4444MINISTRY OF HIGHER EDUCATION, SCIENCE AND INNOVATION OF THE REPUBLIC OF UZBEKISTAN

NAMANGAN ENGINEERING CONSTRUCTION INSTITUTE

FACULTY OF CONSTRUCTION

DEPARTMENT OF “CIVIL ENGINEERING”

EARTHQUAKE RESISTANCE OF BUILDINGS AND STRUCTURES

STUDY METHODOLOGY COMPLEX

NAMANGAN

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Faculty of CONSTRUCTION

DEPARTMENT OF "CIVIL ENGINEERING"

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STUDY METHODOLOGY COMPLEX

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Study methodology complex was created based on the requirements of the sample program on the subject of "Earthquake resistance of buildings and structures".

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It was discussed at the _1_ meeting of the "CI" department of the SMC "_28_" _08_ 2023 and was recommended for discussion at the faculty council.

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Agreed:

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TABLE OF CONTENTS

I. INTERACTIVE EDUCATIONAL METHODS USED IN TEACHING THE MODULE

I.1. “Insert” method

The purpose of the method: This method is used to facilitate students' acceptance of the new information system and the assimilation of knowledge, and this method also serves as a memory exercise for students.

Procedure for implementing the method:

-Before the lesson, the teacher prepares the input text in the form of a handout or presentation, which covers the main concepts of the subject;

- a text explaining the essence of a new topic is distributed to learners or shown in the form of a presentation;

- Learners get to know the text individually and express their personal views through special symbols. When working with the text, students are advised to use the following special characters:

Table 1.

“Insert” method

Signs	Information	Acquaintance information given izo h
"V" is familiar information		
? - I did not understand this information, I need an explanation.		
"+" this information is new to me.		
"-" against this opinion or this information?		

At the end of the specified time, the information that is unfamiliar and incomprehensible to the students will be analyzed and explained by the teacher, and their essence will be fully explained. The training ends after answering the questions.

I.2. Problem teaching technology

Problem-based learning technology is a developmental learning technology that stimulates the process of active learning and forms a logical sequential style of thinking. This technology is one of the most effective technologies in high school. The essence of problem-based teaching is the teacher's management of new knowledge acquisition by organizing problem situations in students' learning and solving educational (better, life) issues, problems and questions.

The problem situation in its nature and content is similar to the logical sequence in the teaching of subjects. The principle of sequence consists in the fact that the knowledge acquired in the previous stages, that is, education, is taken into account when determining the content of education at each stage of higher level of education. Similarly, if new knowledge in a situation is linked to previous knowledge, it is considered a problematic situation.

The activity of knowing, searching consists of the following stages:

1. Problem situation.
2. Learning problem.
3. Search for a solution to the problem.
4. Solve the problem and check it.*The problem solve schedule*

Formulation of the problem:	Final summary:	
Forming subproblems	Content of solutions	Conclusions
1	*2*	*3*
1.		
2.		
3.		

Procedures and regulations

1. To work in a group to solve a problem and write a presentation sheet - 20 min.
2. Presentation of the problem solution - 8 min. up to
3. Team discussion, forming conclusions - 10 min. up to
4. Mutual evaluation - 1 min.

Evaluation indicators and criteria

Each group evaluates the presentation of other groups, sums up the points according to the criteria.

Evaluation indicators and criteria	Maximum score	1 - group	2 - group	3 - group
Solutions:	**1.2**			
- correct formulation of the problem and sub-problem;	0.4			
- matching the solution to the form of the problem and sub-problem;	0.4			
- logicality, accuracy, brevity of conclusions.	0.4			
Presentation:	**1.4**			
- accuracy and comprehensibility of answers;	1.0			
- the activity of each group participant	0.4			

(questions, additions).				
Regulations	**0.4**			
Total score	**3.0**			

Summative assessment of group work

Group	1	2	3	General score	Grade (total score divided by 2) 2.2 - 3 points - "excellent" 1.2 - 2 points - "good" 0.5 - 1.1 points -
1	-				
2		-			
3			-		

I.3. "Case-study" method

"Case-study" is an English word ("case" - specific situation, event, "stadi" - to study, analyze) aimed at carrying out teaching based on the study and analysis of specific situations is a method. This method was first used in Harvard University in 1921 in order to use practical situations in the study of economic management sciences. In a case, open information or a specific event can be used as a situation for analysis. Case actions include: Who, When, Where, Why, How, What.

The work stages	Activity shape and content
Step 1: Introduction to the case and its information supply	– individual audio-visual work; – familiarization with the case (in text, audio or media form); – generalization of information; – information analysis; – identifying problems
Step 2: Clarifying the case and setting the educational task	– individual and group work; – determining the priority hierarchy of problems; – determination of the main problem situation
Step 3: Searching for a solution to the educational task by analyzing the main problem in the case, developing ways to solve it	– individual and group work; – development of alternative solutions; – analysis of opportunities and obstacles of each solution; – choosing alternative solutions
Step 4: Formulation and justification of the case solution, presentation.	– individual and group work; – substantiating the possibilities of implementing alternative options; – preparation of creative project presentation; – clarification of practical aspects of the final conclusion and solution of the situation

I.4. "Severe attack of thoughts" method

The essence of the "Severe attack of ideas" method is as follows:

- helping to realize the personal potential of each student performing certain tasks among the team;
- is to create in students the ability to put forward an idea against the opinion expressed by a certain community (group).

The above-mentioned "Severe Attack of Thoughts" method can be successfully applied in the course of training organized in social, humanitarian and natural sciences.

During the application of the method, the following situations occur:

1) to achieve thorough assimilation of certain theoretical knowledge by students;
2) saving time;
3) encourage each student to be active;
4) forming their ability to think freely. Training based on the use of this method is organized in several stages. They are:

Stages of using the "Severe Attack of Thoughts" method

Step 1: Forming small groups that include students who are close to each other in spirit and are equal in number	Step 2. Identifying the objectives arising from the nature of the task or assignments assigned to the groups
Step 3: Development of certain ideas by groups (solution of tasks)	Step 4: Discuss the solutions to the tasks, classify them into categories according to their correct solutions.
Step 5: Re-categorization of the solutions of tasks, that is, their evaluation based on criteria such as correctness, time spent to find a solution, clear and clear statement of solutions	Step 6: Discussing certain critical comments made in the initial steps regarding the solutions of tasks and coming to a unified conclusion about them

I.5. Discussion exercise

Controversial practical exercise management levers

moderator takes on all the tasks - managing the stages of the discussion, confirming the validity and correctness of the answers, defining the terms and concepts used, using the relationships correctly , etc. Correctly manage the distribution of presentations.

one who determines and fully evaluates the reports of the parties : relevance, scientific aspect, **logicality** and clear presentation of the issues, clear presentation of the conclusions.

Competitors form a competitive process between accepted research. He can not only criticize the main position of the speaker, but also find weaknesses or mistakes in his ideas and offer his own decisive points.

Expert - evaluates the productivity of all discussions, including the opinions expressed by the participants of the discussion, conclusions made, proposals and hypotheses.

Debate regulation transfer order

1. Starter lecture topic and of speakers presentations announcement does _
2. The lecture is 5 minutes continue is enough
3. Reviewer - 2 minutes .
4. The opponent is a lecture topic according to thoughts 1-3 minutes present is enough
5. Collective discussion - 5-10 minutes .

Evaluation indicators and criteria

Evaluation indicators and criteria (in points)	**Debate participants**			
	Speakers			
	1	2	3	4
Content of the lecture (2.5):				
- compatibility with the topic (1.5);				
- rationality, accuracy (0.5);				
- brevity of conclusions (0.5);				
Use of infrastructure technologies (visibility) - (0.9).				
Regulations (0.6)				
Total (4.0)				
	Reviewers			
The lecture description (3.0)				
- of the lecture strong sides identify (1,2)				
- of the lecture weak sides identify (1,2)				
Regulations (0.6)				
Total (3.0)				
	Opponents, participants			
Questions:				
- for each (0.3)				
In addition				
- for each (0.3)				
- by essence (0.3)				
- Total (3.0)				

Debate to the participants note

1. Discussion is not a sum of relations, but a method of problem solving.
2. Don't talk too much and let others do the talking.
3. In order to achieve the goal, restrain your emotions and speak in detail.
4. Study the situation of your opponents and treat them with respect.
5. Be critical and considerate of the opinions expressed by your opponents.
6. Do not deviate from the subject of the discussion and speak with the right approach.

I.6. "Brainstorming"

"Brain Storming" method has universal application. This method was first used by Osborne (USA) in 1963. The task of "Brainstorming" is to create new ideas with the help of a microgroup, or the strength of the microgroup as a whole is greater than the sum of the strengths of its individual members. "Brainstorming" encourages problem solvers to generate more ideas, including incredible and even fantastic ones. The more ideas there are, the more likely at least one of them is the same term. This is the principle behind brainstorming. "Brainstorming" is used to create a bank of ideas for the most appropriate solution to a problem or task.

"Brainstorming" is conducted according to the following rules:

- the opinion should be expressed as loudly as possible without any restrictions;
- any opinion can be said, it is accepted.
- ideas are not explained, they are said directly related to the task;
- Criticism or discussion of said ideas is not allowed until suggestions are stopped;
- an expert group or tape recorder will record all the said proposals.

After the "brainstorming" is stopped, the group of experts discusses all the ideas (opinions) mentioned and chooses the most suitable one. "Brainstorming" can be conducted individually or in pairs (triads) in lectures, in practical and seminar sessions, in microgroups of 4-6 people, as well as in groups and individually. "Brainstorming" creates conditions for increasing students' activity in training and for everyone to search for the most optimal solution to the topic.

In mastering the topic, it can be organized by clarifying words and phrases that are used in the topic in the form of ideas for "Brainstorming", but that the student has certain ideas about the subjects he has previously mastered.

I.7. Bloom's taxonomy

Bloom's questions. Observations and analysis of pedagogical literature show that an important factor in the development of students' thinking ability is the questions the teacher asks them and students to each other. It is noted that 80-85 percent of the questions that teachers ask students require only evidential knowledge, and they limit themselves to repeating (doing) what they remember in their answers. It is probably because of this, that the knowledge acquired by students is often bookish, and it is not a secret that they face serious difficulties in their practical application.

So, what question can be added to the list of questions that develop thinking skills? In our opinion, only a question, the correct answer of which is not clearly stated in the educational literature or not told by the teacher, makes the student think. An example of such questions can be the questions known as "Bloom's questions" in world pedagogy and corresponding to the six levels of mastery: knowledge, understanding, application, analysis, synthesis and evaluation. For example, questions such as: "Why?", "Compare?", "Divide into components?", "What are the most important features?", "How would you solve this?", "What is your attitude to this?" encourages thinking at the level of higher intellectual operations (analysis, synthesis, evaluation). Or, after reading a passage from the text, it is appropriate to ask the following questions that encourage students to think: "How can you title this passage?", "Five points from the passage that fully convey its content find a word?", "What question would you ask the author?".

When thinking about the question that the teacher asks the students, it should be clear, concise, understandable and concise, and only one learning element (concept, law, rule, etc.) should be asked per question. it should be emphasized that it is necessary. It is also important to use key words and phrases related to the topic or text in the content of the given questions. Categories of Bloom's Taxonomy

I.8. Cluster formation

Cluster - an English word that means a cluster. Sorting information into clusters is an interactive pedagogical strategy that develops multivariate thinking, the skills of making connections between the studied concepts (events, events), helps students to think freely and openly about a topic. will give. Clustering can be used to stimulate thinking during the invitation, comprehension, and reflection phases of a lesson. Basically, it encourages new ideas and new thinking on a particular topic. The sequence of creating a cluster is as follows:

• write the main word or sentence on a large sheet of paper in the middle of the blackboard;

• write words or sentences that you think are related to this topic ("brainstorming");

• make connections between concepts and ideas;

• write down all the options you remember.

II. THEORETICAL MATERIALS

1-LECTURE. Introduction. significance of the science of earthquake resistance of buildings and constructions and its duties

Earthquakes, sometimes also referred to as quakes, shocks, seism or temblors, are one of the most alarming and destructive natural phenomena that people can experience. It is also known and well documented that these events are distressing to animals as well, although no one knows as yet what the animals' sense just before the occurrence of an earthquake. The occurrence of large earthquakes is often sudden, their duration is short (on the order of seconds or at most minutes) and the devastation they cause can be extensive or even total. Large earthquakes are often followed by aftershocks, which are tremors that follow a larger earthquake, or main shock. Aftershocks may be felt for several days after the main shock. The number and severity of the aftershocks contribute greatly to the sense of panic felt by the affected population.

The scientific study of earthquakes is relatively new, and a reasonable understanding of their occurrence can only be traced back for a couple of hundred years. Prior to that time, the early historical record of earthquakes is cryptic at best because people did not understand the reason for their occurrence. In fact, there are very few factual descriptions of earthquakes prior to the 18th century because before then, people believed that an earthquake was a massive punishment imposed by the gods to punish the sinners and warn the unrepentant. During these early times, the occurrence of strong earthquakes usually triggered passionate discussions between philosophers and theologians resulting in lengthy and convoluted explanations about a long overdue and deserved retribution by God in response to the pervasive problems of evil in the world. The few that looked for natural causes for these unexplained phenomena reached equally strange conclusions. For example, an early popular theory postulated that earthquakes were caused by strong winds blowing out of deep caverns within the earth.

A drastic change in attitude regarding this issue can be traced back to a strong earthquake that occurred on All Saints' Day, November 1, 1755, near Lisbon, Portugal. Just before 10 am, the city was shaken ferociously for several minutes. The convulsions were so great that the water was sucked out of the city's harbor and returned soon thereafter as a fifty-foot wave that contributed greatly to the destruction of the city. The survivors that had fled to the waterside were drowned by the great waves that raced on them from the Atlantic. The motion of this first earthquake had not ceased for more than a few minutes when a second shock came, only slightly less severe than the first. A third and less severe final shock occurred about two hours later. The end of this mayhem reduced virtually every building within miles of the city center to rubble. Over 60,000 people lost their lives.

For the first time in history, however, we have detailed descriptive information of what happened, soon after the earthquake struck. All over

Portugal priests were asked by their bishops to document their observations in as much detail as they could. Their records are still preserved and represent the first systematic effort in history to describe the effects of an earthquake as, or soon after, it occurred. One of the many archived contemporary descriptions is given below:

"The sea rose boiling in the harbor and broke up all the crafts harbored there. The city burst into flames, and ashes covered the streets and squares. The houses came crashing down, roofs piling up on foundations, and even the foundations were smashed to pieces."

Hypocenter and Epicenter

Geologists have found that earthquakes tend to occur along faults that correspond to zones of weakness in the crust of the earth. A fault is a fracture that separates two blocks of the crust that have slipped with respect to each other. An earthquake is triggered at the actual moment of slip initiation on the fault surface. The hypocenter is the position within the earth from which the motion and energy of an earthquake originates. The epicenter of an earthquake is the point on the earth's surface directly above the focus, or hypocenter. The following diagram illustrates the spatial relationship between the fault, that generates an earthquake, the focus (or hypocenter) and the epicenter:

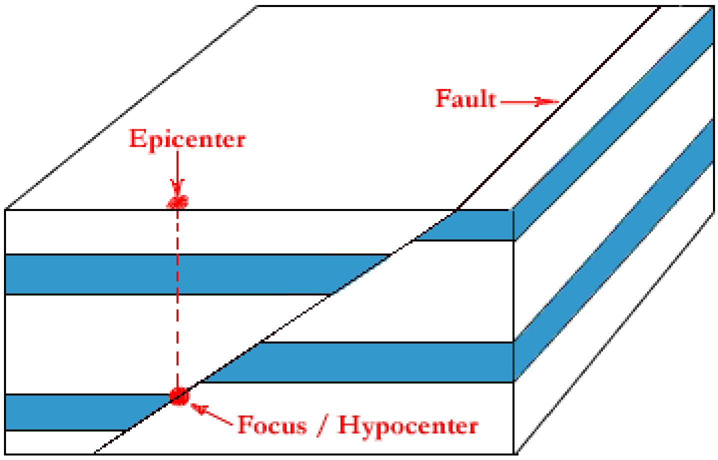

Figure 1. Diagram showing the relationship between the focus, or hypocenter, and the epicenter. The hypocenter is directly located on the fault plane, while the epicenter is the vertical projection of the hypocenter onto the ground surface.

2-LECTURE. Earthquakes and their effects on buildings and constructions

Earthquake is the most dangerous natural phenomenon that generates sizable destruction in structures. It is reported that two sources of mistakes which would seriously endanger structures are ignoring the ways an earthquake affects buildings and shoddy construction practices.

That is why a proper understanding of the seismic effects on a structure is extremely important, and designers and contractors should consider the influence of seismic forces on buildings in order to be able to set prevention measures against failures and collapses.

As earthquake hits structures, it generates inertia forces which could be greatly destructive causing deformations and, horizontal and vertical shaking. These effects are discussed and presented below.

Inertia Forces in Structures

The generation of inertia forces in a structure is one of the seismic influences that detrimentally affect the structure. When an earthquake causes ground shaking, the base of the building would move but the roof would be at rest. However, since the walls and columns are attached to it, the roof is dragged with the base of the building.

The tendency of the roof structure to remain at its original position is called inertia. The inertia forces can cause shearing of the structure which can concentrate stresses on the weak walls or joints in the structure resulting in failure or perhaps total collapse. Finally, more mass means higher inertia force that is why lighter buildings sustain the earthquake shaking better.

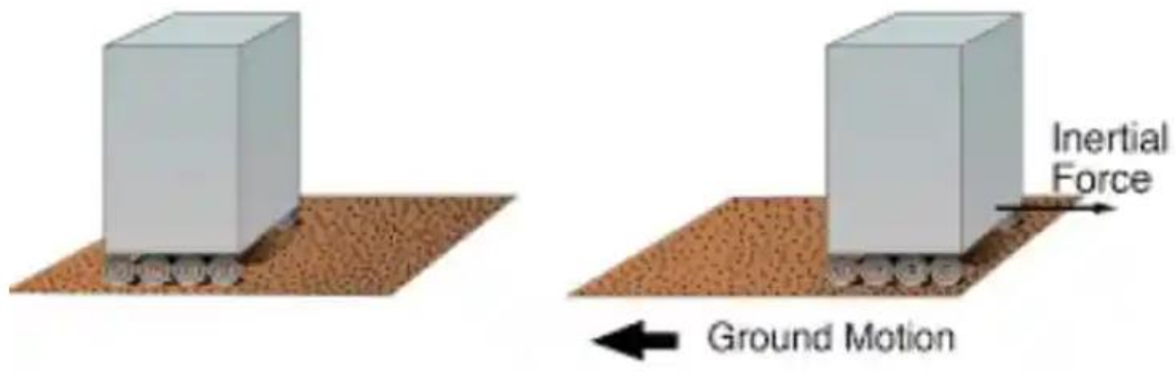

Fig. 1: Direction of Inertia Forces

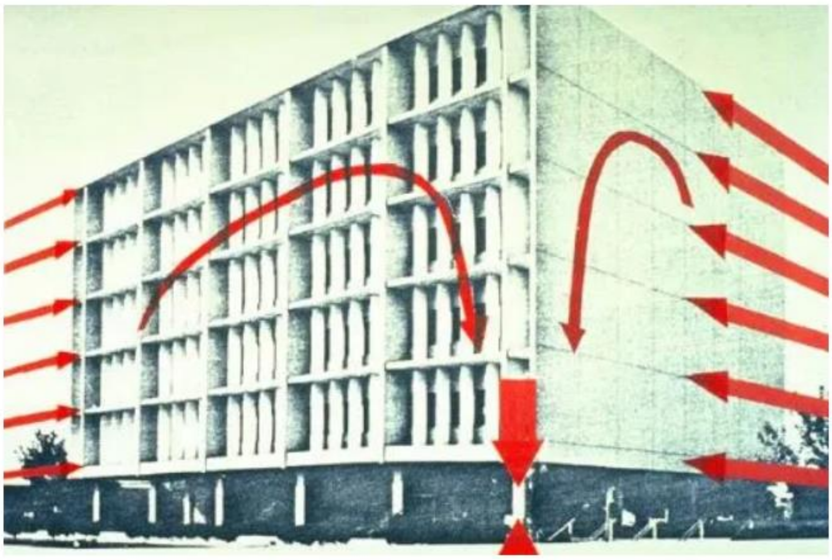

Fig. 2: Development of Great Inertia Forces in the Six Storey of Imperial County Services Building

Effect *of Deformations in Structures*

When a building experiences earthquake and ground shaking occurs, the base of the building moves with the ground shaking. However, the roof movement would be different from that of the base of the structure. This difference in the movement creates internal forces in columns which tend to return the column to its original position.

These internal forces are termed stiffness forces. The stiffness forces would be higher as the size of columns gets higher. The stiffness force in a column is the column stiffness times the relative displacement between its ends.

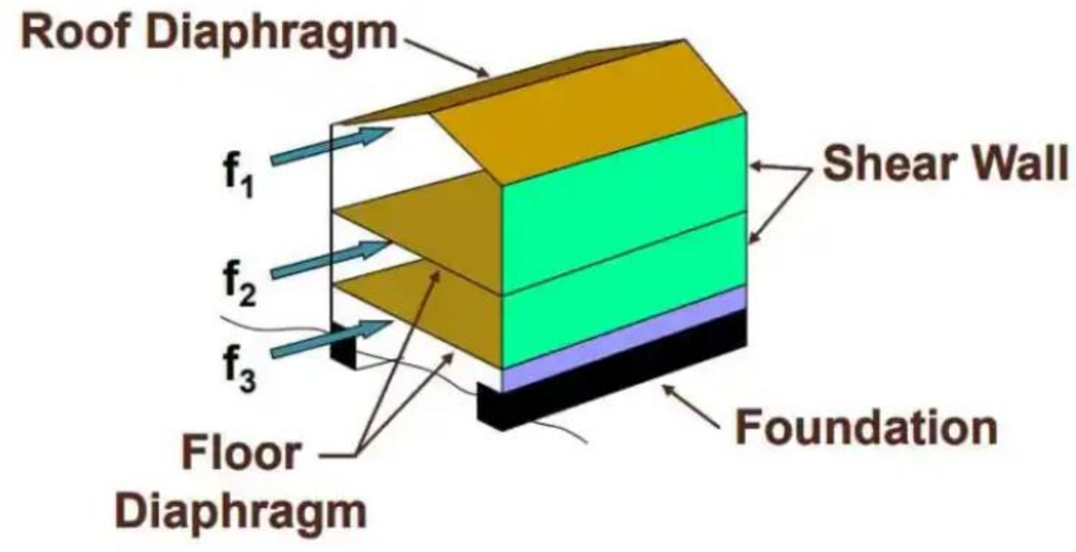

Fig. 3: Lateral Force Resisting System in a House

Horizontal and Vertical Shaking

Earthquake causes shaking of the ground in all the three directions X, Y and Z, and the ground shakes randomly back and forth along each of these axis directions. Commonly, structures are designed to withstand vertical loads, so the vertical shaking due to earthquakes (either adds or subtracts vertical loads) is tackled through safety factors used in the design to support vertical loads.

However, horizontal shaking along X and Y directions is critical for the performance of the structure since it generates inertia forces and lateral displacement and hence adequate load transfer path shall be provided to prevent its detrimental influences on the structure.

Proper inertia force transfer path can be created through adequate design of floor slab, walls or columns, and connections between these structural elements. It is worth mentioning that the walls and columns are critical structural members in transferring the inertial forces. It is demonstrated that, masonry walls and thin reinforce concrete columns would create weak points in the inertia force transfer path.

3-LECTURE. Consequences of strong earthquakes

Some of the common impacts of earthquakes include structural damage to buildings, fires, damage to bridges and highways, initiation of slope failures, liquefaction, and tsunami. The types of impacts depend to a large degree on where the earthquake is located: whether it is predominantly urban or rural, densely or sparsely populated, highly developed or underdeveloped, and of course on the ability of the infrastructure to withstand shaking.

As we've seen from the example of the 1985 Mexico earthquake, the geological foundations on which structures are built can have a significant impact on earthquake shaking. When an earthquake happens, the seismic waves produced have a wide range of frequencies. The energy of the higher frequency waves tends to be absorbed by solid rock, while the lower frequency waves (with periods slower than one second) pass through the solid rock without being absorbed, but are eventually absorbed and amplified by soft sediments. It is therefore very common to see much worse earthquake damage in areas underlain by soft sediments than in areas of solid rock. A good example of this is in the Oakland area near San Francisco, where parts of a two-layer highway built on soft sediments collapsed during the 1989 Loma Prieta earthquake (Figure 3.1).

Figure 3.1 A part of the Cypress Freeway in Oakland California that collapsed during the 1989 Loma Prieta earthquake.

Building damage is also greatest in areas of soft sediments, and multi-storey buildings tend to be more seriously damaged than smaller ones. Buildings can be designed to withstand most earthquakes, and this practice is increasingly applied in earthquake-prone regions. Turkey is one such region, and even though Turkey had a relatively strong building code in the 1990s, adherence to the code was poor, as builders did whatever they could to save costs, including using inappropriate materials in concrete and reducing the amount of steel reinforcing. The result was that there were over 17,000 deaths in the 1999 M7.6

Izmit earthquake (Figure 3.2). After two devastating earthquakes that year, Turkish authorities strengthened the building code further, but the new code has been applied only in a few regions, and enforcement of the code is still weak, as revealed by the amount of damage from a M7.1 earthquake in eastern Turkey in 2011.

Figure 3.2 Buildings damaged by the 1999 earthquake in the Izmit area, Turkey.

Fires are commonly associated with earthquakes because fuel pipelines rupture and electrical lines are damaged when the ground shakes (Figure 11.19). Most of the damage in the great 1906 San Francisco earthquake was caused by massive fires in the downtown area of the city (Figure 3.3). Some 25,000 buildings were destroyed by those fires, which were fuelled by broken gas pipes. Fighting the fires was difficult because water mains had also ruptured. The risk of fires can be reduced through P-wave early warning systems if utility operators can reduce pipeline pressure and close electrical circuits.

Figure 3.3 Some of the effects of the 2011 Tohoku earthquake in the Sendai area of Japan. An oil refinery is on fire, and a vast area has been flooded by a tsunami.

Figure 3.4 Fires in San Francisco following the 1906 earthquake.

Earthquakes are important triggers for failures on slopes that are already weak. An example is the Las Colinas slide in the city of Santa Tecla, El Salvador, which was triggered by a M7.6 offshore earthquake in January 2001 (Figure 3.5).

Ground shaking during an earthquake can be enough to weaken rock and unconsolidated materials to the point of failure, but in many cases the shaking also contributes to a process known as **liquefaction**, in which an otherwise solid body of sediment is transformed into a liquid mass that can flow. When water-saturated sediments are shaken, the grains become rearranged to the point where they are no longer supporting one another. Instead, the water between the grains is holding them apart and the material can flow. Liquefaction can lead to the collapse of buildings and other structures that might be otherwise undamaged. A good example is the collapse of apartment buildings during the 1964 Niigata earthquake (M7.6) in Japan. Liquefaction can also contribute to slope failures and to fountains of sandy mud (sand volcanoes) in areas where there is loose saturated sand beneath a layer of more cohesive clay.

Figure 3.5 Collapsed apartment buildings in the Niigata area of Japan. The material beneath the buildings was liquefied to varying degrees by the 1964 earthquake.

Parts of the Fraser River delta are prone to liquefaction-related damage because the region is characterized by a 2 m to 3 m thick layer of fluvial silt and clay over top of at least 10 m of water-saturated fluvial sand (Figure 3.6). Under these conditions, it can be expected that seismic shaking will be amplified and, the sandy sediments will liquefy. This could lead to subsidence and tilting of buildings, and to failure and sliding of the silt and clay layer. Current building-code regulations in the Fraser delta area require that measures be taken to strengthen the ground underneath multi-storey buildings prior to construction.

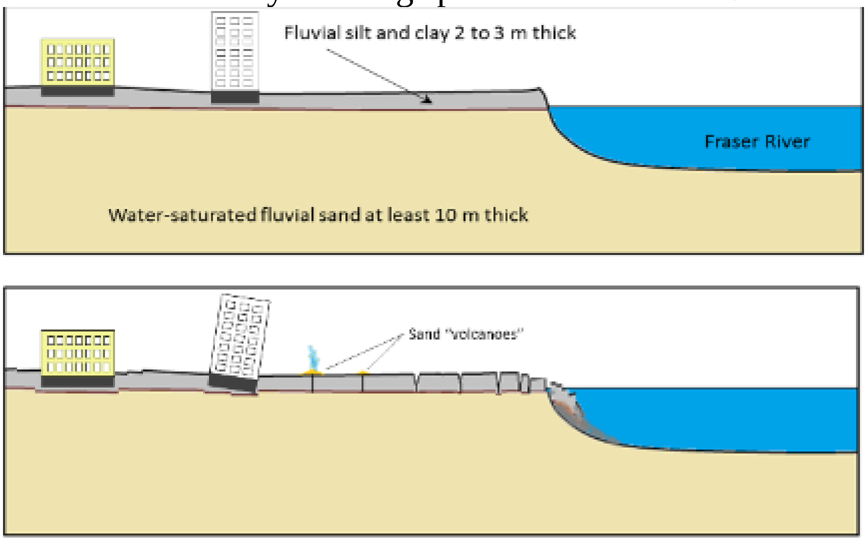

Figure 3.6 Recent unconsolidated sedimentary layers in the Fraser River delta area (top) and the potential consequences in the event of a damaging earthquake.

4-LECTURE. Earthquake power and energy

The time, location, and magnitude of an earthquake can be determined from the data recorded by seismometer. Seismometers record the vibrations from earthquakes that travel through the Earth. Each seismometer records the shaking of the ground directly beneath it. Sensitive instruments, which greatly magnify these ground motions, can detect strong earthquakes from sources anywhere in the world. Modern systems precisely amplify and record ground motion (typically at periods of between 0.1 and 100 seconds) as a function of time.

Magnitude is the size of the earthquake. An earthquake has a single magnitude. The shaking that it causes has many values that vary from place to place based on distance, type of surface material, and other factors. See the Intensity section below for more details on shaking intensity measurements.

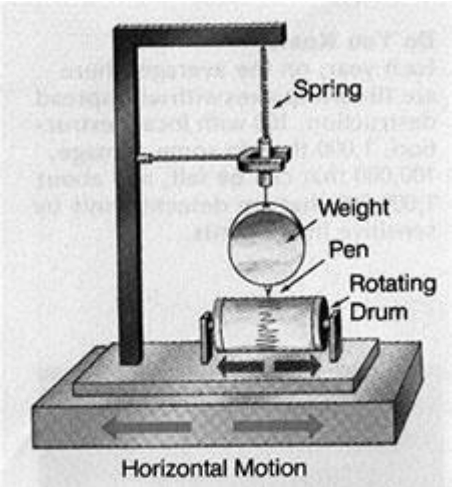

Figure 4.1. Sketch of a traditional seismometer. (Public domain.)

Types of Magnitudes

Magnitude is expressed in whole numbers and decimal fractions. For example, a magnitude 5.3 is a moderate earthquake, and a 6.3 is a strong earthquake. Because of the logarithmic basis of the scale, each whole number increase in magnitude represents a **tenfold increase in measured amplitude as measured on a seismogram**.

When initially developed, all magnitude scales based on measurements of the recorded waveform amplitudes were thought to be equivalent. But for very large earthquakes, some magnitudes underestimate true earthquake size, and some underestimate the size. Thus, we now use measurements that describe the physical effects of an earthquake rather than measurements based only on the amplitude of a waveform recording. More on that later.

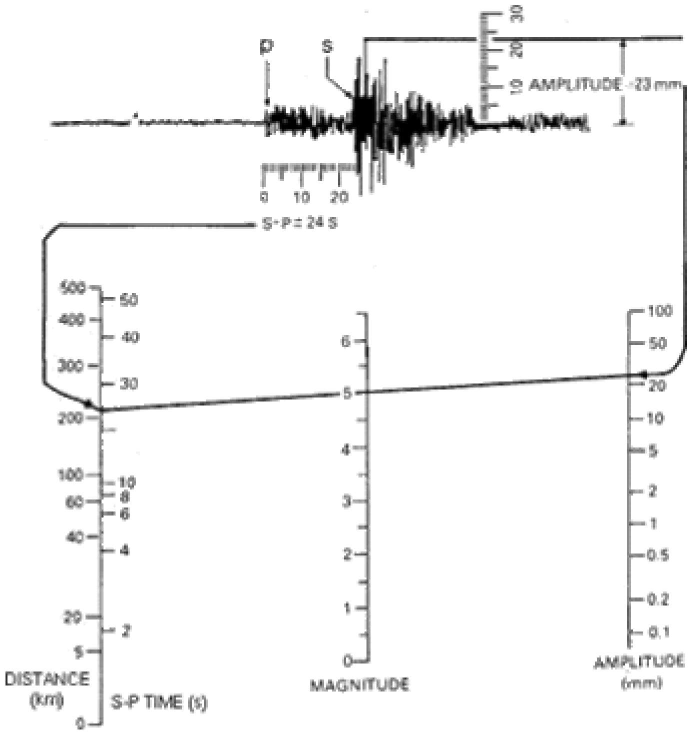

Figure 4.2. From Richter's (1958) book, Elementary Seismology.(Public domain.)

The **Richter Scale (M_L)** is what most people have heard about, but in practice it is not commonly used anymore, except for small earthquakes recorded locally, for which ML and short-period surface wave magnitude (Mblg) are the only magnitudes that can be measured. For all other earthquakes, the moment magnitude (Mw) scale is a more accurate measure of the earthquake size.

Although similar seismographs had existed since the 1890's, it was only in 1935 that Charles F. Richter, a seismologist at the California Institute of Technology, introduced the concept of earthquake magnitude. His original definition held only for California earthquakes occurring within 600 km of a particular type of seismograph (the Woods-Anderson torsion instrument). His basic idea was quite simple: by knowing the distance from a seismograph to an earthquake and observing the maximum signal amplitude recorded on the seismograph, an empirical quantitative ranking of the earthquake's inherent size or strength could be made. Most California earthquakes occur within the top 16 km of the crust; to a first approximation, corrections for variations in earthquake focal depth were, therefore, unnecessary.

The Richter magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. Adjustments are included for the variation in the distance between the various seismographs and the epicenter of the earthquakes.

Moment Magnitude (M_W) is based on physical properties of the earthquake derived from an analysis of all the waveforms recorded from the shaking. First the seismic moment is computed, and then it is converted to a magnitude designed to be roughly equal to the Richter Scale in the magnitude range where they overlap.

Moment (M_0) = rigidity x area x slip

where **rigidity** is the strength of the rock along the fault, **area** is the area of the fault that slipped, and **slip** is the distance the fault moved. Thus, **stronger rock material, or a larger area, or more movement in an earthquake** will all contribute to produce a larger magnitude.

Then,

Moment Magnitude (M_W) = $2/3 \log_{10}(M_0) - 10.7$

See the **Magnitude Types Table** (below)for a summary of types, magnitude ranges, distance ranges, equations, and a brief description of each.

ENERGY RELEASE

For More Information on Magnitudes

Another way to measure the size of an earthquake is to compute how much energy it released. The amount of energy radiated by an earthquake is a measure of the potential for damage to man-made structures. An earthquake releases energy at many frequencies, and in order to compute an accurate value, you have to include all frequencies of shaking for the entire event.

While each whole number increase in magnitude represents a tenfold increase in the measured amplitude, it represents an **32 times more energy release**.

The energy can be converted into yet another magnitude type called the **Energy Magnitude (M_e)**. However, since the Energy Magnitude and Moment Magnitude measure two different properties of the earthquake, their values are not the same.

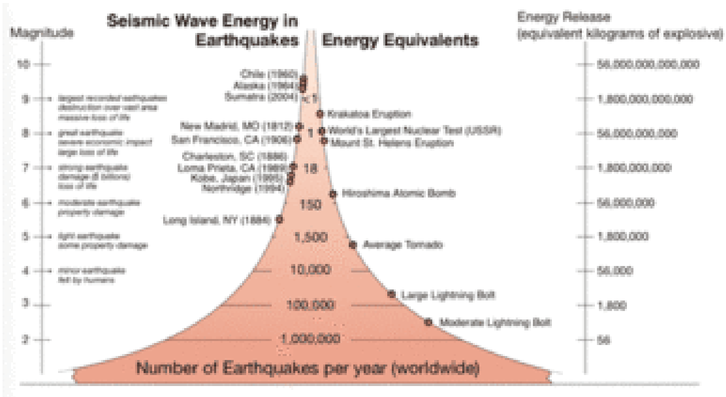

Figure 4.3. Earthquake magnitudes and energy release, and comparison with other natural and man-made events. (Courtesy Incorporated Research Institutes for Seismology, IRIS.)

The energy release can also be roughly estimated by converting the moment magnitude, M_w, to energy using the equation $\log E = 5.24 + 1.44M_w$, where M_w is the moment magnitude.

Whereas the magnitude of an earthquake is one value that describes the size, there are many intensity values for each earthquake that are distributed across the geographic area around the earthquake epicenter. The intensity is the measure of shaking at each location, and this varies from place to place, **depending mostly on the distance from the fault rupture area**. However, there are many more aspects of the earthquake and the ground it shakes that affect the intensity at each location, such as what direction the earthquake ruptured, and what type of surface geology is directly beneath you. Intensities are expressed in Roman numerals, for example, VI, X, etc.

Traditionally the intensity is a subjective measure derived from human observations and reports of felt shaking and damage. The data used to be gathered from postal questionnaires, but with the advent of the internet, it's now collected using a web-based form. However, instrumental data at each station location can be used to calculate an estimated intensity.

The intensity scale that we use in the United States is called the **Modified Mercalli Intensity Scale**, but other countries use other scales.

5-LECTURE. Seismic scales and seismic vibration, Recording instruments

A seismograph, or seismometer, is an instrument used to detect and record seismic waves. Seismic waves are propagating vibrations that carry energy from the source of an earthquake outward in all directions. They travel through the interior of the Earth and can be measured with sensitive detectors called seismographs. Scientists have seismographs set up all over the world to track the movement of the Earth's crust.

Seismic waves are divided into two types: body waves and surface waves.

Body waves include P (compressional or primary) waves and S (transverse or secondary) waves. An earthquake radiates P and S waves in all directions and the interaction of the P and S waves with the Earth's surface and shallow structure produces surface waves. Near an earthquake the shaking is large and dominated by shear-waves and short-period **surface waves**. These are the waves that do the most damage to our buildings, highways, etc.

At farther distances the amplitude of the seismic waves decreases as the energy released by the earthquake spreads throughout a larger volume of Earth. Also with increasing distance from the earthquake, the waves are separated apart in time and dispersed because P, S, and surface waves travel at different speeds.

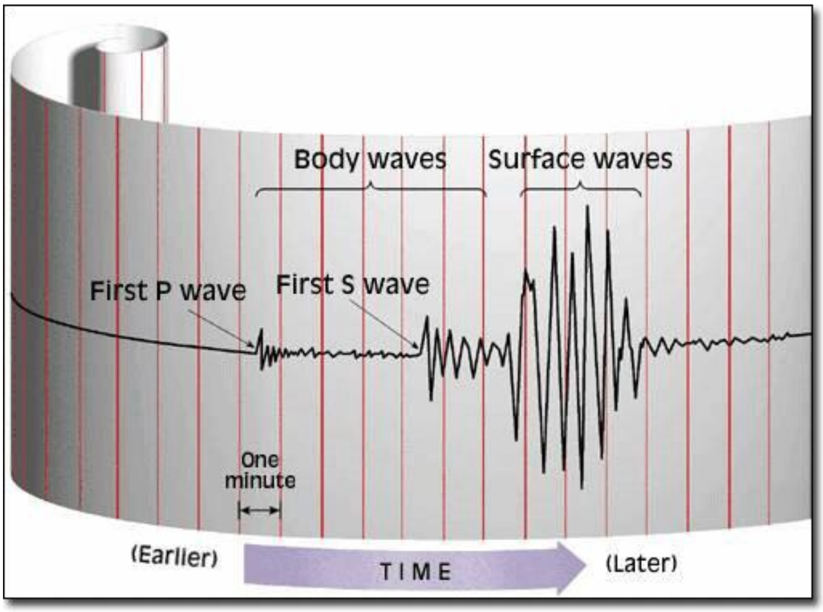

Figure 5.1. Body Waves and Surface Waves

Love waves and Rayleigh waves are surface waves. Love waves are transverse waves that vibrate the ground in the horizontal direction perpendicular to the direction that the waves are travelling. They are recorded on seismometers that measure the horizontal ground motion.

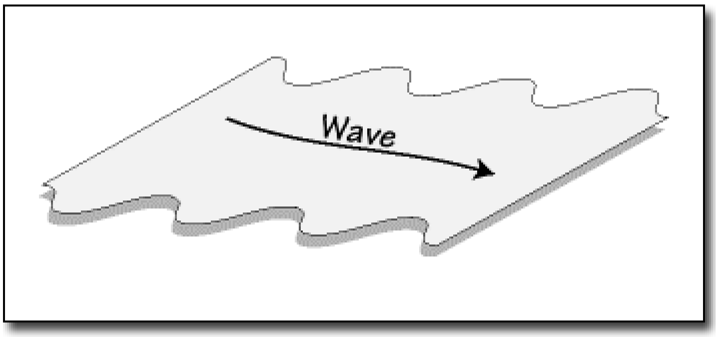

Figure 5.2. Love waves are transverse and restricted to horizontal movement

Rayleigh waves are the slowest of all the seismic wave types and in some ways the most complicated. Like Love waves they are dispersive so the particular speed at which they travel depends on the wave period and the near-surface geologic structure, and they also decrease in amplitude with depth. Typical speeds for Rayleigh waves are on the order of 1 to 5 km/s.

Generally, a seismograph consists of a mass attached to a fixed base. During an earthquake, the base moves and the mass does not. The motion of the base with respect to the mass is commonly transformed into an electrical voltage. The electrical voltage is recorded on paper, magnetic tape, or another recording medium. The record written by a seismograph in response to ground motions produced by an earthquake or other ground-motion sources is called **seismogram**.

Earthquakes are recorded by a seismographic network. Each seismic station in the network measures the movement of the ground at that site. The slip of one block of rock over another in an earthquake releases energy that makes the ground vibrate. That vibration pushes the adjoining piece of ground and causes it to vibrate, and thus the energy travels out from the earthquake hypocenter in a wave.

There are many different ways to measure different aspects of an earthquake:

- ***Magnitude*** *is the most common measure of an earthquake's size. It is a measure of the size of the earthquake source and is the same number no matter where you are or what the shaking feels like. The Richter scale is an outdated method for measuring magnitude that is no longer used by the USGS for large, teleseismic earthquakes. The Richter scale measures the largest wiggle (amplitude) on the recording, but other magnitude scales measure different parts of the earthquake. The USGS currently reports earthquake magnitudes using the Moment Magnitude scale, though many other magnitudes are calculated for research and comparison purposes.*
- ***Intensity*** *is a measure of the shaking and damage caused by the earthquake; this value changes from location to location.*

A **seismometer** is the internal part of the seismograph, which may be a pendulum or a mass mounted on a spring; however, it is often used synonymously with "seismograph".

Seismographs are instruments used to record the motion of the ground during an earthquake. They are installed in the ground throughout the world and operated as part of a seismographic network. The earliest "seismoscope" was invented by the Chinese philosopher Chang Heng in A.D. 132. This did not, however, record earthquakes; it only indicated that an earthquake was occurring. The first seismograph was developed in 1890.

A seismograph is securely mounted onto the surface of the earth so that when the earth shakes, the entire unit shakes with it EXCEPT for the mass on the spring, which has inertia and remains in the same place. As the seismograph shakes under the mass, the recording device on the mass records the relative motion between itself and the rest of the instrument, thus recording the ground motion. In reality, these mechanisms are no longer manual, but instead work by measuring electronic changes produced by the motion of the ground with respect to the mass.

A **seismogram** is the recording of the ground shaking at the specific location of the instrument. On a seismogram, the HORIZONTAL axis = time (measured in seconds) and the VERTICAL axis= ground displacement (usually measured in millimeters). When there is NO EARTHQUAKE reading, there is just a straight line except for small wiggles caused by local disturbance or "noise" and the time markers. Seismograms are digital now - there are no more paper recordings.

For earthquakes that occurred between about 1890 (when modern seismographs came into use) and 1935 when Charles Richter developed the magnitude scale, people went back to the old records and compared the seismograms from those days with similar records for later earthquakes. For earthquakes prior to about 1890, magnitudes have been estimated by looking at the physical effects (such as amount of faulting, landslides, sandblows or river channel changes) plus the human effects (such as the area of damage or felt reports or how strongly a quake was felt) and comparing them to modern earthquakes.

Many assumptions have to be made when making these comparisons. For example, how do you compare the shaking for people living in log cabins or tents in the early 1800s with shaking for people living in high-rise steel and concrete buildings (with waterbeds!) in the 1990s? Because different researchers can get widely varying magnitudes from using different assumptions on how to make these comparisons, many of the old earthquakes have big differences in the magnitudes assigned to them. For example, magnitude estimates for the quakes that occurred near New Madrid, Missouri in 1811 and 1812 vary from the upper magnitude 6 range to as high as 8.8, all because of the choices the researchers made about how to compare the data.

6-LECTURE. Theoretical fundamentals of earthquakes

It is known that the nature of the seismic impact on buildings and structures during an earthquake is closely related to ground vibration. Seismic movement of soil is very complex and cannot be expressed directly by any mathematical expression.

The first part of the complexity of this movement is that this process lasts for a very short time. Ground movement during an earthquake lasts several seconds and is characterized by the non-repetition of the movement, i.e. the chaotic character (disorder) in the ground movement graph is conditional acceptance of the kinematic parameters of the vibration movement (period, frequency, etc.) shows how complex it is (Fig. 1, a). The method of calculating the seismic forces affecting buildings and structures during an earthquake was first proposed by the Japanese scientist F. Omori in 1900. Based on this, the building or structure is considered to be an absolute solid body and it moves in the same way as soil particles (Fig. 87, b). Until recently, this theory, called "static theory" proposed by Omori, formed the basis for calculating the seismic impact of buildings in all countries. Thus, it is assumed that the acceleration of any element of the building or structure during an earthquake is the same as the acceleration of the foundation ground. Therefore, the inertial force appearing in any element of the structure is equal to the product of the mass m of the element and the ground motion acceleration u (Newton's second law known from the physics course). i.e $S = m\ddot{y}$

$$m = \frac{Q}{g}$$

Here: Q - construction weight
g = 9, 8 m/s^2 - free fall acceleration

Given this, the above formula can be written as:

$$S = m\ddot{y} = \frac{Q}{g} \cdot \ddot{y}$$

in this expression $\frac{\ddot{y}}{g} = k_c$ - is called the seismicity coefficient. That is

$$S = K_c Q$$

According to this formula, it is not difficult to calculate the maximum inertial force during an earthquake, knowing the acceleration of the ground movement and the weight of the building or structure. These forces are called seismic force.

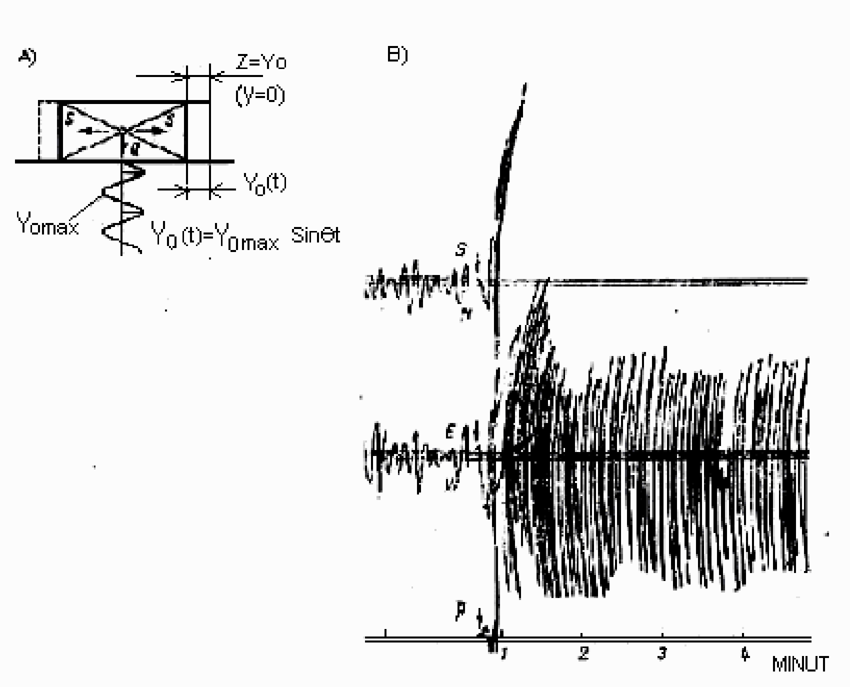

Figure 6.1. *Regarding the determination of seismic loads: a) seismogram of the 1923 Tokyo earthquake; b) F. Omori's model.*

Seismicity coefficient K_s is determined depending on the level of seismic activity of the regions.

That is, for zones with 9 points $K_c = 0,1$

For 8-point zones $K_c = 0, 05$

For zones with 7 points $K_c = 0, 0025$

Analyzing the state of seismic stress of buildings and structures in the course of earthquakes has shown that the static theory cannot fully explain the state of this process. It is known that any building or structure is deformed, and these deformations play an important role in the vibration of the structure. In 1920, the Japanese scientist Mononobe proposed to take into account that the seismic force affecting buildings or structures does not depend only on the acceleration of the ground movement, but also on the dynamic characteristics of the structure or building. In solving this problem, he considers structures as a system with equal degrees of freedom, and the base ground vibrates according to the harmonic law. This case makes it possible to use the following expression as a dynamic coefficient.

$$\beta = \frac{1}{\left|1 - T^2 / T_0^2\right|}$$

where: T is the specific oscillation period of the system

To- period of special oscillation of the base

In the method proposed by Mononobe, the maximum value of the seismic forces acting on the structure is determined by the following formula:

$$S = \beta_1 K_c Q$$

where: Q = mg - building weight

$K_c = \ddot{y}_{0\max} / g$ - coefficient of seismicity.

$T = 2\pi\sqrt{m/k}$ - the period of the particular oscillation of the structure.

$$\beta_1 = \frac{1}{1 - T^2 / T_0^2}$$

In 1927, the famous Georgian scientist K.S. Zavriev, unlike the above theory, proposed to take into account private vibrations along with forced vibrations. Dynamic coefficient at the moment of the beginning of vibration based on it

$$\mu_g = \frac{2}{1 - T^2 / T_0^2}$$

In this case, the value of the seismic force affecting the simple structure without taking into account the frictional forces is determined as follows.

$$S_{max} = \mu_g k_c Q$$

With this work, K.S. Zavriev further developed the foundations of the dynamic theory of determining seismic forces.

Omoro theory

During an earthquake, the "irregular" vibration of the earth creates great difficulties in creating a precise and perfect theory of calculation of structures under the influence of seismic forces. As a result, in the first quarter of the 20th century, the "static theory" proposed by the Japanese scientist Omori (1900) came to rule in all countries. According to this theory, the building is considered as an absolute rigid body and vibrates with the ground, that is, it is assumed that all its points get the same acceleration as the ground. In simple terms, this score can be compared to gently swinging a matchbox in the palm of your hand. In this case, the inertial force generated in any element of the structure is equal to the product of its mass m and the acceleration of the ground vibration, i.e.

$$S = m\ddot{y}_0. \tag{6.1}$$

The relationship between the weight Q and the mass m of an object

$$Q = mg \tag{6.2}$$

it is known. Here is the acceleration of gravity.

From expressions (6.1) and (6.2).

$$S = \frac{\ddot{y}_0}{g} Q = K_c Q \tag{6.3}$$

K_c in this expression is called the coefficient of seismicity and is determined according to the level of seismicity of the area. In regulatory documents, its amount is 0.1 for areas with 9, 8 and 7 points, respectively; 0.05 and 0.025 are considered.

If the maximum acceleration of the ground and the weight of the building are known, it is not difficult to determine the maximum inertial force - seismic force (load) generated in the structure using the formula (6.3).

The analysis of the state of buildings and structures during the earthquake showed that the static theory is not free from shortcomings. As it turns out, very few buildings are a set of absolutely unique structures. It turned out that deformation of structures plays an important role in vibration. However, Omori's formula was undoubtedly a step forward in the scientific approach to the design of earthquake-resistant structures.

In 1920, the Japanese scientist Mononobe proposed taking into account the deformation of the structure in the analysis of seismic forces. He considers structures as a system with equal degrees of freedom and assumes that the earth vibrates according to the harmonic law. This allows us to use the following formula as the dynamic coefficient β:

$$\beta = \frac{1}{\left|1 - \frac{T^2}{T^2_0}\right|} \qquad (6.4)$$

here: T va T_0 – specific oscillation periods of the system and the ground.

Mononobe's formula for determining seismic force looks like this:

$$S = \beta\ K_c Q, \qquad (6.5)$$

For an absolutely rigid body, T=0. It follows from (6.4) that β=1. This shows that formulas (6.3) and (6.5) are mutually compatible.

While noting the importance of Mononobe's theory, we will dwell on some of its shortcomings that have hindered its widespread use. Experience has shown that most of the structures are destroyed in the initial phase of the earthquake, that is, in the first minutes before the individual vibrations have reached. Special vibrations are combined with forced vibrations, and the impact effect increases. This score is not reflected in the Mononobe formula. In addition, Mononobe did not consider the phenomenon of stretching in his theory. This leads to S=∞ when $T=T_0$. It is self-evident that this is contrary to the truth. Finally, in Mononobe's theory, as in Omori's theory, since structures are taken in the form of a system with equal degrees of freedom, the issue of distribution of seismic forces by the height of the structure is not solved.

In 1927, the Russian scientist K.S. Zavriev was the first to prove that the role of special vibrations in the initial phase of an earthquake is significant. K.S. Zavriev Coefficient of dynamism in the first minutes of vibration

$$\beta = \frac{2}{1 - \frac{T^2}{T^2_0}}. \qquad (6.6)$$

noted that.

Comparing (6.4) with (6.6), we see that the values of the seismic forces analyzed based on the Zavriev and Mononobe formulas are quite different from each other. With this work, K.S. Zavriev laid the foundation for the dynamic theory of seismic force analysis. The USA scientists M.A.Bio, G.V. Hauzner, R.R. Martel, J.A. Alford and others made a significant contribution to the development of the dynamic theory.

In 1934, M.A.Bio proposed a method of determining the dynamic effect of an earthquake in models with the aim of avoiding difficulties in mathematically expressing the complex and irregular movement of the earth during an earthquake. The essence of this method is that pendulums with different periods of free oscillation (0.1-2.4 s) are attached to the monitoring platform and the platform is vibrated as in an earthquake. The vibration of the platform moves the pendulums; the deflection and acceleration of the pendulum are recorded using measuring instruments. In this way, each earthquake accelerogram can be analyzed experimentally, and the maximum effect it causes in the structure model (pendulum) can be determined. Using the record of accelerations of all pendulums, a graph representing the connection between the maximum acceleration of the oscillation of the pendulum masses and the period of free oscillation of the mass, that is, the spectrum of accelerations, is created.

Many experimental analyzes of earthquakes that occurred in the United States were carried out in the present period, based on the collected materials, a graph called the standard spectrum of accelerations was developed. This chart is included in the California Code, the California State Building Code.

If the period of free oscillations of a system is known, using the graph, it is possible to determine the maximum inertial force generated in this system when the earth shakes. This force is equal to the product of the acceleration of the graph corresponding to the period of free oscillations of the system by the mass of the system. According to the California Code, the seismic force acting on a structure is determined by the following formula:

$$V = C\sum Q. \qquad (6.7)$$

where: S is the coefficient depending on the period of special vibrations of the structure (found from the graph); $\sum Q$- the total weight of the structure.

Due to the fact that the mass of any project is not concentrated in one point (dispersed along the height of the building), the total force determined above is distributed according to the weight and height of the elements of the building structure. In this case, it is assumed that the structure is not deformed during seismic vibrations, but shakes on the ground. When the problem is approached in this way, the inertial force that occurs in an element is proportional to the weight of this element and the distance from the base of the structure; i.e., the amount of seismic force generated at point k located at a distance hk from the base of the structure is as follows:

$$S_k = \frac{V h_k Q_k}{\sum_1^n h_i Q_i}. \qquad (6.8)$$

In this method of calculation adopted in America, the dynamic nature of the earthquake event and the dynamic parameters of the structure are calculated. Therefore, this method of calculation is considered a dynamic method.

When talking about the development of dynamic methods for calculating seismic forces, we consider it necessary to briefly dwell on the scientific works of I. L. Korchinsky, because the importance of these works in the practical application to the calculation of earthquake-resistant structures is extremely high.

In his book published in 1954, I.L. Korchinsky, based on the analysis of seismograms of some weak earthquakes that occurred in the seismic zones, presented the sinusoids that represent the vibration of the earth.

$$y_0(t) = \sum_{n=1}^{t} a_{0n} e^{-\varepsilon_{0n} t} \sin \ \omega_n t \qquad (6.9)$$

offered to take it in the form of

A single extending sinusoid in the practical calculation of structures under the influence of seismic forces

$$y_0 = a_0 e^{-\varepsilon_0 t} \sin \ \omega t \qquad (6.10)$$

7-LECTURE. Methods of determining seismic forces

After the adoption of the first normative document based on the dynamic theory (in 1957), for a quarter of a century, huge researches were carried out in this field of science: a number of earthquakes occurred. The earthquakes clearly showed the mistakes and shortcomings in the building design and construction. All of this led to changes and amendments to the construction standards. SNiP II-A.12-62, adopted in 1962, was in use until 1970. From July 1, 1970 to December 31, 1981, SNiP II-A.12-69 came into force. From January 1, 1982, SNiP II-7-81 began to be used. After the Republic of Uzbekistan gained independence in 1996, a new normative document KMK 2.01.03-19 ("Construction in earthquake zones") was developed and started to be used in the construction process.

In this paragraph, we will get acquainted with the method of determining seismic forces according to KMK 2.01.03-19, which is currently in practice.

In the standards, calculated seismic forces are assumed to statically affect buildings and structures. However, this force does not have a static effect, but causes internal distortions that can be caused by inertial forces in the parts of the structure. Therefore, calculated seismic forces are forces equivalent to the inertial forces generated in buildings and structures during an earthquake.

According to the first form of specific vibrations of buildings and structures, the calculated seismic force (load) generated at point k is determined using the following formula:

$$S_{ik} = K_0 K_n K_x S_{0ik}, \qquad (6.14)$$

$$S_{0ik} = \alpha Q_k W_i K_\delta \eta_{ik}, \qquad (6.15)$$

Where: S_{0ik} the inertia force generated when it is assumed that the structure is elastically deformed;

α – the coefficient obtained from Table 2 depending on the seismicity of the construction site;

Table 2

Values of coefficient α

Construction site seismicity, in points	7	8	9	>9	9*
Coefficient	0,25	0,5	1,0	1,4	2

Q_k – is the weight of the building placed at point k in the calculation scheme, and the calculated loads applied to the structure [6] are determined based on the summation coefficient (table 3) in clause 2.1;

Table 3

Values of the summation coefficient

Load types	Aggregation factor
Permanent	0,9
Long-term temporary	0,8
Short-term (medium and short-term)	0,5

W_i – Spectral coefficient (dynamic coefficient according to the former KMK 2.01.03-19). The spectral coefficient is determined from Table 4 or [6] from the graphs given in Fig. 2.2, depending on the period of specific vibrations of the building being designed, the location index, and the category of seismic properties of the soil.

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Spectral coefficient values depending on location index, seismic properties and categories of soils

Address index and seismic address	I		II		III		IV	
	District 9 of Tashkent city		District 8 of Tashkent city, Tashkent region		Fargona Valley		Bukhara, Samarkand and other regions	
Grunt category	I, II	III	I, II	III	I, II	III	I, II	III
T_i, sec	Spectral coefficient W_i							
1	2	3	4	5	6	7	8	9
0	0,40	0,40	0,40	0,40	0,40	0,40	0,40	0,40
0,5	0,87	0,58	0,61	0,48	0,52	0,45	0,92	0,58
0,10	1,11	0,73	0,83	0,55	0,79	0,50	1,13	0,73
0,15	1,21	0,81	1,0	0,63	0,97	0,56	1,21	0,83
0,20	1,24	0,87	1,09	0,70	1,09	0,65	1,24	0,88
0,25	1,22	0,91	1,14	0,75	1,15	0,73	1,22	0,91
0,30	1,17	0,92	1,16	0,80	1,16	0,79	1,18	0,92
0,35	1,11	0,93	1,16	0,83	1,15	0,83	1,13	0,93
0,40	1,04	0,92	1,15	0,86	1,11	0,85	1,07	0,92
0,45	0,97	0,89	1,10	0,87	1,06	0,87	1,01	0,91
0,50	0,89	0,88	1,03	0,88	1,00	0,87	0,94	0,89
0,55	0,82	0,85	0,97	0,88	0,94	0,87	0,88	0,86
0,60	0,76	0,82	0,91	0,87	0,88	0,86	0,82	0,84
0,65	0,69	0,79	0,85	0,86	0,81	0,84	0,76	0,81
0,70	0,63	0,76	0,79	0,85	0,75	0,82	0,71	0,78
0,75	0,58	0,73	0,73	0,83	0,69	0,80	0,66	0,76

0,80	0,53	0,69	0,67	0,79	0,64	0,77	0,61	0,73
0,85	0,49	0,66	0,62	0,76	0,59	0,74	0,57	0,70
0,90	0,45	0,63	0,58	0,74	0,54	0,72	0,53	0,67
0,95	0,42	0,60	0,54	0,71	0,50	0,69	0,50	0,64
1,00	0,38	0,57	0,52	0,68	0,47	0,66	0,47	0,62
1,05	0,36	0,54	0,49	0,65	0,43	0,63	0,44	0,59
1,10	0,33	0,51	0,48	0,63	0,40	0,60	0,41	0,57
1,15	0,31	0,49	0,47	0,60	0,38	0,57	0,39	0,54
1,20	0,29	0,46	0,46	0,57	0,35	0,55	0,36	0,52
1,25	0,27	0,44	0,45	0,55	0,33	0,52	0,35	0,50
1,30	0,26	0,41	0,44	0,52	0,32	0,50	0,33	0,47
1,35	0,25	0,39	0,43	0,50	0,30	0,47	0,31	0,45
1,40	0,24	0,37	0,42	0,47	0,29	0,45	0,30	0,44
1,45	0,23	0,36	0,41	0,45	0,27	0,43	0,29	0,42
1,50	0,22	0,34	0,40	0,44	0,26	0,41	0,28	0,40
1,55	0,21	0,32	0,39	0,42	0,26	0,39	0,27	0,38
1,60	0,20	0,31	0,38	0,40	0,25	0,37	0,26	0,37
1,65	0,20	0,29	0,37	0,39	0,24	0,35	0,25	0,35
1,70	0,19	0,28	0,37	0,38	0,24	0,34	0,24	0,34
1,75	0,19	0,27	0,36	0,37	0,23	0,32	0,24	0,33
1,80	0,18	0,26	0,35	0,36	0,23	0,31	0,23	0,32
1,85	0,18	0,25	0,35	0,36	0,22	0,30	0,23	0,30
1,90	0,18	0,24	0,34	0,35	0,22	0,29	0,22	0,29
1,95	0,18	0,23	0,33	0,35	0,22	0,28	0,22	0,28
2,00	0,17	0,22	0,32	0,34	0,22	0,27	0,2	0,27

K_δ – The dissipation coefficient can be determined from the following formula:

$$K_\delta = e^{(0{,}548-\sqrt{\delta})(0{,}1+\frac{0{,}7}{\sqrt{T_1}})} \qquad (6.16)$$

Where: δ – is the decrement of vibrations, it is determined by natural testing of buildings similar to the planned buildings, if it is not possible to determine by experiment, it is determined from table 5;

Table 5

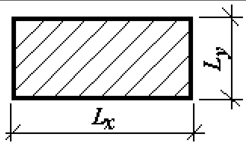
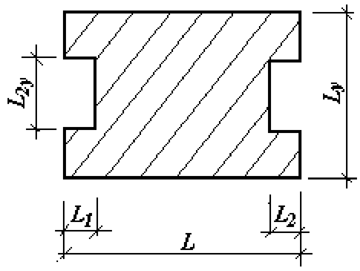
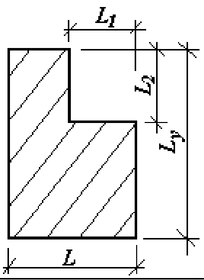
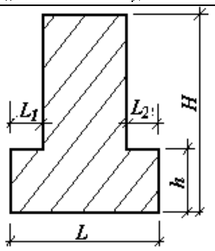
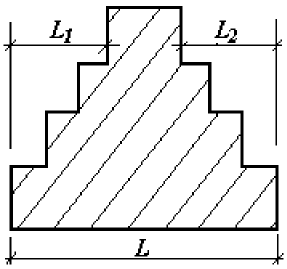
Decrement of oscillations

№	Constructive solution of buildings	Decrement of oscillations
1	High-rise buildings of small size in the plan (towers, masts, towers, separate shafts of elevators, etc.)	0,15
2	Buildings that are not affected by wall struts and have a column height ratio of 25 or greater to the direction of the building's seismic force to the daily dimension.	0,15
3	Buildings not mentioned in paragraphs 1 and 2	0,3

K_r– The coefficient of regularity can be determined from table 6;

Table 6

Coefficient of regularity

№	Plan view	Parameter	Regularity indicator		
			regularly	very regular	irregular
1	2	3	4	5	6
1.		$\frac{L_x}{L_y}$	$\frac{\prec 5}{1{,}0}$	$\frac{5 \div 8}{1{,}1}$	$\frac{\succ 8}{1{,}2}$
2.		$\frac{L_1}{L}$ $\frac{L_2}{L}$	$\frac{\prec 0{,}15}{1{,}0}$	$\frac{\prec 0{,}15 \div 0{,}25}{1{,}15}$	$\frac{\succ 0{,}25}{1{,}25}$
		$\frac{L_{2y}}{L_y}$	$\frac{\prec 0{,}5}{1{,}25}$	$\frac{\succ 0{,}5}{1{,}25}$	$\frac{\succ 0{,}5}{1{,}25}$
3.		$\frac{L_1}{L}$ $\frac{L_2}{L_y}$	$\frac{\prec 0{,}15}{1{,}0}$	$\frac{\prec 0{,}15 \div 0{,}25}{1{,}15}$	$\frac{\succ 0{,}25}{1{,}25}$
4.		$\frac{L_1 + L_2}{L}$	$\frac{\leq 0{,}2}{1{,}0}$	>0,2 $\frac{h}{H} \leq 0{,}15$ *when* 1,1	>0,2 $\frac{h}{H} > 0{,}15$ *when* 1,2
5.		$\frac{L_1 + L_2}{L}$ $\frac{L_j + L_{j+1}}{L_j}$	$\frac{\prec 0{,}15}{1{,}0}$ $\frac{\prec 0{,}1}{1{,}0}$	$\frac{0{,}25 \div 0{,}5}{1{,}1}$ $\frac{0{,}1 \div 0{,}3}{1{,}1}$	$\frac{\succ 0{,}5}{1{,}2}$ $\frac{\succ 0{,}3}{1{,}2}$

Note: 1. Rows 1, 2, 3 in the table refer to the plan shape of the building, and rows 4 and 5 refer to the change of dimensions according to height.

2. If the dimensions of the building change unilaterally according to the height (4.5 rows), the calculated parameters are multiplied by 2.

3. If one plan has a parameter, then the parameter that provides the Kr coefficient is accepted for calculation.

K_0 =responsibility coefficient determined from table 7;

Table 7

Values of reliability coefficient K_0

K_0 –7-jadvaldan aniklanadigan mas'ullik koeffitsienti;

№	Description of the building	Reliability category	Reliability coefficient,, K_0
1	2	3	4
1	Buildings (hospitals, launch sites, energy supply buildings, etc.) whose operation was vital during the period of the earthquake and its consequences.	I	1,4
2	Crowded places (schools, cultural institutions, meeting halls, etc.)	II	1,2
3	Buildings not included in items 1, 2 and 4	III	1,0
4	Low-responsibility buildings (agricultural buildings, warehouses, etc.)	IV	0,8

K_k–8- coefficient depending on the number of floors of the building determined from the table;

Table 8

K_k coefficient values depending on the number of building floors.

№	Constructive solution of buildings	K_k coefficient
1	Large-block, complex construction or monolithic reinforced concrete buildings with more than 5 floors	$K_k = 1+0,1(n-5)$ birok 1,5 dan katta emas
2	Large panel buildings with the number of floors up to 5	0,75
3	Large panel buildings and volume block buildings with more than 5 floors	$K_k = 0,9+0,075(n-5)$ birok 1,3 dan katta emas
4	Buildings not provided for in paragraphs 1-3	1,0

η_{ik} – coefficient depending on the form of special vibrations and the calculation scheme when the building vibrates by i - ton:

8-LECTURE. Earthquake influence of buildings and constructions

When designing earthquake-resistant buildings, it is necessary to strive to achieve a symmetrical appearance in the plan and an even distribution of masses and units. Walls and frames should be placed symmetrically with respect to the longitudinal and transverse axes of the building. In this way, torsional vibrations are prevented or their development is stopped.

Longitudinal and transverse walls should be connected continuously in the plan of the building. A wall separated (disconnected) in the plan can damage the second wall to which it is connected (Fig. 8.1). If for some reason the continuity of the wall is required, then its structural continuation can be taken in the form of a frame.

The plan of the building should be as simple as possible. Circular, regular polygonal, square or rectangular buildings in plan are superior to buildings with complex shapes in resisting earthquake forces. If, according to the requirements of architecture or use, it is necessary to build a complex-shaped building in the plan, then the building should be divided into simple-shaped parts by means of anti-seismic joints (Fig. 8.2). The walls and structural elements of buildings of normal shape have equal or close to each other strength and uniformity in different directions; therefore, such buildings have equal resistance in any direction of horizontal seismic force. Such buildings also withstand torsional vibrations relatively well. The auditorium of the Palace of Arts in Tashkent is circular in plan, and despite being located near the epicenter, it withstood the earthquake of 1966 very well.

The length of the building or its separate parts is limited according to the standard, because if some parts of the building with a length exceeding the standard fall into different phases of vibration, the seismic effect increases. Therefore, long buildings are divided into small parts using anti-seismic joints. From the point of view of economy, anti-seismic seams are combined with temperature and subsidence seams, that is, a temperature seam serves as both an anti-seismic and a subsidence seam at the same time. In contrast to sinking seams, anti-seismic seams do not need to be separated along the entire height of the building: the foundations can be left intact. Depending on the structural solution of the building, anti-seismic joints are taken in the form of a double wall or a double column.

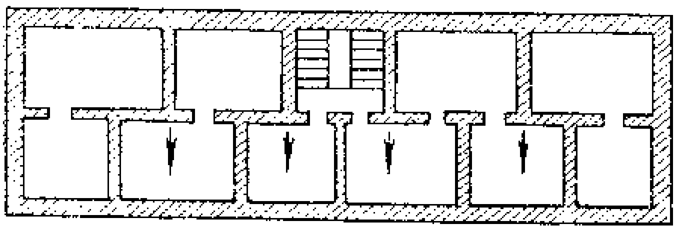


Figure 8.1. Building plan with error solution

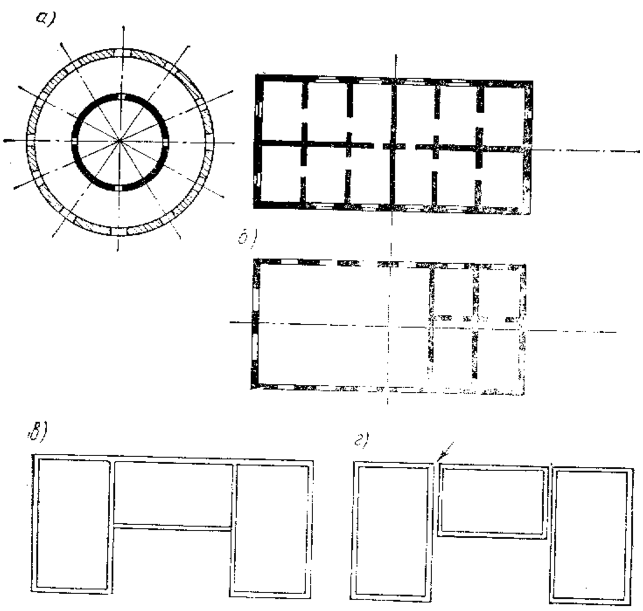


Figure 8.2. Seismic-resistant buildings plan: α-symmetric building; b-symmetrical building; в, г,- complex shaped building (a-incorrect solution; г- correct solution

The width of the anti-seismic joints depends on the height and height of the building. In buildings with a height of up to 5 m, the width of the seam should not be less than 3 cm. In a high-rise building, the width of the seam is increased by 2 cm every 5 m. In addition, the width of the seam should be smaller than the double value of the maximum displacement of the building. Anti-seismic joints should allow free movement (vibration) of separated parts. Otherwise, adjacent parts may collide and be seriously damaged. The distance between anti-seismic joints and the height of buildings are specified in the construction standards (Table 16).

It is advisable to take the same height of the building within the boundary of one block. Increasing the height of a part leads to an increase in the mass of this part and, in turn, to an increase in the amount of seismic force; which requires an increase in the cross-sectional dimensions of the elements of that part.

In general, to reduce the amount of seismic forces, it is necessary to reduce the weight of building structures. For this, the cross-section of the construction elements is reduced (without compromising the strength) and light building materials are used. In order to reduce the amount of maximum internal forces (transverse force, bending moment) generated at the base of the building, it is necessary to achieve that the equal impactor of seismic forces passes as low as possible. This can be achieved by making the upper parts of the building from light materials and moving heavy equipment to the lower floors.

In recent years, reinforced concrete structures are widely used in construction. When resisting earthquake forces, the joints of composite elements are delicate. Therefore, knots and seams should be processed carefully. In order to reduce the number of seams, it is recommended to take the dimensions of the assembled elements larger.

Buildings constructed in seismic areas are divided into the following groups depending on the size of the main load-bearing structures: 1) buildings with load-bearing walls (brick or stone walls; large-block, large-panel, cast concrete or reinforced concrete, wooden buildings); Prefab buildings made of volumetric reinforced concrete elements also belong to this group; 2) single-diaphragm and single-diaphragm thin-walled buildings whose fillers take part in receiving seismic forces; 3) concrete buildings with suspended panels, which are less involved in concrete work in receiving seismic forces; This category also includes thin buildings whose walls support their own weight. The buildings of the first group are distinguished by their large size, and those of the last group, on the contrary, by their small size.

Table 16

T/r	Load-bearing constructions of buildings	Dimensions in terms of length (width), m			Height, m (number of floors)		
		Estimated seismicity, in points					
		7	8	9	7	8	9
1	Metal or reinforced concrete thin, cast reinforced concrete walls	In accordance with the requirements of non-seismic areas, but it should not exceed 150 m			In accordance with the requirements of non-seismic areas		
2	Large paneled walls	80	80	60	45(14)	39(12)	30(9)
3	Complex construction walls: a). When reinforced concrete joints and girders form a clear cinch:						
	Class I handicraft	80	80	60	30(9)	23(7)	17(5)
	Class II handicraft	80	80	60	23(7)	20(6)	14(4)
	b). Vertical reinforced concrete additions that increase the strength of the wall, when they do not form a clear crack:						
	Class I handicraft	80	80	60	20(6)	17(5)	14(4)
	Class II handicraft	80	80	60	17(5)	14(4)	11(3)
4	Vibro brick panel or block walls: concrete block walls	80	80	60	23(7)	20(6)	14(4)
5	Walls made of brick or stone, except for those specified in clauses 3 and 4:						
	Class I work	80	80	60	17(5)	14(4)	11(3)
	Category II work	80	80	60	14(4)	11(3)	8(2)

The general requirements and design rules introduced in this paragraph apply to one type of building. The task is to choose a structural solution that is economically based and can ensure the safety of people and valuable equipment when the ground moves.

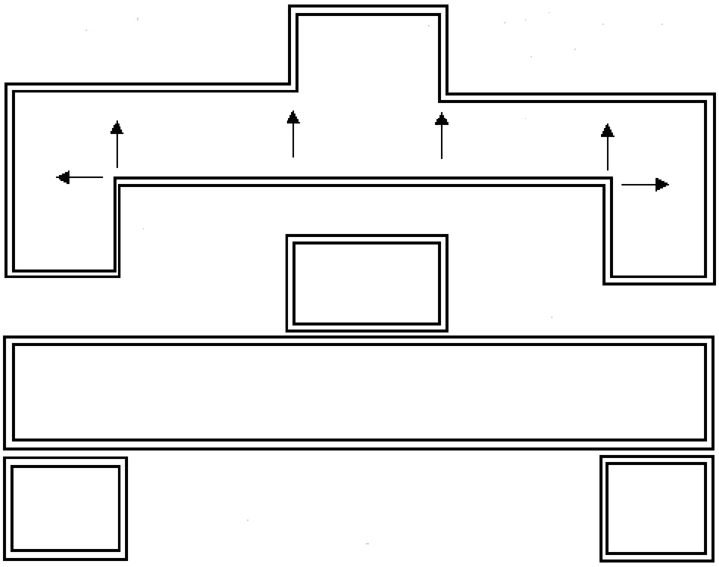


Fig. 8.3. Separation of complex-shaped buildings into simple-shaped parts according to earthquake resistance requirements. a- a solution that is not recommended when designing buildings in seismically active areas: b- division of the building into simple parts

In order to achieve the value of seismic forces by reducing the specific weight of structures, the following conditions must be met:

a) reducing the specific weight of structures by using materials that have the ability to effectively use their strength and thermotechnical properties as load-bearing structures;

b) transfer of technological processes using heavy machines and mechanisms to the lower floors (if possible, to the first floor), place warehouses and other similar rooms on the first floor. (Fig. 8.4)

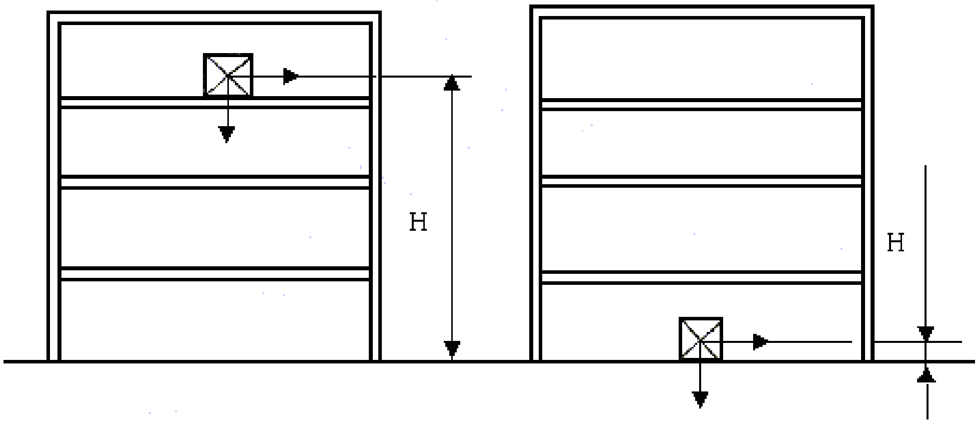


Figure 8.4. Reducing the seismic impact by placing the main technological processes and warehouses in the buildings on the first lower floor.

c) replacement of bridge-type cranes, which are placed on columns under the crane beams in a one-story building, with a crane designed to walk on rails on the floor. (Fig.8.5)

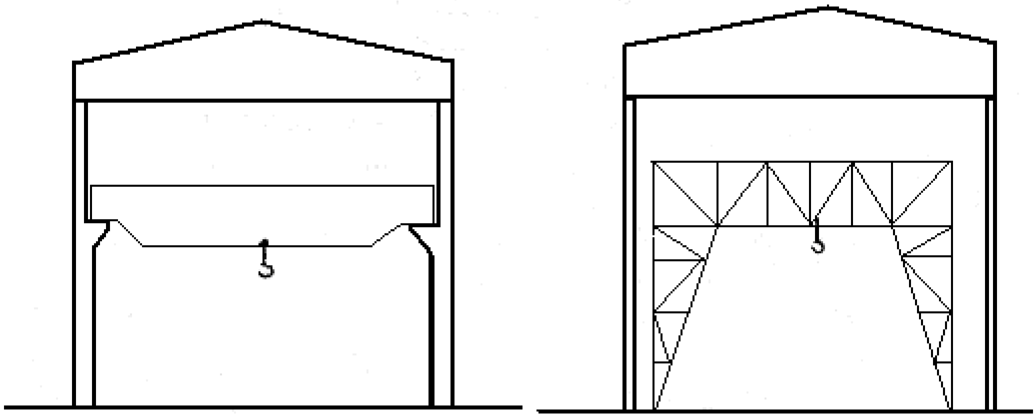


Figure 8.5. Reducing seismic impact by replacing overhead cranes with floor cranes.

3. The principle of creating conditions for spatial cooperation of building structures and elements during an earthquake.

Constructions of buildings manufactured in factory conditions from large panels and volumetric elements together provide good spatial working conditions. The load-bearing elements of buildings with such a constructive scheme, consisting of horizontal and vertical intersecting diaphragms, are considered to be buildings with good spatial uniformity and priority.

In frame-frame buildings, the frame itself is a spatially invariant system, and they are characterized by evenly distributed steps and frames with uniform uniformity.

Frame constructions are often statically uncertain systems. That's why local damage caused by the formation of plastic hinges in individual elements does not cause damage to the entire system. The high load-bearing capacity of this type of structures comes from this.

Requirements for building size-planning and urban planning solutions in seismically active regions

It is known that the geography of earthquakes is formed in such a way that almost 85% of the urban population of our republic is concentrated in these seismically active areas. This, in turn, imposes strict requirements on urban planning. In seismically active areas, taking into account the danger to human life, the tasks aimed at fulfilling these requirements should be solved constructively.

At this point, it is appropriate to briefly touch upon the impact of the building configuration (volumetric and spatial dimensions) on seismic strength.

It is known that the larger the spatial dimensions of the building, the more its characteristics change: the price increases, the number (volume) of technological processes increases, the weight increases, etc. k. The smaller the size of the building, the smaller its weight and, of course, the value of the inertial forces generated during an earthquake. In addition, the size of these buildings' profiles is much smaller compared to the surface of the floor of the building, and in such conditions, static (dynamic) forces are distributed to a large number of wall structures that make up the spatial system of the building.

The increase in the volume-spatial dimensions of the building, in addition to the increase in its price, complicates the working conditions of the constructions that make up the volume-planning system of the building. Buildings with small spatial dimensions have been known to be less damaged in the study of the consequences of many earthquakes.

As the height of the building increases, its period of free (private) oscillation also increases. Usually, the change in the period of free oscillation of the building leads to the change of the reaction of the building and corresponding stresses at the upper and lower levels. It is known that the dominant vibration period of an earthquake depends on the geological conditions of the furnace surroundings, and it lasts 0.1-2 seconds. An increase in the height of the building (and, accordingly, the vibration period) moves it away from the dominant vibration period of the earthquake.

This does not mean that the problems will be solved in this way. According to many experts, from the point of view of seismic stability of buildings, it is desirable that the number of floors does not exceed 15 floors. (With the increase in the height of the buildings, the overturning stresses that affect them during an earthquake also increase)

The earthquake resistance of the building during an earthquake is negatively affected by the increase in its horizontal volume-spatial dimensions. If the size of the building is large, regardless of its symmetrical and simple appearance, the building cannot resist the effects of seismic waves as a whole body. That is why the normative documents specify the limit values of the dimensions of the buildings.

When designing earthquake-resistant building structures, it is more important to pay attention to the geometric proportions of the building system than its geometric dimensions. The ratio of the length to the width of the building is important when coming to an architectural solution, the extended form is not appropriate for buildings.

The structural solution (planned density) of the building is an important factor in ensuring the earthquake resistance of buildings during an earthquake.

It is known from the history of architecture that in the past, the number and dimensions of the elements and constructions that formed the load-bearing basis of buildings and structures are significantly larger than those of today's buildings and structures. With the passage of time, the improvement of the constructive calculation methodology, the size of the elements that make up the load-bearing basis of buildings, and the level of aesthetic requirements aimed at reducing their number, the load-bearing basis of buildings has reached the current state.

In many cases, aesthetic acceptance conflicts with earthquake-resistant design requirements. The structural solution or plan density of buildings is defined as the size measured by the ratio of the sum of the surfaces of vertical load-bearing elements: columns, walls, joint connections to the total floor area. In today's modern construction, among all types of buildings, frame buildings (with columns made of metal) are projects with the lowest planned density.

However, if the requirements leading to the technological limitation of the height of the building deserve special attention, one of the next requirements is a considerable decrease in the density of buildings in urban planning. This creates a good opportunity to eliminate the consequences of the earthquake in a short period of time.

It is known that the construction of new cities and the expansion of existing ones, the placement of industrial enterprises, buildings and communications can be carried out only in emergency cases and in accordance with the land legislation in accordance with the decision of the Cabinet of Ministers of the Republic of Uzbekistan. Since such large-scale events require a lot of money, this area should be based on production and socio-economic aspects, as well as satisfy a number of requirements.

When choosing any territory, local, hydrogeological, technical-economic, sanitary-hygienic and similar indicators should be taken into account.

In urban planning, it is especially important to take into account climatic conditions and wind direction. Under normal conditions, the urban residential zone should be located in relation to the industrial zone in such a way that the direction of the wind to the residential zone should not match the direction of the toxic gases that may poison the atmosphere in the industrial zone. Wind direction is one of the most important factors in preventing the risk of environmental pollution due to damage to industrial facilities caused by earthquakes in seismically active regions.

9-LECTURE. Requirements for urban planning and dimensional design solution of buildings

In the early 20th century, the first seismic provisions in building codes were introduced in a few countries with high seismicity. These early seismic codes have been periodically updated with increasing knowledge in earthquake engineering. In the 1960's and 1970's, countries with moderate seismicity began to adopt seismic requirements in their building codes. In the same period, the better understanding of dynamic soil behavior as well as inelastic structural behavior led to the development of more advanced seismic codes.

Today, the principles of capacity design together with the concepts of ductile behavior allow a safe and cost effective earthquake resistant design. The latest efforts of seismic code development were mainly focused on internationally harmonized standards like ISO 3010, Eurocode 8, and UBC.

Unfortunately, even today, the seismic provisions of the building codes are not always respected; this is due to either ignorance, indifference, convenience, or negligence. Moreover, appropriate official controls and checks are lacking. Buildings that are very vulnerable and at risk from even a relatively weak earthquake continue to be built today. Investigations of existing buildings (e.g. [La 02]) showed however, that enforcing the building code requirements makes it possible to significantly reduce the seismic vulnerability of buildings with no significant additional costs while improving their resistance against collapse.

The ignorance or disregard of the seismic provisions of the building codes, even if only partial, can result in an inferior building [Sc 00]. The reduction in value may include, among other things, the costs of retrofitting minus the additional costs that would have been incurred to ensure the seismic resistance of the building at its design and construction stage. The designers can be responsible for retrofitting costs, as well as jointly liable with the building owners for loss of life , injury or for any resulting material damage in the case of an earthquake. A retrofit generally costs several times more than what it would have cost to ensure adequate seismic resistance of the new building. Considerable costs may also be incurred by disruptions of the building's use, such as temporary evacuation and business interruption. Furthermore, determining the responsibility of the architect and engineer can necessitate lengthy and complex legal procedures. The building owner, the architect, the engineer, and the authorities therefore have a vested interest in ensuring that the seismic provisions of the building codes are strictly enforced, and that appropriate structural calculations and verifications are kept with the construction documents

Many building collapses during earthquakes may be attributed to the fact that the bracing elements, e.g. walls, which are available in the upper floors, are omitted in the ground floor and substituted by columns. Thus a ground floor that is soft in the horizontal direction is developed (soft storey). Often the columns are damaged by the cyclic displacements between the moving soil and the upper part of the building. The plastic deformations (plastic hinges) at the top and bottom end of the columns lead to a dangerous sway mechanism (storey mechanism) with a large concentration of the plastic deformations at the column ends. A collapse is often inevitable.

Figure 9.1. This sway mechanism in the ground floor of a building under construction almost provoked a collapse (Friaul, Italy 1976).

Figure 9.2. Sway mechanisms are often inevitable with soft storey ground floors (Izmit, Turkey 1999).

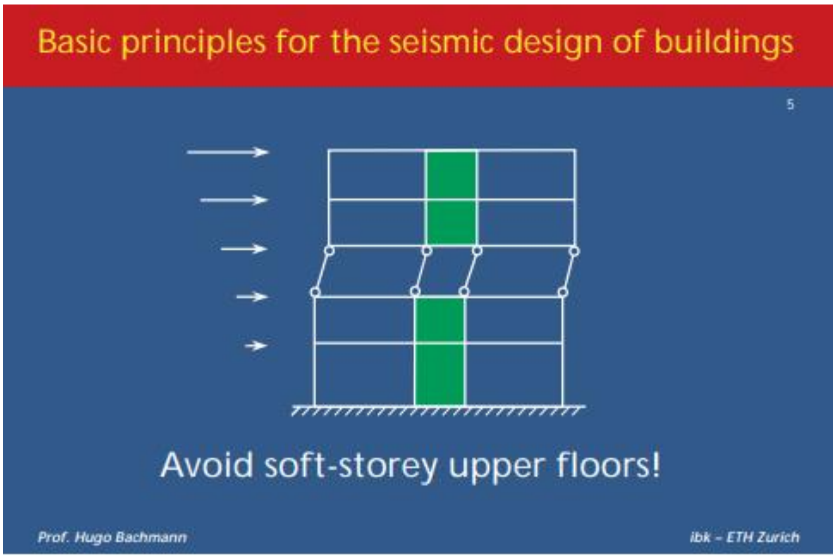
Figure 9.3. Here the front columns are inclined in their weaker direction, the rear columns have failed completely (Izmit, Turkey 1999).

Figure 9.4. The well-braced upper part of the building collapsed onto the ground floor

Figure 9.5. This multi-storey building escaped collapse by a hair's-breadth…

Figure 9.6. … and these are the remains of the left edge ground flour column (Kobe, Japan 1995).

Figure 9.7. …thanks to resistant columns with well detailed stabilising and confining reinforcement (Taiwan 1999).



An upper storey can also be soft in comparison to the others if the lateral bracing is weakened or omitted, or if the horizontal resistance is strongly reduced above a certain floor. The consequence may again be a dangerous sway mechanism.

Figure 9.8. In this commercial building the third floor has disappeared and the floors above have collapsed onto it (Kobe, Japan 1995).

Figure 9.9. In this office building also, an upper storey failed. The top of the building has collapsed onto the floor below, the whole building rotated and leaned forwards.

Figure 9.10. This close-up view shows the crushed upper floor of the office building (Kobe, Japan 1995).

10-LECTURE. The main requirements for the constructive solution of buildings and structures

Experience in past earthquakes has demonstrated that many common buildings and typical methods of construction lack basic resistance to earthquake forces. In most cases this resistance can be achieved by following simple and inexpensive princi-ples of good building construction practice. Adherence to these simple rules will not prevent all damage in moderate or large earthquakes, but life threatening collapses should be prevented, and damage limited to repairable proportions. These principles fall into several broad categories:

a) Planning and layout of the building involving consideration of the location of rooms and walls, openings such as doors and windows, the number of storeys, etc. At this stage, site and foundation aspects should also be considered.

b) Layout and general design of the structural framing system with special attention to providing lateral resistance, and c) Consideration of highly loaded and critical sections with provision of reinforcement as required.

Importance of building

The importance of a building should be a factor in grading it for earthquake strength purposes, and the following buildings are classified into two groups:

- IMPORTANT -Hospitals, clinics, communication buildings, fire and police sta-tions, water supply facilities, cinemas, theatres and meeting halls, schools, dor-mitories, cultural treasures such as museums, monuments and temples, etc.
- ORDINARY -Houses, hostels, offices, warehouses, factories, etc.

Classification of foundation soil

Four soil profile types are considered here as shown in Table 3.2.

Buildings can be constructed on hard, medium and soft soils, but it is dangerous to build them on weak soils. Weak soils must be avoided or compacted to improve them so as to qualify at least as medium or soft.

Table 3.2: Classification of soil

Soil profile	Ground Characteristics: Description	V_s (m/s)	N_s	N_a* (t/m²)
Hard	Rock, deposits of very dense sand, gravel, or very stiff clay, etc.	> 400	> 50	50
Medium	Deposits of dense or medium-dense sand, gravel, or stiff clay, etc.	400 ~ 200	50 ~ 15	20
Soft	Deposits of loose-to-medium cohesionless soil, or soft-to-firm cohesive soil, etc.	< 200	< 15	5
Weak	Very soft soil that is liable to large differential settlement, or liquefaction during an earthquake	–	–	–

Combination of parameters

For defining the categories of buildings for seismic strength purposes, four categories I to IV are defined in Table 3.3 in which category I requires maximum strength and category IV the least. The general planning and design principles are, however, equally applicable to all categories.

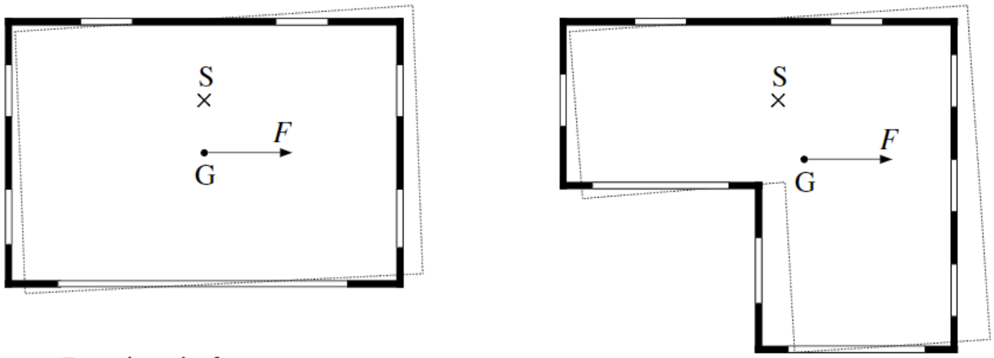
Table 3.3: Category of buildings for seismic strength purposes

Building category	Combination for the category		
	seismic zone*	building**	soil profile***
I	A	important	soft
II	A	important	medium to hard
	A	ordinary	soft
	B	important	soft
III	A	ordinary	medium to hard
	B	Important	medium to hard
	B	ordinary	soft
	C	important	soft
IV	B	ordinary	medium to hard
	C	important	medium to hard
	C	ordinary	soft

Plan of building

a) Symmetry: The building as a whole or its various blocks should be kept symmetri-cal about both X and Y axes. Asymmetry leads to torsion during earthquakes and is dangerous (see Fig. 3.1). Symmetry, as far as possible, is also desirable in the plac-ing and sizing of door and window openings.

Torsion or twisting of unsymmetrical plans



F: earthquake force,
S: centre of stiffness or resisting force,
G: centre of gravity or applied inertia force

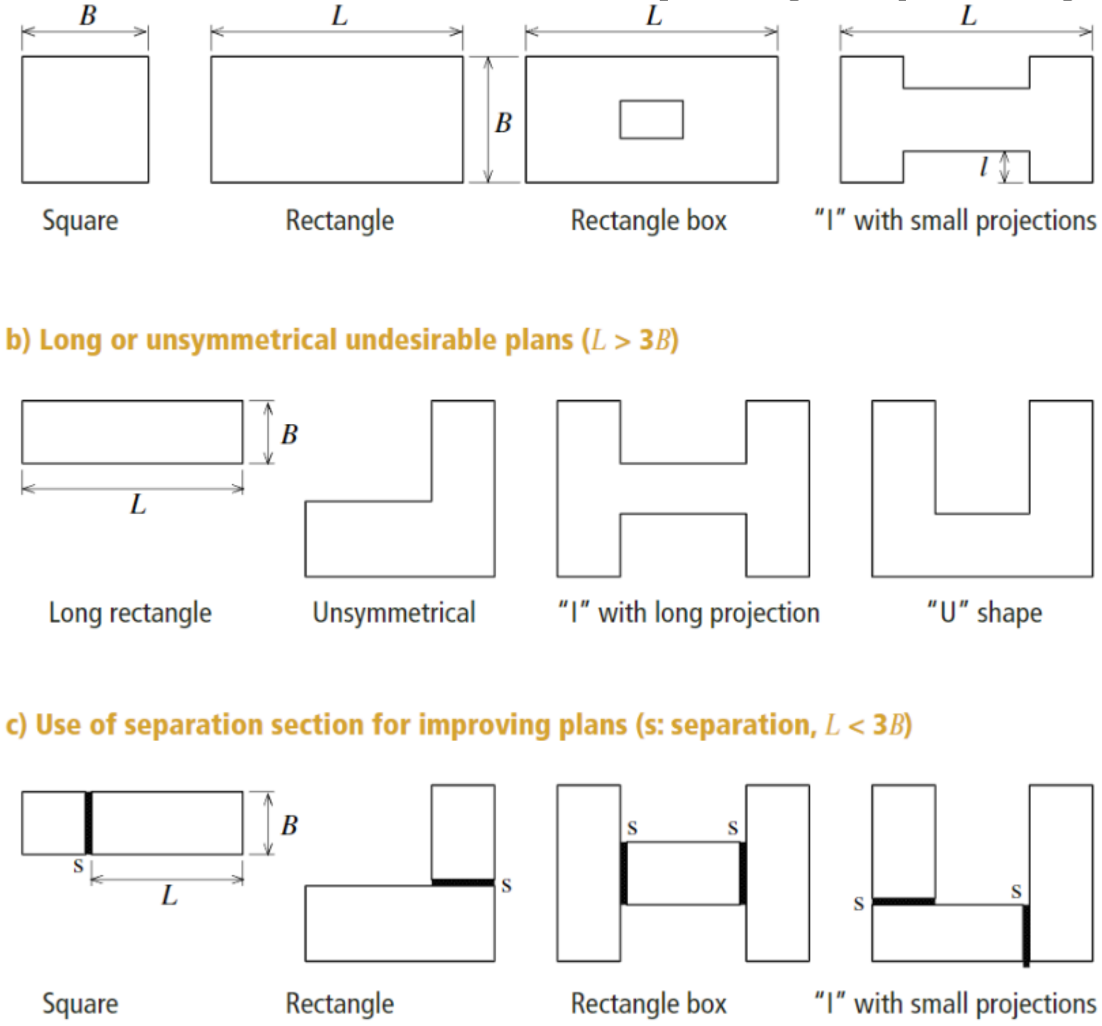
b) Regularity: Simple rectangular shapes (see Fig. 3.2 a) behave better in an earth-quake than shapes with projections (see Fig. 3.2 b). Torsional effects of ground mo-tion are pronounced in long narrow rectangular blocks. Therefore, it is desirable to restrict the length of a block to three times its width. If longer lengths are required two separate blocks with sufficient separation between should be provided (see Fig. 3.2 c).

c) Separation of Blocks: Separation of a large building into several blocks may be required so as to obtain symmetry and regularity of each block. For preventing hammering or pounding damage between blocks a physical separa-tion of 30 to 40 mm throughout the height above the plinth level will be adequate as well as practical for up to 3 storey buildings (see Fig. 3.2 c).
The separation section can be treated just like expansion joint or it may be filled or covered with a weak material which would easily crush and crumble during earth-quake shaking. Such separation is more practical in larger buildings since it is less convenient in small buildings.

d) Simplicity: Ornamentation involving large cornices, vertical or horizontal cantile-ver projections, facia stones and the like are dangerous and undesirable from a seis-mic viewpoint. Simplicity is the best approach. Where ornamentation is insisted upon, it must be reinforced with steel, which should be properly embedded or tied into the main structure of the building.

e) Enclosed Area: A small building enclosure with properly interconnected walls acts like a rigid box, since long walls are supported by transverse walls to prevent out-of-plane failure of the walls and to increase their lateral strength. Structurally it is advisable to have separately enclosed rooms rather than one long room (see Fig. 3.3). For masonry walls of thickness t and wall spacing of a, the ratio of a/t = 40 should be the upper limit between the cross walls for mortars of cement : sand = 1:6 or richer, and less for poor mortars. For larger panels or thinner walls, framing elements should be introduced as shown in Fig. 3.3 c).
f) Separate Buildings for Different Functions: In view of the difference in impor-tance of hospitals, schools, assembly halls, residences, communication

and security buildings, etc., it may be economical to plan separate blocks for different functions so as to lessen the cost in providing earthquake strength.

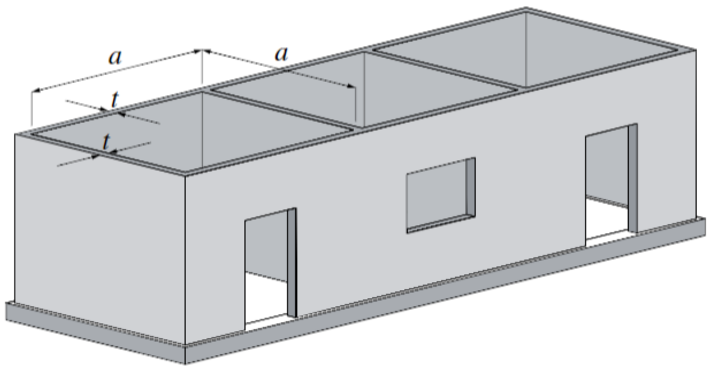


Structural design

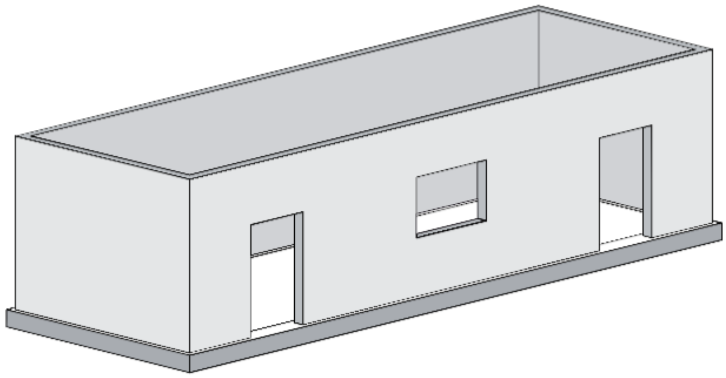
Ductility (defined in Sec.3.6) is the most desirable quality for good earthquake per-formance and can be incorporated to some extent in otherwise brittle masonry con-struction by introduction of steel reinforcing bars at critical sections as indicated in Chapters 4 and 5.

Enclosed areas forming box units

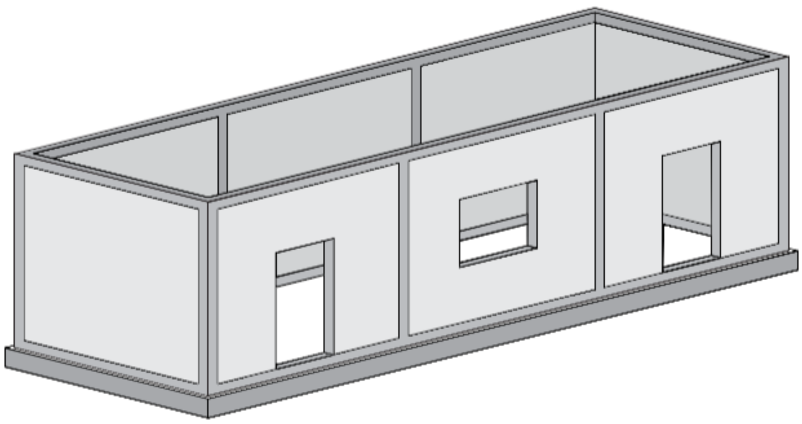
a) Many crosswalls, small boxes, seismically strong (Wall length and thickness ratios should be a/t < 40, or framing be used as c) below.)



b) No crosswalls, large box, seismically weak



c) Wall with framing elements (usually reinforced concrete)



It is not unusual during earthquakes that due to snapping of electrical fittings short circuiting takes place and gas pipes develop leaks and catch fire. Fire could also be started due to kerosene lamps and kitchen fires. Post-earthquake fire damage can be more serious than the earthquake damage due to ground shaking. Buildings should therefore preferably be constructed of fire resistant materials.

11-LECTURE. Earthquake resistance of frame buildings

Earthquake resistance of frame buildings. Pardevors. Stairs and elevators. Principles of design of frame buildings

Detailed buildings have been used in Central Asia since ancient times. The cymbals were made of different wooden materials in those times. History has repeatedly confirmed that such buildings are resistant to earthquakes. Therefore, it is absolutely natural that the idea of meticulousness enters modern architecture with bold steps.

As science and technology developed, it was also reflected in meticulousness in the appearance of progressive construction materials such as metal and reinforced concrete in construction. Now the buildings are not rebuilt from wooden beams, but from steel or reinforced concrete beams. The physical and mechanical properties of the new materials, the possibilities of use are fundamentally different from wooden materials, and the structural schemes of the woodwork made from them are also different from the previous ones. It is mainly used in constructions of reinforced concrete and partially steel-framed buildings. From now on, instead of the term "sinch", we will use the term "frame", which is used in modern technical literature.

The calculation and design principles of frame buildings intended for seismic regions are the same as for non-seismic regions. The difference is that buildings in seismic regions are subjected to seismic forces outside of normal calculation, and constructive measures are determined accordingly.

The frame of the building is made up of a column, a beam and a cover, and when they are firmly connected to each other, a single, whole spatial system is formed. All elements accept both vertical and horizontal (seismic) forces. Walls are hammered between the frames. Walls are involved in frame work to one degree or another. Depending on the length of the wall structure and the method of connecting it to the frame, the calculation schemes of frame buildings differ.

The first of them is a scheme in the form of a simple frame (one-node spatial frame). According to this scheme, the column, rigel and cover discs are connected to each other; the walls do not interfere with the deformation of the frame during seismic effects. In this case, the integrity and superiority of the building is ensured by the edge of the frame. The specific weights of the walls and walls are taken into account when calculating inertial masses.

The second scheme has the appearance of a link frame. The difference from the previous one is that in this scheme, additional connections (svyaz) are inserted diagonally in order to increase the horizontal integrity of the frame. Connections are usually made of metal. Part of the horizontal forces are transferred from the columns to the connections. The strength of the connecting frames is smaller than the previous one.

The third scheme includes frames with a single aperture. Sometimes, in order to increase the overall uniformity of the building, solid walls are restored between the frames, along the entire contour. In such buildings, the walls (single diaphragm) work together with the frame during an earthquake. As a result, single diaphragms on the one hand limit the deformation of the building, and on the other hand, accept large parts of the seismic forces.

Depending on the strength of single diaphragms, two points can be found in the work of frame buildings:

1. The building frame only supports vertical loads, seismic forces are absorbed by single walls (diaphragms). In this case, the seismic strength of the building is ensured only by single diaphragms. Therefore, diaphragms must be calculated and designed to withstand the entire seismic force;

2. The strength of the single diaphragm is not enough to accept the seismic force. In this case, the seismic forces are accepted until the single diaphragms are damaged, and then the frame starts to work. Damaged diaphragms absorb some of the energy transmitted from the vibrating ground to the upper part of the building. The rest of the earthquake energy is transferred to the frames. The failure of single diaphragms changes the dynamic characteristics of the building. In this case, the carcasses should be counted as frames.

It is recommended to use the next two schemes of frame buildings, that is, connecting frames and single-diaphragm frames in multi-story buildings, as well as in places with high seismic forces.

Diaphragms, connectors and single cores that accept horizontal seismic loads must be continuous along the entire height of the building, lie in orthogonal directions and be symmetrically located with respect to the center of gravity of the building.

It is not necessary to install a diaphragm at the level of the technical floor above. In buildings with a composite diaphragm, the load should be transferred from the upper connecting panel directly to the lower panel, bypassing the intervening monolithic concrete layer.

If the length of the building or buildings with a single core is more than 24 m, at least two single cores are kept in the fall.

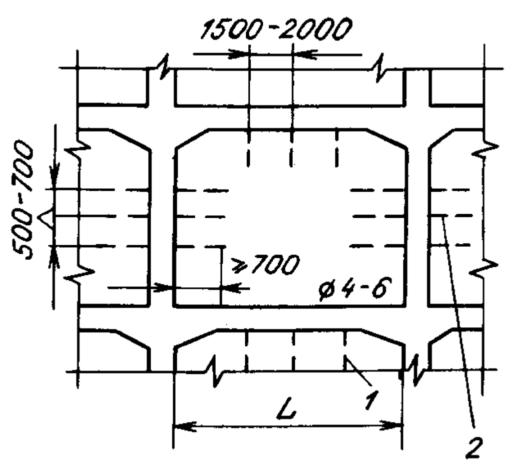


Figure 11.1. Attaching the wall to the frame: 1 – connections; 2 fittings

Frame buildings also differ depending on the method and material of restoration. For example, there are reinforced concrete and metal frames; Reinforced concrete frames can be made monolithic, monolithic and prefabricated.

The outer walls of frame buildings built according to the frame scheme are designed in the form of standing or hanging panels. The length of the large hanging panels is equal to the distance between the columns.

Suspended panels are made of light and porous concrete. In frames with a single diaphragm, the walls must be carefully attached to the frame elements. Reinforcements protruding from columns and crossbars are taken between wall studs (Fig. 6). When the space between the frames is filled with monolithic concrete, they are connected to such fittings. If the single diaphragm is made of reinforced concrete panels, the panel is attached to the column and crossbars with a welding rod. In turn, the reinforcement is removed from the sides to connect the covering plates to the frames and to each other. After the reinforcements are welded, concrete is poured on top of it.

Light concrete blocks, stones or rocks, or soil materials can be used as non-compacting fillers in frame work. In this case, an open seam of at least 20 mm should be made between the filler and the frame, and measures should be taken to ensure that the filler does not shake during an earthquake.

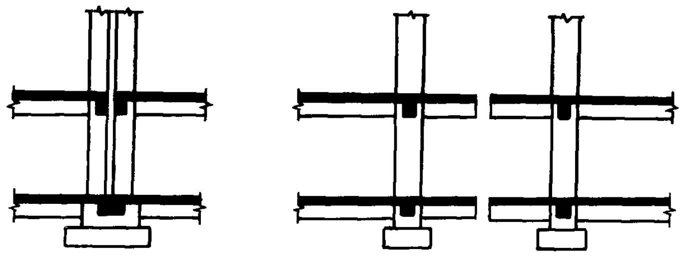


Figure 11.2. Anti-seismic joints in frame buildings

The raised seam is filled with elastic material. The priority and durability of the filler is ensured by its reinforcement in horizontal and vertical directions, by the use of frame elements and fasteners. It is very convenient if the foundations of frame buildings are made in the form of a solid slab or a reinforced concrete tape. If the foundation is made separately for each column, then it is necessary to connect the outer columns with the help of rods. In 9-point regions, all foundations (internal and external) are interconnected.

Building blocks (parts of the building) are separated from each other with the help of anti-seismic joints.

Anti-earthquake seams should be separated along the entire height of the building. It is not allowed to have a seam in the foundation, except for the case where the earthquake resistant seam coincides with the subsidence seam. Temperature and subsidence seams should be combined with earthquake resistant seams.

The distance between earthquake-resistant seams should not exceed 150 m. When the calculated seismicity is 7 points, one-story frame buildings (compartments) with a longitudinal length exceeding 144 m, 8 points - 120 meters, 9 points - 96 m should be accepted. For multi-storey industrial buildings, the size of buildings (compartments) is taken as in non-seismic regions. Buildings higher than 5 floors will be built in the regions with a seismicity of 9 points only if agreed upon.

Earthquake-proof joints of frame industrial buildings are made by connecting double columns.

The width of the seam against the earthquake should be determined in accordance with the calculated seismic stress in the selected direction. The width of such a seam (mm) is determined depending on the height of the building and is determined by the following formula:

$$\alpha = \Delta_1 + \Delta_2 + 20 \text{ mm}$$

where: Δ_1 va Δ_2 – maximum displacements (mm) of two connecting frames of a building (partition) separated by an earthquake-resistant seam under the influence of calculated horizontal seismic stresses.

If the height of the building is up to 5 m, the seam width should not be less than 30 mm. The width of the high-rise building's earthquake resistance seam should be increased by 20 mm for every additional 5 m of height.

The filling of earthquake-resistant seams should not hinder the movement of building units in the horizontal direction.

The building's prefabricated reinforced concrete walls and ceilings should be integrated and uniform in the horizontal plane, as well as connected to the vertical structure.

It is possible to ensure the integrity of the precast reinforced concrete structure of the building in the following ways:

A) connecting the intermediate plates and burning the cement joint between the plates;

B) construction of fasteners that accept tensile and shear forces that appear at the seam between plates and frame elements.

Precast-monolithic and precast versions of the reinforced concrete frame are very widespread in seismic regions.

There are several ways to divide precast reinforced concrete frames into separate elements. The most common of these is dividing the frame into linear elements. In this case, linear elements are connected to each other at the node. Manufacturing, transportation and installation of linear elements at the factory is very easy. In order to reduce the number of connecting elements at the node, the columns are lengthened (2-3 stories high).

12-LECTURE. Earthquake resistance of brick-walled buildings

The experience of past earthquakes shows that if they are properly calculated, designed and constructed in full compliance with construction rules, brick-walled buildings can withstand seismic forces to a sufficient degree.

The building resists the earthquake forces as a whole spatial structure only if all the load-bearing structures (bending and day walls, covers) are firmly connected with each other. If this bond does not exist or is weak, the lateral walls can separate from the internal walls and in some cases fall. Behind the wall, the media also press completely or partially. In buildings where anti-seismic measures are not used, such events are expected. Special constructions that have passed the test are used to preserve buildings in an earthquake. For example, anti-seismic belts are made along the perimeter of the building, covers are carefully connected to each other and to the walls, reinforcement is placed at the corners and intersections of the walls, etc.

Let's get acquainted with the main structural measures aimed at increasing the seismic strength of brick-walled buildings.

In general, anti-seismic measures used in brick-walled buildings, on the one hand, are aimed at strengthening the connections between separate structural elements during an earthquake, and on the other hand, at increasing the strength of load-bearing structures.

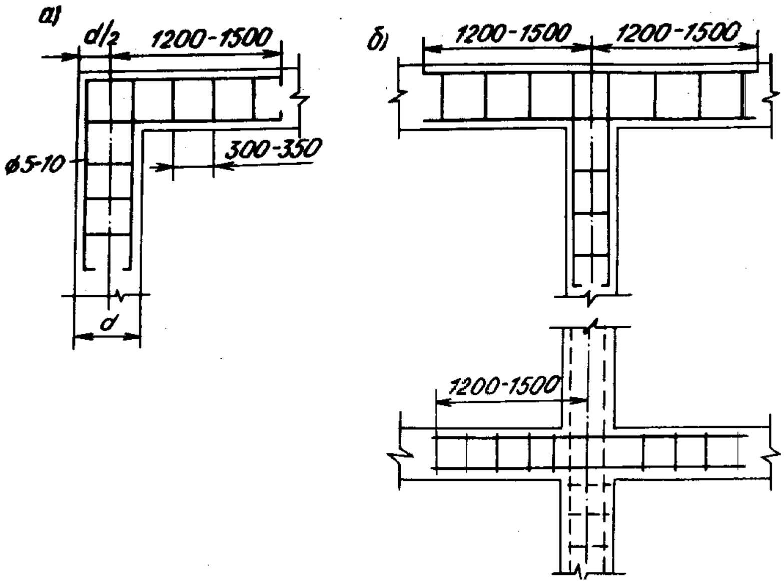


Figure 12.1. Joints of longitudinal and transverse walls: a) corners, b) intersections

The spatial uniformity of the buildings is mainly ensured by the work of the coverings. Covers act as horizontal diaphragms and distribute seismic forces to load-bearing structures (walls). Such a distribution, consequently, the seismic strength of the building depends in many respects on the uniformity of the covering in the plane. At present, in the construction of brick-walled buildings, prefabricated reinforced concrete slab coverings with multiple bushings are widely distributed.

In order to prevent the panels from shifting, a shim is used; for this, a cement mixture is burned in the niches raised on the side of the panels. These clamps absorb the compressive forces generated in the joints between the panels.

In addition, in order to accept bending forces, a reinforced concrete bond is used to ensure the integrity of the panel plane. Covering panels are attached with fasteners using reinforcement loops. Where there are reinforced concrete connections, it is possible if the connection between the panels is not burnt.

In brick-walled buildings, the junction of the lateral and transverse walls is considered a sensitive area. Tendencies tending to separate the walls in two directions are concentrated in these places. In order to strengthen the connection of the walls in two directions, a wire is laid on the horizontal seams at the joints (Fig. 9). The wire types are 1.5-2.0 m long and are placed in 7-8 point seismic regions - every 50 cm.

Anti-seismic belts made of reinforced concrete are widely used for the purpose of strengthening the interconnection of walls. K.S. Zavriev proposed the idea of using anti-seismic belts in buildings built in seismic regions. Such belts are passed along all side and side (internal and external) walls and laid at the height of the ceiling of each floor; it is closely connected with walls and covers and forms a single closed system. Anti-seismic belts play an important role in increasing the seismic strength of brick-walled buildings. Anti-seismic belts strengthen the interconnection of walls; increases the hardness of the walls in the plane: ensures an increase in the uniformity and monolithicity of the coverings.

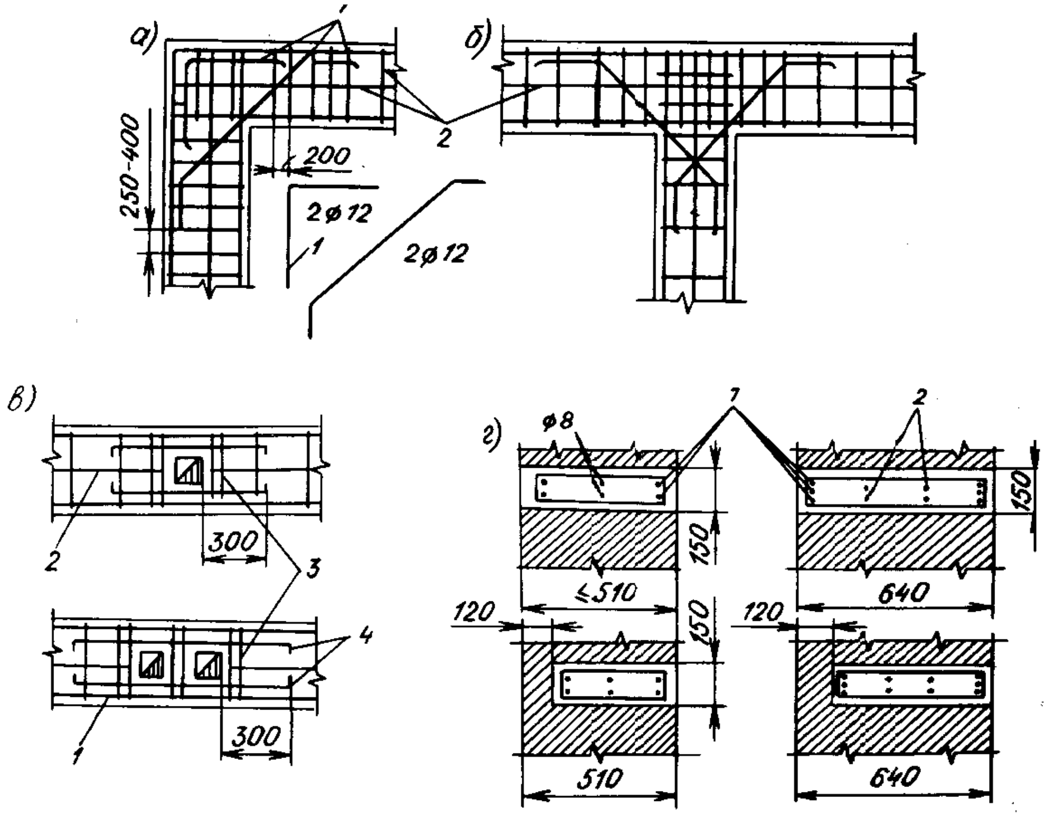


Figure 12.2. Details of anti-seismic belts:

a – building corner; b - junction of external and internal walls; v - places where the channel has won; 1-main fixture; 2-mounting armature; 3-hooks; 4 additional fixtures.

Reinforcement is laid on the belts along the entire perimeter and connected with a ∅4-6 steel clamp every 25-40 cm. A-1 class steel is used as reinforcement, and their amount should not be less than 4∅10 in seismic zones with 7-8 points, and 4∅12 in 9-point zones. The class of concrete to be poured should not be lower than V15. It is recommended to burn Stergens in the corners and intersections. Some details of anti-seismic belts are shown in Fig. 10. The width of the arches is multiplied by the width of the walls; if the width of the wall is more than 50 cm, the width of the belt can be taken 10-15 cm smaller than that of the wall. The height of the belt should not be less than 15 cm. Due to the fact that there is no load on the belts installed at the roof level of the highest floor of the building, the belt can move from the urn when the ground settles. To prevent this, a 25-30 cm length of reinforcement is pulled out from the arch up and down every 50 cm along the length of the wall. You can also use a key instead of the armature. For this purpose, a 14x14x30 cm hole is made in the wall of the arch, a vertical reinforcement is placed in the arch, and concrete is poured into the arch and the arch. In the places where pipes and ventilation ducts pass, the belts are strengthened with the help of additional reinforcements.

Above, it was mentioned that because the walls are made of brittle materials, their resistance to earthquake forces is low compared to reinforced concrete constructions. In fact, the stress points that occur when the ground moves are less dangerous for reinforced concrete structures than for masonry walls. Based on this, experts consider it appropriate to install reinforced concrete elements - beams in the vertical direction between the walls, to create a complex construction. Reinforced concrete beams significantly increase the load-bearing capacity of the walls. In order to ensure that the remotes work in cooperation with the wall, a 50 cm long armature is placed between the remote and the wall; and the end of the long one is concreted with an anti-seismic belt. The cross-section and fittings of vertical reinforced concrete beams are determined according to the calculation results, depending on the amount of force acting on the wall. The dimensions of non-load-bearing walls and walls (part walls) are taken on the basis of the norms established for non-seismic regions.

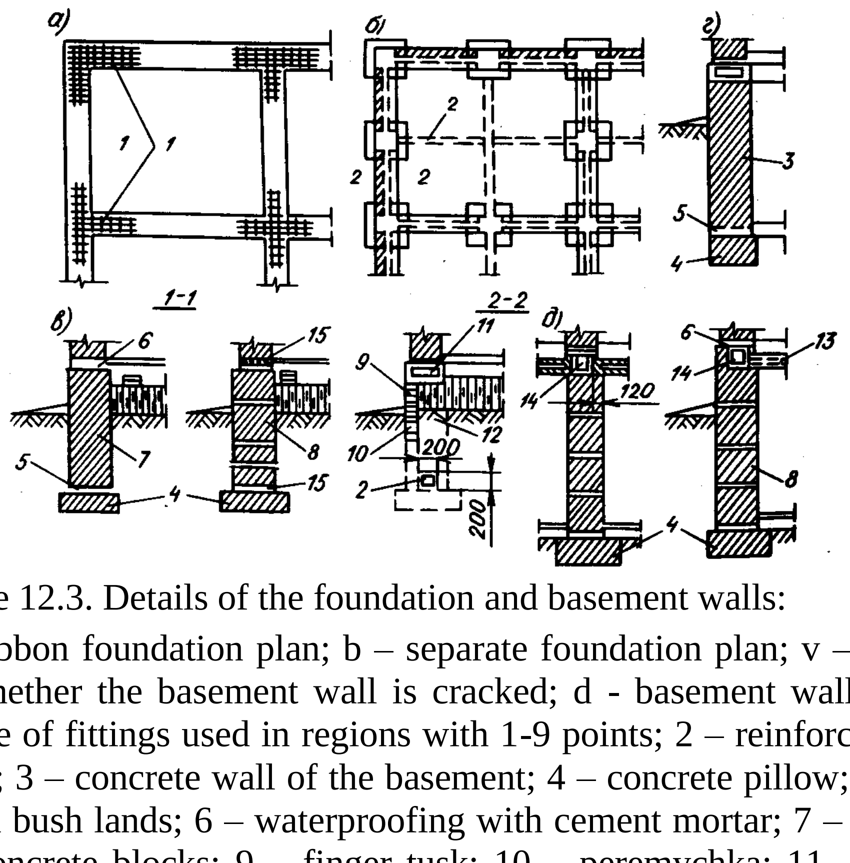


Figure 12.3. Details of the foundation and basement walls:

a – ribbon foundation plan; b – separate foundation plan; v – foundation cuts; g - whether the basement wall is cracked; d - basement wall with large blocks; Type of fittings used in regions with 1-9 points; 2 – reinforced concrete connections; 3 – concrete wall of the basement; 4 – concrete pillow; 5 – type of wire used in bush lands; 6 – waterproofing with cement mortar; 7 – foundation; 8 – large concrete blocks; 9 – finger tusk; 10 – peremychka; 11 – reinforced concrete tusk; 12 - columnar base; 13 – closure; 14 – monolithic reinforced concrete connection; 15 – different types of cement mixture.

Thin walls made of brick should be reinforced by burning reinforcement every 70 cm in the regions with 8-9 points. Ducts must be fixed to walls and ceilings.

Most of the earthquakes that have occurred show that foundations and basement walls are less damaged than other structures when the ground shakes; however, if they are designed and built correctly, the seismic strength of the building will increase.

It is appropriate to build tape foundations under load-bearing brick walls (Fig. 11, a). If the foundations are reconstructed from large blocks, then it is necessary to pay special attention to the interlocking of the blocks. Materials used in non-seismic regions are also used for foundations in seismic regions. In this case, however, the use of large stones is limited to the whole smooth surface; they can be used in one-story buildings with a height of up to 5 m in 7-point zones. The depth of the foundation is taken as in non-seismic regions.

If the foundations are columnar, then all of them are interconnected with the help of a reinforced concrete beam. The waterproofing layer, which is burned under the brick walls, is made of cement mixture. It is not allowed to use rolled materials such as willow and ruberoid as a waterproofing layer.

When the calculated seismicity is 9 or more, it is recommended to carry loads in cold temperatures and to cover the masonry or stone walls with ash (even if they are reinforced with reinforcement or reinforced concrete).

When the calculated seismicity is less than 9 points, additional reinforcement is required, which ensures that the cement mixture can withstand the cold temperature when the concrete work is carried out.

It is allowed to use the following items and materials in the restoration of load-bearing and self-bearing walls or filling between frames:

1. Whole grain of not less than 75 or holes with holes up to 14 mm;

2. earthen stones with a grade of not less than 75 when the calculated seismicity is 7 points, at least 100 when the calculated seismicity is 8 and 9 points, with up to 20% voids;

3. concrete stones, solid and bushy blocks of grade 50 or more (including lightweight concrete with a density of about 1200 kg/m3);

4. Shaped stones and blocks made of chiganoktostone and limestone with a grade of not less than 35.

If the wall stones are collected in ash, then the brand of cement mixture is 25 in summer and 50 in person.

Vertical reinforced concrete elements (beams) in complex constructions should be attached to anti-seismic belts and at least one side should be exposed when installed. The beams should be installed at the edge of the beams, at least every 5 m on solid walls.

The junctions of the walls are reinforced with reinforced concrete blocks, the distance between the wall and the intersection should not exceed 2 m. It is necessary that the class of long concrete is higher than B12.5, and the grade of the wall compound is not lower than 50.

The stairwells must be fastened to the wall by at least 250 mm.

It is necessary to fasten the steps, cosaurs, folding marches, and cover the stairwell in the fall. It is not allowed to install console units fixed to the wall. Door and window openings in brick-walled stairwells must be covered with a reinforced concrete frame in zones 8-9.

13-LECTURE. Earthquake resistance of large panel buildings

The general requirements for ensuring the seismic strength of brick-walled buildings constructed in the previous topic also apply to large-block buildings. In resisting earthquake forces, the role of structural measures and closures, which ensure the equal functioning of all blocks, is extremely important.

The above-mentioned general requirements aimed at ensuring the seismic strength of brick-walled buildings also apply to large-block buildings. In resisting earthquake forces, the role of structural measures and closures, which ensure the equal functioning of all blocks, is extremely important.

The number of rows on the wall depends on the size of the blocks. For seismic regions, the option with two rows of blocks is appropriate.

One of the measures to ensure the seismic stability of large block buildings is the method of using vertical reinforcement on the banks of the block (Fig. 48). Reinforcement nails are passed from the foundation to the cornice along the grooves left on the side edges of the wall blocks. Special holes are left in the peremichka blocks for vertical fittings. After the reinforcement is placed, concrete is placed on the beams. Reinforcement wedges are welded to rings (scoba) fastened to the block.

The advantage of the two-row silicalite block buildings, which are common in the rural construction of Uzbekistan, is that they use T and corner blocks at the junction of the longitudinal and transverse walls. Vertical seams are reinforced from the base to the rounding belt of the attic cover. A dowel is formed from the hooks protruding from the side surface of the wall blocks. Figure 49 shows part of the building plan and connection nodes of wall blocks. After the reinforcing bars are installed, the vertical cylindrical space between the blocks is filled by pouring concrete.

Another measure that increases the seismic strength of large-block buildings is to lay reinforced concrete between the blocks. For this purpose, a vertical element of the screed is placed between the wall blocks, and a horizontal element is placed between the peremichka block and the cover. Reinforcements are welded to each other to connect the concrete elements, and then the joints are filled with concrete (Fig. 50). Block walls are more resistant to earthquakes than brick walls. Because concrete is a harder material than brick, a block wall is harder than a brick wall. Peremichka blocks work like reinforced concrete belts. As for the vertical fittings that serve to strengthen the walls, their installation is somewhat easier compared to brick walls, and does not interfere with the installation of blocks.

Large-panel buildings are widely used in seismic and non-seismic regions due to the large possibilities of industrialization. The light weight of the building (1.2-2 times lighter compared to buildings with brick walls), the strength of the wall material, the simplicity of the load-bearing constructions and the fact that they are evenly distributed on the plan are the advantages of large panel houses, and they are a great way to quickly enter seismic zones. revealed.

The depth of the foundation is taken as in non-seismic regions. Tape foundation work is suitable for load-bearing walls. Foundations can be made of monolithic or prefabricated concrete.

It is attached to the fittings protruding from the lower walls of the building or basement walls. If the foundation is prefabricated, a monolithic reinforced concrete pad is made under the wall. If the ground is not available, the precast concrete blocks are connected to each other by means of a 100 mm thick reinforced concrete belt. External and internal walls are installed on the arch, welded reinforcements are welded, and it is rounded with V15 class concrete. Basement walls are constructed from 140 mm thick concrete grade V15 panels; reinforcements protruding from the edges of the panels allow them to be firmly connected to the elements of the roof along the vertical and horizontal seams.

The construction of external wall panels used in seismic regions can be one- and three-layer. Single-layer panels are usually made of expanded clay concrete or other types of lightweight concrete. Two outer layers of three-layer panels are made of reinforced concrete, and the outer layer is made of heat-insulating materials such as mineral wool and foam concrete. A layer of reinforced concrete with three-layer panels facing inward is considered a load-bearing layer. Its thickness is determined by calculation, this thickness should not be less than 8 cm for regions with 7-8 points and 10 cm for regions with 9 points. The inner and outer layers are connected with the help of a reinforced concrete pipe. Internal walls should be made of single-layer plaster, and the thickness of the panel should not be less than 12

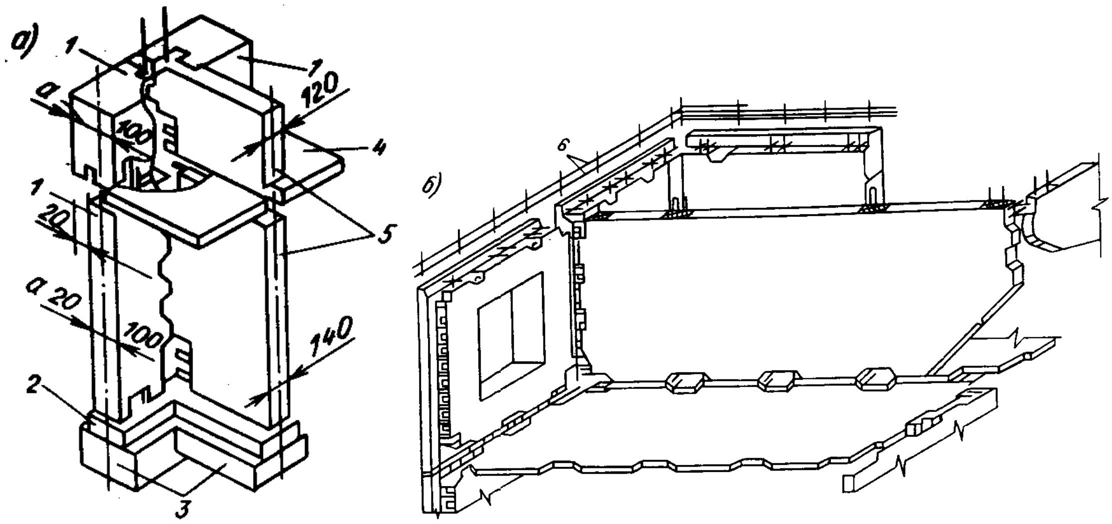


Figure 13.1. Large panel building structures: a - connection of foundation and wall; b - connection of walls and covers; 1 – outdoor courtyard panels; 2 – monolithic reinforced concrete belt; 3 – foundation blocks; 4 – closing panel; 5 – internal wall panels; 6 – rounding belt frame.

Wall panels used in seismic areas are reinforced with steel reinforcement in the form of a space frame. In buildings with a height of up to 5 floors, which are built in 7-point zones, the fittings can be installed on one floor.

A certain part of the fittings should protrude from the wall panels; it is necessary to connect the kushni panels and cover panels (Fig. 12,b). After the reinforcements are welded together, the joints are filled with concrete.

It is necessary that the structural solutions of the joints accept the calculated delays. Sections of metal fasteners welded to panel seams are determined with a calculation method. For a 1 m seam, their smallest section should be 0.5 cm2/m in zones 7 and 8, and 1.0 cm2/m in zones 9. The diameter of fasteners should not be less than 10 mm.

Covering panels of earthquake-resistant buildings should be made in the size of the room and attached to the wall with a turttala kirra. It is allowed to use tusin tiles in public buildings with large panels. Covering slabs should be designed as a single spatial system that can accept seismic loads by connecting the transverse and transverse walls. Cladding panels are made of solid or bushy plates. Solid slabs are considered the best construction because they are easy to connect with adjacent coverings and walls. If the cover consists of separate elements, the elements must be firmly connected to form a single horizontal disc that can distribute seismic forces. For this purpose, nests, eaves and open fittings are raised from the edges of the panels. Reinforcements are welded to the elements of each element, and concrete is poured into the nests. As a result, the resulting wedge resists the sliding and breaking of adjacent panels.

The tension surface of integral covering plates depends on the thickness of the wall panels. If the thickness of the panel is 12, 14 and 16 cm, then the tension distance is at least 5, 6 and 7 cm. Covering panels are installed on a layer of cement mortar with a grade of more than 100, which is laid on top of the wall panels. This ensures that the weight of the elements of the upper floor is transferred to the walls of the lower floor in a uniform manner.

If the closures rest on the outer wall or the walls of anti-seismic and temperature seams, the ends of the reinforcement protruding from the closure panels are welded to the vertical reinforcements of the wall panels.

Continuous horizontal reinforcement (at least 2□12) attached to the upper part of the wall panels of the public buildings with burnt-out cover plate should be kept in the fall.

14-LECTURE. Earthquake resistance of monolithic buildings

Structural systems with intersecting walls are used in the design of buildings to be reconstructed from monolithic concrete. Closures can be monolithic or composite. It is also allowed to use prefabricated reinforced concrete slabs that act as beams.

Load-bearing internal walls of monolithic buildings and structures are made of heavy or light concrete of at least B 7.5 class and average density of not less than 1700 kg/m^3, and in districts with a seismicity of more than 9 points and 9 points shall be restored from concrete of at least class B15.

External walls are made of one or more layers of monolithic concrete of class V 5. As such walls, it is possible to use composite panels or granular materials. The heat-retaining layer is applied to the outer side of the load-bearing layer. The height of the floor should not exceed 20 in relation to the thickness of the wall, and the ratio of the length of the wall to the width between the windows should not exceed 2.5.

The beams should be designed in such a way that their load-carrying capacity in general sections is 1.25 times greater than the load-carrying capacity in normal sections.

The walls are reinforced with space frames, and horizontal and vertical beams are spread evenly.

At the level of prefabricated reinforced concrete covers, continuous reinforcement is laid on the inner and outer walls. The cross-section of the reinforcement is at least 1 cm2 when the calculated seismicity is 7-8 points, 2 at 9 points, at least 3 cm^2 at > 9 and 9 points.

The percentage of reinforcement of external and internal walls should not be less than 0.025% of the wall section. To improve the adhesion of old and new concrete, the surface of old concrete in the technological seam is specially treated.

III- PRACTICAL TRAINING MATERIALS

1-practical training. Determination of seismic forces according to normal document (CR 2.01.03-96).

Each country located in earthquake zones has its own normative documents for determining seismic forces. For example, UBC-97 in America, BCJ in Japan, EC8 in Europe, SniP II-7-81* and CP 14.13330.2011 in Russia are being used. In the Republic of Uzbekistan, from March 1, 1996, CR2.01.03-96 Construction in seismic areas (Construction norms and rules) was introduced in the territory of the Republic of Uzbekistan. From this day on, buildings and structures to be built in the earthquake-prone regions of our Republic will be designed, calculated and built on the basis of this official document.

According to CR 2.01.03 - 96, the estimated seismic force acting on the K-point of the structure according to the i-form of private vibrations of buildings and structures is determined by the following formula:

$$S_{ik} = K_o\ K_п\ K_{эт}\ K_p\ S_{oik} \quad (1)$$

$$S_{oik} = \alpha\ Q_k\ W_i\ K_\delta\ \eta_{ik} \quad (2)$$

Here, S_{oik} – the inertia (seismic) force generated when it is assumed that the structure is elastically deformed;

K_o – responsibility coefficient;

K_p – coefficient that takes into account the frequency of earthquakes.

K_{et} – coefficient depending on the number of floors of the building;

K_r – coefficient of regularity (regularnost);

α – seismic coefficient of the building area;

Q_k – building weight collected at point K in the calculation scheme;

V_i – is a spectral coefficient and is determined depending on the period of special vibrations of the designed object, the index of regions and the category of soil seismic properties. When determining the dynamic characteristics of buildings, it is necessary to take into account the elastic elasticity of the ground in terms of displacement and deflection.

K_δ – dissipation coefficient;

η_{ik} – the coefficient that depends on the form of specific vibrations when the building vibrates according to i-ton and the location of the loads in the calculation scheme;

K_δ - coefficient is determined from the following formula:

$$K_\delta = e^{(0{,}548 - \sqrt{\delta})(0{,}1 + \frac{0{,}7}{\sqrt{T_1}})} \quad (3)$$

here, δ – the decrement of vibrations, which is determined by natural testing of buildings similar to the ones being designed.

T_1 – period of particular vibrations of the building.

1. The following types of it can be used to receive seismic loads in frame buildings:
- single-node spatial framework;
- a space frame with a filler that absorbs a part of seismic loads;
- space frame with filler not designed to receive seismic loads;
- a space frame with a single core that fully absorbs seismic loads.
Vertical loads are usually received by the frame. Inter-floor coverings must be made of monolithic reinforced concrete, firmly connected with the core of the unit and ensure the joint operation of the whole system.
2. In districts with a seismicity of 7 points, the external part of the building is made of stone-brick, prefabricated or cast reinforced concrete walls, and the internal part is a single-node frame.
3. Diaphragms, connectors and single cores that receive horizontal seismic loads must be continuous along the entire height of the building, lie in orthogonal directions, and be located symmetrically with respect to the center of gravity of the building.

It is not necessary to install a diaphragm at the level of the technical floor above. In buildings with a composite diaphragm, the load should be transferred directly to the lower panel, bypassing the intervening monolithic concrete layer, from the upper connecting panel.

If the length of the building or buildings with a single core is more than 24 m (in case of seismicity >9 and 9* points - more than 18 m), at least two single cores are provided.

4. It is necessary to provide raised areas, metal or reinforced concrete consoles on the places where the prefabricated beams are attached to the columns.
It is not possible to connect the prefabricated elements of the frame by welding the parts that are inserted around the single node of the frame. The nodes of the frame of the frame are conditionally considered as short floating elements during the strength calculation process. When calculating the spatial frame node formed from the intersections of the column and longitudinal and transverse beams, the width of the transverse short element is assumed to be equal to the double width of the column section.

5. The following structures are used as external barrier walls of frame buildings:

- light hanging panels that do not prevent the deformation of the frame during an earthquake;

- self-supporting reinforced concrete or stone-brick walls attached to the load-bearing frame with flexible fasteners

In districts with a seismicity of up to 9 points, brick or stone fillers that accept or do not accept seismic loads can be used.

As fillers that do not participate in the frame work, you can use light concrete blocks, stones, bricks or earth materials. In this case, an open seam of at least 20 mm should be left between the filler and the frame, and measures should be taken to ensure that the filler does not fall during an earthquake.

The left seam is filled with elastic material. The priority and strength of the filler is ensured by its reinforcement in horizontal and vertical directions, the use of frame elements and fasteners.

It is not allowed to use non-reinforced stone-brick wall as frame filler in districts with seismicity > 9 and 9*. To strengthen the filler, it is recommended to reinforce the horizontal seams, use reinforced concrete cores, make the inner side of the wall with reinforced cement plaster or shotcrete in districts with a score of 9*.

6. In districts with a seismicity of up to 9 points, if the distance between the columns does not exceed 6 m and the compressive strength is not less than 50 kgk/cm2, self-supporting walls can be built from blocks, stones and bricks. If the distance between the load-bearing columns is greater than 6 m, additional columns with a step of no more than 6 m are placed. The free height of the self-supporting wall should not be higher than the height of the floor (building); In 7, 8, and 9 points, the height of the building should not exceed 9, 6, and 4.2 m, respectively, when the height of the building is 18, 16, and 9 m.

If the span of load-bearing columns is less than 6 m, it is allowed to use self-supporting reinforced concrete walls of concrete grade not less than 7.5.

7. An open seam of not less than 20 mm is left between the self-supporting wall and the column. Along the entire length of the wall, anti-seismic belts are installed at the level of the cover, which are attached to the frame.

It is necessary to install vertical seams along the entire height of the wall at the intersection of the edge transverse wall and longitudinal walls. Self-supporting walls and their fasteners should be considered for seismic forces acting on the ground perpendicular to the wall.

8. The number of diaphragms and fasteners should not be less than 2 for each calculated direction of the section in multi-layer frame-connector systems.

In this case, they should be placed symmetrically, on different planes. The distance between diaphragms and fasteners is determined by calculations depending on the type of inter-floor covering.

9. In frame buildings, the elements of the stairwell and the elevator shaft can be equipped in the form of a single core that does not work together with the frame or receives seismic loads.

In frame buildings with a height of 1 - 5 floors, when the calculated seismicity is 7, 8 points, the stairwell and the elevator shaft can be worked on the boundary of the building plan, separated from the frame. It is not allowed to operate the stairwell as a separate building.

10. It is not possible to build buildings with a frame lower floor and a brick upper floor on sites with soil category III, and in zones with a seismicity of 9 and more, and on soils of category I and II.

11. Foundations of buildings with 9 or more floors are made in the form of piled or integral foundation slabs if the soil is free of stones.

2-practical training. Determination of liability, earthquake frequency, floors, regularity, seismicity and dissipation coefficients according to normative document (CR2.01.03-19)

Structures and foundations of buildings (structures) designed for seismic regions are calculated for basic and special combinations of loads, taking into account seismic effects. Loads and actions of the main combination are determined in accordance with the requirements of the CR "Loads and actions", and a special combination - taking into account seismic actions in accordance with this document. In this case, the values of the calculated loads should be multiplied by the combination coefficients taken according to Table 2.1.

Table 2.1

Type of load	Combination coefficient, Ψi
Permanent	0.9
Temporary long	0.8
Short-term (for floors and coatings)	0.5

When calculating for a special combination of loads, horizontal seismic loads from masses on flexible suspensions, temperature and climatic effects, wind loads, dynamic effects from equipment and vehicles, braking and lateral forces from the movement of cranes are not taken into account.

When determining the vertical seismic load, one should take into account the weight of the crane, the weight of the trolley, as well as the weight of the load equal to the lifting capacity of the crane with a factor of 0.3. The horizontal seismic load from the weight of bridges and crane bogies should be taken into account in the direction perpendicular to the axis of the crane runways.

Calculation of buildings (structures) according to the limit state of PS-1 should be carried out for the design seismic impact corresponding to the maximum possible intensity of earthquakes for a given construction site.

Calculation of buildings (structures) according to the limit state of PS-2 should be carried out for the maximum seismic impact, the return period of which is less than the estimated service life.

In the absence of data on the estimated service life or if the minimum earthquake recurrence period, determined according to Appendix 1, is longer than the estimated service life of the building (structure), the verification of the non-occurrence of the limit state of PS-2 is carried out with a seismic impact 1 point lower than the calculated one. The estimated life of the object should be indicated in the design assignment. If for the construction site the recurrence period of earthquakes of maximum intensity, determined according to Appendix 1, is less than the estimated service life and the object, then when checking the non-occurrence of the limit state of PS-1, the level of the calculated impact intensity increases by 20%.

For buildings (structures) that will be built on sites with seismic activity > 9 and 9 * points, calculations for the second design situation are not performed.

3-practical training. Determination of spectral coefficients corresponding to the vibration form according to the normative document (CR2.01.03-19)

When calculating according to clause 2.6b, the design seismic load in the selected direction, applied at point K and corresponding to the i-th tone of natural oscillations of the building (structure), is determined by the formulas:

$$S_{ik} = K_o K_n K_{эт} K_p S_{oik}$$

$$S_{oik} = \alpha Q_k W_i K_\delta \eta_{ik}$$

where

S_{oik} - inertial force determined under the assumption of elastic deformation of structures;

α - coefficient determined according to Table 2.7 depending on the seismicity of the construction site;

Qk is the weight of the building (structure), referred to point K of the design scheme (Fig. 2.1), determined taking into account the design loads on the structures, in accordance with clause 2.1;

Wi-spectral coefficient determined according to clause 2.14;

Kδ-dissipation coefficient, determined according to item 2.16;

Kp - regularity coefficient determined according to clause 2.25;

Co-responsibility coefficient, taken according to Table. 2.3;

Cat-coefficient depending on the number of storeys of the building (structure), determined according to clause 2.17;

ηik - coefficient depending on the shape of natural oscillations of the building (structure) along the 1st run and the location of the load on the design scheme, determined according to clauses 2.18, 2.19;

Kп is the coefficient for accounting for the recurrence of earthquakes, taken according to Table 2.4.

4-practical training. Selection of static and dynamic schemes of buildings.

Preliminary information: Seismicity of the construction area - 7 points, Fergana sh.

Seismic category of the ground of the construction site - III, cross-section of Rigel dimensions - b_1=0.6 m; b_2=0.4 m; h_1=0.45 m; h_2=0.32 m; Cross-section of edge columns – bxh = 0.55x0.60 m; Cross-section of middle columns - b\`xh\`= 0.50x0.50 m; The distance between the columns - ℓ=8.0 m; Column pitch – L= 6.0 m; The height of the floors is N_1 = 5.0 m and N_2 = 5.2 m.

Determination of moments of inertia of cross-sections of the beam and column.

Calculations usually begin with determining the moments of inertia of cross-sections of beam and column structures. (Figure 4)

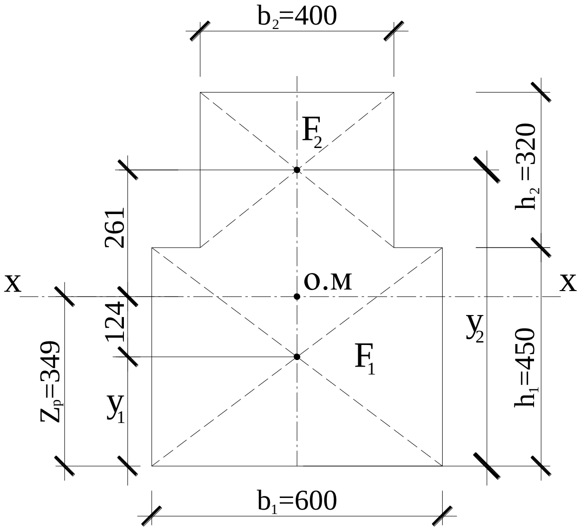


Figure 4.1. Cross-sectional surface of the Rigel.

$h_p = h_1 + h_2$ =0,45+0,32=0,77 m the full height of the cross section

$S = b_1 h_1 \cdot 0.5 h_1 + b_2 h_2 \cdot (h_1 + 0.5 h_2)$ =0,6x0,45x0,5x0,45+0,40x0,32x(0,45+0,5x0,32) = =0,13883 m^4 section static moment

$F = b_1 h_1 + b_2 h_2$ =0,6x0,45+0,40x0,32=0,398 m^2 cross-sectional surface of the rigging

$Z_P = S / F$ = 0,13883/0,398=0,349 m cross section center of gravity

5-practical training. Determination of moments of inertia of sections of building structures

We calculate the moment of inertia of the entire section relative to the X-X axis passing through the center of gravity of the rigel:

$J_{x-x} = \frac{b_1 h_1^3}{12} + b_1 h_1 (Z_P - 0.5 h_1)^2 + \frac{b_2 h_2^3}{12} + b_2 h_2 (h_1 + 0.5 h_2 - Z_P)^2$ = (0,6x0,45³/12) + +0,6x0,45x(0,349-0,5x0,45)²+(0,40x0,32³/12)+0,40x0,32x(0,45+0,5x0,32- -0,349)²=0,01852 m^4

The moment of inertia of the section of the edge columns:

$$J_u^{ch} = \frac{b \cdot h^3}{12} = \frac{0,55 \cdot 0,60^3}{12} = 0,0099\ \text{ì}^{4}$$

The moment of inertia of the section of the middle columns:

$$J_u^{o'} = \frac{b' \cdot (h')^3}{12} = \frac{0,5 \cdot 0,5^3}{12} = 0,005208\ \text{ì}^{4}$$

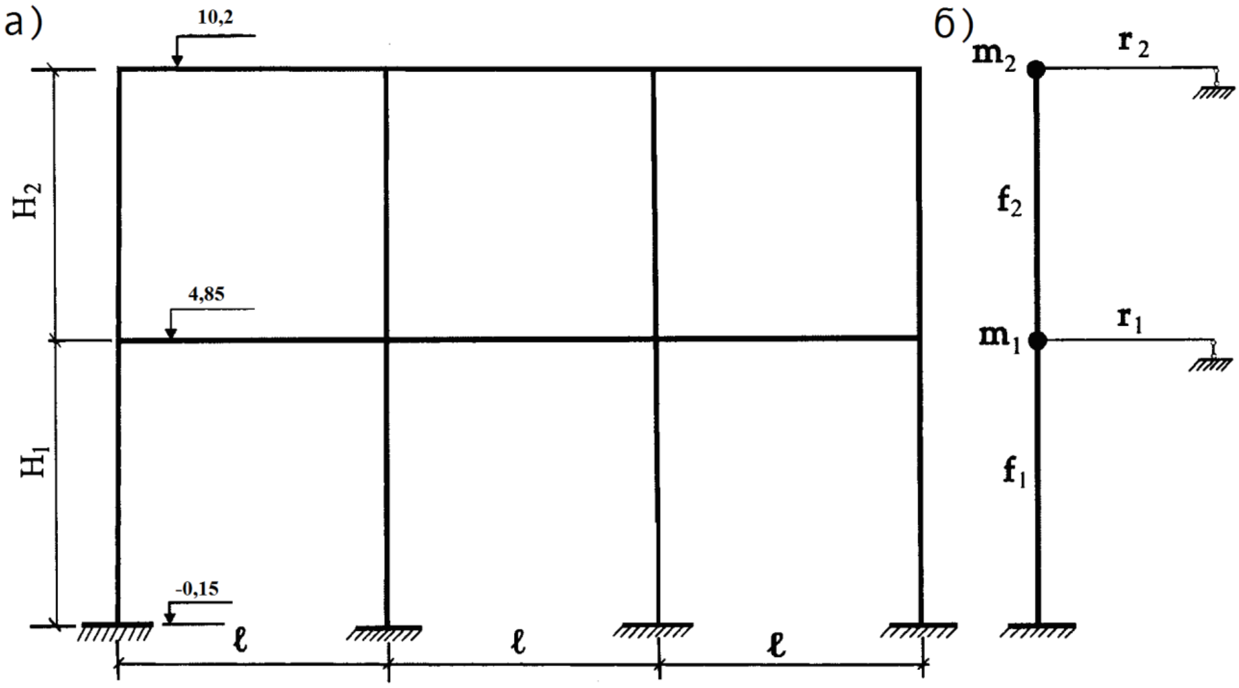


Figure 5.1. Static (a) and dynamic (b) calculation schemes of the building frame.

The static (a) and dynamic (b) calculation schemes of the building frame are presented in Fig. 5.

The level marks of the first (+4.85 m) and second (+10.2 m) floors of the building correspond to the centers of gravity of the beams, and (-0.15) to the level of the upper surface of the foundation.

6-practical training. Determination of aggregate relative specifications

Cumulative ratio of columns and beams identify the similarities
Relative singularities are determined using the following formulas:

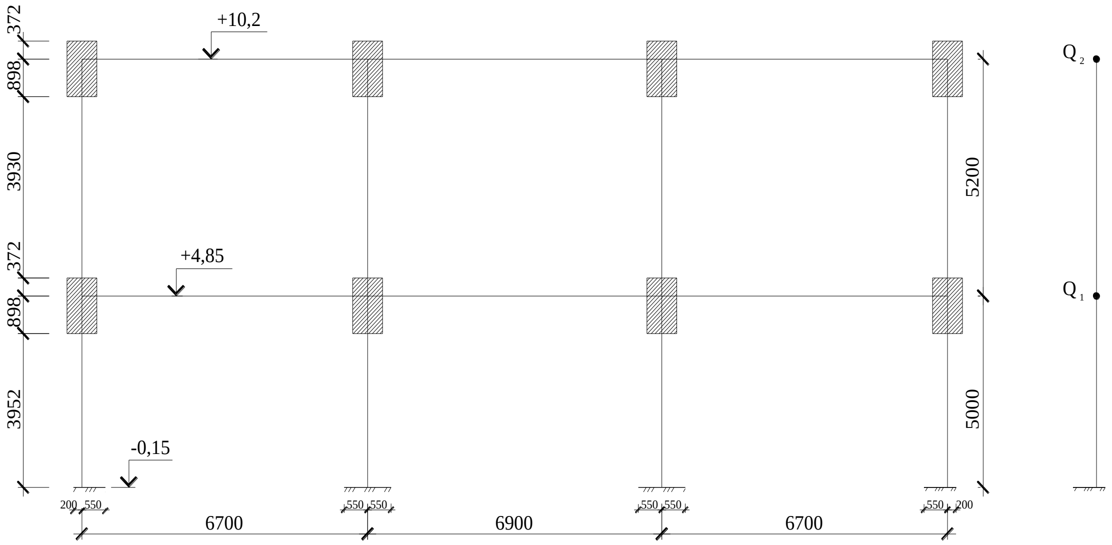


Figure 6.1. Calculation scheme of the transverse frame of the building frame.

We consider the junction of columns and beams as a single node. Accordingly, we use their free length to determine the relative unity of the elements. The calculation scheme of the transverse frame is given in Fig. 5.

Here h_1 and h_2 are defined as follows:
$h_1 = H_1 – Z = 4,85 – 0,898 = 3,952$ m.
$h_2 = H_2 – (Z+C)=(0,898+0,372) = 5,2 – 1,27 = 3,93$ m.
$Z=Z_p + 500 = 0,275+0,500=0,898$ m – is the sum of the distances to the center of gravity of the column console and the rigging (Fig. 7).

First floor column free length
$h_{S1} = H_1 - Z_P$ =5,0-0,898= 4,102 m
The free length of the second floor column
$h_{S2} = H_2 - (h_p - Z_P) - Z$ =5,2-(0,77-0,398)-0,898=3,93m.
The calculated length of the Rigel edge interval
$\ell_{01}= \ell$ - (550+550+200) = 8000 - 1300 = 6700 mm = 6,7 m.
Calculated length of Rigel mean interval
$\ell_{02}= \ell$ -(550+550) = 8000-1100 = 6900 mm = 6,9 m.
The relative uniformity of the columns of the first floor:
$f_1 = \frac{E(2J_C + 2J_U)}{h_{S1}}$ =27000x(2x0,0099+2x0,005208)/4,102=198,8864 m^3

The relative uniformity of the columns of the second floor:

$f_2 = \frac{E(2J_C + 2J_U)}{h_{S2}}$ =27000x(2x0,0099+2x0,005208)/3,93=207,5908 m^3

Since the sections of the rafter are the same in the first and second floors:

$r_1 = r_2 = r_i = \frac{E \cdot 2J}{l_{01}} + \frac{EJ}{l_{02}}$ =27000x2x0,01852/6,7+27000x0,01852/6,9= 221,7352 m^3

7-practical training. Determination of unit displacements of systems.

We use approximate formulas to determine displacements:

$A_1 = \frac{h_{S1}^2}{f_1}$ = $4{,}402^2$/198,8864 = 0,084603

$A_2 = \frac{h_{S1}^2}{f_1} + \frac{h_{S2}^2}{f_2}$ = $4{,}102^2$/198,8864 + $3{,}93^2$/207,5908 = 0,159004

$R_1 = \frac{h_{S1}^2}{4r_i + 0.33 f_1}$ = $4{,}102^2$/(4x221,7352+0,33x198,8864)=0,017664 m^{-1}

$R_2 = \frac{(h_{S1} + h_{S2})^2}{4r_i + 0.33 f_1}$ =$(4{,}102+3{,}93)^2$/(4x221,7352+0,33x198,8864)=0,272821 m^{-1}

$M = \frac{h_{S1}^2}{4r_i}$ = $4{,}102^2$/(4x221,7352)= 0,018971 m^{-1}

$MM = \frac{h_{S2}^2}{4r_i}$ = $3{,}93^2$/(4x221,7352)= 0,017414 m^{-1}

$MMM = \frac{h_{S1} h_{S2}}{48 r_i + 4 f_1}$ =4,102x3,93/(48x221,7352+4x198,8864)=0,001409m^{-1}

Putting the found values into the formula, we determine the unit displacements:

$\delta_{11} = \frac{1}{12}(A_1 + R_1)$ = (0,084603+0,017664)/12= 0,008522

$\delta_{22} = \frac{1}{12}(A_2 + R_2 + MM)$ =(0,159004+0,272821+0,017414)/12= 0,037437

$\delta_{12} = \delta_{21} = \delta_{11} + MMM$ = 0,008522+0,001409= 0,009932

Check. If all operations are performed correctly, the following equality is satisfied:

$$\frac{1}{12}\left(\sum_{i=1}^{k} A_k + \sum_{i=1}^{k} R_k + \sum_{i=1}^{k} \frac{h_k^2}{4\mathrm{r}_\mathrm{k}}\right) = \sum_{i=1}^{k} \delta_{kk}$$

For our case, this equality is written as follows:

$\delta_{11}+\delta_{22}=\frac{1}{12}(A_1+A_2+R_1+R_2+M+MM)$ =(0,084603+0,159004+0,017664+0,272821+0,018971+0,017414)/12= 0.04754

$\delta_{11}+\delta_{22}=$ 0,008522+0,037437=0,045959

Error percentage. $x=\frac{0,04754-0,045959}{0,045959}\cdot 100\%=3,44\%\langle 5\%$

The error is tolerable. So unit displacements are correctly defined.

***8-practical training*. Determination of total loads in the structure.**

Determination of masses on inter-floor and roofing levels

We calculate the accumulated loads Qk at the level of inter-floor and roof covering according to the standard loads given in Table 3.

№	Designation of vertical loads	At the intermediate level, Q_1, kN.	At the roofing level, Q_2, kN.
	A. PERMANENT		
1.	Roof weight	-	1,35 x 24 x 6 = 194,4
2.	Weight of roof and roof panels	6 x 24 x 6 = 864	6 x 24 x 6 = 864
3.	Floor and fence weight	2,5 x 24 x 6 = 360	-
4.	Weight of panel walls	2,0 x 3,0 x 6 x 2=72	2,0 x 3,0 x 6 x 2=72
5.	The weight of strip windows	0,5x6x2,1x2=12,6	0,5x0,8x6x2=12,6
6.	Column and rigging weight	[(0,55x0,60+0,5x0,5)x 5,1x2+(0,6x0,45+ +0,40x0,32)x(6,7x2+ +6,9)]x25=349,888	[(0,55x0,60+0,5x0,5)x 2,6x2+(0,6x0,45+ +0,40x0,32)x(6,7x2+ +6,9)]x25=277,385
		1658,488	1225,985
	B. LONG-TERM TEMPORARY LOADS		
7.	Stationary equipment weight	16x24x6=2304	-
	V. SHORT-TERM CHARGES		
8.	Short-term loads on closures	5,0x24x6x0,8=576	-
9.	Snow	-	0,5x24x6x0,8=57,6
		4538,488	1283,585

9-practical training. Determination of specific oscillation frequency and periods.

The equation of special oscillations of a system with two degrees of freedom has the following form:

$$\begin{cases}(m_1\delta_{11}-\frac{1}{\omega_i^2})X_1+m_2\delta_{12}X_2=0;\\(m_1\delta_{21}X_1+(m_2\delta_{22}-\frac{1}{\omega_i^2})X_2=0;\end{cases}$$

here:

$$m_1=\frac{Q_1}{g}= 4538488/9{,}81= 462638{,}9\ (N\ s^2)/m$$

$$m_2=\frac{Q_2}{g}= 1283585/9{,}81= 130844{,}5\ (N\ s^2)/m$$

In order for the values of X1 and X2 to be different from zero, the determinant of the system of equations must be equal to zero:

$$\begin{vmatrix}(m_1\delta_{11}-\frac{1}{\omega_i^2}) & m_2\delta_{12}\\ m_1\delta_{21} & (m_2\delta_{22}-\frac{1}{\omega_i^2})\end{vmatrix}=0.$$

Opening the determinant, we get the recurrence equation:

$$\frac{1}{\omega_i^4}-(m_1\delta_{11}+m_2\delta_{22})\frac{1}{\omega_i^2}+m_1m_2(\delta_{11}\delta_{22}-\delta_{12}^2)=0.$$

The equation can be solved using the following formula:

$$\omega_i^2=\frac{A\pm\sqrt{A^2-4B}}{2B};$$

where: $A=m_1\delta_{11}+m_2\delta_{22};$

$B=m_1m_2(\delta_{11}\delta_{22}-\delta_{12}^2).$

We determine the repetition of free oscillations of the system:

$A=m_1\delta_{11}+m_2\delta_{22}$=(462638,9x0,008522+130844,5x0,037437)/10^6 = 0,008841 s^2

$B=m_1m_2(\delta_{11}\delta_{22}-\delta_{12}^2)$ =(462638,9x130844,5x(0,008522x0,037437-0,009932^2))/10^{12} = 0,00001334 s^4

Determining the frequency of free oscillations of the system and their corresponding periods

$D = \sqrt{A^2 - 4B} = \sqrt{0.008841^2 - 4 \cdot 0.00001334} = 0.00498$ - discriminant

$O_1 = \frac{A - D}{2B}$ = (0,008841-0,00498)/(2x0,00001334)= 144,704 s^{-2}

$O_2 = \frac{A + D}{2B}$ =(0,008841+0,00498)/(2x0,00001334)=518,039 s^{-2}

$\omega_1 = \sqrt{O_1} = \sqrt{144{,}704} = 12{,}03\ c^{-1}$ $\quad \omega_2 = \sqrt{O_2} = \sqrt{518{,}039} = 22{,}76\ c^{-1}$

Oscillation periods corresponding to these repetitions:

$T_1 = \frac{2\pi}{\omega_1}$ = 2x3,14/12,03= 0,52 s $\qquad T_2 = \frac{2\pi}{\omega_2}$ = 2x3,14/22,76= 0,28 s

10-practical training. Determination of specific building shapes and shape coefficients.

Determination of free vibration patterns

The first form of vibrations. We take X_{11}=1.0. In that case

$X_{21} = \frac{m_1 \delta_{12} \omega_1^2}{1 - \delta_{22} m_2 \omega_1^2}$ =((462638,9x0,009932x12,03^2)/10^6)/((1-0,037437x130844,5 x12,03^2)/10^6)= 2,284

The second form of vibrations. X_{12}=1,0. In that case

$X_{22} = \frac{m_1 \delta_{12} \omega_2^2}{1 - \delta_{22} m_2 \omega_2^2}$ =((462638,9x0,009932x22,76^2)/10^6)/((1-0,037437x130844,5 x22,76^2)/10^6)= -1,548

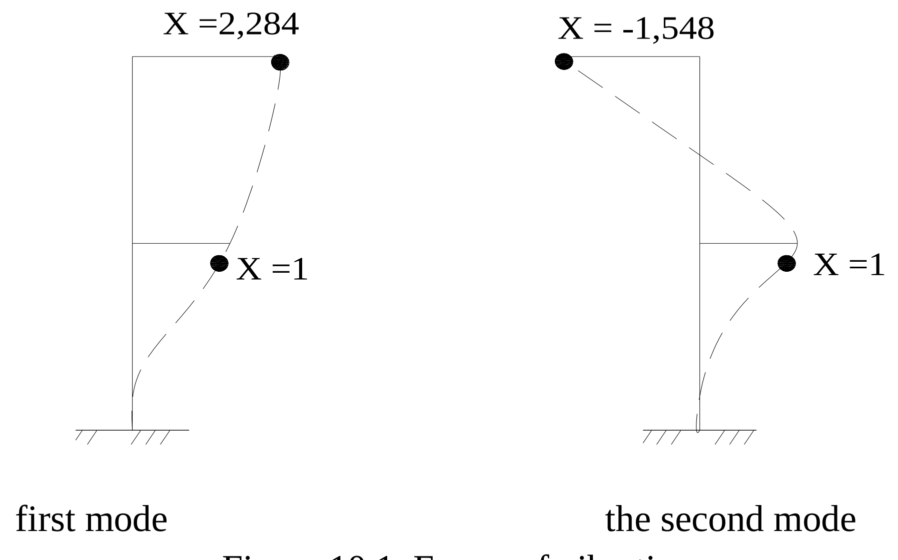


Figure 10.1. Forms of vibration.

Determination and verification of shape coefficients of vibrations

Coefficients of the first form of vibrations

$\eta_{11} = X_{11} \cdot \frac{Q_1 X_{11} + Q_2 X_{21}}{Q_1 X_{11}^2 + Q_2 X_{21}^2}$=1x(4538488x1+1283535x2,284)/(4538488x1^2+1283535 x2,284^2)=0,665

$\eta_{12} = X_{21}\eta_{11}$= 2,284x0,665=1,519

Coefficients of the second form of oscillations

$\eta_{21} = X_{12} \cdot \frac{Q_1 X_{12} + Q_2 X_{22}}{Q_1 X_{12}^2 + Q_2 X_{22}^2}$=1x(4538488x1+1283585x(-1,548))/(4538488x1^2+1283585x(-1,548$^{2)}$)=0,335

$\eta_{22} = X_{22}\eta_{21}$= -1,548x0,335= - 0,519

In systems with infinite degrees of freedom, the sum of shape coefficients at an arbitrary point must be equal to one.

Check: $\eta_{11} + \eta_{21} = 1$; 0,665+0,335= 1;

$\eta_{12} + \eta_{22} = 1$; 1,519+(-0,519)= 1;

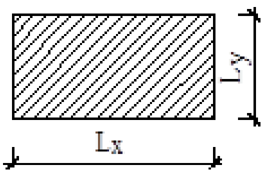
Orthogonal check: $m_1 X_{11} X_{12} + m_2 X_{21} X_{22} = 0$

462638,9x1,0x1,0 + 130844,5x2,284x(-1,548)=0

Error (462638,9 – 462618)x100/462618= 0,005%

11-practical training. **Determination of calculated seismic forces affecting the building.**

According to CR 2.01.03 - 96, we get the following values. Since the building we are considering has responsibility category IV, the responsibility coefficient is equal to K_0 = 1.0 (Table 5). The coefficient taking into account the frequency of earthquakes is K_p=0.8 (Table 6). According to item 4 of Table 4 - K_{et}=1.0. According to item 1 of table 10



$\frac{L_x}{L_y} = \frac{48}{24} = 2,0 \; \langle \; 5$, because K_r=1,0.

We have determined the coefficients related to formula (1).

Now let's determine the coefficient and other physical quantities in formula (2).

Seismicity coefficient of the construction area according to Table 7 for the area with 7 points - a = 0.25;

From Table 9, the value of the spectral coefficient for the first form is equal to W_1=0.82 when the address (region) index for the city of Fergana is I and the ground category is II, and the period of the specific vibrations of the building is T_1=0.52 s;
(1) formulaga tegishli koeffitsientlarni aniqlab bo‘ldik.
Endi (2) formuladagi koeffitsient va boshqa fizik miqdorlarni aniqlashga o‘tamiz.

$$W_1 = W_{50} - \frac{W_{50} - W_{55}}{5} = 0{,}89 - \frac{0{,}89 - 0{,}82}{5} \cdot 2 = 0{,}862$$

For the second form of oscillations, when T=0.28 s, the spectral coefficient is equal to:

$$W_2 = W_{25} - \frac{W_{25} - W_{30}}{5} = 1{,}22 - \frac{1{,}22 - 1{,}17}{5} = 1{,}21$$

To determine the dissipation coefficient, we determine the logarithmic decrement from Table 8, depending on the structural solution of the building. We put the values T_1= 0.52 s and δ = 0,3 in formula (3):

$$K_\delta = e^{(0{,}548 - \sqrt{\delta})(0{,}1 + \frac{0{,}7}{\sqrt{T_1}})} = e^{(0{,}548 - \sqrt{0{,}3})(0{,}1 + \frac{0{,}7}{\sqrt{0{,}52}})} = 1{,}1.$$

Putting the determined coefficients and physical quantities into formulas (1) and (2), we determine the values of seismic forces.

Calculated seismic forces according to the first form of vibrations:

At the level of Orayopma

$S_{011} = \alpha Q_1 W_1 K_\delta \eta_{11}$=0,25x4538488x0,876x1,1x0,665/10^3= 660,96 kN

$S_{11} = K_0 K_n K_{эm} K_P S_{011}$= 1,0x0,8x1,0x1,0x660.96= 528,80 kN

At roof level

$S_{012} = \alpha Q_2 W_1 K_\delta \eta_{12}$= 0,25x1283585x0,876x1,1x1,519/10^3= 469,70 kN

$S_{12} = K_0 K_n K_{эm} K_P S_{012}$ = 1,0x0,8x1,0x1,0x469,70= 375,76 kN

Calculated seismic forces according to the second form of vibrations:

At the level of Orayopma

$S_{021} = \alpha Q_1 W_2 K_\delta \eta_{21}$= 0,25x4538488x1,21x1,1x0,335/10^3= 505,91 kN

$S_{21} = K_0 K_n K_{эm} K_P S_{021}$= 1,0x0,8x1,0x1,0x505,91= 404,73 kN

At roof level

$S_{022} = \alpha Q_2 W_2 K_\delta \eta_{22}$= 0,25x1283585x1,21x1,1x(-0,519)/10^3= -221,67 kN

$S_{22} = K_0 K_n K_{эm} K_P S_{022}$= 1,0x0,8x1,0x1,0x(-221,67)= -177,34 kN

12-practical training. Calculation of the frame of the building frame under the effect of seismic forces

We use the method of points with zero moments when calculating the frame under the influence of horizontal seismic forces. Frame calculation scheme9-rasmda keltirilgan.

We calculate the relative unity of the elements.

First floor, for edge columns

$$i_{1-5} = i_{4-8} = \frac{J_u^{ch}}{h_1} = \frac{99,0 \cdot 10^{-4}}{3,952} = 25,05 \cdot 10^{-4} м^3$$

First floor, for middle columns

$$i_{2-6} = i_{3-7} = \frac{J_u^{O'}}{h_1} = \frac{52,08 \cdot 10^{-4}}{3,952} = 13,18 \cdot 10^{-4} м^3$$

Second floor, for edge columns

$$i_{5-9} = i_{8-12} = \frac{J_y^{ch}}{h_2} = \frac{99,0 \cdot 10^{-4}}{3,93} = 25,19 \cdot 10^{-4} м^3$$

Second floor, for middle columns

$$i_{6-10} = i_{7-11} = \frac{J_k^{O'}}{h_2} = \frac{52,08 \cdot 10^{-4}}{3,93} = 13,25 \cdot 10^{-4} м^3$$

For rigels in marginal intervals

$$i_{5-6} = i_{7-8} = i_{9-10} = i_{11-12} = \frac{J_{x-x}}{\ell_1} = \frac{185,2 \cdot 10^{-4}}{6,7} = 27,64 \cdot 10^{-4} м^3$$

For mid-range rigels

$$i_{6-7} = i_{10-11} = \frac{J_{x-x}}{\ell_2} = \frac{185,2 \cdot 10^{-4}}{6,9} = 26,84 \cdot 10^{-4} м^3$$

13-practical training. Construction of the curve of bending moments arising under the influence of seismic forces of the first form of vibrations

To do this, we divide the total transverse forces acting on the second floor into individual columns. The distribution is carried out in proportion to the relative unity of the columns.9-rasm. Ramani hisoblash sxemasi.

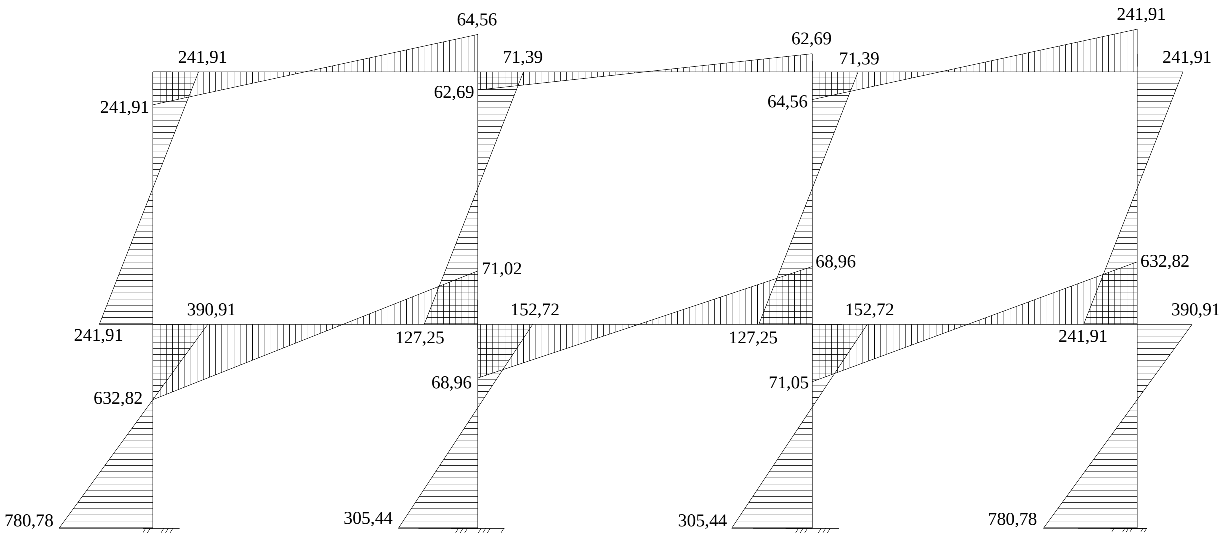


Figure 13.1. Regarding the first form of vibrations
curve of bending moments.

Transverse forces generated at the hinges of the second floor columns:

$$Q_1 = \frac{S_{12} \cdot i_{5-9}}{2(i_{5-9} + i_{6-10})} = \frac{375{,}76 \cdot 25{,}19 \cdot 10^{-4}}{2(25{,}19 + 13{,}25) \cdot 10^{-4}} = 123{,}11\,кН;$$

$$Q_2 = \frac{S_{12} \cdot i_{6-10}}{2(i_{5-9} + i_{6-10})} = \frac{375{,}76 \cdot 13{,}25 \cdot 10^{-4}}{2(25{,}19 + 13{,}25) \cdot 10^{-4}} = 64{,}76\,кН.$$

Bending moments occurring in the columns of the second floor:

$$M_{5-9} = M_{9-5} = M_{12-8} = M_{8-12} = Q_1 \cdot \frac{h_2}{2} = 123{,}11 \cdot \frac{3{,}93}{2} = 241{,}91\ кН \cdot м;$$

$$M_{6-10} = M_{10-6} = M_{7-11} = M_{11-7} = Q_2 \cdot \frac{h_2}{2} = 64{,}76 \cdot \frac{3{,}93}{2} = 127{,}25\ кН \cdot м.$$

Transverse forces generated at the hinges of the first floor columns:

$$Q_3 = \frac{(S_{12} + S_{11}) \cdot i_{1-5}}{2(i_{1-5} + i_{2-6})} = \frac{(375{,}76 + 528{,}80) \cdot 25{,}05 \cdot 10^{-4}}{2(25{,}05 + 13{,}18) \cdot 10^{-4}} = 296{,}35кН;$$

$$Q_4 = \frac{(S_{12} + S_{11}) \cdot i_{2-6}}{2(i_{1-5} + i_{2-6})} = \frac{(375{,}76 + 528{,}80) \cdot 13{,}18 \cdot 10^{-4}}{2(25{,}05 + 13{,}18) \cdot 10^{-4}} = 115{,}93кН.$$

Bending moments occurring in the columns of the first floor:

$$M_{1-5} = M_{4-8} = Q_3 \cdot \frac{2}{3} h_1 = 296{,}35 \cdot \frac{2}{3} 3{,}952 = 780{,}78\ кН \cdot м;$$

$$M_{5-1} = M_{8-4} = Q_3 \cdot \frac{1}{3} h_1 = 296{,}35 \cdot \frac{1}{3} 3{,}952 = 390{,}91кН \cdot м;$$

$$M_{2-6} = M_{3-7} = Q_4 \cdot \frac{2}{3} h_1 = 115{,}93 \cdot \frac{2}{3} 3{,}952 = 305{,}44\ кН \cdot м;$$

$$M_{6-2} = M_{7-3} = Q_4 \cdot \frac{1}{3} h_1 = 115{,}93 \cdot \frac{1}{3} 3{,}952 = 152{,}72\ кН \cdot м.$$

Bending moments that occur in the beams:

$$M_{9-10} = M_{12-11} = M_{9-5} = 241{,}91\ кН \cdot м;$$

$$M_{10-9} = M_{11-12} = \frac{M_{6-10} \cdot i_{10-9}}{i_{10-9} + i_{10-11}} = \frac{127{,}25 \cdot 27{,}64 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} = 64{,}56\ кН \cdot м;$$

$$M_{10-11} = M_{11-10} = \frac{M_{6-10} \cdot i_{10-11}}{i_{10-9} + i_{10-11}} = \frac{127{,}25 \cdot 26{,}84 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} = 62{,}69\ кН \cdot м;$$

$$M_{5-6} = M_{8-7} = M_{5-9} + M_{5-1} = 241{,}91 + 390{,}91 = 632{,}82\ кН \cdot м;$$

$$M_{6-5} = M_{7-8} = \frac{(M_{6-10} + M_{6-2}) \cdot i_{6-5}}{i_{6-5} + i_{6-7}} = \frac{(127{,}25 + 152{,}72) \cdot 27{,}64 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} =$$

$$= 71{,}02\ кН \cdot м;$$

$$M_{6-7} = M_{7-6} = \frac{(M_{6-10} + M_{6-2}) \cdot i_{6-5}}{i_{6-5} + i_{6-7}} = \frac{(127{,}25 + 152{,}72) \cdot 26{,}84 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} =$$

$$= 68{,}96\ кН \cdot м.$$

Construction of the curve of bending moments arising under the influence of seismic forces related to the second form of vibrations.

The calculation of Rama is carried out in the same way as in the first form.

Transverse forces generated at the hinges of the second floor columns:

$$Q_1 = \frac{S_{22} \cdot i_{5-9}}{2(i_{5-9} + i_{6-10})} = \frac{-177{,}34 \cdot 25{,}19 \cdot 10^{-4}}{2(25{,}19 + 13{,}25) \cdot 10^{-4}} = -58{,}11\ кН;$$

$$Q_2 = \frac{S_{22} \cdot i_{6-10}}{2(i_{5-9} + i_{6-10})} = \frac{-177{,}34 \cdot 13{,}25 \cdot 10^{-4}}{2(25{,}19 + 13{,}25) \cdot 10^{-4}} = -30{,}56\ кН.$$

Bending moments occurring in the columns of the second floor:

$$M_{5-9} = M_{9-5} = M_{12-8} = M_{8-12} = Q_2 \cdot \frac{h_2}{2} = -58{,}11 \cdot \frac{3{,}93}{2} = -114{,}19 кН \cdot м$$

$$M_{6-10} = M_{10-6} = M_{7-11} = M_{11-7} = Q_2 \cdot \frac{h_2}{2} = -30{,}56 \cdot \frac{3{,}93}{2} = -60{,}05 кН \cdot м$$

Transverse forces generated at the hinges of the first floor columns

$$Q_3 = \frac{(S_{22} + S_{21}) \cdot i_{1-5}}{2(i_{1-5} + i_{2-6})} = \frac{(-177{,}34 + 404{,}73) \cdot 25{,}05 \cdot 10^{-4}}{2(25{,}05 + 13{,}18) \cdot 10^{-4}} = 74{,}50 кН;$$

$$Q_4 = \frac{(S_{22} + S_{21}) \cdot i_{2-6}}{2(i_{1-5} + i_{2-6})} = \frac{(-177{,}34 + 404{,}73) \cdot 13{,}18 \cdot 10^{-4}}{2(25{,}05 + 13{,}18) \cdot 10^{-4}} = 39{,}20 кН.$$

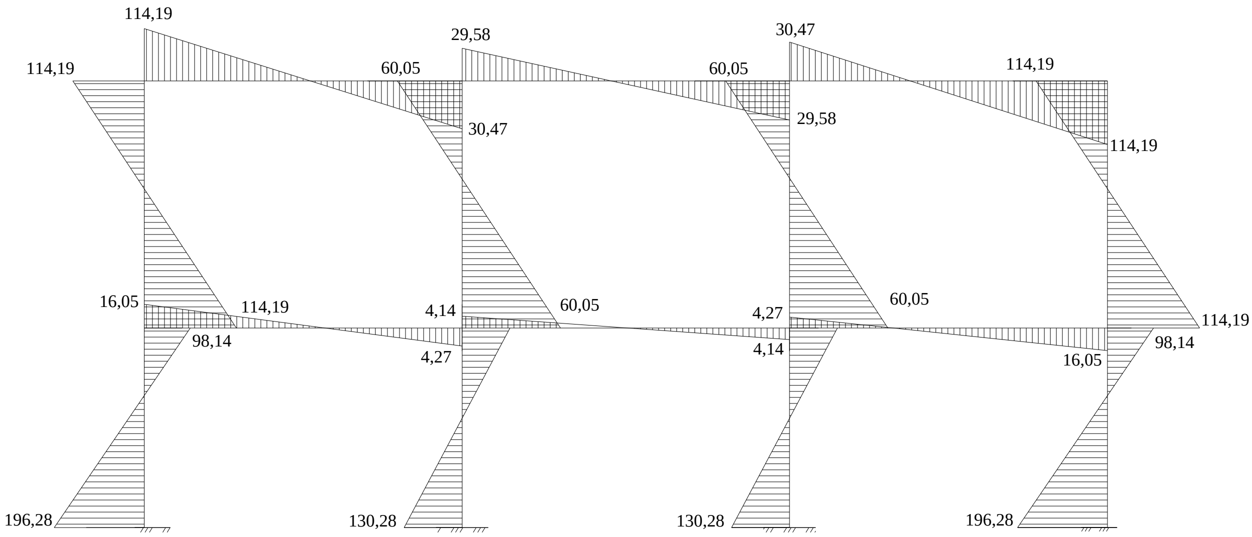


Figure 13.2. Regarding the second form of vibrations curve of bending moments.

Bending moments occurring in the columns of the first floor:

$$M_{1-5} = M_{4-8} = Q_3 \cdot \frac{2}{3} h_1 = 74{,}50 \cdot \frac{2}{3} 3{,}952 = 196{,}28 кН \cdot м;$$

$$M_{5-1} = M_{8-4} = Q_3 \cdot \frac{1}{3} h_1 = 74{,}50 \cdot \frac{1}{3} 3{,}952 = 98{,}14 кН \cdot м;$$

$$M_{2-6} = M_{3-7} = Q_4 \cdot \frac{2}{3} h_1 = 39{,}20 \cdot \frac{2}{3} 3{,}952 = 103{,}28 кН \cdot м;$$

$$M_{6-2} = M_{7-3} = Q_4 \cdot \frac{1}{3} h_1 = 39{,}20 \cdot \frac{1}{3} 3{,}952 = 51{,}64 кН \cdot м.$$

Bending moments that occur in the beams:

$$M_{9-10} = M_{12-11} = M_{9-5} = -114{,}19 кН \cdot м;$$

$$M_{10-9} = M_{11-12} = \frac{M_{6-10} \cdot i_{10-9}}{i_{10-9} + i_{10-11}} = \frac{-60{,}05 \cdot 27{,}64 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} = -30{,}47 кН \cdot м;$$

$$M_{10-11} = M_{11-10} = \frac{M_{6-10} \cdot i_{10-11}}{i_{10-9} + i_{10-11}} = \frac{-60{,}05 \cdot 26{,}84 \cdot 10^{-4}}{(27{,}64 + 26.84) \cdot 10^{-4}} = -29{,}58 кН \cdot м;$$

$$M_{5-6} = M_{8-7} = M_{5-9} + M_{5-1} = -114{,}19 + 98{,}14 = -16{,}05 кН \cdot м.$$

$$M_{6-5} = M_{7-8} = \frac{(M_{6-10} + M_{6-2}) \cdot i_{6-5}}{i_{6-5} + i_{6-7}} = \frac{(-60{,}05 + 51{,}64) \cdot 27{,}64 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} =$$

$$= -4{,}27 кН \cdot м;$$

$$M_{6-7} = M_{7-6} = \frac{(M_{6-10} + M_{6-2}) \cdot i_{6-5}}{i_{6-5} + i_{6-7}} = \frac{(-60{,}05 + 51{,}64) \cdot 26{,}84 \cdot 10^{-4}}{(27{,}64 + 26{,}84) \cdot 10^{-4}} =$$

$$= -4{,}14 кН \cdot м;$$

14-practical training. **Construction of the final diagram of bending moments, taking into account the first and second forms of vibrations.**

Construction of the final diagram of bending moments, taking into account the first and second forms of vibrations.

$$M_{як} = \sqrt{M_1^2 + M_2^2},$$

Here, M_1 is the bending moments in nodes related to the first form of vibrations; M_2 - bending moments in nodes related to the second form of vibrations.
Calculate for one node, i.e. 6 nodes:

$$M_{6-5} = \sqrt{(M_{6-5}^1)^2 + (M_{6-5}^2)^2} = \sqrt{(71{,}02)^2 + (-4{,}27)^2} = 71{,}15 кН \cdot м;$$

$$M_{6-7} = \sqrt{(M_{6-7}^1)^2 + (M_{6-7}^2)^2} = \sqrt{(68{,}96)^2 + (-4{,}14)^2} = 69{,}08 кН \cdot м;$$

$$M_{6-10} = \sqrt{(M_{6-10}^1)^2 + (M_{6-10}^2)^2} = \sqrt{(127{,}25)^2 + (-60{,}05)^2} = 140{,}71 кН \cdot м;$$

$$M_{6-2} = \sqrt{(M_{6-2}^1)^2 + (M_{6-2}^2)^2} = \sqrt{(152{,}72)^2 + (51{,}47)^2} = 161{,}16 кН \cdot м.$$

$$M_{1-5} = \sqrt{(M_{1-5}^1)^2 + (M_{1-5}^2)^2} = \sqrt{(780{,}78)^2 + (196{,}28)^2} = 805{,}07 кН \cdot м.$$

$$M_{2-6} = \sqrt{(M_{2-6}^1)^2 + (M_{2-6}^2)^2} = \sqrt{(305{,}44)^2 + (103{,}28)^2} = 322{,}43 кН \cdot м.$$

$$M_{5-6} = \sqrt{(M_{5-6}^1)^2 + (M_{5-6}^2)^2} = \sqrt{(632{,}82)^2 + (-16{,}05)^2} = 633{,}02 кН \cdot м.$$

$$M_{5-1} = \sqrt{(M_{5-1}^1)^2 + (M_{5-1}^2)^2} = \sqrt{(390{,}91)^2 + (98{,}14)^2} = 403{,}04 кН \cdot м.$$

$$M_{5-9} = \sqrt{(M_{5-9}^1)^2 + (M_{5-9}^2)^2} = \sqrt{(241{,}91)^2 + (-114{,}09)^2} = 267{,}46 кН \cdot м.$$

$$M_{10-11} = \sqrt{(M_{10-11}^1)^2 + (M_{10-11}^2)^2} = \sqrt{(62{,}69)^2 + (-29{,}58)^2} = 69{,}32 кН \cdot м.$$

$$M_{10-9} = \sqrt{(M_{10-9}^1)^2 + (M_{10-9}^2)^2} = \sqrt{(64{,}56)^2 + (-30{,}47)^2} = 71{,}39 кН \cdot м.$$

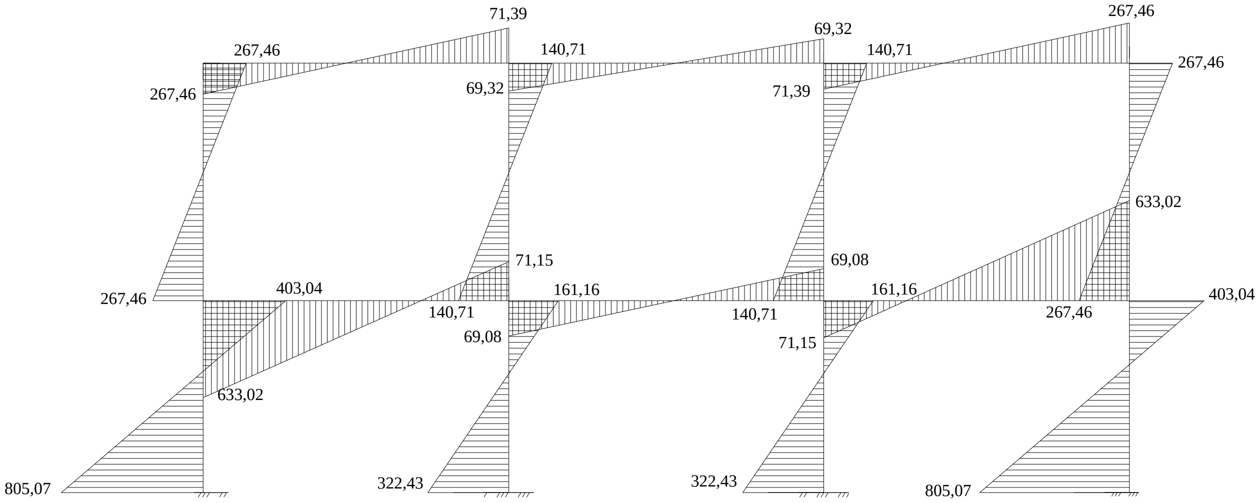


Figure 14.1. Plot of ultimate bending moments.

V- INDEPENDENT STUDY ASSIGNMENTS

When preparing a student's independent work, taking into account the characteristics of a particular subject, it is recommended to use the following forms:

- mastering the part of lectures on handouts;
- work on subject sections and topics of special literature;
- educational sessions using active and problem-based teaching methods;
- distance education.Talabalar mustaqil ta'limining mazmuni va hajmi

№	**Subjects of independent education**	**Assignments given**	**Term**	**Size**
1	Facility priority issues	Solving problems. Complete independent tasks	1, 2 weeks	10
2	Analysis of the consequences of strong earthquakes in recent years.	Solving problems. Complete independent tasks	3 weeks	8
3	Analysis of the methods of calculation of structures under the influence of seismic forces on the example of world experience.	Summarizing from the literature	4 weeks	10
	VII- Semester total:			28
4	Issues of earthquake resistance of special structures.	Summarizing from the literature	9, 10 weeks	4
5	Issues of earthquake resistance of architectural monuments.	Summarizing from the literature. Complete independent tasks.	11, 12 weeks	4
6	Issues of ensuring earthquake resistance of private buildings.	Summarizing from the literature. Complete independent tasks.	13, 14 weeks	4
	VIII- Semester total:			**16**
	All in all:			**36**

QUESTIONS FOR CONTROL

1. What types of dynamic forces do you know?
2. Explain the causes of the earthquake?
3. Give and explain the formulas of Omori and Mononobe for determining seismic forces?
4. Degree of freedom of the system.
5. G.F. Reed's hypothesis about the causes of the earthquake.
6. How is the Korchinsky formula for determining the strength of an earthquake expressed?
7. Free oscillations of a system with one degree of freedom (resistance forces are not taken into account).
8. What is a tectonic earthquake?
9. What do you understand by hypocenter, epicenter and aftershock?
10. Give the formula for determining seismic forces according to SN-8-57 and explain it?
11. Give formulas that determine the circular frequency (frequency) and period of specific vibrations?
12. What is the strength of an earthquake and how is it determined?
13. General principles of designing earthquake-resistant buildings.
14. What is the scale of the Earth Physics Institute?
15. Explain the formula Sik = K1K2Soik given in SniP II-7-81?
16. Brick-stone construction buildings.
17. Seismic waves.
18. How is the dynamic coefficient b determined according to SniP II-7-81?
19. Frame buildings.
20. Seismic scales.
21. Explain the formula Sik = K0 Kp Kr Ket Soik given in QMQ 2.01.03 – 96.
22. What is earthquake energy and how is it determined?
23. Seismic fogging.
24. Explain the formula Soik = a Qk Wi Kps ēik given in SniP II-7-81?
25. What types are divided according to the depth of the earthquake source?
26. What is magnitude and how is it defined?
27. Explain the formula Soik = a Qk Wi Kd ēik given in QMQ 2.01.03 – 96.
28. Give the damage levels of buildings according to the scale of Yefi?
29. Specific oscillations of systems with degrees of freedom equal to one (taking into account resistance forces).
30. In which seismic belts do most of the earthquakes that occur on Earth occur?
31. Seismic and microseismic zoning of territories is based on what factors?

32. How is the formula proposed by Mononobe for determining the dynamic coefficient b expressed?
33. Calculation schemes of systems are selected according to what parameters.
34. When will territories be microseismically fogged?
35. Write the equation of eigenvibrations of a system with two degrees of freedom. Set its determinant to zero and construct the recurrence equation.
36. Where are the three main seismic belts on Earth? In which seismic zone is Uzbekistan located?
37. Explain the nature of the earthquake and the causes of its origin?
38. Compare the formulas for determining seismic forces according to SNiP II-7-81 and QMQ 2.01.03-96 and explain the difference.
39. Draw a graph of oscillations (sinusoidal) for the cases where the resistance forces of the system with one degree of freedom are taken into account and not taken into account.
40. What issues are studied in the dynamics of structures?
41. Instruments that record vibrations?
42. Types of earthquakes.
43. What types of dynamic forces do you know?
44. What does the form factor η_{ik} of free vibrations take into account and how is it found?
45. What are measures to ensure earthquake resistance of buildings?
46. Types of vibration.
47. Vibration records (seismogram and accelerogram).
48. General rules for the design of earthquake-resistant buildings.
49. What is the strength and energy of an earthquake measured?
50. What parameters determine the degree of freedom of the system?

VI-GLOSSARY

Dynamic forces are the forces that cause acceleration in the building masses.

Free (intrinsic) vibration – When an external force is applied to a mechanical system at rest (for example, a hammer or a mathematical pendulum) and is immediately removed, the system oscillates. Such oscillation of the system is called free or private oscillation.

Forced Vibration - If the oscillating system is always under the influence of an excitation force or shock force, then such vibration of the system is called forced vibration.

Amplitude - the largest deviation of the points in them from their equilibrium position when calculating the strength of the structure or machine parts in the state of vibration.

The period of oscillation is the time taken for one complete oscillation.

Vibration frequency (repetition) is the number of vibrations in a certain time.

Calculation scheme - a scheme representing a simplified representation of facilities.

The degree of freedom of the system is the number of geometric parameters that determine the state of the system when it vibrates.

Resonance is a case where the frequency of the excitation force and the frequency of the specific vibration are equal.

The spectrum of repetitions is a set of all repetitions of free oscillations of the system.

Hypocenter or focus of an earthquake - the place where rupture-displacement occurred.

Aftershock – Repeated earthquakes.

Foreshock - A weak earthquake that occurs before the main earthquake.

Tectonic earthquakes - They are tectonic earthquakes because they depend on the tectonic movement of the Earth's crust.

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