EFFECTS OF THE KYZYL-KUM EARTHQUAKES ON APRIL 8 AND MAY 17, 1976

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On April 8 and May 17, 1976 at 5:40 a.m. and 6:00 a.m. (Moscow time) severe earthquakes took place in Western Uzbekistan. The epicentral zones of both quakes lie 30-40 km north of Gazli and about 150 km north-west of Bukhara. The average magnitude determined in terms of the data of a few scores of of quake-registering stations was 7.0 for the first earthquake. According to the tentative data the magnitude of the second earthquake was about 7.3, and the depth of the focuses was 20-30 km.The ground tremors were felt over a considerable territory of Middle Asia and according to the tentative data they registered the intensity of 4 in Tashkent and Ashkhbad, 5 in Navoi, about 6 in Bukhara and about 8 in Gazli. The intensity of the second earthquake in the same regions was one point higher. according to the tentative data of the Institute of Earth's Physics, Academy of Sciences of the U.S.S.R., vertical accelerations in the epicentral zone of the May 17 quake were about 1.0 g and maximum accelerations in horizontal directions were 0.8 and 0.62 g.

Scientists from several research Institutes of the U.S.S.R. investigated consequences of the April 8 quake in the township of Gazli according to an agreed program and by the same methods. A summary schematic schedule of buildings damage in the township was compiled indicating the structural schemes of those buildings. The degree of damage was determined in terms of a new version of the seismic scale with corrections adopted after the discussion of the methods during the analysis of the buildings, with all the investigators participating. Due to the preliminary analysis of damage of practically all the buildings in Gazli the intensity of the April 8 quake was assessed as about 8.

It is difficult to appraise the intensity of the May 17 quake in Gazli as most buildings were severely damaged during the first earthquake and only the total effect of both quakes can be ascertained. As the survey results indicate, the intensity of the second quake in Gazli was higher than that of the first one. A more precise determination of the intensity requires a particular analysis.

The township of Gazli has been developing since 1958 and up to now its population has reached 13 thousand people.

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It is built mainly of one-two-storey brickwork dwellings, 2-storey large-panel dwellings, one-storey adobe brick and wooden board wall dwellings. Besides there is an industrial area in the town with buildings of various structural schemes. No measures were taken to make buildings earthquake-resistant. Sand and sandy loam of 1 to 3 m thick make the soil of the town. The level of ground waters is rather high, and at some places water even comes to the surface.

The majority of 2-storey brickwork buildings have cross load-bearing walls,multi-cavity reinforced-concrete floor slabs, roofs of corrugated asbestos-cement plates on inclined wooden rafters. It is of importance that all those buildings have terraces along one facade, some buildings have terraces on the end walls and on the opposite ones. Enclosure of terraces is of brick or reinforced concrete. The external walls were 38 cm thick, the design brick brand is 75 and that of the mortar is 25.

After the April 8 earthquake the brickwork buildings suffered severe damage. Most typical destructions were falling out of portions of external walls (Fig.1), diagonal cracks in wide interfenestrations, shear of floor slabs, damage of wall corners on the second floor, inclined cracks in internal wall, disintegration of brickwork and falling out of bricks from walls above door openings. In all buildings failure of parapets, chimneys, falling out of gable walls and infilling brickwork at the loft level were observed. In some cases lintels and brickwork over them on the upper floor fell out.

The pattern of damage and failures was governed by the absence of earthquake-resistant measures,

absolutely necessary in a hot climate, had not been satisfied, thus adding to the worsening of damage. The two-storey silicate brick building of School of Music is a striking example. End walls on the first floor came down on both sides, brickwork collapsed into separate bricks and short lengths of reinforcing bars stretching from longitudinal walls proved to be of no effects.

Of public buildings with brick walls the secondary school building and hospital will be considered. The school is a 4-storey main brick building linked with a single-storey gymnasium and school assembly hall. The main building is designed with a longitudinal internal load bearing wall. Partitions between classes are made of brick and gypsum-concrete slabs. After the first earthquake intensive damage of internal walls was observed, on the two upper floors in particular. Interfenestrations of outer walls of the corridor gave way to horizontal cracks at the floor level. The inner longitudinal wall was covered with a network of inclined continuous cracks. Cross walls also had continuous diagonal cracks up to 1 cm wide open. The major part of gypsum-concrete partitions on the upper floor collapsed. The masonry hospital building had a complicated plan and an open gallery along one side. After the April 8 earthquake the end wall of one of sections suffered most of all and deformations of outer walls brought about the collapse of the roof slabs because of insufficient resting area.. There was a staircase at the end of that wing which appeared to be buried as the slabs came down. On the first floor in the physical-therapy room roof slabs also collapsed. After the 17 May earthquake the whole hospital building collapsed (failure of all the structures).

Single-storey brickwork public and industrial buildings (restaurant, stores, confectionery factory, fire station, etc.) suffered severe damages during the first quake, and a great many of them collapsed during the second one.

The bakery (a single-storey building with a large number of openings in load-bearing walls) was in a hazardous state after the first quake. Stoves and brick foundation of the metal chimney were severely damaged. In all the two-storey children's day care facilities parts of outer walls came down during the first earthquake thus bringing about collapse of floors. This happened mainly in the end walls of buildings where there were large rooms, some load-bearing walls did not fail and still supported floors. The same was observed in the House of Domestic Service. After the second earthquake all those buildings also collapsed.

A great majority of damage in brickwork buildings was due to poor cohesion between mortar and brick. As the test data obtained by the Institute ISMiS, Academy of Sciences of the Georgian SSR, show, the cohesion was within 0.09 - 0.33 kg/sq.cm despite fairly high grades of mortar. One of the reasons for the above mentioned damage was poor quality of brick-laying workmanship.

Individual houses were mainly of a wooden board type and houses with walls of adobe brick. Wooden board houses suffered only light damage during both earthquakes. Failure of brick infilling near stoves and chimneys was among most serious. During the first earthquake single-storey buildings of adobe brick were damaged severely and some even collapsed. After the second earthquake most such buildings came down.

There were built 36 large-panel dwellings, among them one 4-storey building, and the rest were two-storey high with 22 apartments. After the April 8 earthquake most buildings had damage in the form of cracks along panel joints, at places of intersection of longitudinal and transverse walls. In many panels there were horizontal and vertical cracks near openings, sloped cracks in the middle of transverse walls and in corners. It will be observed that most severe damage was in the joints of panels, which were tied up by welding poorly anchored backing details or by connecting erection loops. In most buildings inter-panel displacement was up to 1-2 cm and partitions underwent intensive damage. Some buildings suffered substantial deformations caused by differential settlement of bases done in the form of individual pillar members where wall panels intersected. In one of such buildings floor slabs collapsed.

After the May 17 earthquake damages in large-panel buildings worsened. In four buildings structures collapsed in part which was caused by substantial deformations of walls, absence of connection between adjacent floors and inadequate resting area for floor slabs. Reciprocal shearing of longitudinal and transverse walls reached 15-20cm. Joints between panels collapsed completely. Panels themselves were damaged by vertical, horizontal and sloped cracks (see Fig.2,3). The survey results show that the load-carrying capacity and deformability of large-panel buildings were practically exhausted and limit states were reached. Data of instrumental measurements prove that rigidity of those buildings became several times less. Very typical were damages of floor slabs in the form of intensive cracks, at the level of upper storeys in particular.Nevertheless it should be emphsized that though there were no earthquake-resistant provisions, large-panel buildings withstood two severe earthquakes much better than brick masonry buildings, and in the majority of cases there were no failures of load-bearing structures.

Among public buildings constructed wholly or in part in reinforced concrete frames, the analysis of behaviour of a two-storey school building, department store, House of Engineering as well as passageway and sport hall of the 4-storey school are most interesting.

The 2-storey framed school building was erected following the project for the design seismic intensity of 8, modified for conditions of non-seismic regions. It has three wings in plan, adjacent to the main building. After the April 8 quake a great deal of columns were damaged at the intersection with girders, with concrete spalling at some places and buckling of reinforcing bars. Partitions in classrooms and corridor were destroyed by sloped and x-shape cracks, some of them failed. Serious damage was observed in external brickwork walls of infilling, particularly where individual sections of the building joined. In the assembly hall portions of walls collapsed and reinforced concrete columns cracked.

After the April 8 earthquake the major structures of the school were restored: part of the frame joints was reinforced by metal laps, under the most damaged girders in the span portal bracing of steel rolled shapes were installed, and in corners channel brackets were placed which increased the frame effect of the system. Brick and gypsum-cast partitions were made with reinforcement. Brick walls of the assembly hall were erected anew, at the floor levels aseismic belts were provided to make the structure earthquake resistant.

After the May I7 earthquake all the load-carrying and enclosing structures of the school were severely damaged or collapsed. The lap-frame joints reinforced had horizontal and sloped cracks, in a great many connections concrete came down partly and reinforcing bars buckled. Structural and technological defects of workmaship in erecting the frame such as interruption of frame concreting at the column top level which did not ensure solidity of the structure, absence of coupling of column and girder reinforcement and inadequate (from the view point of earthquake resistance) confined reinforcement, produced more adverse effects during the second quake.

As a result of failure of connection zones and concrete crushing in columns at a height of 30-50 cm under the girder in a few classrooms and near the staircase roof slabs collapsed (Fig. 4). In fact, all the partitions in the building were damaged and many failed. Girders reinforced with portal bracing suffered not so severely as before damage being in the form of vertical and sloped cracks. However in the lower joints of bracing with columns cracks and spalling of encasing concrete were observed. Ruptures of pipes of heating and water-supply systems in the school were reported. Walls of the assembly hall, partitions in particular, were damaged by horizontal and sloped cracks, reinforced concrete columns being damaged severely.

There are a few parking sheds on the territory of the industrial zone. Three of them have a frame of tubular members (gas pipes) in the form of struts and trusses manufactured in-situ. In a two-span (2x4.5) shed, 78 m long, cantilever zones of trusses rested upon struts of pipes I00 mm dia embedded in the longitudinal wall I-brick thick. On the opposite side there were no walls. The roof was done of panels I.5x6 and 3x6 m, the roofing was laid on cement layer and mineral wool.

After the May I7 earthquake large areas of longitudinal walls collapsed. Having nothing to rest upon, cantilever zones of trusses bent, thus leading to failure of reinforced concrete roof slabs. There was observed instabity and flattening of tubular chords over supports, tearing off and failure of horizontal struts between trusses. It should be noted that tubular trusses had no posts and diagonals at resting zones over the intermediate column, erection welding of the majority of structures was replaced by slight connections only. The estimations have shown that stresses in the bottom chord due to vertical dead loads with end supports being removed can reach 2 200 kg/sq.cm.

The tentative analysis of consequences of the Kyzyl-Kum earthquakes on April 8 and May I7 proved the necessity for providing special structural and planning arrangements for buildings erected in that region to make them earthquake resistant. The analysis necessitates also corrections to be introduced into the map of seismic regionalization and into the scale for estimating intensity of earthquakes in terms of the amount and pattern of damage in buildings of different structural design.

Captions

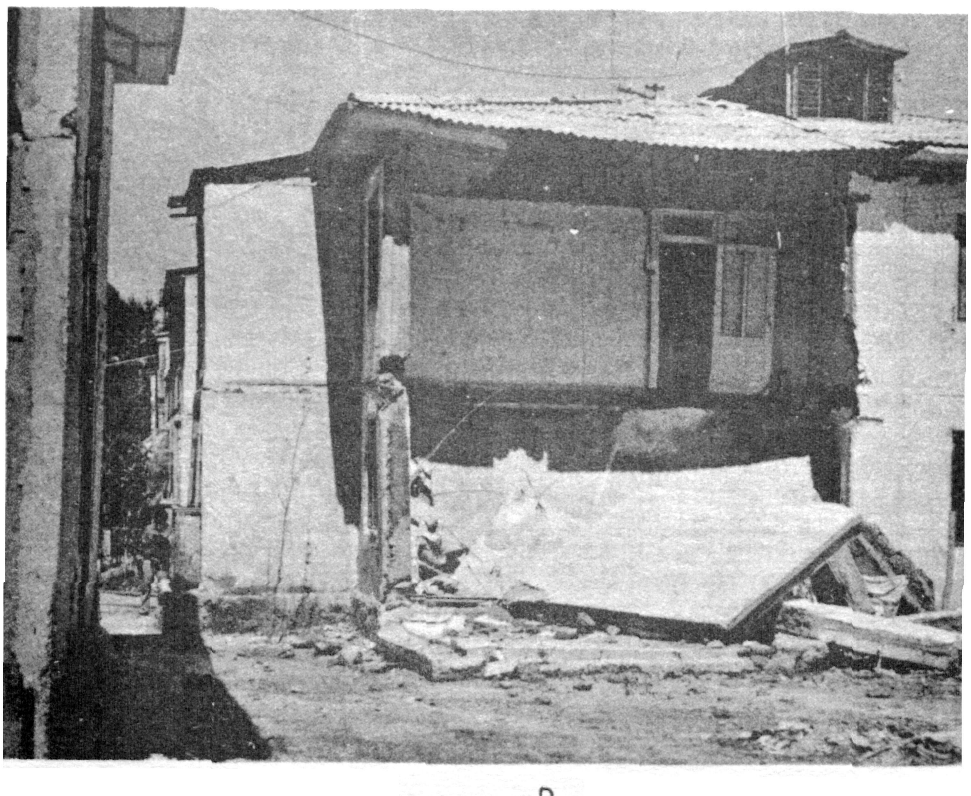
Fig. I Collapse of a brick masonry wall of a two-storey dwelling.

Fig. 2 Damage of the end wall of a two-storey large-panel building.

Fig. 3 A section of a four-storey large-panel building facade.

Fig. 4 Collapse of structures of the two-storey school with a reinforced concrete frame.

Fiq 1



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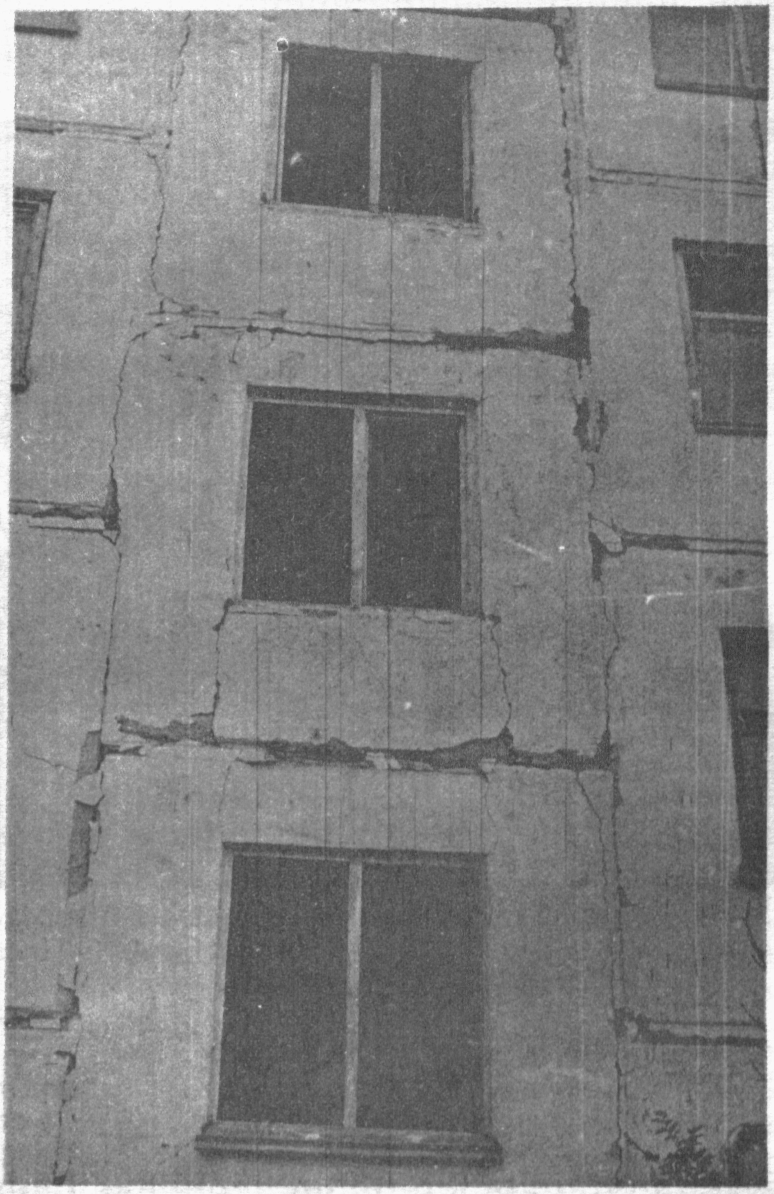

Fig 3

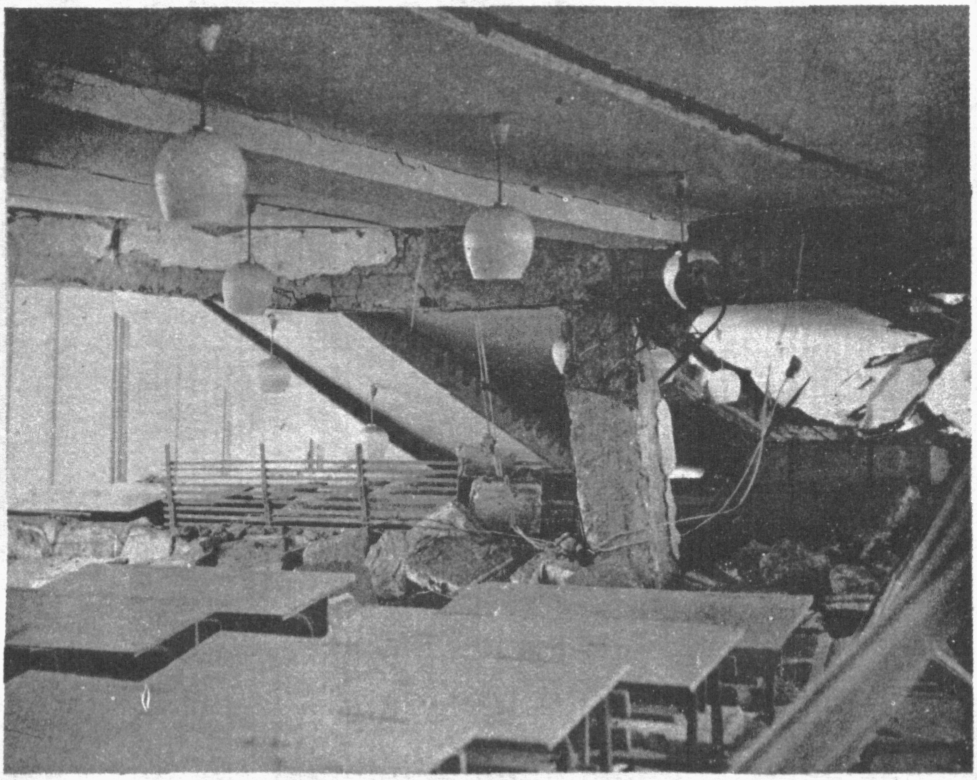

Fig 4

DISCUSSION

W.O. Keightley (India)

The slides showed the failure of second story brick walls in two-story buildings, without accompanying failure of 1st story walls, particularly the falling out of these walls, perpendicular to the buildings. This is unusual in the discussor's experience. Was this caused by some aspect of the construction, by unusual ground motion or both ?

J.L. Justo (Spain)

It is felt that the vertical acceleration in author's earthquake is much larger than the horizontal one. Do the author have some explanation for that ?

Author's Closure

With regard to the question of Prof. Keightley, we wish to state that the character of damage of two-story brick buildings in the township of Gazli resulted from high intensity of the earthquake and lack of antiseismic precautions, as the regional seismicity was considered to be 5.

Greater damage of upper stories is typical of such buildings because the decrease of gravity load on the walls (as compared with the first stories) results in lower masonry resistance to major tensile stresses and shear forces. The similar damage could be seen in Tashkent after the earthquake in 1966.

With regard to the question of Mr. Justo, we wish to state that the larger acceleration amplitudes in the vertical component are characteristic of the sites near the foci. During the Gazli earthquake May 17,1976 the instrumental data were obtained practically in the very center of the epicentral zone (about 35 km North-West to Gazli). And this fact accounts for severe vertical accelerations. The mechanizm of buildings damage, including greater damage to the second stories, is also the result of large vertical mass loads on the elements.