUIREMENTS

MINIMUM DIMENSIONS OF ELEMENT CROSS SECTIONS

12.1. The cross-sectional dimensions of centrally and eccentrically compressed concrete and reinforced-concrete elements should in all cases be taken to be such, that their flexibility does not exceed the maximum indicated value:

for concrete elements - in Table 17, and for reinforced-concrete elements - in Tables 21 and 24.

The dimensions of columns of rectangular cross section which are elements of buildings should be taken to be such that the ratio of the rated length of a column to the dimension of its transverse cross section in the appropriate direction would not be more than 30.

The thickness of monolithic slabs should be not less than:

a) for surfaces - 50 mm;

b) for inter-storey spanning structures [floors] of civic buildings - 60 mm;

c) for inter-storey spanning structures [floors] of industrial buildings - 70 mm;

d) under vehicular travelled sections - 80 mm.

The minimum thickness of precast slabs, in which there is reinforcements, should be determined under the condition of the requirements imposed on the distribution of reinforcements with respect to slab thickness and observance of the magnitude of protective concrete layers (see 12.2).

THE PROTECTIVE CONCRETE LAYER

12.2*. The thickness of the protective concrete layer for the working reinforcements of elements, not subjected to prestressing, and also of prestressed elements with longitudinal reinforcements stressed in abutments, should be taken to be:

a) in slabs and walls with a thickness of up to 100 mm inclusively of heavy-aggregate concrete - not less than 10 mm, and from light-aggregate concrete - not less than 15 mm;

b) in slabs and walls with a thickness of more than 100 mm, and also in beams and ribs with a height of up to 250 mm when $d^1 \leq 20$ mm - not less than 15 mm;

c) in beams and ribs with a height of 250 mm and more, and also in columns when $d^1 \leq 20$ - not less than 20 mm;

d) in beams, columns and slabs when $20 < d^1 \leq 32$ mm - not less than 25 mm; when $d^1 > 32$ mm - not less than 30 mm; when employing strip, angle and shaped steel - not less than 50 mm;

e) in foundation beams, and also in precast foundations - not less than 30 mm;

f) for the lower reinforcement of monolithic foundations (individual, slab and strip) in the absence of pre-conditioning - not less than 70 mm, and with pre- conditioning - not less than 35 mm.

In single-layer structures of light-aggregate concrete of brands 100 and below, made without cover [texture] layers, the thickness of the protective layer for the working reinforcements in all cases should be not less than 20 mm.

The thickness of the protective concrete layer for stirrups and transverse rods of welded frameworks in beams and columns should be not less than 15 mm, for distributed reinforcement of slabs - not less than 10 mm, and in single-layer structures of light-aggregate concrete of grades 100 and below not less than 15 mm.

In hollow elements of circular or rectangular cross section the distance from the rods of the longitudinal reinforcements to

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[1]d - the diameter of the working reinforcements; rods, wire, stands, cables.

the interior surface of the concrete should be not less than to the exterior surface.

The thickness of the protective concrete layer in precast elements of heavy-aggregate concrete of job-grade of more than 200 can be reduced by 5 mm in comparison with the above indicated values, but should be in any case not less than 10 mm for slab reinforcements and not less than 20 mm for the working reinforcements of the columns, beams and ribs indicated in subparagraph "c".

In beams with prestressed reinforcements stressed in abutments, the thickness of the protective concrete layer for working fittings with a diameter of $d > 32$ mm should be not less than d.

Under the systematic effects on reinforced-concrete structures of smoke, acid vapors, etc., and also under increased humidity the thickness of the protective layer should be designated taking into account the requirements of the appropriate standard documents on the protection of structural elements against corrosion.

In designating the thickness of a protective layer the requirements of chapter II-A.5-62 "Anti-Fire Requirements of SNiP. Basic Design Aspects" should also be considered.

12.3*. In all precast flexural elements the ends of the longitudinal rods of the stressed reinforcements, not welded to anchoring components, should be a distance from the face of an element of: in panels, flooring and slabs - not more than 5 mm, in other elements - not more than 10 mm.

The ends of stressed reinforcements, and also of an anchor should be protected by a mortar layer of not less than 5 mm or by concrete.

12.4*. In elements with stressed longitudinal reinforcements stressed in concrete and located in channels, the thickness of the protective concrete layer from the surface of an element to the channel surface should be:

a) in the positioning in a channel of one bundle or rod - not less than 20 mm and not less than half the diameter of the channel, and with rod reinforcements cables d ≥ 32 mm - not less than d;

b) in the group positioning of bundles, strands or rods for side walls - not less than 80 mm, and for lower walls - not less than 60 mm and not less than half the channel width (Fig. 40).

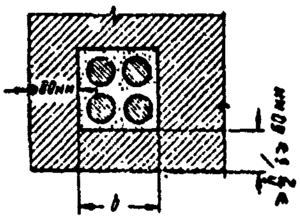


Fig. 40. The thickness of a protective concrete layer of a channel surface intended for the group positioning of bundle or rod prestressed reinforcements.

In positioning reinforcements in grooves or outside the cross section of an element the thickness of the protective layer formed by subsequent guniting or by concreting is not less than that indicated in 12.2 and not less than 20 mm.

12.5*. In prestressed elements the thickness of the protective concrete layer at the ends of an element in an anchoring area with a length of $l_{ан}$ (see 7.28) should be:

for rod reinforcements of classes A-IV, At-IV, A-IIIv, A-IIv, A-III and for reinforcing strands - not less than 2d;

for rod reinforcements of classes A-V, At-V and At-VI - not less than 3d, but not less than 40 mm for rod reinforcements and

20 mm for reinforcing strands. Departures from the indicated requirements are permissible in the following cases:

a) in installing a steel supporting component (a web or channel) reliably anchored in the concrete of an element, the protective concrete layer of the support can be the same as for a cross section in a span;

b) in slabs, panels, flooring and electric power transmission line (ЛЭП) pylons it is permissible not to increase the thickness of the protective concrete layer at the ends of an element, if it is:

not less than 20 mm with a rod diameter of 16-25 mm and a strand diameter of 15 mm;

not less than 15 mm with a rod diameter of 10-14 mm and a strand diameter of 9-12 mm;

not less than 10 mm with a rod diameter of 6-9 mm and a strand diameter of 4.5-7.5 mm.

In this case within the limits of the supporting sections of an element over a length of not less than $0.6l_{ан}$ it is necessary to install additional transverse (oblique) reinforcements in the form of spirals, flat or U-shaped welded grids or individual rods (stirrups) encompassing all rods of the longitudinal stressed reinforcements; the sectional area of all the additional transverse rods (or the rods of a grid, directed perpendicular to the longitudinal rods of the element) should be not less than half of the sectional area of one longitudinal stressed rod of the greatest diameter.

The spacing of the first two transverse grids or transverse rods of the spirals, U-shaped grids and stirrups should be not more than 50 mm (along the length of the element), and the rod diameter in the grids and the spiral diameter - not less than 5 mm.

DISTANCES BETWEEN REINFORCEMENT RODS, AND BUNDLES

12.6. The interior distances between rods, bundles, strands, cables or channel envelopes with respect to the height and width of the cross section should be designated considering the laying and compacting convenience of the concrete mixture; for prestressed structures the degree of local concrete compressing and the overall dimensions of the tensioning equipment (jacks, clamps, etc.) should also be considered. In elements made without employing platform vibrators or vibrators fastened to the framework, free passage should be ensured between the reinforcing rods, bundles, etc., for the heads of internal vibrators or the vibratory-tamping elements of the machines compacting the concrete mixture.

12.7*. The interior distances between the individual longitudinal rods of unstressed reinforcements, and also between the rods of adjacent flat welded frameworks should be:

a) if the rods during the concreting occupy a horizontal or an inclined position - not less than the rod diameter and not less than: for the lower reinforcements - 25 mm and for the upper reinforcements - 30 mm; in positioning the lower reinforcements in more than 2 rows in height the distances between the rods in the horizontal direction (except the rods of the two lower rows) should be not less than 50 mm;

b) if the rods during the concreting occupy a vertical position - not less than 50 mm.

In slabs made without prestressing, the distances between the axes of the working rods in the middle part of the span and over the support (above) should be not more than 200 mm when the thickness of the slab is up to 150 mm and not more than $1.5h_n$ when the thickness of the slab is more than 150 mm, where h_n - the thickness of the slab. In all sections of the slab the distances between the axes of the rods of both of the working and distribution reinforcements should be not more than 350 mm. The distances between rods in welded frameworks and grids should be taken in accordance with the appropriate instructions.

Notes. 1. The interior distance between deformed rods is taken from the maximum diameter not considering the projections and ribs.

2. In multicored panels the distance between the longitudinal rods can be increased up to 400 mm.

12.8. In prestressed elements the interior distance between the individual stressed rods, bundles, strands, cables, etc., occupying a horizontal or inclined position during concreting, should be not less than the diameter of the channel for the reinforcements and not less than 25 mm.

In structures with continuous reinforcement the arrangement of the wire turns and the distances between them are designated taking the specifications of coiling machines and the spools into account.

With continuous reinforcement in ensuring the anchoring of the wires it permissible to arrange the wires or strands in one row close to each other without a clearance; in this case if the stressed reinforcement is situated in the surface of the element, structural measures should be specified which eliminate the possibility of the cracking of the concrete and the exfoliation of the protective layer of the concrete from the surface of the reinforcing bundles (the arrangement of encompassing wire bundles or light-weight grids).

The interior distances between the bundles (rows of wires) with the wires situated in a row close to each other without a clearance, should be not less than 15 mm.

In positioning the wires in pairs with an interior clearance between each pair of wires of not less than 5 mm the interior distance between their rows can be reduced to 10 mm.

ANCHORING UNSTRESSED REINFORCEMENT

12.9 Deformed rods are made without hooks. The smooth reinforcing rods used in welded frameworks and welded grids, are also made without hooks; these rods should terminate in hooks only when it is impossible or inexpendient to weld transverse (anchoring) rods at the end of a framework or grid (see 12.11 and 12.12). The tensile-stressed smooth rods of tied frameworks and tied grids should terminate in semicircular hooks.

The compressed rods of tied frameworks and tied grids in flexural, eccentrically compressed and eccentrically tensile-stressed elements, made from round (smooth) steel of class A-I with a rod diameter of up to 12 mm, can not have hooks, and with greater diameters should be made with hooks at the ends. In centrally compressed members these types of rods can be made without hooks independent of the rod diameter.

12.10. In structures of heavy-aggregate concrete the interior diameter of the hooks of round (smooth) reinforcement rods should be not less than 2.5d.

In structures of light-aggregate concrete the interior diameter of the hooks should be when $d < 12$ mm - not less than 2.5d; when $d \geq 12$ mm - not less than 5d.

12.11. The longitudinal compressed rods should be brought beyond the section normal to the axis of the element, at which they cease being required by the rating for a length of not less than 15d. In this case in the welded grids and welded frameworks with working reinforcement of round (smooth) rods at this length not less than two transverse rods should be welded to each cut off longitudinal rod. For round (smooth) rods, not having hooks at the ends and employed in tied frameworks, this length should be increased to 20d.

Note. The length of the thrust of the longitudinal tensile-stressed rods beyond the section, at which they cease being required by the rating, should be determined in accordance with the instructions of 7.40. The tensile-stressed reinforcements of tied frameworks made from round (smooth) rods, should not be broken in a span.

12.12. In extreme free supports of flexural elements for ensuring anchoring of all the longitudinal reinforcing rods, reaching to the support, the following requirements should be fulfilled.

a) If condition (61) is observed (i.e., the transverse reinforcement is not required by the rating, see 7.30), length l_a of the thrust of the tensile-stressed rods beyond the inner face of the free support (Fig. 41, a, b) should be not less than 5d. It is recommended that $l_a = 10d$. In welded frameworks and welded grids with longitudinally working reinforcements of round (smooth) rods to each tensile-stressed longitudinal rod there should be welded at least one transverse (anchor) rod situated from the end of the framework (grid) a distance of

$$c \leqslant 15 \text{ мм when } d \leqslant 10 \text{ мм};$$

$$c \leqslant 1{,}5\, d \text{ when } d > 10 \text{ мм}.$$

The diameter of anchoring rod d_a in beams and ribs should be not less than half of the greatest diameter of the longitudinal rods.

b) If condition (61) is not observed (i.e., the rated transverse reinforcements is required, length l_a should be not less than the 15d; with heavy-aggregate concrete of job-grade 200 and above and when the tensile-stressed longitudinal reinforcements is made from hot-rolled deformed steel of classes A-II and A-III or from draw-hardened steel of class A-IIv, length l_a can be reduced to 10d.

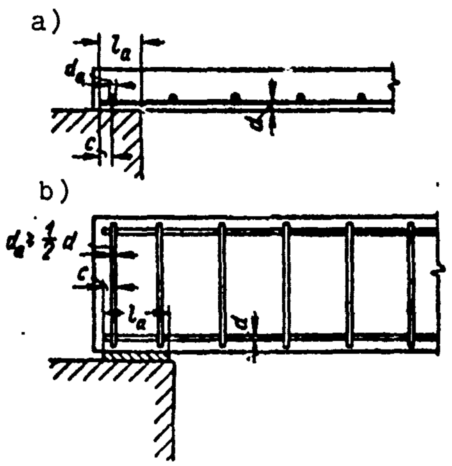


Fig. 41. The anchoring of welded reinforcing grids or frameworks on the free supports of slabs and beams a - slab; b - beam.

In welded frameworks and welded grids with working reinforcement of round (smooth) rods over length l_a to each longitudinal rod there should be welded not less than two transverse (anchoring) rods with a diameter of $d_a \geq \frac{1}{2}d$; in this case the distance from the extreme anchoring rod to the end of the framework (grid) should be not greater than the above indicated values of c.

A reduction in length l_a with respect to the requirements of the present paragraph is permissible only under the condition of the acceptance of special measures for proper anchoring of the reinforcements (an increase in the sectional area of the transverse rods in the section of the element near the support, the welding of additional anchoring rods or washers, the welding of the protruding ends of the rods to steel insert components which should be designated depending on the conditions of the element support, the type and class of reinforcements and the job-grade of the concrete).

Note. Transverse anchoring rods in welded frameworks and welded grids should be welded by point electric welding; the quality of the resistance point welding, and also the arc welding should conform to the requirements of the existing standard documents on welded reinforcement and insert components for reinforced-concrete structures.

LONGITUDINAL REINFORCEMENT OF ELEMENTS

12.13*. The sectional areas of a longitudinal working reinforcement in reinforced-concrete elements should be assumed to be not lower than that indicated in Table 25.

The minimum sectional area of all the longitudinal reinforcement in centrally compressed elements, in percents of the entire sectional concrete area, should be assumed to be double the values indicated in 2 and 4 of Table 25, and in all elements of annular cross-section - double the values indicated in 1, 2 and 4 of Table 25.

The above indicated requirements do not pertain to prestressed reinforced-concrete elements of the 1st and 2nd category of crack resistance rated for crack formation (see 4.3).

Table 25. The minimum sectional area of longitudinal Reinforcement in reinforced-concrete elements (in % of the area of the rated concrete section).

Characteristics of the position of the reinforcement and the nature of the operation of the element	Minimum percent of reinforcement with concrete grade.		
	200 and below	250-400	500 and 600
1. Reinforcement A in all flexural and eccentrically tensile-stressed elements.	0.1	0.15	0.2
2. Reinforcement A, and also A' in eccentrically compressed columns:			
when $\frac{l_0}{r_u} \leq 35$	0.15	0.15	0.2
when $35 < \frac{l_0}{r_u} \leq 83$	0.2	0.2	0.2
when $\frac{l_0}{r_u} > 83$	0.25	0.25	0.25
3. Reinforcement A, and also A' in the wall panels:			
when $\frac{l_0}{r_u} \leq 83$	0.1	0.15	0.2
when $\frac{l_0}{r_u} > 83$	0.25	0.25	0.25
4. Reinforcement A in other eccentrically compressed elements, reinforcement A' in other eccentrically compressed elements of the 2nd case and in all eccentrically tensile-stressed elements of the 2nd case.	0.1	0.15	0.2

In prestressed structures of the 1st and 2nd categories of crack resistance, and also in all structures subject to dynamic effects, it is not permissible to use elements with weak reinforcement, whose strength diminishes upon crack formation in the concrete of the tensile-stressed area (the forces causing the cracking, in this case should be determined in accordance with the instructions of 8.2-8.5 with the replacement in all formulas of these paragraphs of R_T or R_p on R_p^H; in this case the instructions of 8.5 should also be extended to eccentrically compressed elements, which do not have the stressed reinforcement), in elements, in which the limiting condition with respect to strength is determined by the attainment of the rated resistance of the reinforcement to tension, the force which determines the bearing capacity of the element, should exceed the force causing crack formation, by not less than 10%.

The requirements of the present paragraph can not be considered in designating the sectional area of reinforcement placed along the contour of slabs, or panels, due to the flexure rating in the plane of the slab (panel), and also in designating their thickness for thermotechnical rating.

Notes: 1. For elements of T-shaped cross section with a flange situated in the compressed zone (with the exception of wall panels), the indicated percents of reinforcement pertain to a concrete sectional area, equal to the product rib width b and working height h_0.

2. Elements, which do not satisfy the requirements of 12.13 for the value of the minimum percent of reinforcement should be treated like concrete elements.

12.14. In constructing centrally and eccentrically compressed elements the sectional area of the entire longitudinal reinforcement should be, as a rule, not more than 3% of the sectional concrete area required by the rating.

If in certain cases elements for any reasons are designed with a reinforcement content in the cross section of more than 3%, then the requirements of 12.20 should be observed.

12.15*. The diameter of longitudinal working rods of centrally and eccentrically compressed elements of monolithic structures should be not less than 12 mm and, as a rule, not more than 40 mm; for especially heavy-duty columns with a job-grade of concrete higher than 200 rods of large diameter can be employed.

In structures of light-aggregate concrete the use of reinforcement with a diameter of more than 25 mm is not recommended; with concrete of grades of 100 and below it is not permissible to use rods with a diameter of more than 16 mm.

12.16. In eccentrically compressed linear elements in faces, perpendicular to the plane of flexure, and also in each face of centrally compressed elements with a width of these faces of up to 400 mm it is permissible to place two working rods each. With a greater width of these same faces in each of them working rods should be placed at distances, not exceeding 400 mm.

In eccentrically compressed elements with unstressed reinforcement or of prestressed elements of the 3rd category of crack resistance, in the faces, parallel to the plane of flexure with the dimension of these faces more than 500 mm, it is necessary to place structural reinforcement (if this reinforcement has not been specified by the rating) with a diameter of not less than 12 mm so that the distances between the longitudinal rods would be not more than 500 mm.

12.17*. In beams with a width of 150 mm and more the number of longitudinal working rods brought up to a support, should be not less than two. In the ribs of precast panels, flooring, close-ribbed spanning structures, etc., with a width of less than 150 mm it is permissible to bring one longitudinal working rod up to a support.

In slabs the distances between the rods brought up to a support, should not exceed 350 mm, and the sectional area of these rods per 1 running m should be not less than $\frac{1}{3}$ the sectional area of the lower rods in the span, determined in accordance with the greatest flexural moment.

Notes. 1. In multicored panels the distances between the rods brought up to a support, can be increased up to 400 mm.

2. In reinforcing continuous slabs with welded roll grids it is permissible near the intermediate supports to bend up all the lower rods into the upper zone.

12.18. In linear flexural elements with unstressed reinforcement or prestressed elements of the 3rd category of crack resistance with a height of their cross section of more than 700 mm in the lateral faces longitudinal structural rods should be placed with the distances between them over the height of not more than 400 mm. The total sectional area of these rods should be not less than 0.1% of the transverse sectional area of the beam.

12.19*. In cases when the unstressed longitudinal tensile-stressed reinforcement of an element at the site of its anchoring is considered in the rating with full rated resistance, the length of its extension beyond the face of the support should be not less than value l_H indicated in Table 26.

When it is not possible to fulfill this requirement measures should be taken for anchoring the longitudinal rods to ensure their operation with total rated strength in the cross section drawn through the face of the support.

In elements which operate in torsion with flexure, all the longitudinal rods introduced into the rating for torsion with total rated strength, should satisfy the requirements of the present paragraph.

with the presence of compressed reinforcement (considered in the rating) unstressed or with a prestressing of $\sigma'_0 \leq 4500$ kg/cm^2, the transverse rods (stirrups) should be placed in all cases at distances of not more than 500 mm, and also:

a) in tied frameworks - at distances of not more than 15d;

b) in welded frameworks - not more than 20d, where d - the least diameter of the longitudinal compressed rods.

In this case the structure of the transverse reinforcement should ensure the attachment of the compressed rods against their lateral bulging in any direction.

At the sites of the joining of unstressed working reinforcement with overlap without welding the distances between the stirrups should be designated in accordance with the requirements of 12.43.

If the total saturation of an element with longitudinal reinforcement is more than 3%, the stirrups should be placed at distances of not more than 10d and be welded to the unstressed longitudinal reinforcement.

Note. In checking the observance of the requirements of subparagraphs "a" and "b" of 12.20 it is permissible not to take into consideration the longitudinal compressed rods, not considered in the rating, if their diameter does not exceed 12 mm and half of the thickness of the protective concrete layer.

12.21. The structure of tied stirrups in centrally and eccentrically compressed elements should be such, that the longitudinal rods, at least every other one, are situated at the sites of the bending of the stirrups, and these bends are at distances of not more than 400 mm along the width of the element face. With the width of the face not more than 400 mm and the

Table 26. The length of the overlap of tensile-stressed rods of tied frameworks at overlap joint sites (without welding).

Type of working reinforcement	Joint working conditions	The least length of overlap l_H in concrete of job-grade.	
		150	200 and above
1. Hot-rolled deformed of class A-II and round (smooth) of class A-I.	a[1] b[2]	35d 40d	30d 35d
2. Hot-rolled deformed of class A-III and deformed draw-hardened of class A-IIv.	a[1] b[2]	45d 50d	40d 45d

[1]a - reinforcement joints situated in the tensile-stressed zone of flexural elements, eccentrically compressed and eccentrically tensile-stressed in accordance with the first case;

[2]b - reinforcement joints situated in elements centrally tensile-stressed or in elements eccentrically tensile-stressed in accordance with the 2nd case, (this type of joint is permitted only in slabs and in walls);

d - the nominal diameter of joined rods.

Notes: 1. Unstressed deformed rods of steel of classes A-III and A-IIv can extend beyond the face of a support by a length of 5d less than values l_H indicated in Table 26.

2. Unstressed longitudinal rods in the structural elements of concrete of job-grades of 400 and above can extend beyond the face of a support by a length of 5d less than values l_H indicated in Table 26 for concrete of job-grades of 200 and above.

TRANSVERSE REINFORCEMENT OF ELEMENTS

12.20*. In centrally and eccentrically compressed linear elements, and also in the compressed zone of flexural elements number of longitudinal rods in this face not more than four it is permissible to cover all the longitudinal rods with one stirrup.

In reinforcing centrally or eccentrically compressed elements with flat welded frameworks the two extreme frameworks (situated in the opposite faces) should be connected with each other for the formation of a three-dimensional framework. For this in the faces of an element, normal to the plane of the frameworks transverse rods welded by resistance spot welding to the angular longitudinal rods of the frameworks, or pins connecting these rods should be placed; the distances between the welded transverse rods should be not more than 20d, and between the pins - 15d, where d - the least diameter of the compressed longitudinal rods.

If the extreme flat frameworks have intermediate longitudinal rods, then the latter, at least every other one and not less infrequently than every 400 mm along the width of the element face, should be connected with the longitudinal rods situated in the opposite face, using pins installed along the length of the element at the same distances, as the transverse rods of the flat frameworks; it is permissible not to place these pins when the width of the given element face is not more than 500 mm, if the number of longitudinal rods in this face does not exceed four.

12.22. In centrally compressed elements with indirect reinforcement considered in the rating, the spacing of the spiral or annular unstressed reinforcement should be not more than $\frac{1}{5}$ the diameter of the core and not more than 80 mm. The given cross section of spiral or circular reinforcement, if it is considered in the rating (see 7.12), should be not less than 25% of the sectional area of the longitudinal reinforcement.

12.23. The diameter of the stirrups in tied frameworks of the monolithic elements indicated in 12.20 should be not less than 5 mm and not less than:

0.2d - when making the stirrups of standard reinforcing wire with a diameter of 5 and 5.5 mm or of class A-III steel;

0.25d - when making the stirrups from other types of reinforcement, where d - the greatest diameter of the longitudinal rods.

The diameter of the stirrups in tied frameworks of flexural elements should be:

with an element cross-sectional height of up to 800 mm - not less than 6 mm;

the same, when more than 800 mm - not less than 8 mm.

The relationship of the diameters of the transverse and longitudinal rods in welded frameworks and in welded grids should correspond to the requirements of special instructions.

12.24. In beams and ribs with a height of more than 300 mm the transverse rods, parallel to the flexural plane, or the stirrups should be always placed independent of the rating. In beams and ribs with a height of from 150 to 300 mm these transverse rods, if they are also not required in accordance with the rating, should be placed in the ends of an element along the length of not less than $\frac{1}{4}$ of its span. With a beam or rib height of less than 150 mm it is permissible not to place transverse reinforcement, if condition (61) is observed.

It is also permissible not to place transverse reinforcement in multicored precast flooring with a height of 300 mm and less, or in similar close-ribbed structures in those portions, where the following condition is observed

$$Q \leq \sqrt{0,6 R_{\text{и}} b h_0^2 g_1}. \qquad (208)$$

where g_1 - the evenly distributed load including half of the dead load of the element and the remaining part of the constant uniformly distributed load; b - the sum of the minimum thickness of walls of multicored construction or of the ribs of close-ribbed structure over the width of a precast element, for which force Q has been determined.

12.25. In the absence of bends the distances between the transverse rods, parallel to the plane of the bend, or the stirrups in beams and ribs in portions, where condition (61) is not observed, and also in portions near supports should be with a cross-sectional height h of up to 450 mm - not more than $\frac{1}{2}$h and not more than 150 mm, and with a greater cross-sectional height - not more than $\frac{1}{3}$h and not more than 300 mm; the length of circum-support portions, to which this requirement extends, is taken to be with a uniformly distributed load, equal to $\frac{1}{4}$ the span of the element, and with concentrated loads - to the distance from the support to the load nearest to it. In the remaining part of the span with beam heights of more than 300 mm the distance between the indicated transverse rods or stirrups should be not more than $\frac{3}{4}$h and not more than 500 mm.

12.26. With tied reinforcement in the intermediate (middle) T-beams, monolithically connected on top with a slab, it is recommended that open stirrups be placed. If the working reinforcement of the slab passes parallel to rib, it is necessary to lay additional reinforcement perpendicular to it with a cross section of not less than $\frac{1}{3}$ the greatest cross section of the working reinforcement of a slab in the span, extending it into the slab in each direction from the face of the rib by a length of not less than $\frac{1}{4}$ the rated span of the slab.

12.27. In all surfaces of reinforced-concrete elements, near which longitudinal reinforcement is placed, transverse reinforcement should also be specified which encompasses the extreme longitudinal rods, bundles, strands, etc. This type of reinforcement can be made in the form of welded grids or stirrups closed or U-shaped, in the form of pins which encompass the extreme longitudinal rods, or in the form of straight rods welded to the longitudinal unstressed rods. The distances between the transverse rods in each surface of an element should be not more than 500 mm and not double the width of the given element face.

It is permissible not to place transverse reinforcement in the narrow faces of an element, along the width of which only one longitudinal rod or one welded framework is situated.

12.28*. In elements operating in torsion with flexure, tied stirrups should be closed by connecting their ends over 30 diameters, and with welded frameworks all transverse rods of both directions should be welded with spot welding to the angular longitudinal rods, forming a closed loop.

In this case the distances between the transverse rods situated in the faces, parallel to the flexural plane, should satisfy the requirements of 12.25. The distances between the transverse rods situated in the faces, normal to the flexural plane, should be not more the width of the cross section of element b; when $\kappa \leq 0.2$ and with the observance of condition (138) in the faces of elements compressed due to flexure, it is permissible to increase the distances between the transverse rods, assuming them to be in accordance with 12.20 and 12.27.

The requirements of the present paragraph pertain, in particular, to extreme beams, to which secondary beams or a slab abut only on one side (fastening beams, expansion joint beams, etc.).

12.29. The sectional area of distributive unstressed reinforcement in grider slabs should be not less than 10% of the sectional area of the working reinforcement placed at the site of the greatest flexural moment.

BENDS IN STRESSED REINFORCEMENT

12.30. Bent-up rods should be used in flexural elements in reinforcing them with tied frameworks. The use of bent-up rods in welded frameworks is not recommended. The bends of rods should be accomplished along a circular arc with a radius of not less than 10d. At the ends of the bent-up rods straight portions should be situated with a length of not less than 20d in the tensile-stressed and not less than 10d in the compressed zone; straight portions of bent-up round (smooth) rods should terminate in hooks.

12.31. The angle of inclination of the bends to the longitudinal axis of an element should, as a rule, be equal to 45°. In beams with a height of more than 800 mm and in wall-beams it is permissible to increase the angle of inclination of the bends within the limits of up to 60°, and in low beams with concentrated loads, and also in slabs - to decrease it within the limits of up to 30°.

12.32. Rods with bends should be situated at a distance of not less than 2d from the lateral faces of an element, where d - the diameter of the bent-up rod.

The use of bends in the form of "floating" rods (Fig. 42) is not permitted.

Fig. 42. "Floating" rod.

12.33. The distance from the face of a free support to the upper end of the first bend (reckoning from the support) should be not more than 50 mm. The beginning of a bend in a tensile-stressed zone should be located from the cross section normal to the axis of the element, in which bent-up rod is completely used for a moment of not less than $h_0/2$, and the end of the bend should be situated not closer than that cross section, in which the bend is not required by the moment diagram. If bends are placed in accordance with the rating, then the distances between them should conform to the requirements of 7.36.

12.34. The lower end of the bend most-distant from the support should be situated: with a uniformly distributed load - not closer to the support, than that cross section, in which the transverse force becomes greater than the force received by the concrete and by the stirrups ($Q_{x.б}$), and with concentrated loads - at a distance from this cross section (reckoning to the direction of the support) of not more than $u_{макс}$, determined using formula (71) (see 7.36).

WELDED REINFORCEMENT JOINTS

12.35*. Reinforcement of reinforced-concrete structures of hot-rolled deformed steel, round (smooth) steel and standard reinforcing wire should, as a rule, be manufactured by joining the rods by resistance spot, resistance butt, and also in the cases indicated below (see 12.39-12.41) arc and electroslag welding. The reinforcement weld quality should conform to the requirements of the existing standard documents for welded reinforcement and insert components for reinforced-concrete structures.

Welded joints of thermally hardened rod reinforcement (see 2.7 "c") are not permitted.

Welded-joints of high-strength reinforcing wire, reinforcing strands and cables (see 2.7 "e"-"i"), as a rule, are not permitted.

Notes. 1. Welded joints of the indicated types of reinforcement of high-strength wire can be permitted with special welding techniques and special technological measures; in this case, both when designing a structure and in stressing the wire, the possibility of reducing the joint strength should be considered.

2. Thermally hardened rod reinforcement and hot-rolled reinforcement of class A-IV of grade 80S should be used in the form of whole rods of unit length (without welding) for elements with a length of up to 12 m inclusively.

12.36*. For manufacturing welded frameworks and grids employing resistance spot welding it is necessary to use the hot-rolled steels indicated in 2.7 "a" and "b" (with the exception of reinforcement of classes A-VI and A-V), and standard reinforcing wire (2.7 "e").

12.37*. Resistance butt weldings is recommended for joining along the length of billets of reinforcing rods or for joining to them bolsters with a thread in all types of hot-rolled steel (see 2.7 "a" and "b") with a diameter of not less than 10 mm.

Notes: 1. The resistance butt welding of rods with a diameter of less than 10 mm can be employed only under plant conditions with special equipment.

2. Resistance butt welding of steel rods of class A-IV of grade 80S can be permitted only with special welding techniques.

12.38*. When employing reinforcement subjected to strain hardening (see 2.7 "d"), the joining of rods with resistance welding should, as a rule, be carried out before they are drawn.

In elements of prestressed structures with the reinforcement stressed in abutments, for eliminating the effect of local annealing during manufacture of structures reinforcement joined by resistance butt welding should stressed, as a rule, before the controlled stressing required for its hardening (see Appendix III, note 2 to Table 35), after which prestressing is reduced to the value, assigned by the rating for the compressing of concrete.

In those individual cases, when resistance butt welding is carried out after hardening of the reinforcement which subsequently is not subjected to secondary stressing before the controlled stressing, it is necessary to assume the rating strength of such reinforcement to be the same as for unhardened steel. It is permissible not to consider the reduction in the rated strength of hardened reinforcement in that case when the sectional area of the draw-hardened working rods, joined in one section of an element or in sections situated a distance from each other of less than 30d, is not more than 25% of the sectional area of the entire working reinforcement of the tensile-stressed zone of the element in the given cross section.

12.39*. Arc welding should be employed:

a) for joining reinforcing rods of hot-rolled steel (see 2.7 "a" and "b") with a diameter of more than 8 mm during assembly, except classes A-IV and A-V, and for joining such rods with rolled steel (insert components), and also with anchoring and fastening devices;

b) for making steel insert components and for joining them with each other in assembly in the joints of precast reinforced-concrete structures.

Manual arc welding can be empolyed for only the following types of joints:

c) for butt-joining rods of steel of class A-IV of grades 20KhG2Ts and 20KhGST with each other with two butt straps of rods of the same grade of steel (it is permissible to use as butt straps reinforcement rods of class A-III of the same diameter);

d) for joining rods of stressed hot-rolled reinforcement of classes A-IV and A-V (2.7 "b"), heat-hardened (2.7 "c") and draw-hardened (2.7 "d") with anchor bolsters or loops, and after releasing the stressing - with anchor washers or anchor plates.

12.40. The types of welded butt joints of reinforcement (see Appendix III Table 38) should be designated and executed in accordance with the recommendations of existing standard documents on welded reinforcement and insert components for reinforced-concrete structures.

For draw-hardened reinforcing steels it is permissible to use only such welded joints (make in accordance with special instructions), in which practically no reduction occurs in the mechanical properties of the hardened metal.

12.41*. When no resistance welding equipment is available for use it is permissible to use arc welding for hot-rolled reinforcing steels (2.7 "a" and "b", except classes A-IV and A-V) with the diameter of all rods being joined of more than 8 mm in the following cases:

a) for joining along the length of reinforcing rod billets, in this case the butt joints of rods with a diameter of 20 mm and more are executed, as a rule, by pool welding techniques, and rods with a diameter of up to 20 mm - by arc welding the joints with butt straps or with overlap;

b) for making reinforcing grids only in individual cases, when the rod joints at intersections (crosswise) have only assembly significance;

c) for making reinforcing frameworks (including rolled steel) with the necessary additional structural elements at the sites of the joining of the rods of longitudinal and transverse reinforcement (knee plates, lugs, hooks, etc.).

If the joints of intersecting rods of welded frameworks or grids in a crosswise manner have not only an assembly significance, but also should ensure the strength of the structures, then the execution of these joints without the use of the additional structural elements indicated in paragraph "c" of the present section, is not permitted.

Note. The use of arc welding for intersecting reinforcing rods of steel of class A-II of grade St. 5 and of class A-III of grade 35GS is not recommended.

OVERLAPPING JOINTS OF UNSTRESSED REINFORCEMENT (WITHOUT WELDING)

12.42*. The joints of unstressed working reinforcement with a diameter of up to 32 mm both in welded and in tied grids and frameworks can be executed by overlapping (without welding). With rods of larger diameters such joints are not recommended, and with rods of diameters of more than 40 mm they are not permitted.

Working joints of overlapping rods (without welding) in the tensile-stressed zone of flexural or eccentrically compressed elements should not be studied at the sites of total utilization of the reinforcement.

The employment of lapped joints (without welding) in linear elements, whose cross section is completely tensile-stressed (for example in tie beams), and also in all cases of the use of reinforcement of steel of classes A-IV, A-V and A-IIIV is not permitted.

12.43. The joints of tensile-stressed working reinforcement of tied grids and frameworks, made overlapping without welding, should have an overlap length (laps) l_H of not less than that determined in accordance with Table 26 and not less than 250 mm.

The joints of tensile-stressed rods of tied grids and frameworks should in all cases be staggered; the sectional area of the rods joined at one site or at a distance of less than the lap length should be: with round (smooth) rods - not more than 25%, and with deformed rods - not more than 50% of the total area of the tensile-stressed reinforcement in the cross section of the element.

In joining the reinforcement of monolithic columns with projections from the foundations having [the columns] in the tensile-stressed face a total of three longitudinal rods, it is permissible, as an exception, to join in one cross section two rods of the three, in this case locating the joint of one (the middle) rod closer to the foundation.

The length of the overlap of the rods, joined in a compressed zone, can be assumed to be 10d less than magnitude l_H determined in accordance with the paragraphs of "a" of Table 26, but not less than 200 mm, and in this case for compressed rods made of round (smooth) steel of class A-I without hooks in the ends, the length of the overlap should be not less than 30d.

In centrally and eccentrically compressed linear elements within the limits of the joint of the compressed reinforcement the distances between the stirrups should be not more than 10d.

In structures of light-aggregate concretes of job-grade 150 the length of the overlap of the rods at overlapped joint sites is increased by 10d as compared with the recommendations of the present paragraph.

12.44*. The joints of welded grids in the working direction should be made in accordance with Fig. 43; in each of the grids joined in a tensile-stressed zone over the length of the lap there should be situated not less than two transverse rods welded to all the longitudinal rods of the grid. When using grids of round (smooth) rods for the working reinforcement the diameters of the transverse (anchoring) rods within the limits of the joint should be not less than those indicated in Table 27. The same types of joints can also be used for the lap joining of welded frameworks with one-way positioning of the working rods. The lap joining welded frameworks with two-way positioning of the working rods is not permitted.

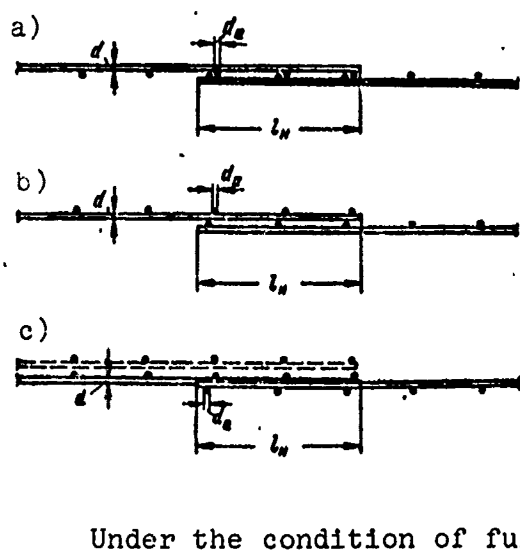


Fig. 43. The lapped joints of welded grids (without welding) in the direction of the working reinforcement when making the latter from round (smooth) rods. a - the distributive (transverse) rods are situated in one plane; b and c - the distributive rods are situated in different planes.

Under the condition of fulfilling the requirements of the present paragraph the length of the overlap of welded grids and welded frameworks should be assumed to be:

a) in positioning a joint in a tensile-stressed zone - 5d less than the values determined in accordance with Table 26, but not less than 200 mm;

b) in positioning a joint in a compressed zone - 15d less than the v lues determined in paragraph "a" of Table 26, but not less than 150 mm.

Table 27. The least diameters of transverse rods of welded grids and welded frameworks with longitudinal reinforcement of round (smooth) rods at the sites of working lapped joints (without welding).

Type of lapped joint (without welding).	The least diameters of the transverse rods of welded grids and frameworks in mm with the diameter of the longitudinal rods in mm.														
	3—4	5—7	8—9	10	12	14	16	18	20	22	25	28	32	36	40
After Fig. 43, a.	3	4	4	5	5	6	8	8	10	10	12	14	18	20	22
After Fig. 43, b and c	3	4	4	5	5	6	8	10	12	14	16	18	20	22	25

When making the working reinforcement of welded grids from standard reinforcing wire the length of the overlap should be taken to be the same as for welded grids with the working reinforcement from deformed hot-rolled steel of class A-III.

With light-aggregate concrete of grade 100 and below the length of the lap is established by special standard documents.

12.45. The joints of welded grids with the working reinforcement of deformed rods can be made with the positioning of the working rods in one plane; in this case one of the joined grids (Fig. 44, a) or both grids (Fig. 44, b) within the limits of the joints cannot have welded transverse rods. In this case the length of the overlap of the grids should be taken in accordance with the instructions of 12.43, as in the joining of the rods of tied reinforcement.

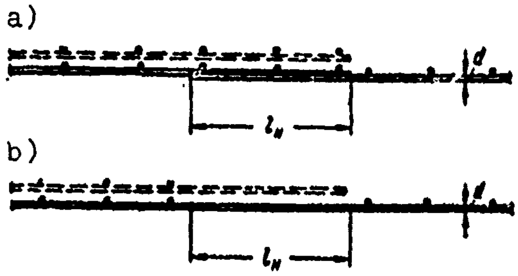


Fig. 44. The lapped joints of welded grids (without welding) in the direction of the working reinforcement when making the latter of deformed rods; a - transverse rods within the limits of the joint are absent from one of the joined grids; b - transverse rods within the limits of the joint are absent from both joined grids.

12.46*. Working joints of welded grids and welded frameworks in the tensile-stressed zone of elements should not be positioned at the sites of total reinforcement utilization. It is necessary to stagger the joints, and the sectional area of the working rods, joined in one cross section or at a distance of less than the length of their overlap, should be not more than 50% of the total sectional area of the tensile-stressed reinforcement

The joining of welded grids without staggering the joints is permissible only in those portions, where the working reinforcement is not utilized more than 50%.

12.47. If the diameter of the working rods, lap joined in a tensile-stressed zone, exceeds 10 mm and the distances between the rods is less than value $\frac{d}{30} \cdot \frac{R_a}{R_p}$ (where d - the least diameter of the joined rods in cm), then at the joint sites it is necessary to place additional transverse reinforcement in the form of stirrups or suspension ties of U-shaped bent welded grids extended into the compressed zone; in this case the sectional area of the additional transverse reinforcement placed within the limits of a joint, should be not less than $0.4F_a \frac{R_a}{R_{a.x}}$, where F_a - the sectional area of all the joined longitudinal rods.

12.48. In lap joining welded frameworks in beams over the length of the joint additional transverse reinforcement should be placed in the form of stirrups or U-shaped bent welded grids; in this case the spacing of the additional transverse rods within the limits of the joint should be not more than 5d, where d - the least diameter of the longitudinal working rods.

In lap-joining of welded frameworks of centrally or eccentrically compressed columns within the limits of the joint there should be placed additional stirrups at distances of not more than 10d.

12.49. The joints of welded grids in the non-working direction are made overlapping with a lap, reckoning between the extreme working rods of the grid (Fig. 45, a and b):

a) with a diameter of the distributive reinforcement of up to 4 mm - of 50 mm;

b) with a diameter of the distributive reinforcement of more than 4 mm - of 100 mm.

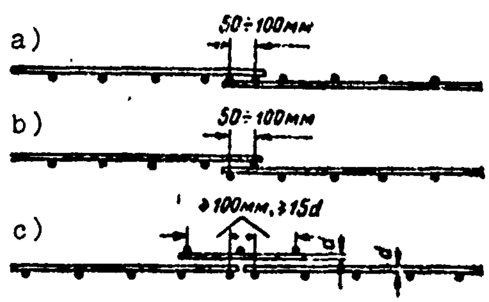


Fig. 45. Joints of welded grids in the direction of the distributive reinforcement . a - lapped joint with positioning of the working rods in one plane; b - lapped joint with positioning of the working rods in different planes; c - butt joint with the superimposing of an additional joining grid.

With a diameter of the working reinforcement of 16 mm and more the welded grids in the non-working direction should be laid abutting each other covering the joint with special joining grids laid with an overlap in each direction of not less than 15 diameters of the distributive reinforcement and not less than 100 mm (Fig. 45, c).

Welded grids in the non-working direction can be laid abutting without an overlap and without additional joining grids in the following cases:

a) when laying welded strip grids in two mutually perpendicular directions;

b) with the presence at joint sites of additional structural reinforcement in the direction of the distributive reinforcement .

JOINTS IN PRECAST STRUCTURES

12.50. When joining precast reinforced-concrete elements the forces from one element to another is allowed to pass through the joined working reinforcement , steel insert components, joints filled with concrete or with mortar, concrete keys or (for compressed elements) directly through the concrete surfaces of the joined elements.

12.51. The joints of precast elements should, as a rule, be monolithized by filling the joints between the elements with concrete or with mortar. If in the manufacture of precast reinforced-concrete elements special measures are used to ensure the tight fitting of the concrete surfaces to each other (for example, by employing the face of one of the joined members as the framework for the face of the other), then the making of "dry" joints is permissible with the passage through the joint of only the compressive force.

12.52. The joints of precast reinforced-concrete elements which should ensure the immutability of a structure or its continuity must be made rigid.

12.53. The joints of precast reinforced-concrete elements receiving the rated tensile forces should be made by one of the following methods:

a) by welding of steel insert components;

b) by welding reinforcement projection;

c) for prestressed structures - by running bundles, shafts of the bolts or reinforcement rods through the channels or grooves of the members being joined with subsequent stressing of them and filling the grooves and channels with cement or cement-sand mortar.

When designing the joints of precast elements it is necessary to specify those types of insert component joints, in which unbending of their elements, or breaking out of the concrete will not occur.

12.54. The joints of precast reinforced-concrete elements with stressed reinforcement of hot-rolled steel can be made by welding reinforcement projections, not having prestressing; if reinforcement is used subject to strain hardening before welding (without redrawing after welding), then it is recommended those types of welded joints be used, in which there is practically no reduction in the mechanical properties of the hardened metal (in accordance with the instructions of appropriate standard documents); otherwise the rated strength of the reinforcement in the joint zone must be taken to be the same as that of unhardened steel.

12.55. Steel for insert components and butt straps of welded joints should be designated in accordance with the instructions of 2.7. Insert components should be designed so that they do not project beyond the planes of the element faces.

Insert components should be welded to the working reinforcement of elements or be anchored in the concrete with special anchor devices.

In making of welded joints and insert components it is necessary to specify welding techniques, which do not cause significant warping of the steel components of the joint.

12.56*. Steel insert components with anchors should, as a rule, consist of individual plates (angles plates or shaped steel) with predominately deformed anchor rods welded to them with the face under a layer of flux; the number of anchor rods should, as a rule, be not less than four (Fig. 46); the installing of two anchor rods is permitted if the shearing force acts perpendicular to the plane, in which these rods are situated, and in the absence of flexural moment.

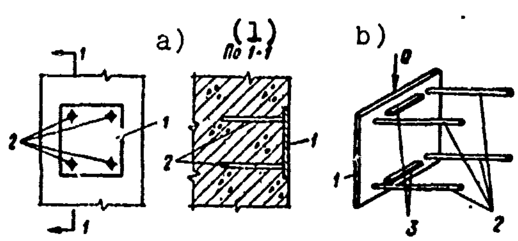


Fig. 46. The structure of steel insert components consisting of; a - a plate of four deformed anchor rods; b - the same, with the welding of additional thrust plates; 1 - an insert component (steel plate); 2 - the anchor rods T-welded; 3 - thrust plates. KEY: (1) According to.

If the compressive stress at the level of the extreme row of compressed anchors is less than or equal to 0.3 of the shearing forces, then it is necessary:

a) to weld thrust plates to the insert component (or bolsters made from reinforcing rods) with a width (or a diameter) of not less than 10 mm, situating them between the anchors within the limits of the protective layer of concrete, or

b) to use insert components which have besides the anchors T-welded, also bent-up anchors lap-welded at an angle to the shearing force and completely receiving this force; in the presence of flexural moment or tensile force, acting on the insert component, it is recommended that in the zone of the bent-up anchors stirrups be installed with a spacing of not more than 100 mm.

In the presence of the tensile stresses in all anchors and with the simultaneous effect of shearing force it is necessary to specify special measures for receiving the shearing force.

The number of lap-welded anchor rods, is not less than two, and the positioning of these should be symmetrical with respect to the plane of the shearing force. The angle of inclination of these anchors to the direction of the shearing force should be not more than 25° and not less than 15°. The placing of only some lap-welded anchors, in the absence of anchors T-welded to the plate, is not allowed.

The joining of anchor rods with flat rolled elements should be carried out in accordance with the requirements of the "Instructions on Welding Reinforcement and Insert Components of Reinforced-Concrete Structures" (SN 393-69).

The length of the anchor rods and the distances between the anchors and from the axis of the anchors to the faces of the reinforced-concrete structure should be taken in accordance with the "Instructions of the Designing of Reinforced-Concrete Structures."

12.57*. Annular parts of joined compressed elements (for example, the ends of precast columns should be designed with the force of the compressed zone of the cross section near the joint as compared with its strength required in accordance the rating for the forces acting in this cross section, in accordance with the "Instructions on the Designing of Reinforced-Concrete Structures." In these types of joints with the force of the compressed zone at the ends of an element with welded grids the requirements of 7.13 should be observed.

In joining compressed elements with a break in the working reinforcement at the joint site (for example in column joints with a spherical hinge, at the support sites of the compressed elements over the entire surface of the face, etc.) the ends of the joined elements should be reinforced with indirect reinforcement in the form of grids (Fig. 47), whose rating should be carried out in accordance with the instructions of 7.65.

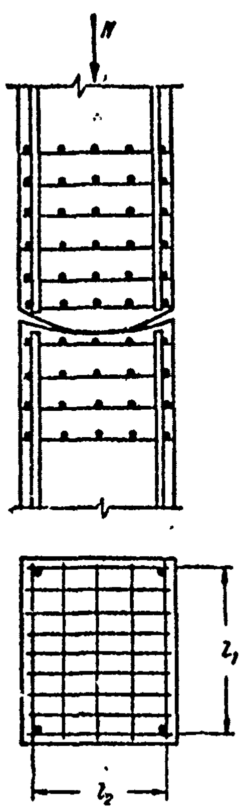


Fig. 47. The structure of the joint of precast reinforced-concrete columns.

INDIVIDUAL STRUCTURAL INSTRUCTIONS

12.58. In concrete and reinforced-concrete structures of considerable length expansion-contraction joints should be specified; the distances between them should be designated in accordance with the instructions of 4.17.

When necessary, for example, with heterogeneous soils, at the sites of an abrupt variation in the loads, keyed expansion joints should be specified.

Keyed expansion joints, and also expansion-contraction joints in solid concrete and reinforced-concrete structures should be made through, cutting the structure at the foundation footing. Expansion-contraction joints in reinforced-concrete frameworks should be accomplished either with double columns bringing the joint to the top of the foundation, or in the form of bilateral cantilevers without inserts.

The distances between expansion-contraction joints in concrete foundations and basement walls can be taken in accordance with the distances between the joints accepted for the overlying structures.

12.59. In precast or precast monolithic structures, on the supports of which as a result of the monolithization of the joints (the welding of reinforcements projections, the placing of additional reinforcements in the joints between the element, overlapping the joint, the installing above of joined structures of reinforced-concrete elements, overlapping the joints) negative moments can arise, it is recommended that the sectional area of the super-supporting reinforcements be designated in accordance with the instructions of the existing standard documents for the rating of statically indeterminable reinforced-concrete structures taking into account the redistribution of the forces. The sites of the break in this reinforcement should be determined in accordance with the instructions of 7.40.

12.60. In precast monolithic reinforced-concrete structures reliable connection should be ensured between the precast elements and the additionally laid concrete. For this across their joining surfaces it is necessary to provide for the placing of keys receiving the longitudinal shearing forces. The number and the dimensions of the keys should be designated in accordance with the instructions of 7.66.

In the compressed zone of precast monolithic structures it permissible not to provide for keys, if measures are taken for imparting roughness to the surfaces of the precast elements and if in this case the magnitude of the shearing stresses on the contact surface between the precast element and the additionally laid concrete does not exceed 1/4 R_p

In solid precast monolithic spanning structures keys on the upper tensile-stressed zone (in circum-support portions) must be mandatorily specified not only in the portion with negative moments, but also beyond the zero point of the moment diagram, up to the site of the break in the rated longitudinal reinforcement . On the surfaces of precast elements which are in contact with monolithic concrete, it is necessary in accordance with the rated or design specifications to insert transverse reinforcement normal to the surface of the element or in the direction of the main tensile stresses. The inserted rods should have a reliable anchoring in the additionally laid concrete.

12.61. In concrete structures it is necessary to specify structural reinforcement in the following cases:

a) in sites of abrupt variation in the dimensions of the cross section of elements;

b) in sites of a variation in the height of walls (in section with a length of not less than 1 m);

c) in concrete walls under and over apertures in each storey;

d) in external and internal wall panels (in both faces);

e) in the tensile-stressed face of eccentrically compressed elements rated for strength without considering the resistance of the concrete of the tensile-stressed zone (see Note 1 to 6.7);

f) in structures subject to the systematic effect of a temperature of more than 70°C or to the effect of a dynamic load;

g) in massive constructions of light-aggregate concrete.

In concrete wall panels (subparagraph "d") the sectional area of the structural reinforcement in each face should be not less than:

when $\frac{l_0}{r_и} \leq 35$-0.012%,

when $\frac{l_0}{r_и} > 35$-0.025%

from the transverse sectional area of the panel.

For the cases indicated in subparagraphs "e" and "h," the sectional area of structural reinforcement should be not less than 0.05% of the transverse sectional area of the element.

12.62. The conformity of the distribution of reinforcement to its designed position should be ensured by special measures (the installation of braces in the form of welded frameworks or grids, diaphragms, pins, suspensions ties, etc.).

12.63. In wall panels (both of reinforced-concrete and concrete) reinforcing frameworks should be mandatorily along the periphery of the panel.

12.64. Apertures of considerable dimensions in reinforced-concrete slabs, panels, etc., should be rimmed with additional reinforcement with a cross section not less than the cross section of the working reinforcement (of the same direction) which is required over the width of an aperture when a slab is rated as solid. Additional reinforcement should be extended beyond the edges of the aperture for a length of not less than value l indicated in 12.43.

12.65. In designing elements of precast spanning structures it is necessary to specify the placing of joints between them filled with concrete or mortar. The width of the joints should be designated so as to ensure their qualitative filling and should be not less than 20 mm in the case of elements with a height of up to 250 mm and not less than 30 mm in elements of greater height.

12.66. In precast elements measures should be specified for gripping them when they are being lifted (the insertion of steel pipes to form apertures, the installing of lifting loops of reinforcing rods, etc.). Lifting loops should be made from round hot-rolled steel in accordance with the instructions of 2.19 and be welded or tied to the reinforcing framework.

12.67. The construction of facings fastened to the surfaces of concrete and reinforced-concrete elements, should ensure their prolonged and reliable operation during use.

For facings fastened to the compressed faces of loaded concrete or reinforced-concrete elements, the thickness of the unfilled joints between the elements of the facing (in the direction of compressive stress) should be not less than

$$h_{ш} = c_{пр} \sigma h, \tag{209}$$

where c_{np} - the maximum value of the degree of concrete creep which depends upon its age at the moment of the application of the facing; for heavy-aggregate concrete value c_{np} can be determined from Table 28; σ - the compressive stresses in the concrete of the face, to which the facing is attached; h - the distance between the unfilled joints of the facing in the direction of the effect of the compressive stresses.

Table 28. The maximum degree of concrete creep c_{np} for heavy-aggregate concrete.

The age of the concrete in days at the moment of the application of the facing	7	14	28	60 and more
$c_{np} \cdot 10^6$ in $\frac{mm/mm}{kg/cm^2}$	15	12	9	6

Note. 1. The degree of creep is the value of relative creep deformation per unit of stress.

2. For light-aggregate concrete the maximum value of the degree of creep is established in accordance with the appropriate standard documents or on the basis of experimental data.

13. ADDITIONAL INSTRUCTIONS ON THE CONSTRUCTION OF PRESTRESSED REINFORCED-CONCRETE ELEMENTS

GENERAL INSTRUCTIONS

13.1. When designing prestressed reinforced-concrete structures it is necessary, as a rule, to ensure the reliable adhesion of the reinforcement with the concrete by employing deformed steel, by filling the channels with cement or cement-sand mortar, and the grooves and hollows - with motar or concrete.

13.2. When designing prestressed statically indeterminable structures it is recommended that the selection of their design and method of erection be carried out in such a way that when creating the prestressing the possibility of the appearance in a structure of additional forces which impair its operation will be eliminated. It is permissible to use temporary joints or hinges monolithized after stressing of the reinforcement.

13.3. In precast monolithic reinforced-concrete structures the adhesion of the prestressed precast elements with additionally laid concrete (see 1.15), and also the anchoring of their end sections should be ensured. Furthermore, measures which ensure the joint operation of the elements in the transverse direction (the installation of transverse reinforcement or prestressed elements in the transverse direction) should be ensured.

13.4. In prestressed elements of precast monolithic reinforced-concrete structures with the positioning of the reinforcement outside of the concrete it is necessary to specify a clearance between this reinforcement and the surface of the concrete of the element, and also between the rows of reinforcement of adjacent elements, ensuring the filling of the joints with concrete or with mortar and the protection of the reinforcement against corrosion and temperature effects.

13.5. When designing prestressed flexural, and also eccentrically compressed and eccentrically tensile-stressed elements with the large eccentricities it is recommended that the cross sections be assumed to have developed tensile-stressed and compressed zones of concrete (double-T, hollow rectangular, etc.).

At the sites of the joining of walls with flanges it is necessary to set up smooth transitions. Apertures in the walls of elements should have a rounded shape and be reinforced along the edges with reinforcement .

13.6. It is permissible to use part of the longitudinal hot-rolled reinforcement of an element without prestressing, if in this case the requirements for the rating for crack formation and for deformations are satisfied.

13.7. The local reinforcement of portions of prestressed elements under anchors of stressed reinforcement , and also at the support sites of tensioning devices, it is recommended be carried out by the installation of insert components or additional transverse reinforcement , and also by increasing the dimensions of the cross section of the element in these portions (Fig. 48).

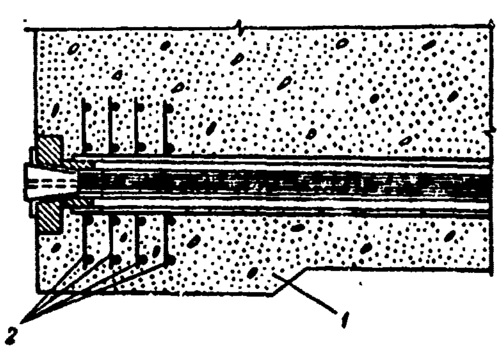


Fig. 48. Local reinforcement of the supporting portion of prestressed reinforced-concrete elements with bundle reinforcement. 1 - increasing the thickness of the protective layer of concrete at a support under an anchor; 2 - installing additional welded grids near the anchor.

13.8*. The part of a longitudinal stressed reinforcement in the supports of flexural elements it is recommended be made curvilinear, distributing it on the face of the element uniformly over its height; part of the bent-up reinforcement can be brought out into the upper face of the element.

If the longitudinal reinforcement is not bent-up, it is necessary:

a) to stress the transverse reinforcement, or

b) to increase the width of the cross section of the element and in this case to install additional transverse unstressed reinforcement, or

c) to decrease the height of the cross section of the element at its face.

The transverse stressed reinforcement should be situated as close as possible to the face of the element and it should be stressed before the stressing of the longitudinal reinforcement by a force of not less than 15% of force of the stressing of the entire longitudinal reinforcement of the stressed zone of the supporting cross section. In this case the magnitude of the prestressing of the transverse reinforcement should be designated maximum (see 5.6).

The increase in the width of the cross section of the element (see subparagraph "b") in structures with longitudinal rod reinforcement, not having anchors at the ends, should be taken over a length (reckoning from the face of the element) of not less than 10 diameters of the longitudinal reinforcement.

In the absence of stressed transverse reinforcement or with the positioning of stressed longitudinal reinforcement concentratedly in lower or in the upper and lower zones of the supporting cross section the unstressed transverse reinforcement should receive in structures, not rated for durability - not less than 20%, and in structures rated for durability - not less than 30% of the force in the longitudinal stressed reinforcement of the lower zone of the supporting cross section determined by rating for strength. The transverse rods should be reliably anchored at the ends by welding them to insert components (Fig. 49).

13.9. When designing prestressed reinforced-concrete structures with increased requirements for fire-proofness special measures should be taken for protecting the stressed reinforcement from being heated, especially in its anchoring zones.

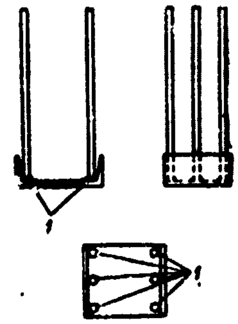
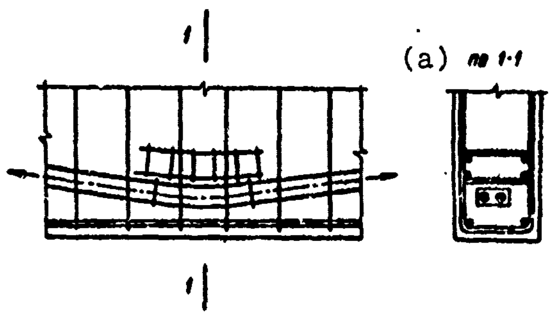


Fig. 49. The anchoring of unstressed transverse rods by welding them to steel insert components 1 - welded joints.

13.10. Channels in structural elements for the positioning of reinforcement stressed in the concrete, should be made with the use of rods removed from the concrete, rubber hoses, etc., or with the use of a shell of corrugated or smooth steel pipes. At the sites of an abrupt variation in the curvature of the channels it is necessary to install segments of rigid steel pipes.

In the positioning in one channel of several bundles or rods the channel should have a widening at ends for the deployment of anchoring and tensioning devices. At the sites of the bending of reinforcement (Fig. 50), and also at the sites of the positioning of the widening in a channel it is necessary to reinforce the concrete of the element by installing steel bands, stirrups or grids, and also to increase the cross section of elements.

Fig. 50. The reinforcing concrete with additional reinforcement at the sites of the bending of the stressed reinforcement. KEY: (a) According to 1-1.



13.11. Reinforcement of high-strength wire in prestressed elements should, as a rule, be made without joints. When employing continuous reinforcement it is permissible to connect the end of the wire of one coil with the end of another coil by making a splice or with the aid of coupling dies.

THE POSITIONING OF REINFORCEMENT IN ELEMENTS

13.12. When using reinforcement of curvilinear contour stressed in concrete, the angle of inclination of the bundles or rods should be not more than 30°, and the radius of curvature:

a) for bundle reinforcement and strands: with a wire gauge of 5 mm and less and a strand diameter from 4.5 to 9 mm - not less than 4 m; with a wire gauge of 6-8 mm and a strand gauge of 12-15 mm - not less than 6 m;

b) for rod reinforcement: with a diameter of up to 25 mm - not less than 15 m; with a diameter of from 28 to 40 mm - not less than 20 m.

13.13. In bundle reinforcement clearances should be specified between the individual wires or groups of wires (by installing spirals within the bundles, bolsters in the anchors, etc.), ensuring the passage between the wires of the beam of cement or cement-sand mortar during the filling of the channels.

13.14. In hollow and ribbed elements stressed reinforcement in the form of rods, bundles or strands should be positioned, as a rule, along the axis of each rib of the elements.

13.15. Longitudinal unstressed reinforcement , if such exists, should be situated nearer the outer surfaces of the elements, so that the transverse reinforcement (stirrups) would encompass the stressed fittings (Fig. 51).

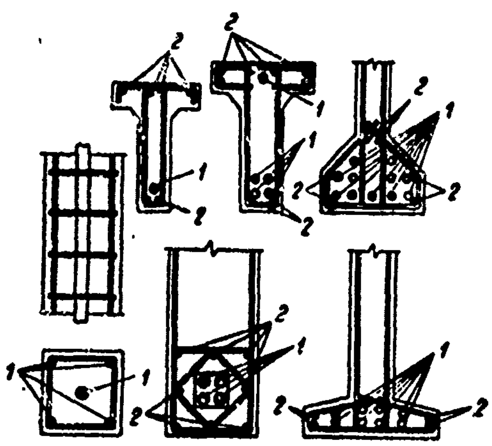


Fig. 51. Diagrams of the arrangement of stressed and unstressed reinforcement in the transverse section of prestressed reinforced-concrete elements. 1 - stressed reinforcement ; 2 - unstressed reinforcement.

13.16*. At the end of prestressed elements additional welded grids or closed stirrups should be installed with an interval of 5-7 cm over a length (reckoning from the face of the element), equal to two lengths of the anchoring attachments, and in the absence of anchors - over a length of not less than 10d and not less than 20 cm, and for the elements operating at rated temperatures of minus 40°C and below - not less than 20d and not less than 40 cm.

The diameter of stirrups or the rods of grids would be not less than 5 mm and not less than 0.25d, where d - the rod diameter of the longitudinal reinforcement.

$R_{пр}$ and $R^{н}_{пр}$ - respectively the rated and standard strength of concrete in axial compression (prismatic strength);

$R_{и}$ and $R^{н}_{и}$ - respectively the rated and standard strength of concrete in compression with flexure;

$R_{р}$ and $R^{н}_{р}$ - respectively the rated and standard strength of concrete in tension;

$R_{т}$ - the rated strength of concrete in tension in rating prestressed elements for crack formation and in checking the necessity for rating reinforced-concrete elements for crack opening;

$R^{н}_{a}$ - standard strength of reinforcement;

R_{a} - the rated strength of longitudinal tensile-stressed reinforcement and transverse reinforcement in rating for flexure in an inclined cross section;

$R_{a.x}$ - the rated strength of transverse reinforcement in rating for transverse force;

$R_{a.c}$ - the rated strength of compressed reinforcement;

$E_{б}$ - the initial elastic modulus of concrete in compression and tension;

E_{a} - the elastic modulus of reinforcement;

$$n = \frac{E_a}{E_б}.$$

Note. The additional transverse reinforcement placed at the ends of an element, can be taken into account in the rating for local compression (crushing), made in accordance with the instructions of 7.13.

ANCHORING OF REINFORCEMENT

13.17*. The placing of anchors at the ends of reinforcement is mandatory for the reinforcement stressed in hardened concrete, and also for reinforcement stressed in abutments, when its adhesion with the concrete is insufficient; in this case the anchor devices should ensure the reliable fixing of the reinforcement in the concrete at all stages of its operation.

The installation of anchors is not necessary, if the following are used:

a) high-strength deformed reinforcing wire under the condition of the observance of the requirements of 2 of "b," of Table 1;

b) reinforcement, twisted from two high-strength wires (see Note 3 to 2.7) under the condition of the observance of the requirements of 2 "d," of Table 1;

c) reinforcing strands under the condition of the observance of the requirements for 2 "e," of Table 1 and 12.5;

d) hot-rolled, heat-hardened and draw-hardened deformed rod reinforcement (with the observance of the requirements for 3 of Table 1) under the conditions of installing additional transverse reinforcement (welded grids, stirrups) in accordance with the instructions of 13.16; in this case the length of the fixing of the rods beyond the face of the support should be not less than 4d, and the thickness of the protective layer of concrete should satisfy the requirements of 12.5.

13.18*. In structures with reinforcement of curvilinear contour anchoring devices should be placed in the faces of an element without increasing the thickness of the lower protective layer of concrete, in this case the bundles or the rods of the reinforcement should be positioned over the height of the transverse section of the element taking into account the placing of the anchoring and tensioning devices on the faces of the element.

In prestressed structures operating at rated temperatures of minus 40°C and below it is necessary, as a rule, to place stressed reinforcement in the circum-support portions for more uniform stress distribution on the faces of the element.

13.19. In placing the anchors it is necessary to consider their displacement during elongation of the reinforcement during its tensioning in the abutments and in the concrete; after tensioning of the reinforcement an anchor should occupy its designed position.

Anchoring devices situated on the surface of concrete, should be protected by a layer of additionally laid concrete or mortar (with a thickness of not less than that indicated in 12.2 and 12.4) or by an anti-corrosion coating.

13.20. In breaking stressed reinforcement within the limits of the length of an element its anchors should be placed in the zone of the cross section compressed from the effect of an external load.

In the case of the positioning of anchors in a zone operating in tension due to an external load, the placing of reinforcement should be specified receiving the local forces in the cross sections adjacent to the site of the breaking of the stressed reinforcement.

APPENDIX I

STANDARD STRENGTHS, COEFFICIENTS OF UNIFORMITY AND THE ELASTIC MODULI OF CONCRETE AND REINFORCEMENT

1.1*. The standard strengths of concrete are taken in accordance with Table 29.

Table 29*. Standard strengths of concrete

Type of stressed condition	Designa-tions	Standard strengths of concrete in kg/cm² with a job-grade of concrete for strength in compression										
		35	50	75	100	150	200	250	300	400	500	600
		Job-grades of concrete in tension										
		—	—	—	P11	P15	P18	P20	P23	P27	P31	P35
Axial compression (prismatic strength)	R^{H}_{np}	28	40	60	80	115	145	175	210	280	350	420
Compression with flexure	R^{H}_{u}	35	50	75	100	140	180	215	260	350	440	520
Tension	R^{H}_{p}	5	6	8	10	13	16	18	21	25	28	30

Note. 1. For concretes based on alumina cement the values of the standard strengths of concrete in tension R^H_p are multiplied by coefficient 0.7

2. For light-aggregate concrete based on porous coarse and fine fillers with the presence of verified experimental data the values of the standard strengths of concrete in tension R^H_p can

be taken higher than the values given in Table 29, but not more than by 25%.

3. For heavy-aggregate concrete in establishing their grade by tensile strength and with the satisfaction by these concrete of the requirements, imposed for hydraulic engineering concrete, it is permissible to take the values of the standard strengths of concrete in tension R^H_p equal to their job-grade for tensile strength.

4. In rating structures, in which the strength of the concrete did not attain job-grade, the standard strengths of the concrete are determined by interpolation.

5. For light-aggregate concretes of job-grade 350 the values of the standard strengths are determined by interpolation.

6. For light-aggregate concretes of job-grades 200 and above, prepared on a base of natural porous fillers of volcanic origin, the values of the standard strengths of the concrete in elongation R^H_p are taken in accordance with Table 29 with the coefficients:

for concretes of job-grades 200 and 250 - 0.8;
for concretes of job-grades 300 and 350 - 0.7;
for concretes of job-grade 400-0.65.

7. For porous light-aggregate concretes, and also concretes prepared with the use of expanded perlite sand, the values of the standard strengths of the concrete in tension R^H_p are taken in accordance with Table 29 with coefficient 0.8.

Table 30. Coefficients of uniformity of concrete.

Type of stress condition	Designations	Coefficients of uniformity of concrete with the job-grade of the concrete by strength in compression		
		<100	100-200	>200
Axial compression and with flexure..........	$k_{\text{б.c}}$	0.5	0.55	0.6
Tension................	$k_{\text{б.p}}$	0.45	0.45	0.5

Note. For concrete prepared at factories or batch plants with the use of automatic or semi-automatic batching components, the values of the coefficients of uniformity of concrete during compression (axial and with flexure) $k_{\text{б.c}}$ can be increased by 0.05 under the condition, that its corresponding increased value is confirmed by systematic control of the degree of uniformity of concrete during compression.

Table 31*. Initial elastic moduli of concrete in compression and tension $E_{б}$.

Job-grade of concrete by strength in compression	Initial elastic moduli of concrete $E_{б}$ in kg/cm²					
	heavy-aggregate		light-aggregate			
	standard	based on fine filler with an expenditure of 500 kg/m³ and more	base on artificial fine and coarse fillers		based on natural coarse and fine fillers	
			with the volumetric weight of the coarse filler in kg/m³			
			>700	300-700	>700	300-700
35	–	–	50,000	35,000		30,000
50	–	–	70,000	50,000		40,000
75	–	–	95,000	65,000		50,000
100	190,000	140,000	110,000	80,000		65,000
150	230,000	170,000	130,000	100,000		80,000
200	265,000	200,000	150,000	115,000		95,000
250	–	–	165,000	125,000		–
300	315,000	235,000	180,000	135,000		–
400	350,000	255,000	200,000	150,000		–
500	370,000	285,000	–	–		–
600	380,000	300,000	–	–		–

Note. 1. As the initial elastic modulus of concrete in compression and tension is taken the ratio of normal stress in the concrete σ to its relative deformation ε at stress level $\sigma \leq 0.2R^{H}_{np}$.

2. If light-aggregate concrete is used in structures, for which an increase in the elastic modulus of the concrete is disadventageous, its value is determined from Table 31 with coefficient 1.3.

3. For light-aggregate concretes the values of the initial elastic moduli in the following cases can be taken to be:

a) if the fine filler is quartz sand - from Table 31 with coefficient 1.3;

b) if concrete is subjected to autoclave processing or if coarse filler of volumetric weight of less than 300 kg/m^3 is used in it - according to experimental data;

c) if coarse filler of a volumetric weight of more than 1000 kg/m^3 is used, with the presence of appropriate experimental data - increased in comparison with the values indicated in Table 31;

d) if natural coarse and fine filler of volcanic tuff or pumice is used - from Table 31 as for light-aggregate concrete based on artificial coarse and fine fillers of appropriate volumetric weights; in this case for concretes of job-grades of 250-400 values $E_б$ should be taken with coefficient 0.9;

e) if natural coarse and fine fillers of the limestone-coquinas are used:

at a volumetric weight of the heavy filler $\gamma > 700$ kg/m^3 - from Table 31 as for light-aggregate concrete based on artificial coarse (when $\gamma > 700$ kg/m^3) and fine fillers;

with a volumetric weight of coarse filler of $300 \leq \gamma \leq$ ≤ 700 kg/m^3 - from Table 31 on an appropriate column for light-aggregate concrete based on natural coarse and fine fillers;

f) if according to experimental data for light-aggregate concretes based on artificial porous fillers the value of the initial elastic modulus is higher than the values given in Table 31, by more than 15%, then in the ratings it is permissible to take value $E_б$ from Table 31 with coefficient 1.15;

g) if porous light-aggregate concrete are used, then values $E_б$ should be taken from Table 31 with coefficient 0.75.

4. The values of the initial elastic modulus for light-aggregate concretes of job-grade 350 based on artificial fillers are determined by interpolation.

1.2. The coefficients of uniformity of the concrete are taken from Table 30.

1.3. The initial elastic moduli of a concrete in compression and tension $E_б$ are taken from Table 31, but the shear modulus for concrete $G_б$ (in the absence of the experimental data) can be assumed to be $G_б = 0.4E_б$.

1.4. The standard strengths of reinforcement $R_a^н$, the coefficients of uniformity of reinforcement k_a and the elastic moduli of reinforcement E_a are given in Tables 32 and 33.

Table 32*. The standard strengths of reinforcement R^{H}_{a}, the coefficients of uniformity k_a and the elastic moduli E_a of rod reinforcement.

Type of reinforcement	Standard strengths of reinforcement R^{H}_{a} in kg/cm²	Coefficients of uniformity of reinforcement k_a	Elastic moduli of reinforcement E_a in kg/cm²
1. Hot-rolled round (smooth) steel of class A-I, and also band, angular and shaped groups of "steel 3" grades......	2400	0.9	2,100,000
2. Hot-rolled deformed steel of class A-II...	3000	0.9	2,100,000
3. The same, of class A-III....................	4000	0.85	2,000,000
4. The same, of class A-IV....................	6000	0.85	2,000,000
5. The same, of class A-V.....................	8000	0.8	1,900,000
6. Heat hardened deformed steel of class At-IV....................	6000	0.85	1,900,000
7. The same, of class At-V.....................	8000	0.8	1,900,000
8. The same, of class At-VI...................	10,000	0.8	1,900,000
9. Deformed draw-hardened steel of class A-IIv with control of the given:			
a) elongation and stressing...........	4500	0.9	2,100,000
b) only of elongation	4500	0.8	2,100,000
10. The same, of class A-IIIv with control:			
a) elongation and stressing...........	5500	0.9	2,000,000
b) only of elongation	5500	0.8	2,000,000

Table 33. Standard strengths R^H_a, coefficients of uniformity k_a and elastic moduli E_a of wire reinforcement.

Type of reinforcement	Wire gauge in mm	Standard strength of reinforcement R^H_a in kg/cm²	Coefficient of uniformity of reinforcement k_a	Elastic moduli of reinforcement E_a in kg/cm²
1. Standard reinforcing wire of class V-I (employed in welded grids and frameworks)	Fr. 3 to 5.5	5500	0.8	1,800,000
	Fr. 6 to 8	4500	0.8	1,800,000
2. High-strength smooth wire of class V-II	3	19,000		
	4	18,000		
	5	17,000	0.8	1,800,000
	6	16,000		
	7	15,000		
	8	14,000		
3. High-strength deformed wire of class Vr-II	3	18,000		
	4	17,000		
	5	16,000		
	6	15,000	0.8	1,800,000
	7	14,000		
	8	13,000		
4. Seven-wire reinforcing strands of class P-7	1.5	19,000		
	2	18,000	0.8	1,800,000
	2.5	18,000		
	3	17,000		
	4	16,000		
	5	15,000		
5. Multi-strand steel cables per GOST:				
3066-66	Fr. 1 to 3	17,000		
3067-66	Fr. 1 to 3	16,000	0.8	1,600,000
3068-66	Fr. 1 to 3	15,500		

<u>Note</u>: The standard strengths of wire and seven-wire strands (see 2-4 of Table 33) are determined from the value of the least temporary strength in tension, and the standard strengths of steel cables (see 5 of Table 33) - from the value of the ultimate tension of the cable as a whole with values of the least tensile strength of the wire in cables 19,000 kg/cm²; with the use in the cables of wires with other values of least tensile strength the standard strengths of the cables should change accordingly.

APPENDIX II

Table 34. Values of coefficient γ for determining the moment of strength of cross section $W_T = \gamma W_0$.

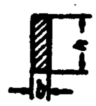
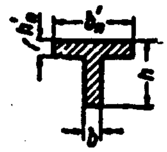
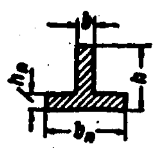
Characteristics of the cross sections	γ	Shape of transverse cross section
1. Rectangular...............	1.75	
2. T-shaped with a flange situated in the compressed zone.	1.75	
3. T-shaped with a flange (broadening) situated in the tensile-stressed zone:		
a) when $\frac{b_n}{b} \leq 2$ independent of ratio h_n/h	1.75	
b) when $b_n/b > 2$ and $h_n/h \geq 0.2$	1.75	
c) when $b_n/b > 2$ and $h_n/h < 0.2$	1.75	

Table 34 (Cont'd.).

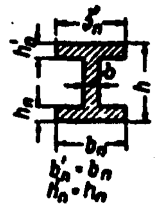
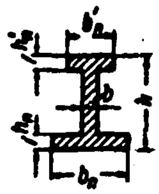
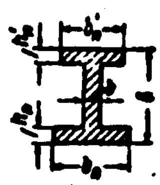
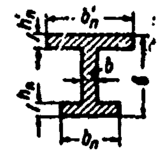
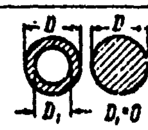
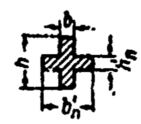
4. Double-T symmetrical (box-shaped):		
a) when $b'_{\text{п}}/b = b_{\text{п}}/b \leq 2$ independent of ratios $h'_{\text{п}}/h = h_{\text{п}}/h$	1.75	
b) when $2 < b'_{\text{п}}/b = b_{\text{п}}/b \leq 6$ independent of the ratios $h'_{\text{п}}/h = h_{\text{п}}/h$..............	1.5	
c) when $\frac{b'_{\text{п}}}{b} = \frac{b_{\text{п}}}{b} > 6$ and $\frac{h'_{\text{п}}}{h} = \frac{h_{\text{п}}}{h} \geqslant 0{,}2$	1.5	
d) when $6 < \frac{b'_{\text{п}}}{b} = \frac{b_{\text{п}}}{b} \leqslant 15$ and $\frac{h'_{\text{п}}}{h} = \frac{h_{\text{п}}}{h} < 0{,}2$	1.25	
e) when $\frac{b'_{\text{п}}}{b} = \frac{b_{\text{п}}}{b} > 15$ and $\frac{h'_{\text{п}}}{h} = \frac{h_{\text{п}}}{h} < 0{,}1$	1.1	
5. Double-T unsymmetric, satisfying the condition $b'_{\text{п}}/b \leq 3$:		
a) when $\frac{b_{\text{п}}}{b} \leqslant 2$ independent of the ratio $h_{\text{п}}/h$...........	1.75	
b) when $2 < \frac{b_{\text{п}}}{b} \leqslant 6$ independent of the ratios $h_{\text{п}}/h$........	1.5	
c) when $\frac{b_{\text{п}}}{b} > 6$ and $\frac{h_{\text{п}}}{h} > 0{,}1$	1.5	
6. Double-T unsymmetric, satisfying the condition $3 < \frac{b'_{\text{п}}}{b} < 8$:		
a) when $\frac{b_{\text{п}}}{b} \leqslant 4$ independent of ratio $h_{\text{п}}/h$................	1.5	
b) when $\frac{b_{\text{п}}}{b} > 4$ and $\frac{h_{\text{п}}}{h} \geqslant 0{,}2$	1.5	
c) when $\frac{b_{\text{п}}}{b} > 4$ and $\frac{h_{\text{п}}}{h} < 0{,}2$	1.25	

Table 34 (Cont'd.).

7. Double-T unsymmetric, satisfying the condition $\frac{b'_n}{b} \geq 8$:		
a) when $\frac{h_n}{h} > 0.3$	1.5	
b) when $\frac{h_n}{h} \leq 0.3$	1.25	
8. Annular and circular.......	$2-0.4\frac{D_1}{D}$	
9. Cross-shaped:		
a) when $\frac{b'_n}{b} \geq 2$ and $0.9 \geq \frac{h'_n}{h} > 0.2$	2	
b) in the remaining cases..	1.75	

Note: 1. In Table 34 the designations b_Π and h_Π correspond to the dimensions of the flange which in rated for crack formation is tensile-stressed, and h'_Π and b'_Π - to dimensions of the flange which for this case of rated is compressed

2. W_0 - the moment of strength for the tensile-stressed face of the cross section, determined by the rules of the strength of elastic materials.

APPENDIX III

DATA ON REINFORCING STEEL AND THE CONDITIONS OF THEIR USE

Table 35*. Reinforcing steels, to the use of which chapter SNiP II-V.1-62* extends.

Reinforcing steel			Diameter d in mm	Document regulating reinforcing steel quality
type	class	grade		
1. Round smooth hog-rolled rod	A-I	St.3sp, St.3ps St.3kp; VMSt.3sp VKSt.3sp VMSt.3ps VMSt.3kp VKSt.3kp	6-40	GOST 5781-61 GOST 380-60*
2. Hot-rolled deformed rod	A-II	VMSt.5sp VKSt.5sp	10-40	GOST 5781-61 GOST 380-60*
		VMSt.5ps and VKSt.5ps	10-40	ChMTU 2-114-70
		10GT	10-32	ChMTU 1-89-67
		18G2S	40-90	GOST 5781-61 GOST 5058-65*
	A-III	25G2S 35GS	6-40	GOST 5781-61 GOST 5058-65*
		18G2S	6-9	

Table 35* (Cont'd.).

	A-IV	20KhG2Ts	10-32	GOST 5781-61 GOST 5058-65*
		80S	10-18	
		20KhGST	10-18	ChMTU/TsNIIChM 871-63
	A-V	23Kh2G2T	10-18	ChMTU 1-177-67
3. Heat hardened deformed rod	At-IV	–	10-25	GOST 10884-64*
	At-V	–	10-25	GOST 10884-64*
	At-VI	–	10-25	GOST 10884-64*
4. Draw-hardened deformed rod	A-IIv	VMSt.5sp VKSt.5sp	10-40	CHiP 1-V.4-62
		St.5ps KSt.5ps	10-40	
		18G2S	40-90	
	A-IIIv	25G2S 35GS	6-40	CNiP I-V.4-62
5. Smooth reinforcing wire	Standard V-I	–	3-8	GOST-6727-53*
	High-strength V-II	–	3-8	GOST 7348-63
6. Deformed reinforcing wire	High-strength Vr-II	–	3-8	GOST 8480-63
7. Seven-wire reinforcing strands (cables)	P-7	–	4.5-15	GOST 13840-68

Table 35* (Cont'd.).

8. Multi-strand cables without an organic core	–	–	–	GOST 3066-66 GOST 3067-66 GOST 3068-66

Note: 1. For hot-rolled rod reinforcement of classes A-I, A-II, A-III and A-IV it is permissible to indicate in designs only GOST 5781-61, regulating mainly the mechanical characteristics of the fittings and the requirements imposed on the profile, if under the condition of use of the structures (see Table 37) grades of steel need not be specified.

In tying designs of standard structures, and also in other cases, when this is necessary, the grade of reinforcing steel should be indicated along with the class.

2. For draw-hardened rod reinforcements with stress and elongation control or with control of only elongation without stress control, it is assumed that:

a) the value of the controlled stresses:

for steel of class A-IIv - 4500 kg/cm^2;
for steel of class A-IIIv - 5500 kg/cm^2;

b) the value of the controlled elongations:

for steel of class A-IIv - 5.5%;
for steel of class A-IIIv of grade 25G2S - 3.5%;
for steel of class A-IIIv of grade 35GS - 4.5%.

Table 36*. Requirements imposed on reinforced-concrete structures. operating in an aggressive gaseous medium, with respect to the category of crack resistance and maximum permissible width of crack opening depending on the type and class of reinforcing steel used.

Degree of aggressiveness of the effect of the gaseous medium on the concrete	Category of crack resistance (numerator) and the maximum permissible width of crack opening in mm (denominator)								
	for unstressed reinforcement, of classes		for stressed reinforcement, of classes						
	A-I, A-II and A-III	V-I	A-IIv and A-IIIv	A-IV	A-V	At-IV and At-V	At-VI	V-II and Vr-II	P-7 and other types of cables
1. Nonagressive	—/0,3	—/0,3	3/0,3	3/0,3	3/0,2	3/0,2	2/—	2/—	2/—
2. Weak	—/0,2	—/0,2	3/0,2	3/0,2	3/0,1	2/—	2/—	2/—	2/—
3. Medium	—/0,2	—/0,2	3/0,1	3/0,1	2/—	1/—	1/—	2**/—	2**/—
4. Strong	—/0,1	—/0,1	2/—	2/—	1/—	Cannot be employed		1/—	1/—

**With a high-strength wire gauge (including the cables and strands) of less than 4 mm the structures should conform to the requirements for the 1st category of crack resistance.

Note. 1. The degree of aggressiveness of the effect of a gaseous medium on concrete is established by the classification of Table 1 "Instructions on designing the anti-corrosive protection of building structures."

2. The category of structures for crack resistance is taken in accordance with the requirements of Table 9 Chapter SNiP II-V.1-62*.

3. The values of the width of crack openings and the categories of structures with respect to crack resistance given in Table 36 are established by mandatory observance of the requirements of SN 262-67 on the protection of reinforcement (minimum thickness of the protective layer of concrete, concrete density, protective coatings of a concrete surface, etc.), and also of the requirements of 2.16; 4.4 and 4.16 of Chapter SNiP II-V.1-62*.

Table 37*. Areas of the use of reinforcing steels in reinforced-concrete structures depending on the nature of the loads and temperature effects (plus sign means "it is permitted," minus sign - "it is not permitted").

Type of reinforcing steel and its basic characteristics				Structure use conditions							
				static loads				dynamic and multiply repeated loads			
type of reinforcement	class of steel	grade of steel and diameter in m		in heated buildings	out of doors and in unheated buildings when t,			in heated buildings	out of doors and in unheated buildings when t,		
					to -30°C	fr. -30 to -40°C	-40°C and below		to -30°C	fr. -30 to -40°C	-40°C and below
Hot-rolled smooth rod	A-I	St.3sp (open-hearth and converter) Ø 6-40		+	+	+	+	+	+	−	−
		St.3ps (open-hearth and converter) Ø 6-40		+	+	+	−	+	+	−	−
		St.3kp (open-hearth and converter) Ø 6-40		+	+	−	−	+	+	−	−
		VMSt.3sp Ø 6-40	VKSt.3sp Ø 6-40	+	+	+	+	+	+	+	+
		VMSt.3ps Ø 6-40	VKSt.3ps Ø 6-40	+	+	+	−	+	+	+	−
		VMSt.3kp Ø 6-40	VKSt.3kp Ø 6-40	+	+	−	−	+	+	−	−

Table 37* (Cont'd.).

Hot-rolled deformed rod	A-II	St.5sp (open-hearth and converter) Ø 10-40	+	+	+	+[1]	+	+	+[1]	–
		St.5ps (Open-hearth) Ø 10-16	+	+	+	+[1]	+	+	+[1]	–
		St.5ps (open-hearth and converter) Ø 18-40 | Ø 10-40	+	+	–	–	+	+[1]	–	–
		18G2S, Ø 40-90	+	+	+	+	+	+	+	+
		10GT, Ø 10-32	+	+	+	+	+	+	+	+
	A-III	25G2S, Ø 6-40	+	+	+	+	+	+	+	+[1]
		35GS, Ø 6-40	+	+	+	+[1]	+	+	+[1]	–
		18G2S, Ø 5-9	+	+	+	+	+	+	+	+
	A-IV	20KhG2Ts, Ø 10-32	+	+	+	+[2]	+	+	+	+[2]
		20KhGST, Ø 10-18	+	+	–	–	+	+	–	–
		80S, Ø 10-18	+	+	–	–	+	–	–	–
	A-V	23Kh2G2T, Ø 10-18	+	+	+	+	+[3]	+[3]	+[3]	+[3]
Heat-hardened deformed rod	At-IV	Ø 10-25	+	+	+	+	–[4]	–[4]	–[4]	–[4]
	At-V	Ø 10-25	+	+	+	+	–[4]	–[4]	–[4]	–[4]
	At-VI	Ø 10-25	+	+	+	+	–[4]	–[4]	–[4]	–[4]
Draw-hardened deformed rod	A-IIv	St.5sp (open-hearth and converter) Ø 10-40	+	+	–	–	+	+[1]	–	–
		St.5ps (open-hearth and converter) Ø 10-40	+	–	–	–	–	–	–	–
		18G2S, Ø 40-90	+	+	+	–	+	+	–	–
	A-IIIv	25G2S, Ø 6-40	+	+	+	–	+	+	–	–
		35GS, Ø 6-40	+	+	–	–	+	–	–	–
Standard reinforcing wire and welded grids made from it	V-I	Ø 3-8	+	+	+	+	+	+	+	+
Smooth high-strength reinforcing wire	V-II	Ø 3-8	+	+	+	+	+	+	+	+
Deformed high-strength reinforcing wire	Vr-II	Ø 3-8	+	+	+	+	+	+	+	+
Reinforcing strands, cables	P-7 etc.	—	+	+	+	+	+	+	+	+

Notes to Table 37*.

[1]Reinforcing steel can be used only in tied frameworks and grids.

[2]Reinforcing steel of class A-IV of grade 20KhG2Ts with a diameter of 20-32 mm at a rated temperature of -40°C and lower should be used in the form of the whole rods of measured length.

[3]Reinforcing steel of class A-V of grade 23Kh2G2T should not be used when the rating of structures for durability is required.

[4]Heat-hardened reinforcement of all classes can be used in structures which are subject during use to loads evaluated by a coefficient of dynamicity of 1.1, and with special justification - up to 1.3.

Notes: 1. Rated winter ambient temperatures should be established for the coldest five-day period in accordance with 1.4 Chapter SNiP II-V.1-62*.

2. In Table 37 as the dynamic loads, the loads considered in the rating of a structure for strength with coefficient of dynamicity 1.1 and more are accepted; for multiply repeated loads - at which the rating of structures for durability is required.

Table 38*. Main types of welded joints of rod reinforcement.

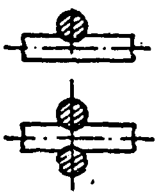
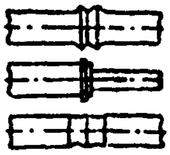
No.	Type of joint	Diameter of joint structure	Welding technique		Class of steel	Rod diameter in mm	Note
1	Cross-shaped GOST 14098-68		Resistance	Spot	A-I A-II A-III V-I	6—40 10—80 6—40 3—8	Single-shear rod joints are permitted for rods with a diameter ratio of up to 1:5
2	Butting GOST 14098-68		Resistance	Butt	A-I A-II A-III A-IV A-V	10—40 10—80 10—40 10—32 10—32	—

Table 38* (Cont'd.).

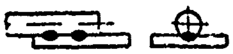
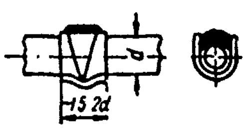
3	Lap		Resistance	Spot	A-I A-II A-III	6—16 10—16 6—16	Relief welding or with a shaped electrode. In the latter case it is permissible to weld steel rods of class A-I with a diameter of up to 25 mm
4	Butt GOST 14098-68		Arc tank	Single-electrode in inventory form with a smooth internal surface. Multi-electrode in inventory form. Semi-automatic in inventory form	A-I A-II A-III	20—40 20—80 20—40	The tank welding technique is also employed to join horizontal multirow reinforcement
5	Butt			Multi-electrode with a grooved steel backing	A-I A-II A-III	20—40 20—80 20—40	For rods with a diameter of 40 mm and more tank multiple-electrode welding of the rods with a grooved backing should be produced with slag discharge

Table 38* (Cont'd.)

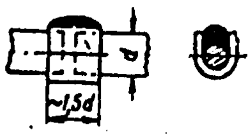
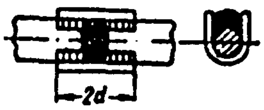
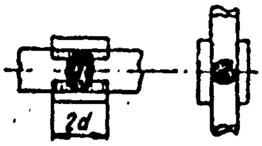
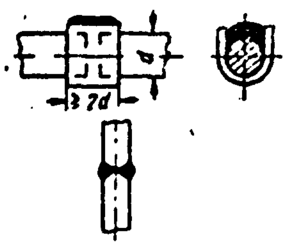
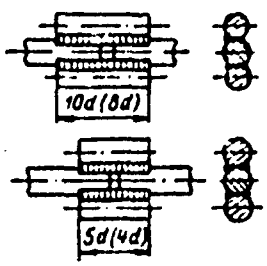
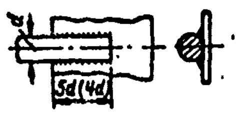
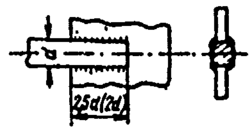
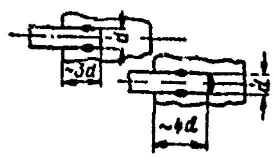
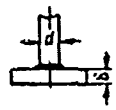
6	Butt		Arc tank	Single-electrode with grooved backing	A-I A-II A-III	20—32	-
7	"			Tank-joint with grooved cover plate	A-I A-II A-III	20—40 20—80 20—40	-
8	"		Arc	Semi-automatic multi-layer joints with (SODGP) with grooved cover plate	A-I A-II A-III	25—40 25—70 25—40	-
9	"			With multi-joints with grooved backing or without it	A-I A-II A-III	20—32	-
10	"			With longitudinal fillets with circular cover plates	A-I A-II A-III A-IV	8—40 10—80 8—40 10—32	The length of bilateral longitudinal fillets without parentheses is shown for steels of class A-IV; in parentheses - the length of longitudinal fillet for steels of classes A-II and A-III. Permitted for steel of class A-I a length of the longitudinal fillets: one way - 6d, bilateral - 3d

Table 38* (Cont'd.)

11	Lap			With longi-tudinal fillets	A-I A-II A-III	8—40 10—25 8—25	Bilateral longitudinal fillets with a length of 4d are permitted only for rods joints of steel of classes A-I and A-II of grade 10GT
12	"			The same	A-I A-II A-III	8—40 10—40 8—25	-
13	T-shaped in the plane of the plate		Arc	With longi-tudinal fillets	A-I A-II A-III	20—40 20—80 20—40	-
14	Lap			Spot	A-I A-II	8—16 10—16	-
15	T-shaped from the plane of the plate			Sub-merged with-out addi-tional elec-trode materi-al	A-I A-II A-III	6—40 10—40 8—40	

APPENDIX IV

REQUIREMENTS FOR CONCRETE FOR CONCRETE AND REINFORCED-CONCRETE STRUCTURES, USED AT RATED AMBIENT TEMPERATURES OF MINUS 40°C AND BELOW (DETERMINATION OF RATED TEMPERATURES SEE 1.4 CHAPTER SNiP I-V.1-62*)

Table 39*. Job-grades of concrete with respect to frost resistance and watertightness, and also coefficients of the service conditions of the concrete in compression for the carrying concrete and reinforced-concrete structures of buildings and structures.

Operating Conditions	Job-grade of concrete, not below:								Coefficients of the service conditions of concrete in compression $m_б$ for structures			
	With respect to frost resistance (Mrz)				With respect to watertightness (V)				Without pre-stressing	Prestressed with the compression of the concrete $\sigma_б$ in fractions of R_0		
	For buildings and structures of the classes											
	I	II	III	IV	I	II	III	IV		From 0.2 to 0.4	More than 0.4 to 0.5	More than 0.5 to 0.65
1. Alternate freezing and thawing under conditions of incidental water-saturation for structures intended for operation at rated temperatures of minus 40°C and below	300	200	150	100	6	4	2	2	0.7	0.85	0.8	0.75
2. Alternate freezing and thawing under conditions of incidental water-saturation for structures intended for operation at rated temperatures of minus 40°C and below	200	150	100	100	4	2	2	2	0.9	1.0	0.95	0.9
3. In soil with possible incidental effect on a structure of temperatures of minus 40°C and below (for example during the period of construction, assembly and others.)	150	100	50	50	Not standardized				1.0	1.0	1.0	1.0
4. The internal construction of structures and heated buildings under the possible incidental effect on the structure of temperatures of minus 40°C and below (for example during the periof of construction, assembly and others.).	100	50	50	50	The same				1.0	1.0	1.0	1.C

Notes: 1. The class of building or structure is established in accordance with Chapter SNiP II-A.3-62 "The classification of buildings and structures. Basic aspects of design."

2. In the presence of an aggressive medium job-grades of concrete with respect to frost resistance and watertightness of structures should be not lower than required by "Instructions for the designing of the anticorrosive protection of building structures" (SN 262-67).

3. The job-grades of concrete with respect to frost resistance and watertightness for piles should be designated in accordance with the requirements of GOST 12587-67 "Solid prestressed reinforced-concrete driven piles of square cross section" and GOST 10628-63 "Solid reinforced-concrete driven piles of square cross section."

Table 40*. Job-grades of light-aggregate concrete with respect to frost resistance for panels exterior walls of buildings used at a rated ambient temperature of minus 40°C and below

Humid condition of protected premises (relative atmospheric humidity ϕ in %)	Job-grade of concrete with respect to frost resistance (Mrz), not below. With the degree of service life of structures in accordance with 1.6 Chapter SNiP II-V.6-62		
	I	II	III
1. Wet ($\phi_B > 75\%$)......................	100	50	50
2. Moist ($60\% < \phi_B \leq 75\%$).............	50	35	25
3. Normal and dry ($\phi_B \leq 60\%$)..........	35	25	25

APPENDIX V

BASIC CONVENTIONAL LITERAL DESIGNATIONS

Forces from external loads in the transverse section of an element

M - flexural moment;

N - longitudinal force;

Q - transverse force;

M_{K} - torsional moment.

Internal forces acting in the transverse cross section of a prestressed element

N_{0} is the resultant of the forces in stressed fittings before compression of the concrete or stressed and unstressed reinforcement with stressing in the concrete, equal to zero;

N_{H} is the resultant of the forces in stressed reinforcement after compression of the concrete.

Characteristics of materials

R - job-grade of concrete with respect to strength in compression (cube strength of the concrete);

Characteristic aspects of longitudinal reinforcement in the transverse cross section of an element

A - the designation of longitudinal reinforcement (entire or unstressed):

a) for flexural elements - situated in a zone tensile-stressed due to the effect of external forces;

b) for eccentrically compressed elements - situated in a zone tensile-stressed due to the effect of external forces or in the least compressed zone of the cross section:

c) for eccentrically tensile-stressed elements - least distant from the point of the application of the external longitudinal force;

A_H - designation of the stressed part of reinforcement A;

A' - designation of the longitudinal reinforcement (entire or unstressed):

a) for flexural elements - situated in the zone compressed due to the effect of external forces;

b) for eccentrically compressed elements - situated in a zone compressed due to the effect of external forces or in the most compressed zone of the cross section;

c) for eccentrically tensile-stressed elements - most distant from the point of the application of the external longitudinal force;

A'_H - designation of the stressed part of reinforcement A'.

Dimensional characteristics

b - the width of a rectangular cross-section; the width of a rib of a T-shaped or double-T-shaped cross section; double wall thickness of an annular or box-shaped cross section;

h - the height of a rectangular, T-shaped or double-T-shaped cross section;

a - the distance from the most tensile-stressed or least compressed edge of a cross section of an element to the resultant of the forces in reinforcement A;

a' - the distance from the most compressed or least tensile-stressed edge of a cross section of an element to the resultant of the forces in reinforcement A';

h_0 - the operational height of a cross section, equal to h - a;

h'_0 - the operational height of a cross section, equal to h - a';

x - the height of the compressed zone of a cross-section;

z - the distance between the resultants of compressive and tensile forces in a cross section (the arm of the internal force pair);

$z_{б}$ - the distance between the center of gravity of the compressed zone of concrete and the resultant of the forces in reinforcement A;

e and e' - for reinforced-concrete structures the distances from the point of the application of longitudinal force N respectively to the resultant of the forces in reinforcement A and A'; for concrete structures the distance from the point of application of force N to the less stressed face of the cross section; in 5.15 e - the base of natural logarithms;

d - the nominal diameter of working reinforcement ;

F - the area of all the concrete in the transverse section of an element;

$F_б$ - the sectional area of the compressed zone of concrete;

$F_п$ - the reduced area of the transverse cross section of an element taking into account all the longitudinal reinforcement ;

$J_п$ - the moment of inertia of a reduced transverse cross section of an element taking into account all the longitudinal reinforcement ;

F_a - the sectional area of all the longitudinal reinforcement for centrally compressed and centrally tensile-stressed elements; in the remaining cases - the sectional area of longitudinal reinforcement A;

F'_a - the sectional area of longitudinal reinforcement A';

S_0 and S'_0 - the static moments of the area of the entire working cross section of concrete relative to the axis, normal to the plane of the effect of flexural moment and passing through the point of the application of the resultant of the forces respecively in reinforcement A and in reinforcement A';

$S_б$ - the static moment of the area of the compressed zone of concrete relative to the axis, normal to the plane of the effect of flexural moment and passing through the point of the application of the resultant of the forces in reinforcement A;

S_a and S'_a - the static moments of the sectional area of the entire longitudinal reinforcement relative to the axis, normal to the plane of the effect of flexural moment and passing through the point of the application of the resultant of the forces respectively in reinforcement A and in reinforcement A'.