The 1988 Giumri (Armenia) earthquake: some thoughts and conclusions on the comparative performance of traditional and reinforced concrete buildings

Vardan Mkrtchyan, Dip.Arch.,Dip.Trans.
Building Conservation Service
e-mail: build-conserve@geo2.poptel.org.uk
fax/tel.: 44 1924 277552

During the 1988 earthquake in Giumri (Armenia), destruction was caused mainly to reinforced concrete buildings or buildings of mixed construction, combining masonry with reinforced concrete. 19th and early 20th century masonry buildings with timber floors and roofs suffered only slight damage; what is more, they had survived the earthquake of 1936 as well. The analyses show that the percentage of collapse within historic monuments in the earthquake zone is only about 5%. These facts illustrate that traditional construction methods and materials in Armenia have stood the test of centuries in an area of high earthquake risk.

Of course we cannot deny the fact that the industrialization of building economy in Soviet period and equalization of salaries reduced the quality of workmanship and materials used, and often that difference in quality proved the deciding factor between collapse and stability during the earthquake. The motto of the 1960-70s "*cheap, fast, with quality",* and Soviet *socialist competition* in reality often resulted in unfinished and low-quality buildings. The masons and the builders in general lost their individuality. All these factors played their role during the earthquake; that is why there was such a high percentage of collapse in 1988.

Of course, the fact that most of the buildings in Giumri which collapsed were multi-stored (4-6) also played its role, but the same time we find examples of unreinforced, timber-floored masonry buildings of the same height which survived merely with some damage to the top storey. This illustrates the dangers of using incompatible materials. The compatibility of wood and stone was proved long ago. You can meet anti-seismic timber runners in the masonry of traditional buildings, not only in Armenia, but also in many other parts of the world. The use of timber floors with floor frames tying the structure between the storeys, utilizing masonry set in lime mortar, enabled traditional buildings working in ductile mode enough flexibility to survive the earthquake. The same result we can be seen in structures without any timber construction: unreinforced masonry buildings with traditional *midis* (middle between rubble masonry core and ashlar) laid in lime mortar (sometimes in such masonry buildings the role of timber runners are playing courses were stones are horizontally tied together), used in combination with clever volumetric solutions, can survive centuries. Here is pertinent to mention again the historic monuments. We can see standing structures, which survive from the middle ages and even from 5th –6th centuries, in the same high seismic activity zone and the right conservation and maintenance can help them to continue their life. One needs to be very careful during conservation in choosing materials or places in the structure for strengthening. Introducing stiffness in the wrong place in a historic structure with reinforced concrete can violate its anti-seismic characteristics. For example, such strengthening of the dome of the Cathedral in Giumri resulted in the almost total collapse of the

building, because the volumes of the main structure and the dome had different amplitudes of vibration during the earthquake, but had been tied together by ill-considered steel reinforcement. Usually in such structures the collapse of the dome extinguishes the earthquake stress and the main structure survives. The Cathedral in Ani (40km west from Giumri), which served as a proportional source for Giumri's cathedral, has already been standing for 1,000 years and only the dome collapsed during a strong earthquake in 14th century. The junction of the dome with main structure was sometimes deliberately built with weak joints; in some buildings, even, the drums of small domes were built dry, without mortar, which allows them to fall down during earthquakes without affecting the main building. The practice of strengthening the masonry of old buildings with reinforced concrete, or repairing lime-mortar-based masonry with cement mortar is hazardous in earthquake zones, because they have different modes of vibration and are the most probably places where earthquake stresses can concentrate. In Giumri we get examples of buildings surviving the 1988 earthquake, which had been successfully strengthened after the 1936 earthquake by the introduction of steel ties linking parallel walls. These performed well during the recent earthquake because they allowed the structure relative flexibility.

In general we can see, that there are two deferent ways of developing antiseismic qualities of the buildings: -stiff structures, which is mainly the conception of modern building industry and relatively more or less ductile structures, which we inherit from our ancestors. Here is the question which way to choose. For using reinforced concrete, or combination of reinforced concrete with metal or masonry, we need very accurate calculations, very high quality materials and workmenship, otherwise the results will be similar Giumri, but it again doesn't give us guaranties from the collapse. From economical point of view it seems cheaper, but it could not be cheaper then using traditional materials, or the difference is very little. Maybe solution is the industrialisation of traditional materials? Anyway researches and analyses of our traditions and heritage can give us more about Earthquake-Safe.