SCHOOL EARTHQUAKE SAFETY PROJECT

RETROFITTING OF MASONRY AND FRAME – PANEL SCHOOL BUILDINGS IN TASHKENT – UZBEKISTAN

FOREWORD

The School Earthquake Safety Project, United Nations Centre For Regional Development – **UNCRD**, sponsored a critical study for the school earthquake safety in Tashkent.

Prevailing constructive types of school buildings in Tashkent are schools erected of masonry (retrofitted or not retrofitted with reinforced-concrete elements) and frame-panel schools.

Masonry schools were erected since 1934. Frame-panel schools since 1974. Number of floors of school buildings typically 1-4 floors.

Frame-panel buildings of schools were erected from modular reinforced-concrete elements. Bearing elements was the frame consisting of modular reinforced-concrete columns by section 30x30 and 40x40 cm and crossbars by section 40x50 cm. As ceilings were used multihollow preliminary strained reinforced-concrete plates with height 220 mm. As external walls were used single-layered panels with thickness 30 cm from light concrete with density 1200 kg / m^3 which were hung on columns. As partitions were served masonry walls with thickness 12 cm, plaster plates 10x30x60 cm.

These two basic constructive types of school buildings were exposed to influence of earthquakes with intensity from 5 up to 9 units by scale MSK-64. As a result of the analysis of consequences of earthquakes the reasons of their damageability were revealed.

Masonry school buildings

1. Age of a building. If age of building is more senior, it is more possibility of damage as in 40-50 years of the last century building codes for seismic areas practically were absent, and recommendations were imperfect.

2. Absence of constructive (appointed without calculation) actions for retrofitting of schools buildings (there is no antiseismic belt, building complex in the plan, bearing walls not axial, large distances (more than 9 m) between bearing walls, there is no horizontal reinforcing (through 5-7 lines grid 206 longitudinal plus cross bars with step 30 cm), there are no cores - vertical reinforced-concrete inclusion in walls and frames of window and doorways, not in each compartment between antiseismic seams there are stairways).

3. By testing calculations it is shown, that actual durability of building equal no more than 50 % from required by building codes.

4. There are damages in bearing walls as cracks from the previous earthquakes, subsidence and settlement of the basements, watering of basements, stratification of brickwork. Differences of marks by height in places of crossing of walls more than 20 % from height of floor. A deviation from vertical of walls by height of building more than 10cm.

5. Instead of reinforced-concrete - ceiling wooden. The hard disk, i.e. ceiling pliable is not provided; at presence of modular plates of reinforced-concrete ceiling seams between them are not filled with mortar or fine-grained concrete.

6. The basements not reinforced-concrete (slag concrete, masonry, concrete blocks).

7. Strength of cohesion of mortar with masonry in horizontal joints is less than 1,2 kg / cm^2 (minimally allowable value), and strength of mortar is less than 25 kg / cm^2 and masonry less than 75 kg / cm^2. Quality of brickwork is low (vertical seams are not filled with mortar, bad bandaging in bricklaying).

8. By architectural - planning parameters the building does not correspond to modern requirements, modernization of rooms therefore is required, that will demand increase of seismic stability also.

9. Reduction of heat isolation properties of external bearing walls also will entail necessity of retrofitting of walls.

Reinforced-concrete frame-panel buildings of schools

1. Year of construction of schools subject to retrofitting approximately since 1974. Therefore this criterion for all schools identical and it, as a rule, was not taken into account. This criterion can be taken into account, if the building during operation was exposed to influences of earthquakes of small (3-4 units) and middle (5-6 units) intensity.
2. Building is located in site with soils with strong subsidence properties or subject to liquefaction.
3. Actual durability of concrete of constructions in the average 30 % below of design.
4. Durability (seismic stability) of building at testing calculation does not exceed 70 % required by building codes.
5. As bearing frame designs of series IIS-04, release 1, section of columns 30x30 cm are used. This frame the most vulnerable at earthquakes due to:
• welded joint of column with a crossbar in a zone of the maximal loads at earthquakes;
• support of crossbar on a column is carried out through steel bars releases from crossbar, instead of through reinforced-concrete;
• the welded joint worsens plastic properties of steel, that at earthquake results in fragile destruction;
• the frame is formed only in a cross direction of a building.
6. The following releases of series IIS -04. Columns - 40x40 cm, and a frame is created in two directions - in cross and longitudinal. These releases are more earthquake resistant. Monolithic frames are even more earthquake resistant, because in it the steel bars is not welded, but tied.
7. There are damages as cracks on a surface of constructions with width of disclosing more 0,4mm, skews of floors more than 1/200 heights of a floor, a skew of buildings as a whole more than 1/70 from height of all building or more than 15 cm. Differences of vertical marks more than 1 % from length of a crossbar or 2 % from height of a floor. Rare more than 30 cm a step of cross cores in columns.
8. High collapsibility of sites of construction - more than 20 cm of settlement of the basement under weight of building.
9. Corrosion of armature with loss of section up to 10-15 %.
10. Between the separate basements under columns there is no connection among themselves with the of edges of rigidity for exception of negative influence просадки the basis.
11. Seams between modular plates of ceiling and coverings are not filled with mortar or fine-grained concrete, and filled by building dust. Support of plates on crossbars less than 7 cm.
12. External hinged wall panels are rigidly connected to bearing elements of frame, thus prevent the frame to be deformed freely.
13. Between end faces of partitions and bearing elements of a frame backlashes up to 2 cm for maintenance of free deformation of a frame are not stipulated at earthquakes.
14. Stairway marches in places of support are not welded on sites.

Presence of the majority of these factors with other things being equal gives advantage at selection of building for retrofitting. At an arrangement of a building in areas of 7,8,9 and more units, the buildings which are located in areas with higher seismicity have advantage.

Presence of these factors were taken into account at a choice of buildings of schools for restoration and retrofitting in Tashkent.

The major factor resulting in serious damages of buildings of schools at earthquakes, is quality of conducting civil and erection works was during construction of object.

According to the Project in Tashkent it was supposed to choose two schools: one - masonry, another - frame-panel for realization on them of indicative retrofitting with training of builders to provide technology of correct implementation of works on retrofitting of buildings of schools.

The objects of schools chosen for retrofitting prior to the beginning of development of working drawings of the project of retrofitting carefully in details were surveyed as visually, as instrumentally by specially developed technique.

The basic information on a technical condition of constructions of school included the following parameters on reinforcement object:

- Year of construction;
- Engineering - geological data of a site;
- Strength and deformation characteristics of underground and ground constructions;
- Dynamic characteristics of a building (actual period of the basic tone of own fluctuations, decrements of attenuation etc.);
- Data on antiseismic actions and constructive restrictions;
- Sizes and characteristics of constructive elements of a building, joint connections (in view of defects and damages);
- Settlement resistance of soil, concrete to compression;
- Actual seismic stability of a building in view of a condition of constructions etc.

Basic elements of retrofitting of masonry buildings of schools

1. Implementation of antiseismic belts with application of retrofitting bars or rolling profile steel as angle bars or channel bars.
2. For creation of a hard disk of ceiling replacement of wooden ceiling on monolithic reinforced-concrete.
3. Introduction of additional reinforced-concrete or metal frames for retrofitting of long walls (more than 9 meters) and supported in a perpendicular direction by walls.
4. Implementation of frames for window and doorways by angular steel or monolithic reinforced-concrete.
5. Retrofitting of walls (from one or two sides) for perception of the main stretching loads by means of retrofitting grids in a layer of high-strength mortar M100.
6. If necessary retrofitting of the basements by implementation of reinforced concrete covering.
7. Creation of the irrigational network excluding watering of the basements and blind area around of building.

Basic elements of retrofitting of reinforced-concrete frame-panel buildings

1. Retrofitting of joint connections of columns and crossbars.

2. Retrofitting of columns by the implementation of reinforced-concrete holder or metal structure.
3. Retrofitting of crossbars by escalating by metal structure.
4. Introduction of connections for increase of rigidity of building from reinforced-concrete diaphragm, transformation of masonry partitions by retrofitting in diaphragms, metal bracings.
5. Retrofitting of the basements by enlarging or introductions of diaphragm from reinforced-concrete.
6. Increase of rigidity of ceiling by an additional layer of the reinforced concrete.

On the chosen model schools the specified elements of retrofitting were applied: it is masonry school N20, 1939 years of construction and frame-panel school N 116 in Tashkent.

Masonry school N20

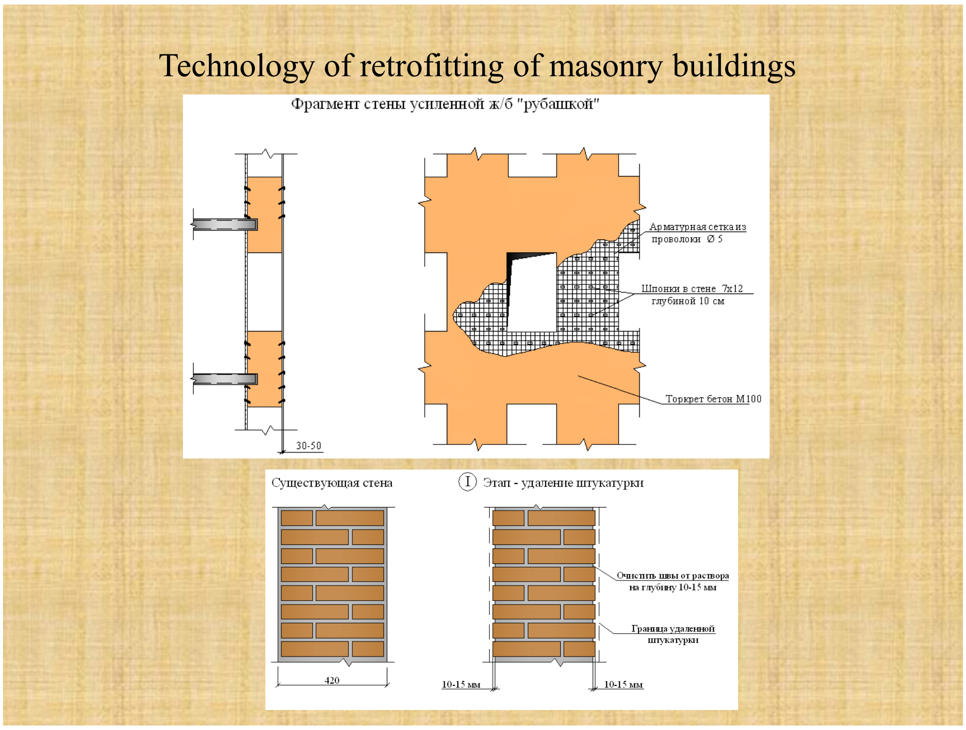

Frame-panel school N 116 in Tashkent.

For builders was held technical seminar - training on which the presentation of the Manual on technology of works on retrofitting of masonry and frame-panel buildings of schools was carried out. Special tests « Antiseismic construction » and the questionnaire of the participant of seminar - training were developed. Participated more than 45 experts - builders and designers.

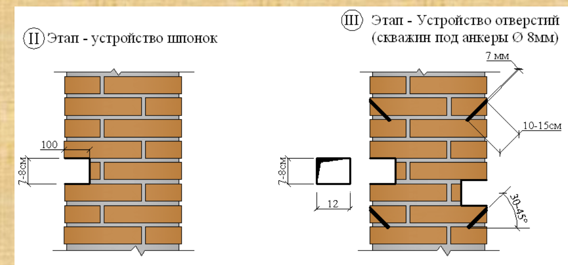
Thus, for the first time experts of Joint-Stock Company " UzLITTI " within the framework of the Project UNCRD develop training Manual for builders in which in enough popular form data on nature of earthquake, why buildings of schools may collapse, what is aseismic buildings, principles of designing of aseismic buildings of schools, technologies of "step by step" performance on construction site the most widespread and frequently ways of retrofitting of masonry and reinforced-concrete frame-panel buildings of schools of existing buildings. Materials are received on an example of retrofitting of exemplary schools in Tashkent.

Also positions by the basic criteria of selection of existing schools for prime development of the project of retrofitting and realization of works on maintenance it safety at earthquakes are prepared. All results obtained within the Project are adapted and as much as possible adapted to local conditions.

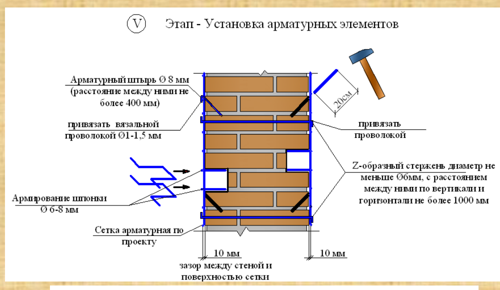
In the following figures separate illustrations on technology of strengthening of brick and frame-panel buildings of schools are presented, explained in Manual.



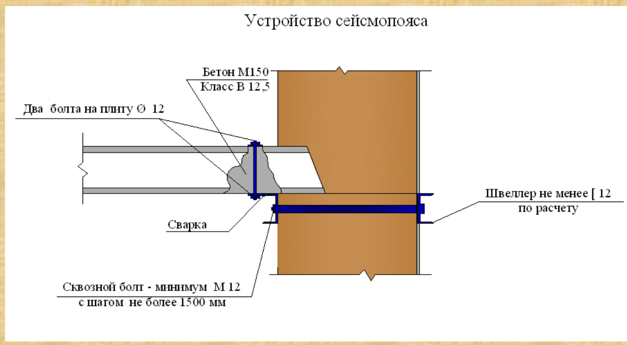
Technology of retrofitting of masonry buildings



Technology of retrofitting of masonry buildings



Technology of retrofitting of masonry buildings



The layer of plaster under channels or angle bars leaves

Channels are established in design position on a layer of a polymeric mortar

Through walls of channels in a wall bore through cross bars for coupling bolts

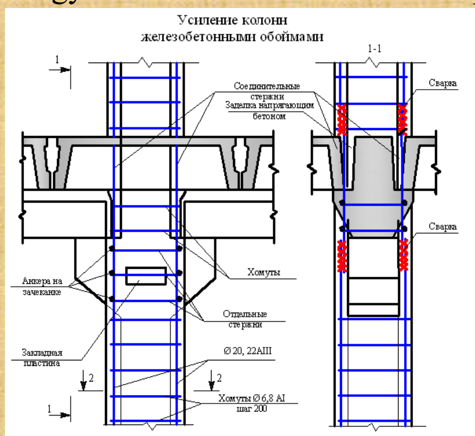
Make installation of bolts and their prolongation. A step of bolts no more than 1500 mm and diameter not less M12

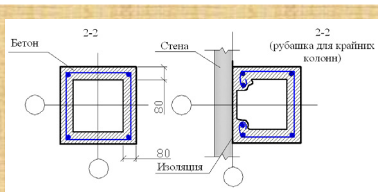
Through one emptiness in plates bore through apertures for the passing anchor bolts

Establish anchor bolts of d 12 mm which from below weld on channel

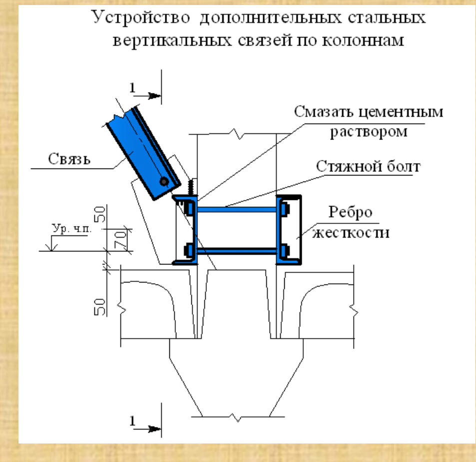
In the widened top aperture in emptiness of plates pour concrete, after that tighten bolt nut. On each plate establish two anchors

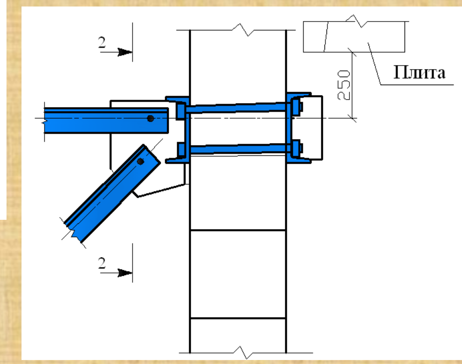
Technology of reinforcement of frame – panel buildings





Technology of reinforcement of frame – panel buildings





Technology of reinforcement of frame – panel buildings