SECTION ONE: GENERAL

Article 1

This code prescribes the technical regulations for the design and construction of buildings in seismic zones of maximum intensity VII, VIII and IX on the MCS-64 Scale. Conditions for the design and construction of buildings in seismic zones with a maximum intensity of X on the MCS-64 Scale are determined on the basis of special studies, as is required for sites where out-of-category buildings are to be constructed.

All buildings within the Republic of Macedonia are located in seismic regions as defined by the Seismological Maps of the Republic of Macedonia, which have been prepared taking into account earthquakes with return periods of 50, 100, 200, 500, 1000 and 10000 years, and which form a constituent part of this code.

Article 2

According to the provisions of this Code, buildings in seismic regions shall be designed so that earthquakes of the highest (expected) intensity may cause damage to the load-bearing structure, but, in no case, collapse of the building.

Article 3

The symbols used in this Code have the following meanings:

K_o	- coefficient of building category;
f_{max} (cm)	- maximum permitted horizontal deflection of the building;
H (m)	- height of the building above ground level;
G (10 kN)	- total weight of the building;
S (10 kN)	- total horizontally or vertically acting seismic load, or seismic load acting on an element of the structure;
K	- total seismic coefficient for the horizontal direction;
K_s	- coefficient of seismic intensity;
K_d	- coefficient of dynamic response;
K_p	- coefficient of ductility and damping;
T (sec)	- period of fundamental mode of structural vibration;
S_i (10 kN)	- horizontal seismic force acting at the height of the "i'-th storey;
G_i (10 kN)	- weight of the "i"-th storey;
H_i (m)	- height of the "i"-th storey, measured from the top of the foundation;
K_v	- total seismic coeffcient for the vertical direction;
Q_i (10 kN)	- transverse seismic force acting at the height of the "i"-th storey;
$M_{t,i}$ (10 kN)	- torsional moment acting in the "i"-th storey;
e_i (m)	- distance between the centre of rigidity and the centre of mass in the "i"-th storey;
K_e	- coefficient for the calculation of seismic effects upon structural elements;
G_e (10 kN)	- weight of structural elements;
μ (%)	- percentage of tensile reinforcement;
μ' (%)	- percentage of compressive reinforcement;

σ (10^2 KPa)	- average stress in a structural element due to vertical loading;
β_C (10 KPa)	- strength of concrete prism;
β_{cube} (10 KPa)	- strength of concrete cube;
h_i (cm)	- height of "i"-th storey;
γ	- safety factor;
d (cm)	- wall thickness;
$\sigma_{n\text{-}perm}$ (10 KPa)	- permissible principal tensile stress;
σ_n (10 KPa)	- principal tensile stress in wall element;
τ_o (10 KPa)	- average shear stress in a wall element due to seismic load;
$\sigma_{n\text{-}ult}$ (10 KPa)	- principal tensile stress in a wall at ultimative load;
K_t	- coefficient defining the increase of eccentricity due to coupling;
P (10 kN)	- axial force due to the vertical loading of a column;
F (cm^2)	- cross-sectional area;

SECTION TWO: CLASSIFICATION OF BUILDINGS

Article 4

According to this Code, buildings and structures shall be classified into one of the following categories:

Building category	Type of building or structure	Building category coefficient K_o
Out-of-category	Buildings forming part of nuclear power stations; buildings for the transport and storage of inflammable liquids and gases; objects for the storage of toxic materials; more important telecommunications buildings and structures; buildings with more than 25 storeys, and other buildings upon whose unimpaired functioning depends the operation of other technical-technological systems, faults which could have disastrous effects on the environment and/or cause great material losses to the wider community;	
Category I	Buildings which contain rooms for assembly use (cinemas, theatres, gymnasiums, exhibition-halls, etc.); university faculty buildings; schools; hospitals and health centres; fire stations; telecommunications buildings and structures not classified as out-of-category buildings (post-office, radio and television broadcasting, etc.); industrial buildings containing particularly valuable equipment; all energy-production buildings with power more then 40MW; buildings containing objects of exceptional cultural and artistic value, and other buildings in which activities of particular importance to socio-political communities are carried out.	1.5

Category II	Residential buildings; hotels; restaurants; public buildings not classified into Category I, industrial buildings not classified into Category I.	1.0
Category III	Auxiliary industrial buildings; agrotechnical buildings.	0.75
Category IV	Temporary buildings and structures whose collapse cannot endanger human lives.	

Article 5

Buildings and structures classified as Category I buildings, but not located in a seismic zone, shall be designed to resist a loading corresponsing to intensity VII. In this case a building category coeffcient of $K_0 = 1.0$ shall be adopted.

Buildings and structures classified as Category IV buildings need not be designed to resist seismic loading.

SECTION THREE: SEISMICITY AND SEISMIC PARAMETERS

Article 6

The seismic hazard associated with a particular seismic region shall be estimated on the basis of the Seismological Maps of the Republic of Macedonia.

When desiging buildings which belong to Category II or Category III, the seismological map of the Republic of Macedonia which corresponds to a return period of 500 years shall be used.

Seismic hazard and the parameters needed to design buildings against earthquakes may also be determined by means of additional research within the framework of detailed seismic zoning studies or seismic microzoning.

Article 7

When desiging buildings classifed into Category I, the coefficient of seismic intensity, as well as other parameters, shall be defined beforehand by means of special studies - with the seismic micro-zoning of building areas.

Article 8

When designing buildings classified as out-of-category according to Article 4 of this Code, it is necessary to carry out first a detailed investigation of the seismicity of sites upon which construction is foreseen. The design and maximum expected earthquake shall be determined on the basis of seismic hazard investigations.

SECTION FOUR LOCAL GROUND CONDITIONS

Article 9

The influence of local ground conditions shall be taken into account, when determining seismic effects on buildings of Category II and III, by means of the dynamic response coefficient as defined in Article 25 and depending on the category of the ground upon which the building is to be constructed. The category of ground shall be determined according to the classification given in Table 1, on the basis of the results of geotechnical investigations of the site, of engineering-geological and hydro-geological data, and of geophysical and other investigations of the ground.

Table 1.

Category of ground	Characteristic soil profile
I	Rock or rock-like ground (crystalline rocks, shales, carbonate rock, limestone, marlstone, well-cemented conglomerate and similar, very dense and hard soils, of thickness less than 60.0 m, consisting of stable layers of gravel, sand and stiff clay on top of a firm geological formation.
II	Dense and medium-dense soils, as well as very dense hard soils, with a thickness of over 60.0 m, consisting of stable layers of gravel, sand and stiff clay on top of a firm geological formation.
III	Soils of low density and soft soils, with a thickness of greater than 10.0 m consisting of loose gravel, medium-dense sand and clay, with layers of sand or other cohesionless soils or without such layers.

Construction sites for buildings belonging to Category II or III, whose ground conditions are not known with sufficient certainty, may be classifed into ground Category II.

Article 10

In the case of ground where, during earthquakes, dynamics instability may occur as a result of the liquefaction of loose sandy soils and other water-saturated materials, as well as a result of severe settlement, landslides, rockslides, soil slips, or similar phenomena, the feasibility and conditions for the construction of buildings on such sites shall be determined by means of special on-site and laboratory investigations.

Unless so dictated by the purpose of the building, buildings and structures shall not be built on ground where dynamic instability may be expected to occur (areas of quicksand or silty soil, landslide-prone areas, unstable slopes, ground where liquefaction and severe settlement may occur).

Article 11

In the case of ground where it has been proved by means of standard geotechnical investigations that the possibility of occurence of dynamic instability phenomena exists, the feasibility and conditions of design and construction for buildings to be erected on such ground shall be determined by means of special onsite and laboratory investigations.

SECTION FIVE: METHODS OF CALCULATION, PERMISSIBLE STRESSES AND DISPLACEMENTS

Article 12

For the structural analysis of the load-bearing structure of buildings either limit-state theory or elastic theory may be used.

Article 13

If calculations are to be based on the elastic theory, then the allowable stresses may be increased by 50%, but must not exceed the yield point. In the case of metals without a distinct yield point, the allowable stress may not exceed 80% of the ultimate strength of the material.

Article 14

The maximum permissible loading of the sub-soil shall be determined, for the most unfavourable combination of seismic and other effects, by taking into account a safety-factor against soil failure of 1.5.

Article 15

If calculations of the seismic resistance of the load-bearing structure are to be based on limit-state theory, then the following safety-factors shall be used:

- for reinforced and prestressed concrete structures 1.30,
- for steel structures 1.15,
- for masonry structures 1.50.

Article 16

The maximum horizontal deflection of a building for the given seismic loading, as determined on the basis of elastic theory without taking into account the influence of soil-structure interaction, shall not exceed a value of

$$f_{max} = \frac{H}{600}$$

where H is the height of the building.

When determining the size of maximum deflections, the influence of soil-structure interaction shall be taken into account separately, if this is essential.

In the case of industrial buildings, as well as other special buildings and structures, larger deflections than the above are permitted if, at the same time, the stability of these buildings can be proved.

SECTION SIX: CALCULATION OF SEISMIC LOADS

1. Fundamental Principles of Calculation

Article 17

When analysing the effect of horizontal seismic loads on the load-bearing structure of a building, the action of these loads on at least two orthogonally-orientated planes shall be considered.

Article 18

In the case of cantilevered structures, as well as other structures where the influence of vertically-acting seismic loads may be of major importance, calculations of the effect of vertically-acting seismic loads shall be carried out separately.

Article 19

The total weight of a building, G, shall be defined as the sum of all dead loads, probable live loads and snow loading.

Probable live loading shall be considered to be equal to 50% of the loading specified in the loading regulations. If live loading is a significant factor (e.g. in the case of warehouses, silos, libraries, archives, etc.), then the seismic loads shall be determined for the most unfavourable case of maximum or minimum actual loading.

Loads caused by the wind, as well as the live load carried by cranes, need not be taken into account when calculating the seismic resistance of buildings.

The full weight of permanently-installed equipment shall be taken into account.

Article 20

The seismic analysis of structures may be carried out either by the equivalent static load method or by the dynamic analysis method.

2. The Equivalent Static Load Method

Article 21

The total horizontal seismic force acting on a building, S, shall be determining according to the formula:

$$S = K * G$$

where K is the total seismic coefficient for the horizontal direction and G is the total weight of the building and its equipment as defined in Article 19 of this Code.

Article 22

The weight of a building shall be defined as the weight above the upper edge of its foundation. In the case of rigid basement structures, however, it shall be defined as the weight above the upper edge of these structures.

Article 23

The total seismic coefficient K shall be calculated from the expression:

$$K = K_o * K_s * K_d * K_p$$

where:
- K_o is the coefficient of building category,
- K_s is the coefficient of seismic intensity,
- K_d is the coefficient of dynamic response, and
- K_p is the coefficient of ductility and damping.

The total seismic coefficient K shall have a minimum value of 0.02.

Article 24

Depending upon zone seismicity, the coefficient of seismic intensity, K_s, shall have one of the following values:

Zone seismicity on the MCS Scale	K_s
VII	0.025
VIII	0.050
IX	0.100

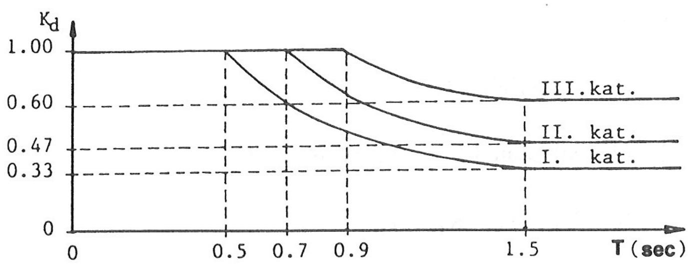
Article 25

The coefficient of dynamic response, K_d, shall be determined according to Table 2 or according to Diagram M, depending on the category of ground:

Table 2.

Category of ground	Coefficient	Limit values of the coefficient K_d
I.	$K_d = \frac{0.50}{T}$	$0.33 < K_d < 1.0$
II.	$K_d = \frac{0.70}{T}$	$0.47 < K_d < 1.0$
III.	$K_d = \frac{0.90}{T}$	$0.60 < K_d < 1.0$

Diagram M



Article 26

Calculation of the natural periods of free vibration of structures shall be carried out using the methods of structural dynamics, or by means of approximate formulae which are based on the principles of structural dynamics.

If, in the case of stiff reinforced-concrete or masonry buildings, up to 5 storeys high, the natural periods of free vibration are not calculated, then the maximum value of the coefficient K_d according to Table 2 shall be assumed, for the corresponding sub-soil conditions.

Article 27

The coefficient of ductility and damping, K_p, depends on the type of structure under consideration:

1) For all modern reiforced-concrete structures, for all steel structures except those mentioned in section 2 of this article, and for all modern wooden structures, except structures listed in section 3 of this article, $K_p = 1.0$;

2) For structures built of reinforced masonry, and for braced steel structures, $K_p = 1.3$;

3) For masonry structures, strengthened by means of vertical reinforced-concrete tie-beams' for reinforced-concrete shear-wall structures which do not satisfy the requirements of article 68 of this Code; for very high and slender structures with low damping, such as high industrial chimneys, aerials and masts, water-towers and other structures with a fundamental natural period of free vibration of $T \geq 2.0$ sec., $K_p = 1.6$;

4) For structures with a particularly flexible ground-floor or any other storey, or with a sudden change in stiffness, as well as for ordinary masonry structures, $K_p = 2.0$.

Article 28

Analysis of structures with a particularly flexible ground-floor or any other storey may be carried out, instead of according to article 23 of this Code, by the dynamic analysis method, taking into account the effect of the design and maximum expected earthquake.

Article 29

The total seismic force acting on a structure shall be distributed over the height of the latter either:

1) By the method of structural dynamics, or

2) According to the approximate formula given in article 30 of this Code.

Article 30

For buildings up to 5 storeys high, the seismic force shall be considered to be distributed according to the approximate formula:

$$S_i = S * \frac{G_i * H_i}{\sum_{i=1}^{n} G_i * H_i}$$

where

- S_i is the horizontally-acting seismic load in the "i"-th storey,
- G_i is the weight of the "i"-th storey, and
- H_i is the height of the "i"-th storey, measured from the upper edge of the foundation.

Article 31

For all other buildings, except for buildings for which calculations based on the methods of structural dynamics are obligatory, the total seismic force shall be distributed over the height of the structure as follows: a force amounting to 85% of S shall be distributed according to the formula given in article 30 of this Code, whereas the remainder, 15% of S, shall be assumed to act as a concentrated load at the top of the building.

Article 32

The total vertical seismic force acting on a building shall be determined in accordance with the formula:

$$S = K_v * G$$

where K_v is the total seismic coefficient for the vertical direction, and G is the total weight of the building (see Article 19).

Article 33

The total seismic coefficient for the vertical direction shall be calculated from the expression:

$$K_v = 0.7 * K = 0.7 * K_o * K_s * K_d * K_p$$

where K is the total seismic coefficient for the horizontal direction.

When determining values of the coeffcient K, the expression given in Article 23 of this Code shall be used, taking into account, for the natural period of vibration, the natural period for the vertical direction of the structure or structural element under consideration.

Article 34

Torsional moments shall be calculated, for each storey of the structure, from the expression:

$$M_{t,i} = Q_i * e_i * K_t$$

where:

- Q_i is equal to the greater of the calculated values of storey shear, in the "i"-th storey, corresponding to the directions chosen for analysis,
- e is the eccentricity of the centre of stiffness with respect to the centre of mass, in the "i "-th storey, and
- K_t is the coefficient defining the increase of eccentricity due to coupling between lateral and torsional vibrations, and due to non-uniform movement of the foundations. If no value of the coefficient K_t is calculated, then a value of $K_t = 1.5$ shall be assumed.

In the calculations, all masses situated above the storey being analysed for torsional moments shall be taken into account.

Article 35

The seismic forces acting on the elements of a structure shall be calculated according to the formula:

$$S = K_s * K_e * G_e$$

where:

- K_s is the coefficient of seismic intensity, according to Article 24 of this Code,
- K_e is the coefficient defmed in Article 36 of this Code, and
- G_e is the weight of the element of the structure for which the seismic force is being calculated.

Article 36

The values of the coefficient K_e are given in Table 3:

Table 3:

Elements of the structure	K_e	Direction of action of seismic force
partition walls, non load-bearing walls	2.5	perpendicular to the flat surface of the wall
balconies	6.0	perpendicular to the flat surface of the balcony
chimney, tanks connected to the building	6.0	in any direction
masonry parapet walls and fences	10.0	perpendicular to the flat surface of the wall
ornamenations	10.0	in any direction

Article 37

In the case of equipment fixed inside buildings whose movement or overturning might endanger human lives or cause damage, the anchoring of such equipment shall be designed according to the formula given in Article 35 of this Code, assuming a value of $K_e = 10.0$, in order to prevent the movement or overturning of such equipment.

Article 38

The design of anchorages for particularly valuable equipment, whose operation is vital, shall be carried out by applying the methods of dynamic analysis to the structure and the equipment.

3. The Dynamic Analysis Method

Article 39

The aim of dynamic analysis is to determine, in both the elastic and post-elastic range, the structural behaviour of buildings when subjected to the ground-acceleration time-histories of earthquakes which may be expected at the construction site. By means of such an analysis the stresses and deformations occuring in the structure for the design and maximum expected earthquake can be determined, as well as the acceptable level of damage which may occur to the structural and non-structural elements of the building in the case of the maximum expected earthquake.

Calculation of seismic resistance by means of the dynamic analysis method is obligatory for the following types of buildings:

1) All out-of-category buildings

2) Prototypes of prefabricated buildings or structures which are produced industrially in large series (except for wooden structures).

Article 40

The seismic parameters defining the action of earthquakes upon the buildings listed in Article 39 of this Code shall be determined according to the local site conditions.

The parameters mentioned in the first paragraph of this Article shall be determined on the basis of the return-period of earthquakes occuring at the site in question, taking into account the expected life-span of the building and its purpose. In this way the level of acceptable seismic risk shall be determined.

The seismic parameters shall be determined for both the design earthquake and the maximum expected earthquake at the construction site in question.

The seismic parameters shall be determined on the basis of the findings of existing theoretical and/or experimental studies, or by means of specially performed investigations.

Article 41

If the structural parameters of linear and non-linear behaviour of the buildings listed in Article 39 of this Code are not determined by means of specially performed theoretical or experimental studies, then it shall be assumed in the calculations:

1) That the maximum relative displacement of storeys for linear behaviour of the structure shall amount to not more than:

$$\frac{h_i}{350}$$

2) That the maximum relative displacement of storeys for the design level of earthquake, i.e. for a modest level of nonlinear deformation of the structure, shall amount to not more than:

$$\frac{h_i}{150}$$

where h_i is the height of the "i"-th storey in cm.

Article 42

The total horizontal seismic forces S obtained by means of the dynamic analysis method shall not be less than 75% of the force obtained by calculations using the equivalent static load method, and not less than 0.02G.

SECTION SEVEN: TESTING OF STRUCTURES

Article 43

The dynamic characteristics of buildings, constructed in zones of seismic intensity VIII and IX on the MCS scale, in the case of out-of-category buildings or prototypes of industrially-produced prefabricated buildings, shall be verifed experimentally.

Experimental evaluation of dynamic characteristic is performed over finished structure using forced vibrations which will cause no damage.

Article 44

The behaviour of structural elements of buildings for which calculations of seismic resistance by means of the dynamic analysis method are obligatory, and which are to be constructed in zones of seismic intensity VIII or IX on the MCS scale, shall be checked experimentally.

SECTION EIGHT: DESIGN OF EARTHQUAKE-RESISTANT STRUCTURES

Article 45

When choosing sites for the construction of buildings, unless special reasons exist, non-homogeneous, embanked or generally unstable ground shall be avoided.

Article 46

Suitable layout of the load-bearing structures of buildings shall be achieved by means of a regular and simple floor-plan arrangement, with a uniform distribution of masses.

If buildings are heavily loaded, then all masses shall be kept as low as possible above ground level.

Article 47

Aseismic joints shall be provided in the case of:

1) Building with irregular floor-plans,

2) Buildings or parts of buildings of unequal height.

'I'he minimum width of the aseismic joint shall be 3.0 cm. The width of the aseismic joint shall be increased by 1.0 cm for every increase of 3.0 metres of height above 5.0 metres.

In the case of buildings higher than 15.0 m, as well as in the case of flexible structures of lesser height, such as unbraced frames, the necessary width of the seismic joint shall be determined by calculation. This width shall not be less than the sum of the maximum deflections of adjacent parts of the building, nor shall it be less than the value following from the first paragraph of this Article.

Article 48

Floor structures shall be designed to form stiff horizontal diaphragms, which, monolithically jointed onto the vertical load-bearing system, can transfer compressive and tension loads onto the latter. Floor structures which do not fulfill this requirement shall be treated in the design procedure as flexible elements.

Article 49

The structural system of a building shall be chosen taking into account the following criteria:

1) The structural elements of the basic system shall be made out of strong and ductile material; lighter material shall be used for the non-structural elements.

2) The structural system, and its structural elements, must have sufficient strength and capacity for large deformations, and for the accumulation and dissipation of energy.

3) Abrupt changes in rigidity and strength over the height of the building are not, as a rule, permitted. If the structural system includes a flexible storey (or storeys), then the building must be analysed taking into account the requirements of Article 27 of this Code.

4) The stiffness of the structural system should be chosen in such a way that severe damage to the nonstructural elements of the building will not be caused by an earthquake loading;

5) Structural elements which could, in the case of imperfections during construction or minor damage of any kind, cause instability of the system or progressive failure, shall not be used for the construction of buildings.

Article 50

During strong seismic motion, structural elements must be able to perform adequately in the non-linear range. For this reason the following conditions must be fulfilled:

1) When designing the structural elements of buildings, the cross-sections and zones where non-linear deformations and plastic hinges may occur must be selected;

2) In zones of plastic hinges, a high capability for plastic deformations must be ensured, so that the structure's ductility and capacity for energy dissipation is increased;

3) The joints, anchorages and supports of structural elements in buildings must be designed so that they are able to transfer the ultimate static loads without being damaged.

Article 51

The foundations of buildings shall be designed in such a way that non-uniform settlements are avoided under design load conditions.

As a rule, the foundations must be built at the same depth. The foundations of individual parts of the building (strip and pad footings) shall be connected together by means of tie-beams in order to achieve adequate rigidity of the foundation structure.

Article 52

The founding of buildings on ground with varying characteristics should be avoided. If this is not possible, then structural joints must be provided in order to separate individual parts of the structure according to the different soil conditions.

Article 53

In the case of unfavourable ground conditions, the optimum design solution for the foundations shall be sought, taking into account especially the influence of groundwater on dynamic seismic effects (non-linear deformation of the soil or liquefaction).

When designing buildings for seismic loads, depending upon the kind of ground and type of foundations the deformation of the foundation structure and the latter's influence upon the whole upper structure of the building shall be verified.

SECTION NINE: REINFORCED-CONCRETE STRUCTURES (GENERAL)

Article 54

According to their basic structural systems, the following different types of reinforced-concrete structures can be distinguished:

1) Frame systems;

2) Shear-wall systems;

3) Frame systems with added shear walls or cores (dual systems).

Article 55

The structure of a building shall be chosen in accordance with the latter's function and purpose, plan layout, height, ard foundation conditions, taking into account the maximum .storey drift and total displacement of the building under seiemic load.

SECTION TEN: REINFORCED-CONCRETE FRAME STRUCTURES

Article 56

Frame systems, as the basic system of a structure, shall be designed in both directions of the building. As a rule, the stiffness of the beams should be less then the stiffness of the column. In this way the conditions for the occurrence of non-linear deformations at the ends of the beams will be created.

Article 57

Frame system shall be designed in a such way that the structural elements will be able to dissipate seismic energy throught bending and the occurence of the nonlinear deformation (plastic hinges) at the ends of the beams. Non-linear deformation in the columns should be avoided.

Article 58

The joints of the structural elements shall be designed so that remain in the linear region even after non-linear deformation have occured in the elements which are conncted together at the joint.

Article 59

At their supports, beams shall be reinforced with dual reinforcement, so that $\mu' \geq 0.5\ \mu$ Maintaining a favourable ratio between the percentage of tensile reinforcement (μ) and that of compressive reinforcement (μ') will increase the ductility of potential plastic hinges in the system.

Article 60

The spacing between transverse reinforcement bars (stirrups) in the beams shall not exceed 20 cm, whereas in the vicinity of joints, up to a distance of one-fifth of the beam span, the spacing of stirrups shall be reduced by half. The stirrups shall be closed by overlapping over the whole length of the shorter side.

Article 61

Columns shall be designed so that the condition $\sigma_0 / \beta_C \leq 0.35$ is always fulfilled, where $\sigma_0 = P / F$, P being the axial force in the column due to gravitational loads, and F. the cross-sectional area of the column. $\beta_C = 0.7 * \beta_{cube}$, where β_{cube} is the cube strength of the concrete in the column.

Article 62

The spacing between transverse reinforcement bars (stirrups) in columns shall not exceed 15 cm. In the vicinity of joints, the spacing of the stirrups shall be reduced by half, over a distance from the joint equal to the largest of the following values:

1) One-and-a-half times the larger dimension of the cross-section,

2) One-sixth of the height of the coiumn,

3) 50 cm;

The stirrups used in columns shall be closed by overlapping over the whole length of the shorter side of the column.

Article 63

In the case of buildings where the seismic resistance of the structural.system is to be calculated using a dynamic analysis procedure, the ultimative shear force in the plalstic hinges shall be cariried exclusively, by the transverse reinforcement.

Article 64

In the case of columns, transverse reinforcement shall be provided throught the joint areas, too.

Article 65

The splicing of reinforcement shall be carried out outside the zones of plastic hinges and in areas where the tensile stresses are the least. If reinforcement is to be spliced by means of overlapping, then no hooks shall be provided at the ends of the overlapping bars.

In the case of columns, reinforcing bars with diameter of over 20mm shall by spliced by welding. If, however the reinforcement consists of a larger number of bars which are not welded, then 50% of the column reinforcement can be spliced by means of overlapping in each of two succesive storeys.

Article 66

Frame systems shall be infilled with lightweight material. If the infill walls do not hinder the deformation of the basic structural system, which has to be proved by means of calculation and achieved by suitable structural measures, then they shall be anchored to the basic structural system (by means of reinforced-concrete connection joints and similar measures). Such anchoring of the infill panels must not result in an increase of rigidity or weight basic structural system.

In the case of flexible structural systcms i.c. systems which can withstand relative storey drifts greater then $h_i/300$ (where h_i is the height of the "i"-th storey in cm) under seismic load, the stability of infill panels and their potential degree of damage shall be proved on the basis of experimental data. The out-of-plane stability of the infill paneles shall also be verified in accordance with Article 35 of this Code.

SECTION ELEVEN: REINFORCED-CONCRETE SHEAR-WALL STRUCTURES

Article 67

Shear-wall structures shall be designed to have sufficient load-bearing capacity in both directions.

The horizontal cross-sectional area of the shear-walls in each of the two orthogonal directions, shall be not less than 1.5 % of the gross floor-plan area of the building.

Article 68

The ratio between the height and width of each individual shear-wall shall not be less then 2 cm. The thickness of the walls shall not be less than 15 cm.

The arrangement of all openings in walls shall be chosen in such a way that they reduce the seismic resistance of the walls to the smallest possible extent.

Article 69

Structural elements, diaphragms and connecting beams above openings shall be designed so that they can dissipate seismic energy by bending and the occurrence of non-linear deformations (the formation of plastic hinges).

Article 70

Shear walls shall be reinforced in the vertical direction using mild steel bars or a combination of welded mesh reinforcement and mild steel bars.

At both ends of the walls, the vertical reinforcement shall be grouped together over a distance equal to one-tenth of the length of the wall. The reinforcement ratio of these grouped bars, at each end of the wall, shall be not less than μ=0.15%, calculated with respect to the total cross-sectional area of the wall. The middle part of the wall shall be reinforced using welded mesh reinforcement with a reinforcement ratio of at least μ= 0.15% of the total cross-sectional area of the wall.

The total reinforcement ratio in the vertical direction shall not be less than 0.45% of the horizontal cross-sectional area of the wall.

In the case of walls whose height-to-width ratio does not satisfy the requirements of Article 68 of this code, and which are used in buildings no higher then 8 storeys, the minimum vertical and horizontal reinforcement ratio shall amount to 0.25% of the cross-sectional area of the wall and shall be spaced uniformly over this cross-section.

Without regard to the total height of the building, the walls of the top five storeys shall be reinforced with, at least, the minimum amount of vertical and horizontal reinforcement.

The reduction from a reinforcement ratio of 0.45% to a ratio of 0.25% shall be spread out over at least two successive storeys.

Article 71

The amount of horizontal reinforcement needed in walls shall be determined by calculation. It shall be assumed that the computed seismic shear force acting at the level under consideration and determined as prescribe by this Code, is to be carried by the horizontal reinforcement only, taking into account the stresses permited by this Code. The reinforcement ratio of the horizontal reinforcement shall amount to not less then μ=0.20% of the vertical cross-sectonal area of the wall.

Article 72

In the case of high buildings where the seismic resistance of the structural system is to be calculated using dynamic analysis method in accordance with this Code, the ultimative shear force in the plastic hinges shall be carried exclusively by the transverse reinforcement.

Article 73

Walls shall be designed so that the condition so that the condition $\sigma_0 / \beta_C \leq 0.20$ is fulfilled, where $\sigma_0 = P / F$, P being the axial force in the wall due to vertical loading, and F being the cross-sectional area of the wall. $\beta_C = 0.7 * \beta_{cube}$.

Article 74

Splicing of the vertical reinforcement shall be carried out as follows: the reinforcement in the middle part of the wall may be spliced by overlapping whereas the reinforcement at the both ends of the wall shall be welded, or else spliced by overlapping. In the latter case, 50% of the reinforcement shall be spliced in each of the two successive storeys.

Article 75

When designing shear-wall structures, the general stability of the structure against overturning must be verified. If it is found that the whole cross-sectional area of a wall or walls is in te-üsion, then the floor-plan layout of the, walls must be redesigned.

Article 76

The resistance of the foundations shall be designed for the ultimate states-of-stress in the shear-wall system, for the level just above the foundations. In this case a safety factor of 1.1 shall be applied when determining the state-of-stress in the soil beneath the foundations.

SECTION TWELVE:
FRAME SYSTEMS WITH ADDED SHEAR WALLS OR CORES

Article 77

The computed seismic forces applicable to frame structures with added shear walls or cores shall be distributed. according to their deformational characteristics, onto each element of the basic structural system.

The frames shall be designed to carry et least 25% of the total seismic shear.The added shear-walls or cores shall be designed to resist that portion of the shear load which follows from analysis according to the first paragraph of this Article.

SECTION THIRTEEN: PRESTRESSED CONCRETE STRUCTURES

Article 78

According to this Code, prestressed concrete structures are considered to be those structures where seismic effect are transmitted and the major part of seismic energy is dissipated throught prestressed concrete elements. If the structural elements contain apart from the prestressing tendons, mild-steel longitudinal reinforcement amounting toa ratio of at least 0.45%, then such structures shall be considered to be reinforced-concrete styructures. The stability of the structural system and its elements shall be proved analytically and experimentally.

Article 79

The elements of prestressed concrete structures shall be designed so that they can dissipate seismic energy by bending and non-linear deformations.

Article 80

Prestressed concrete structures shall, apart from the prestressing steel tendons, be longitudinally reinforced with mild steel bars having a reinforcement ratio of 0.20 %, in order to ensure sufficient dissipation of seismic energy.

At the critical cross-sections, where non-linear deformations can be expected, densely-spaced transverse reinforcement shall be provided. This reinforcement must be capable of carrying the entire ultimate shear load, corresponding to the ultimate bending-moment at the cross-section, increased by a factor of 1.1.

Article 81

The joint areas, where the elements are connected together, shall be designed as follows:

1) So that the ultimate load-carrying capacity of the centre of the joint area is greater than or at least equal to the ultimate strength of the elements which are connected together in the joint;

2) So that they are ductile, thus ensuring their deformability;

3) So that they are reinforced with transverse reinforcement which is capable of carrying, by itself, the ultimative shear force.

Article 82

The prestressing tendons shall be anchored outside the expected plastic-hinge zones.

Article 83

The deformation of such, structures shall be limited with respect to the function of the buildina and the influence of deformations on the non-structural elements of the building.

SECTION FOURTEEN: STEEL STRUCTURES

Article 84

Steel structures shall be designed in such a way that their structural elements are capable of dissipating seismic energy by bending and non-linear deformations. In the case of frame systems, non-linear defnrmations are permitted at the ends of beams or in the diagonal bracing elements.

Article 85

Local plastic buckling is not permitted in plastic-hinge zones. The joints between elements shall be designed so that they are capable of transmitting the ultimate bending-moments and the correspoding shear forces from one element to another without of the occurence of larger non-linear deformations in the joint zone.

SECTION FIFTEEN: PREPABRICATED STRUCTURES

Article 86

In the case of prefabricated reinforced-concrete prestressed structures, as well as that of other kinds of prefabricated structures, the stability of the structural system and of the system of connections shall be proved by experimental and analytical studies.

Article 87

The structural system, as well as the system of connections, must be simple and clear. The system of connections for the prefabricated elements must ensure monolitic perfomance of the system.

The reinforcement which carries the tensile strcssscs duc to bending shall be spliced in such a way tat the transfer of loads in the reinforcement up to the yield point is ensured.

Article 88

The floor structures of prefabricated structures shall be designed as rigid slabs in their own plane.

The horizontal tie-beams, which connect together the floor structures, as well as the vertical load-bearing elements, shall be constructed in such a way that the monolithic operation of the joints, as well as the stability of the whole system, is ensured.

SECTION SIXTEEN: MASONRY STRUCTURES

Article 89

The basic structural system of masonry buildings consists of load-bearing walls placed in both orthogonal directions of the building and connected together at the level of the rigid floor by horizontal tie-beams.

Accordng to this Code, masonry structures are considered in the following categories:

1) Ordinary, plain-masonry structures,

2) Masonry structures with vertical, reinforced-concrete tie-beams,

3) Reinforced-masonry structures with reinforcement placed in the horizontal mortar joints, with reinforcement in the middle of the wall and with reinforcement on the outer faces of the wall.

Article 90

According to this Code, ordinary masonry structures are considered to be those masonry buildings whose walls are constructed of bricks, burnt-clay blocks or other materials, bound together by cement-lime-sand mortar of grade strength at least M 25 (2.5 MPa)

Article 91

According to this Code, masonry structures with vertical tie-beams are considered to be those masonry buildings whose walls are strengthened by means of vertical tie-beams in accordance with Articles 98, 100 and 101 of this Code.

Article 92

According to this Code, reinforced-masonry structures are considered to be those buildings whose walls are built using cement-lime-sand mortar of grade strength M 50 (5.0 MPa), and are reinforced with reinforcement in both the horizontal and vertical direction.

Article 93

The reinforcing of masonry structures in the mortar joints is effected by means of horizontal reinforcing bars, thc amount of reinforcement, being equal to at least two 6 mm diameter bars for each 20 cm of height of the wall.

The reinforcing of masonry walls in the middle of the wall or at the sides of the wall is effected by means of vertical and horizontal reinforceinent having a ratio of $\mu > 0.1\%$ calculated with respect to the total horizontal cross-section of the wall, whereas at the ends of the wall, up to a distance equal to one-tenth of the length of the wall, vertical reinforcing bars having a ratio of $\mu > 0.1\%$ with respect to the total horizontal cross-sectional area of the wall shall be grouped. The total cross-sectional area of the vertical reinforcement shall thus amount to not less than 0.3% of the total horizontal cross-sectional area of the wall. At the same time, the total cross-sectional area of the horizontal reinforcement shall amount to not less then 0.1% of the same area.

Article 94

Masonry structures shall be designed to have a simple and regular floor-plan layout. The load-bearing and connecting walls shall be distributed as uniformly as possible in both directions of the building.

Only the walls with a thickness of d ≥ 19 cm shall be considered as load-bearing and connecting walls.

Combined, simultaneous use of vertical load-bearing elements made of concrete and masonry walls on the same storey is not permited.

Aplying the mixed structural systems, i.e., the down part as reinforced concrete frame structure and the upper part as system with load-bearing walls, are not prmited.

Article 95

The floor structures have to be rigid in their plane. They shall be constructed as cast in place reinforced-concrete slabs or as prefabricateds ceiling with a compressed slab with thickness of at least 4 cm and reinforced with a minimum 6 mm diameter bars at a span off 25 cm in both orthogonal directions.

The floor structures have to be connected with all the load-bearing walls.

Article 96

The greatest distance between the load-bearing walls in one direction for the particular width of the load-bearing walls in the other has to be less than:

- 5.0 m for the width of 19 cm
- 6.0 m for the width of 24 cm
- 6.5 m for the width of 29 cm
- 7.5 m for the width of 38 cm

Article 97

The vertical tie-beams are constructed after building of the wall with dentils. Cross-section of the vertical tie-beams has to be equal to the width of the wall, but not less than 19/19 cm.

The vertical tie-beams have to be placed at all the corners of the structure, at places of crossing of the load-bearing walls, as well as at the free ends of the walls with width d ≥ 19 cm.

The distance between the vertical tie-beams at the walls with larger length, shall not exceeded 5.0 m.

Article 98

Horizontal tie-beams shall be constructed, without exception, on all walls of thickness d ≥ 19 cm.

The width of the horizontal tie-beams must be equal to the thickness of the walls (exceptionally, if thermoinsulation has to be provided, the width of the tie-beams may be 5 cm less). The height of the tie-beams shall be at least 20 cm, but may not be less than the thickness of the floor structure.

Article 99

Vertical tie-beams shall be reinforced with a minimum reinforcement of 4 bars of diameter 14 mm, whereas horizontal tie-beams shall be reinforced with at least 4 bars of diameter 12 mm.

Article 100

The amount of reinforcement needed in the tie-beams shall be determined by calculation. Calculations in which the wall panel is replaced by an equivalent diagonal member are allowed.

Article 101

The thickness of window piers (interfenestrations) shall be not less than two-thirds of the width of the opening in the case of seismic zones of intensity VIII or IX on the MCS Scale, and not less than one-third of the width of the opening in the case of seismic zones of intensity VII.

Article 102

The maximum permitted width of openings shall be 2.50 m in seizmic zones of intensity VIII and IX, and 3.50 m in zones of intensity VII. These widths may be increased by up to 30% if the opening is surrounded by reinforced-concrete elements which are firmly connected to the horizontal tie-beams at the level of the floor structures.

Article 103

Gable walls and parapet walls, which extend more than 50 cm above the highest floor structure, shall be connected to the load-bearing structure by means of vertical and horizontal tie-beams, anchored to the load-bearing structure.

Article 104

Free-standing chimneys shall be designed as primary masonry structures.

Chimneys which pass through the roof of a building must be kept separate from the roof structure by means of suitable aseismic joints.

Article 105

The construction of cantilevered staircases, the steps of which are fixed directly into the walls, is not allowed.

Article 106

Cantilevered structures, fixed into the walls, are not allowed, unless it is possible to provide a suitable connection for them with the floor structures.

Article 107

The seismic resistance of masonry buildings shall be verified either by the permissible stress method or by the limit-state method. The shear strength of the walls must, in all cases, be calculated. In the case of buildings whose overall height-to-width ratio amounts to more than 1.5,. the flexural resistance of the walls, too, shall be checked. In this case the permissible stresses for the vertical loading of walls according to the Technical Regulations for the Construction of Masonry Walls may be increased by 50 w.

Article 108

If the seismic resistance of masonry buildings is to be estimated on the basis of the method of permissible stresses, then the principal tensile stresses in the individual elements (walls) shall be checked. For different types of masonry walls, the principal tensile stress shall not exceed the values given in Table 4.

Table 4.

Type of wall	$\sigma_{n\text{-perm.}}$ (kPa)
Solid brick (6 x 12 x 24 cm) MO 100, MM 25	90
Perforated brick (6 x 12 x 24 cm) MO 150, MM25	110
Modular brick block (29 x 19 x 19 cm) MO 150, MM5	60
Modular brick block (29 x 19 x 19 cm) MO 150, MM 50	90
Lightweight concrete block (39 x 19 x 19 cm) MO 75, MM 50	30

In Table 4 $\sigma_{n\text{-perm}}$ is the permissible principal tensile stress corresponding to the different types of wall.

The principal tensile stresses in the individual elements (walls) shall be calculated from the expression:

$$\sigma = \sqrt{\left(\frac{\sigma_0^2}{4} + (1.5\tau_0)^2\right)} - \frac{\sigma_0}{2} \leq \sigma_{n-\text{perm}}.$$

where:

- τ_0 is the average shear stress in the wall element due to the seismic load which the wall is carrying, and
- σ_0 is the average normal stress in the wall element due to vertical loading.

Article 109

If the seismic resistance of masonry buildings is to be estimated bv means of the limit-state method, then the resistance of the building shall be compared with the total horizontal seismic force defined in Article 21 of this Code, taking into account a safety-factor of at least 1.5

The ultimate average shear stress in individual wall elements shall be calculated from the expression:

$$\tau_{0-ult} = \frac{\sigma_{n-ult}}{1.5} + \sqrt{1 + \frac{\sigma_0}{\sigma_{n-ult}}}$$

where:

- σ_{n-ult} is the principal tensile stress in the wall at the ultimate load, values of which are given for different types of masonry walls in Table 5.

Table 5.

Type of wall	σ_{n-ult} (kPa)
Solid brick (6 x 12 x 24 cm) MO 100, MM 25	180
Perforated brick (6 x 12 x 24 cm) MO 150, MM25	220
Modular brick block (29 x 19 x 19 cm) MO 150, MM5	120
Modular brick block (29 x 19 x 19 cm) MO 150, MM 50	180
Lightweight concrete block (39 x 19 x 19 cm) MO 75, MM 50	270

Article 110

If walls are to be built of materials (blocks, mortar) for which values of the permissible and ultimate principal tensile stresses are not given in Tables 4 and 5, then these values shall be determined from the results of experimental investigations.

Article 111

The maximum number of storeys permitted for individual masonry construction systems is given in Table 6:

Table 6.

Structural system	Zone seismicity on the MCS scale		
	VII	VIII	IX
Ordinary masonry	P+2	P+1	
Masonry with vertical tie-beams	P+4	P+3	P+2
Reinforced masonry	P+7	P+7	P+7

(P = ground-floor)

Article 112

If the seismic resistance of masonry buildings is not verified by calculation, such buildings shall be constructed in accordance with the provisions of this Code. However, in this case the maximum number of storeys permitted shall be limited, without regard to the structural system used, to the following:

- P + 1, in the case of seismic zones of intensity VIII, and
- P + 2, in the case of seismic zones of intensity VII.

Article 113

For the construction of masonry buildings in seismic zones, only the use of cement-lime-sand mortar is permitted.

In the seismic zones of intensity VII and VIII mortar with a grade strength of at least MM 25 shall be used.

In seismic zones of intensity IX mortar with a grade strength of MM 50 shall be used.

For the construction of reinforced masonry structures in all seismic zones mortar with a grade strength of MM 50 shall be used.

The use of pure cement-sand mortar, without added lime, is not allowed.

Article 114

Mortar shall be prepared on the basis of mix ratios known in advance. The individual mortar components shall be added by weight, and the mortar shall be mixed in a powered mixer.

Article 115

The quaiity of materials used in masonry structures shall be checked according to the statistically-based methods described in the Code of Technical Measures and Provisions for Concrete and Reinforced Concrete.

SECTION SIXTEEN A:
ADAPTATION AND RECONSTRUCTION OF THE EXISTING STRUCTURES

Article 115 a

Seismic resistance of the existing structures after their adaptation and reconstruction has to be the following:

1) Seismic resistance of the stuctures in which the process of adaptation and reconstruction does not cause essential changes, has to be the same as it was before performing the measures;

2) Seismic resistance of the structures in which the process of adaptation and reconstruction causes essenial changes, has to be in accordance with this Code.

Essential changes, in accordance with this Code, shall be considered as: i) errection of one or more storeys, ii) construction of an anex with an area greater than 10% of the area of the existing structure, iii) reconstruction and adaptation of the structure by which the existing area has to be diminshed for 10% and the existing mass of the structure has to be enlarged for more than 10%.

SECTION SEVENTEEN: FINAL PROVISIONS

Article 116

On the day upon which this Code comes into force, the provisions of the Code of Temporary Technical Regulations for Construction in Seismic Regions (Official Gazette of S.F.R.Yugoslavia, No. 39/64) which refer to buildings shall no longer be effective.

Article 117

This Code shall come into force one year after the day upon which it is published in the Official Gazette of Republic of Macedonia.

Editorial Notes According to the information provided by the National Delegate, they are working now on the new codes, based on the concept of the Eurocode 8. The new codes will come into effect in two to three year period from now.