1 GENERAL REQUIREMENTS

1.1 Application

1.1.1
This Code provides measures for protection of building structures against structural damage, which might cause loses of human life, collapse of structures and interruption of the activities of economic and public organizations of vital importance for the national economy.

1.1.2
This Code provides design requirements as well as different recommendations for building structures that will be constructed mainly in the areas with seismic intensity over VI (MKS- 64). For building structures located in areas with intensity VI, only constructive measurements are required. Calculation of structures against seismic action is given based on the seismic parameters of the construction sites with intensity from VI 1/2 to IX.

1.2 Seismic intensity of construction sites

1.2.1
The seismic intensity of construction sites, which are not included in a microzoning area, is taken directly from the Map of Seismic Regionalization of Albania (Fig. 1).

1.2.2
The seismic intensity of construction sites which are included in a microzoning area is taken from the respective maps of the seismic microzoning.

1.3 Criteria selection of construction sites

1.3.1
In seismic regions the site soil conditions are classified into three categories: I, II and III, which shall be determined based on the:

1. Seismic microzoning studies (in case when those are available).
2. Table 1, based on respective engineering geological studies.

Table 1

Soil category	Description of soils
I	- All kinds of rock (excluding weathered rock) - Compact gravel - Marl (not weathered)
II	- Weathered rocks and marls - Gravel sands, coarse and medium grained sands compact and semi compact - Fine grained sand - compact - Clayey sand and sandy clay - stiff, semi - stiff and stiff - plastic - Stiff plastic clay
III	- Fine grained sand - semi compact - Dusty sand compact and semi compact - Clayey sand and sandy clay fro medium stiff to soft plastic - Clay from medium stiff to soft plastic

1.3.2
The selection of a construction site in seismic regions should comply with the following:

1. The site soil conditions classified in soil category I, II and having the water table deeper than 5m are considered as the most favorable for construction.
2. The following site soil conditions are unfavorable for construction in seismic regions:
   - sandy soil with liquefaction potential, loose sand, unconsolidated alluvial deposits;
   - steep slopes with a gradient of more than 1:3;
   - sites with extensive karst development, rockfalls potential or with mine galleries;
3. Unsuitable for construction in seismic zones are:
   - sites with passive and active landslide;
   - sites located on or in the neighbourhood of active faults.

1.4 Requirements and recommendations for urban planning, architectural and constructive design

1.4.1

For the construction sites, whose microzoning studies are available, urban planning should be based on those studies. For other cases it should be based on engineering geological studies.

1.4.2

The urban planning and architectural design of structures in seismic regions should aim at avoiding the consequences which might be caused in lifeline system facilities as a result of the damage of particular structures.

1.4.3

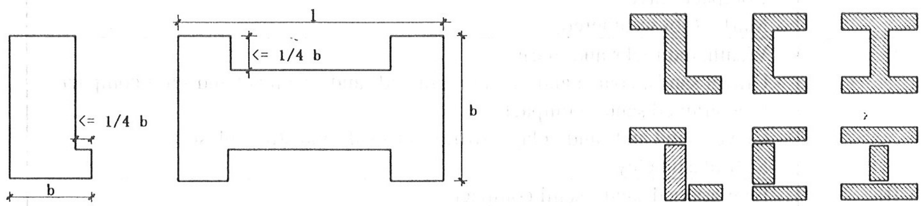
Buildings and structures in seismic regions are recommended to be designed mainly with a symmetric configuration and with mass and stiffness uniformly distributed in plan and height.

Note:

1. Mass and stiffness distribution in height is considered as relatively uniform when the respective difference from one level (story) to the other is not larger than 50 per cent.
2. Buildings are considered with "regular" shape in plan when they fulfill the requirements shown in Fig. 2-a.
3. When the difference in height of the adjacent sections within the same building is less then 5.0m the building is considered to be as "regular" in height.
4. The eccentricity between the center of mass and the center of rigidity at a floor, measured perpendicular to the direction of seismic action, is considered to be not excessive when it is less than 15 per cent of the structure dimension in that direction.

1.4.4

Buildings with a complex irregular shape as well as buildings with different structural systems and different story numbers should be separated by means of seismic joints (Fig. 2-b).



a) b)

Fig. 2

1.4.5

Seismic joints are also necessary in case of long-in-plan structures, even when they have a regular structural shape.

2.2.2

In case of regular structures, x and y axes are selected according to the longitudinal and transverse axis of the structures. For other cases, the axes should be chosen according to the most dangerous direction of the given structure.

2.2.3

As design value of a whatever factor Seq (bending moment, shear force, displacement etc.), caused by a considered seismic action in any structural element, the greatest value resulting from the following combination is accepted:

$$\begin{aligned} Seq &= Seq,x + \lambda Seq,y + \lambda Seq,z \\ Seq &= \lambda Seq,x + Seq,y + \lambda Seq,z \\ Seq &= \lambda Seq,x + \lambda Seq,y + Seq,z \end{aligned} \quad (1)$$

where :

Seq,x - factor-value resulting from the calculation of the given construction subjected to the horizontal seismic excitation, acting in the x-direction;

Seq,y - factor-value resulting from the calculation of the given construction subjected to the horizontal seismic excitation, acting in the y-direction;

Seq,z - factor-value resulting from the calculation of the given construction subjected to the vertical seismic excitation, acting in the z-direction;

λ - coefficient of combination : 0- for regular structures; 0.3- for other cases.

2.2.4

The vertical component of the seismic excitation shall be considered only in the design of:

1. Horizontal and inclined cantilever structures.
2. Frames, arches, trusses, spatial roof structures the span of which is greater than 20 m.
3. Superstructures of bridges spanning more than 18.0 m.
4. Building and structures calculated for overturning and sliding.
5. Brick and stone mansory structures.

2.3 Load combinations

2.3.1

The seismic inertia forces are considered as specific loads. The load combination which includes seismic forces is classified as specific combination.

2.3.2

In case of specific combination of loads, the combination coefficient for seismic internal forces and moments is equal to 1.0. For other loads the combination coefficients are given in Table 3.

Table 3

Type of load	Combination coefficient
Dead load	0.9
Long-term live loads	0.8
Short-term live loads	0.4

2.3.3

In the seismic design of structures the following loads shall not be considered:

1.4.6
For reducing the weight of structures, the usage of light construction materials is recommended. Especially, the exterior and interior heavy decoration materials should be avoided as much as possible. It is also recommended that the heavy live loads to be located at the lower floors.

1.4.7
Direct transmission of vertical and horizontal loads to the foundation shall be provided.

1.4.8
Structural components shall be designed for development of plastic deformation without loss of seismic structural stability, and space resistance of structures should be provided, as well.

1.4.9
For the prefabricated structures it is recommended that, whenever possible the connection of prefabricated elements shall be placed outside the zones of maximum stresses.

2 DESIGN LOADS

2.1 Seismic excitation

2.1.1
Seismic excitation can have any direction in space. It is represented by three orthogonal components, two horizontal components and one vertical.

2.1.2
The intensity of seismic excitation of a construction site is given by the seismicity coefficient k_E, which represents the ratio of the ground acceleration to gravity acceleration, g. For each component of the seismic motion, the values of k_E coefficient, differentiated according to the seismic intensity and the category of soil, are given in Table 2.

Table 2

Category of Soil	Seismic intensity (MSK-64)		
	VII	VIII	IX
I	0.08	0.16	0.27
II	0.11	0.22	0.36
III	0.14	0.26	0.42

2.2 Combination of seismic excitations.

2.2.1
Generally, the calculation of structures subjected to seismic exaction are carried out taking into consideration three orthogonal components of seismic action x, y (horizontal) and z (vertical). These directions are determined according to the geometric and structural characteristics of the structure.

1. Wind loads (except for the cases that are described in the note below).
2. Temperature and climate effects.
3. Dynamic loads caused by machines and equipment.
4. Lateral and break forces due to crane movements.
5. Horizontal loads on elastic suspensions.
6. Settlements of foundations.

Note: For mats, towers, chimneys, other similar structures and buildings (with more than 12 stories and with fundamental period larger than 1.2 sec) 25 per cent of the internal forces and moments due to wind loads are added to those due to seismic loads.

2.3.4
For industrial buildings, the following requirements shall be considered :

1. The vertical seismic forces for overhead cranes should be determined considering both the weight of the crane and the crab (with combination coefficient 0.8) and the weight of live load (lifting capacity) multiplied which a coefficient equal to 0.3.
2. The horizontal seismic forces in one or multyspan industrial buildings is done considering the crane weights supposing them placed on the same transversal axis of the building and choosing, for each span, the heaviest crane. In case when cranes have rigid suspensions, the loading capacity of the crane with greatest loading capacity is taken into consideration, too.
3. For longitudinal seismic forces only the crane cab weight is considered.

2.4 Analytical procedures

2.4.1
Calculations of structures against seismic action can be carried out:

1. Based on modal analysis using design response spectrum method.
2. Based on dynamic response analysis (integrating the equation of motion). The design accelerograms should be selected based on the seismological studies of the site construction and its geotechnic and geomorphologic features; meanwhile the peak acceleration must be not less than $k_E \cdot g$ where k_E is seismic coefficient of the site.

2.4.2
Calculation based on modal analysis using design response spectrum method shall be carried out for all the building structures.

2.4.3
Dynamic response analyses can be carried out for calculation of very important structures. However , in any case, the considered factors (bending moments, shear forces, displacement etc.), resulting from such a dynamic analysis are taken into consideration only when they are not less than 70 per cent of the values determined using spectral acceleration method.

2.5 Mathematical models

2.5.1
A mathematical model of a real structure shall represent "the geometry" as well as the stiffness and mass distribution in plan and elevation of the structure.
The simplified models are conceived lumping the mass at determined levels (points) which make the structures to be treated as systems with reduced number of degrees of freedom. Usually, for regular structures, in conformity to the direction of the considered seismic action, only one degree of freedom is given to each lump mass.

An appropriate model for the seismic calculation of irregular structures may be conceived associating three degrees of freedom with each of the mass located at different levels (floors) of the structure: two horizontal displacement and one rotation in the plane of the floor.

2.6 Design seismic loads.

2.6.1

The seismic calculation of the structures is carried out based on the modal analysis, using the design response spectrum method. In case of horizontal seismic excitation, the design values of the spectral acceleration, are taken from the expression:

$$S_a = k_E \cdot k_r \cdot \psi \cdot \beta \cdot g \qquad (2)$$

where:

k_E - seismicity coefficient (see Table 2);

k_r - building importance coefficient (see Table 5);

ψ - structural coefficient (see Table 4);

β - dynamic coefficient, the value of which are dependent on the free vibration period;

g - gravity acceleration.

2.6.2

In case of vertical seismic excitation, the design values of spectral acceleration, are taken multiplying S_a - values of formula (2) by the coefficient 2/3.

2.6.3

When the calculation scheme of the structure, subjected to a horizontal seismic excitation, is accepted as a simple vertical cantilever with lumped masses (Fig. 3-a), the horizontal seismic force E_{ki}, acting at the point (floor) "k" and corresponding to the "i"-th mode of vibrations, is obtained from the formula:

$$E_{ki} = k_E \cdot k_r \cdot \psi \cdot \beta_i \cdot \eta_{ki} \cdot Q_k \qquad (3)$$

where:

β_i - dynamic coefficient (see 2.6.4) corresponding to the "i"-th mode of vibrations;

η_{ki} - seismic load distribution coefficient, corresponding to level "k" and mode "i"; it shall be determined according with 2.6.5 or 2.6.6;

Q_k - the weight of the lumped mass at point (level) "k" which is determined considering the design loads (dead and lives one), reduced by combination coefficients given in Table 3 and according to the requirements of 2.3.4.

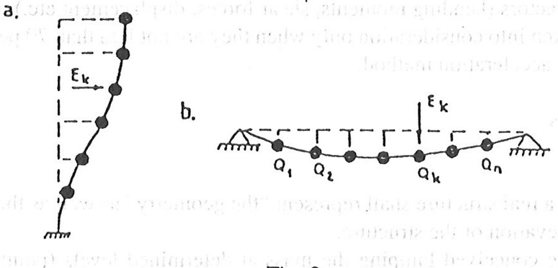


Fig. 3

When the calculation scheme of the structure, subjected to a vertical seismic excitation, is accepted as a simple beam with lumped masses (Fig. 3-b), the vertical seismic force, acting at the point "k" and corresponding to the "i"-th mode of vibrations, is also obtained from formula (3), provided that the value of coefficient β_i should be multiplied by 2/3; the other coefficients are the same as described previously.

2.6.4

The dynamic coefficient shall be determined by formulas (4), (5) and (6) or from the graphs shown in Fig. 4, as a function of both the natural period T_i and the soil category of the construction site.

- for soil category I

$$0.65 \leq \beta_i = \frac{0.7}{T_i} \leq 2.3 \tag{4}$$

- for soil category II

$$0.65 \leq \beta_i = \frac{0.8}{T_i} \leq 2.0 \tag{5}$$

- for soil category III

$$0.65 \leq \beta_i = \frac{1.1}{T_i} \leq 1.7 \tag{6}$$

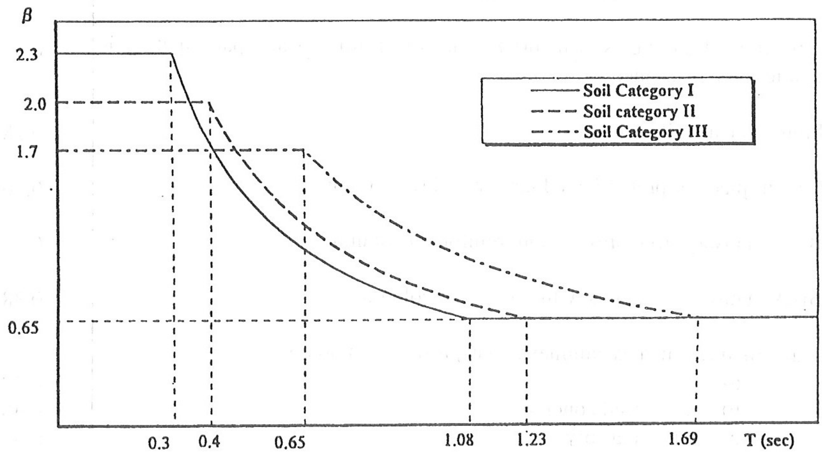


Fig. 4

2.6.5

The coefficient η_{ki} shall be determined by the following formula:

$$\eta_{ki} = \phi_{ki} \frac{\sum_{j=1}^{n} Q_j \cdot \phi_{ji}}{\sum_{j=1}^{n} Q_j \cdot \phi_{ji}^2} \tag{7}$$

where:

ϕ_{ki}, ϕ_{ji} - the modal displacement amplitude of the "i"-th mode of vibration at point "k" or "j" of the structure;

Q_j - the weight of the lumped mass at point "j";

n - number of the degrees of freedom.

Table 4

Nr	Type of structural system	Structural coefficient ψ
1.	Steel framed	0.20
2.	RC structures with brick mansory infilling walls not participating in seismic force resistance	
	a) $\frac{h}{b} \leq 15$	0.25
	b) $\frac{h}{b} \leq 25$	0.38
	c) $15 < \frac{h}{b} < 25$	by interpolation
	where: h- column height; b - the dimension of the cross section of column, parallel to the direction of seismic force.	
3.	RC framed structures with brick mansory infilling walls participating in seismic force resistance	0.30
4.	Frame-shear wall structures	0.28
5.	Cast-in-place or prefabricated large panel RC structures.	0.30
6.	Brick mansory structures without reinforced columns.	0.45
7	Brick mansory structures with reinforced columns.	0.38
8.	Tall structures such as chimneys, mats, towers and others	
	a) steel	0.30
	b) reinforced concrete	0.40
	c) brick mansory	0.45
9.	Silos, bunkers, tanks and other similar structures	
	a) steel	0.20
	b) reinforced concrete	0.25
10.	Bridges and other types of transportation structures	
	a) with reinforce concrete understructure	0.20
	b) with partially or completely concrete understructure	0.28
11.	Retaining walls:	
	a) reinforced concrete	0.25
	b) concrete and stone	0.28
12.	Underground structures	0.25
13.	Hydrotechnical structures:	

	a) earth fill dams and rock fill dams b) concrete and reinforce concrete	0.25 0.35
14.	Other types of hydrotechnical structures	0.35

Table 5

Category	Description of building and structures	Importance coefficient k_r
I	Buildings and Structures of Extraordinary Importance	
	a) Buildings and structures where small damage may cause catastrophic damage like: poisoning of the population, fire explosions, explosions, etc.	4
	b) Buildings and structures of a very big economic or strategic importance.	1.75
	c) Buildings and structures where the interruption of the technological process is not allowed.	1.5
II	Buildings and Structures of Special Importance	
	a)Buildings and structures which have a special importance for post earthquake recovery, like: telecommunication network, fire stations, big hospitals, big flour factories etc.	1.5
	b) Buildings and structures whose damage may cause big causalities, like: schools, nursery schools, kindergarten, cinema, stadiums, hotels, and other objects like these where there are big concentration of peoples.	1.3
	c) Buildings and structures whose damage may cause serious losses for the economy.	1.2
	d) Buildings and structures of special cultural and monumental value.	1.2
III	Buildings and Structures of Ordinary Importance Buildings and structures that are not included in other categories, like: residential buildings, different institutions, like: museums, libraries, hotels, schools, cinemas, etc., different factories and plants, big warehouses, engineering structures like: retaining walls, water towers and others.	1.0
IV	Buildings and Structures of Secondary Importance Buildings and structures whose damage does not cause big losses of human life or interruption of technological process.	0.5
V	Temporary Buildings and Structures Buildings and structures whose collapse do not risk the peoples life.	No calculation is needed

2.6.6

For buildings up to 5 stories, whose mass and stiffness distribution is relatively uniform in height and the fundamental period of free vibrations T_1 does not exceed 0.4 sec, the coefficient η_k can be determined by the following formula:

$$\eta_k = h_k \frac{\sum_{j=1}^{n} Q_j \cdot h_j}{\sum_{j=1}^{n} Q_j \cdot h_j^2} \qquad (8)$$

where:

h_k, h_j - the height above the foundation to the point (level) "k" or "j"

Also, for residential buildings, whose stories' height are almost the same and fundamental period T_1 is less than 0.4 sec , the coefficient η_k can be estimated by the following:

$$\eta_k = \frac{3k}{2n+1} \qquad (9)$$

where:

k - respective level (story).
n - number of stories.

2.6.7

Free vibration periods and free vibration mode shapes of the structures are determined using dynamics analyses procedures based on elastic deformations. For an approximate evaluation of the fundamental period of free vibration, empirical formulae given in Table 6. can be used.

2.7 Combination of modal effects

2.7.1

The combination of the modal effects corresponding to different modes of natural vibrations, is done only in case when the first period of natural vibrations T_1 is greater than 0.8 sec.

For regular structures (see 1.4.3) the combination of modal effects should be done for three or more modes of vibrations, which are the most excited modes for the given seismic action. In case of irregular structures four or more modes of vibrations are combined.

When the fundamental period of free vibration is less than 0.8sec, the combination of modal factors is not needed to be done. In this case, the modal factors (bending moments, shear forces, displacements etc.), corresponding to the most excited mode of vibration are taken as the design value of factors.

2.7.2

When the periods of the modes of vibration chosen for the combination differ from each other more than 10% the combination of modal factors is carried out according to the following formula:

$$S = \sqrt{\sum S_i^2} \qquad (10)$$

where:

S - design value of the factor;
S_i - value of the factor corresponding ti the"i"-th mode of free vibration.

2.7.3

If among the modes chosen for combination there is evidence of closely spaced modes than the combination of modal effects shall be carried out according to the following steps:

1. Absolute values of modal factors of closely spaced modes are first summed up in a single value;
2. Modal factors corresponding to the other modes chosen for combination are then combined with the above resulted single modal factor, by making use of formula 10.

Modes shall be considered to be closely spaced if their periods differ between them in less then 10%.

Table 6

	Type of structure	Period of vibration (sec)
1.	Building with bearing mansory walls a) longitudinal direction b) transverse direction	 $T_1 = 0.045 \cdot n$ $T_1 = 0.040 \cdot n$
2.	RC panel structures	$T_1 = \frac{n}{20}$
3.	RC framed structures with brick mansory infilling walls participating in seismic force resistance.	$T_1 = \frac{0.09 \cdot h}{\sqrt{b}}$
4.	Chimneys a) reinforced concrete (h < 120 m) b) brick mansory (h < 60 m)	 $T_1 = 0.45 + 0.0011 \frac{h^2}{d_m}$ $T_1 = 0.26 + 0.0024 \frac{h^2}{d_m}$

Note : The following notations apply to the above approximate formulas:

n - number of stories;
h - height of structure (metres);
b - dimension of building in the direction parallel to the applied forces (metres);
d_m - diameter of the chimney at the half of the height (metres).

2.8 Torsional effects

2.8.1

Torsional effect is taken into consideration when the structures have structural irregularities (see 1.4.3)

2.8.2

Torsion is considered by the effect on the structure of the torsional moments resulting from the eccentricity of the horizontal forces relative to the center of rigidity.

2.9 Seismic load in nonstructural elements

2.9.1

For nonstructural elements, anchors (such as balconies, canopies, interior partitions, parapets, gables, chimneys, anchors etc.) and other joints tying together individual structural elements the design seismic forces are determined by the following formula:

$$E_e = k_E \cdot k_r \cdot k_e \cdot Q_e \qquad (11)$$

where:

k_E - seismicity coefficient (Table 2).

k_r - building importance coefficient (Table 5).

k_e - coefficient depending on the type of the element or joint; its values are taken from Table 7.

Q_e - weight of the element.

2.9.2

Seismic forces calculated according to the formula (11) are not added to those resulting from main structural calculations.

Table 7

Nr	Type of element or joint	Coefficient k_e	Direction of the action of seismic force E_e
1.	Horizontal and inclined cantilever elements like: balconies, canopies, etc.	1.5	Vertical or horizontal
2.	Elements rising above buildings like: parapets, pediments, chimneys, etc.	1.5	Horizontal
3.	Walls and interior partition walls (non-bearing) on a framed structure.	0.6	Perpendicular to the element's surface
4.	Anchorage of nonstructural elements (machinery, technological equipment, etc.) to the structure, as well as different joints tying together individual structural elements.	1.6	Any direction.

2.10 Structural displacement due to seismic loads

2.10.1

When the calculation of seismic forces is done according to 2.6.3, the elastic displacement of the "i"-th mode of vibration at point "k" of the structure, can be evaluated as follow:

$$U_{ki}^{el} = k_E \cdot k_r \cdot \psi \cdot \beta_i \cdot \eta_{ki} \cdot g \cdot \left(\frac{T_i}{2\pi}\right)^2 \qquad (12)$$

For other calculation schemes, calculation of U_{ki}^{el} should be done according to the seismic loads corresponding to that scheme of calculation. Elastic design displacement is taken from the combination of different mode effects.

2.10.2

Total maximum displacement of a level "k" of a structure due to seismic action, considering the plastic deformations, can be approximately determined by using the following formula:

$$U_k = \frac{U_k^{el}}{\psi} \tag{13}$$

where:

U_k^{el} - elastic displacement of “k” level.

ψ - structural coefficient (Table 4).

2.10.3

For different type of structures, the maximum displacement (determined according to 2.10.2) is limited on the basis of their respective.

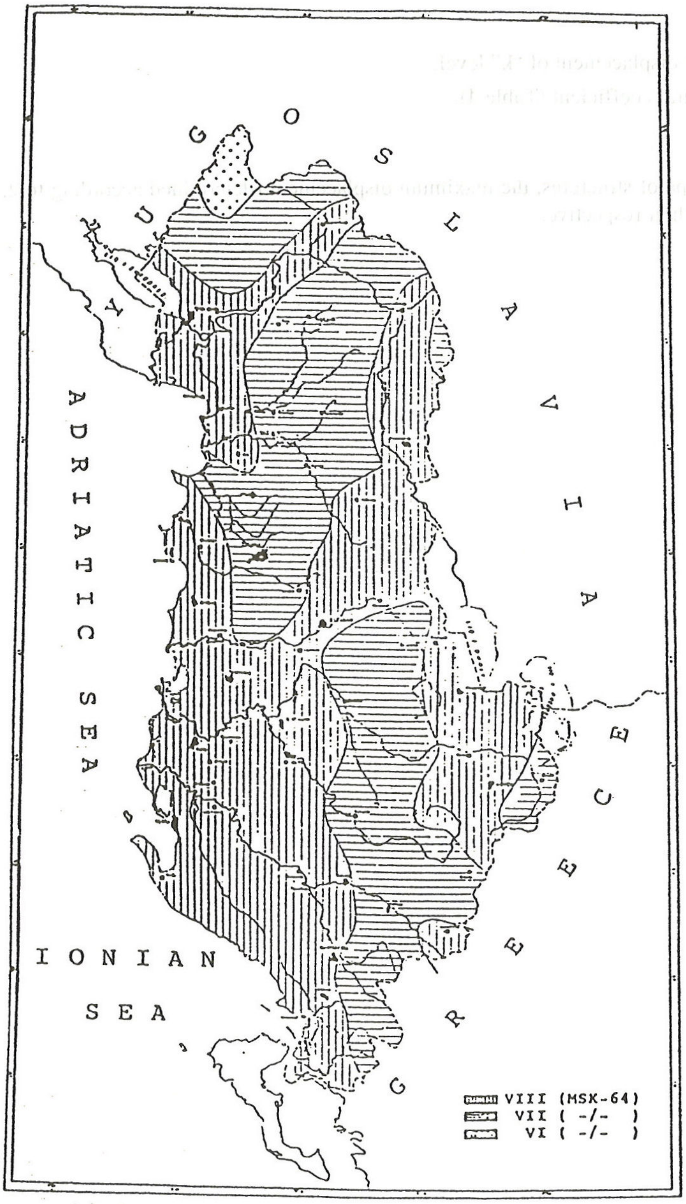


Fig. 1 Map of seismic regionalization of Albania.

Editorial Notes This is an unauthorized English translation prepared by Mr. Xhafer Kongoli.