



AFTER-EARTHQUAKE RECONSTRUCTION IN ARMENIA

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INTRODUCTION

The Spitak-88 earthquake struck Northern Armenia on December 7, 1988 causing extensive damage and loss of life. It has been estimated that the lives of 800,000 individuals had been disrupted as a result of the earthquake which was considered moderate at a Richter scale of 6.9. The official statistics released immediately following the earthquake stated that 25,000 persons were killed and 500,000 were homeless. However, a larger number lost the support of the infrastructure of the region, and even persons who were not homeless had considerable turmoil in their lives. The cities of Leninakan (Gumri), population 270,000, Kirovakan (Vanadzor), population 185,000, Stepanavan, population 30,000, and Spitak, population 25,000, as well as more than 80 villages were paralyzed. According to announcements by government leaders in Moscow and Armenia, the disaster zone should have been completely reconstructed in two years. More realistic estimates that were made as early as 1989 pointed out that this period would be ten years or longer.

The collapse of the Soviet Union immediately after the earthquake disrupted the organized reconstruction plans of the central government. The newly independent Republic of Armenia was unable to keep the reconstruction program on track. Volunteer builders from other countries, such as Italy and Austria, left because of lack of construction materials and a collapsed infrastructure. Labor crews from the other republics of the Soviet Union returned to their homes without fulfilling their commitments.

In the first two years less than 10 percent of the residences planned for construction were successfully completed. During the first year after the earthquake, one building only out of 1195 planned for construction was completed in Leninakan (Gumri). In Kirovakan (Vanadzor) 19 instead of the planned 366, in Spitak, 12 instead of the planned 455, and in Stepanavan 27 instead of the planned 145 were completed. During the second year, however, construction by volunteer units from many countries provided additional living space as well as facilities for schools and hospitals.

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INTERNATIONAL EFFORTS

International rescue efforts were followed by volunteer reconstruction teams that moved into the region and immediately started work for the resettlement of the population. Some examples of the contribution of volunteer units are cited here:

<u>Type of construction</u>	<u>Country as builder</u>
School for 400 pupils	United Kingdom
90 bed hospital	France
Construction materials factory	Austria
Rubble processing factory	Germany
Village with school	Italy
Hospital	Norway
Rehabilitation Center	Finland
School for 480 pupils	Czech Republic
24 cottages and kindergarten	Denmark
Housing building complex	USA
Polyclinic	Poland

These examples illustrate the volunteer effort for reconstruction that brought hope and feelings of gratitude to the disaster region. A total of 40 countries, in addition to all the republics of the Soviet Union, participated in the reconstruction program. And yet, when 1991 came around, a visit to the disaster region showed an overwhelming misery, an infrastructure that was far from normal, and numerous partially-built structures. The population settled as refugees in buildings that were unfit for living. The magnitude of the reconstruction effort that was needed to bring back a normal life to the region was beyond the capacity of the local government and the construction industry. The volunteer efforts of other countries ameliorated to a limited extent the misery of the population, but the socio-economic conditions in the region remained dismal.

The failure to make progress was not entirely due to the inability of the local construction industry to mobilize. Landlocked Armenia was blockaded, fighting escalated in the neighboring country of Azerbaijan between government forces and the enclave of Nagorno-Karabagh, and the sudden breakdown of the administrative support from a central government came as a hard blow at a time when a new government was taking shape, all this resulting in a state of uncertainty and chaos.

INITIAL RECONSTRUCTION PLAN

In the beginning, all attention was concentrated on constructing new large housing districts, while no importance was placed on the reconstruction of buildings directly within the devastated populated areas. Within the old city limits, the plan was to reconstruct schools, hospitals and polyclinics with donations from governments who had shown readiness to help. Thus, the cities of Leninakan (Gumri), Kirovakan (Vanadzor) and Spitak were to be relocated to new cities where new apartments were planned for construction.

Villages, however, were to be reconstructed in their old locations. For the new cities, 580, 240 and 1490 hectares, respectively, were allocated. This decision had a positive impact. It enabled an early start to build new dwellings for the relocation of the inhabitants of the cities, while clearing the cities from the rubble of the collapsed buildings. In addition, it allowed the deployment of equipment and construction material that could not have been deployed for large scale construction in the devastated cities. However, there were negative repercussions.

First, the greater proportion of the new areas allocated for the new buildings were on fertile land used for agriculture. Second, the new cities required new infrastructures involving transportation lines, water and sewage networks, and communication systems. Under the centrally controlled mass construction techniques that were well developed in the Soviet Union, this approach did not seem to present any concern to the construction agencies, but with the collapse of the Soviet Union, the responsibility to execute the plan fell on a newly emerging small republic that at best could carry out the plans over decades instead of years.

The population was inconvenienced and depressed. They did not see dwellings being built where they had lost their ancestral homes, and they knew that the reconstruction program had slowed down considerably. The temporary houses in which they lived, containers, tents, and shacks, had no sanitary facilities or utilities. The infrastructure of the cities was not being rebuilt with the expectation that new cities would emerge in the surrounding areas. The slums in the cities caused sanitary and hygienic hazards, and psychological problems compounded the problems. Reconstruction came to a halt for lack of funds, and the population lived in misery, suffering in severe winters from the cold, and from sickness and malnutrition during the rest of the year. In hindsight, a continuing effort in reconstruction of the devastated area rather than building new cities would have received the approval of the population.

QUALITY OF CONSTRUCTION

It was well known that one of the major reasons for the collapse of numerous buildings was the poor quality of construction. It had become known that there had not been any quality control, and inspection was either non-existent or ineffective. An urgent demand for reconstruction presented the same conditions for poor construction without quality control that had existed in earlier years. Mass construction complicated the procedures for quality control, and no formal methods were enforced to maintain quality.

RESUMPTION OF CONSTRUCTION

Reconstruction was resumed in 1994 when Armenia was allocated a \$28 million credit by the World Bank. Following the bank's recommendation, a Project Implementation Unit (PIU) was created under the jurisdiction of the Ministry of Economy. The PIU prepared a new earthquake zone reconstruction program and commenced its implementation on a fast

track schedule. The original plans developed by the Soviet Union were revised by Armenian design institutes based on local capabilities and approved by the government. The program consisted of the following: apartments for 1600 families, work places for 5000 persons, and 4 schools, 2 hospitals, 1 kindergarten, 1 stadium, 1 community center. The infrastructure would consist of 30 kms of water pipes, cable lines, sewerage system, and 12 public bath houses. Completion was set for June, 1996. The progress was good, and a supplemental credit from the World Bank was expected for the continuation of the reconstruction activities.

PRIVATE SECTOR PARTICIPATION

The design process in Armenia now is administered on a competitive basis. Private and state architectural offices compete for the projects, and designs are approved according to standards set by the PIU. More than 30 Armenian contractors participate in the earthquake zone reconstruction on a contract basis. Contracts are awarded as a result of tenders. As an incidental benefit, the reconstruction program in the earthquake zone has developed a private sector capability for construction, with experience in the rules of competition to win contracts.

The population is directly involved in the reconstruction program. A mechanism developed by the World Bank gives the people that will move into reconstructed or new buildings the option of amortizing the bank loan over the 25 year period by paying or by working in the construction crews. Part of the salary of a working crew member is allocated toward amortizing the loan.

Citizens groups have taken new initiatives. Those among them who want to stay in the old city rather than move to a dwelling in the new city have been collecting sums of money to be used for strengthening of damaged buildings that is not in the plan of the PIU. Reconstruction is implemented when the population raises 20% of the cost of retrofitting the damaged buildings.

Strengthening of buildings require techniques that are carry over from Soviet days as well as new techniques being developed in Armenia. In the latter category are base isolation designs developed by the National Survey of Seismic Protection in cooperation with the American University of Armenia.

Another source of funding for earthquake zone reconstruction is the "All Armenia Fund" which consists of donations by Armenians in the Diaspora. Donations have come from the United States, Europe, South America and Australia.

Information currently available show the following results: 388 apartments were built in 1994. The following year, 1622 apartments were completed, and in 1996, 911 apartments will be delivered from the World Bank program. Another 400 units have been completed using All Armenia funds.

The total number of dwellings in the above inventory comprises 20% of the needs in the earthquake zone. At the current rate of construction, the entire earthquake zone population will be provided dwellings by the year 2000.

SEISMIC CODE

The Ministry of Architecture and Urban Construction issued a seismic code in 1995 that was the result of collaborative studies among various institutes and agencies of the government. The Code divides the country into zones identifying the Spitak region as zone 3, equivalent to a 0.4g effective acceleration. By the old Soviet code, this region is now zoned as 9 bal or higher. It is interesting to note that some parts of southern Armenia are also placed as zone 3. The entire country is microzoned by region and by principal towns.

The code has specific requirements for lateral loads, foundation and soil categories, requirements for residential, public and industrial facilities, design stresses and deformations, structural systems and opening sizes including concrete and stone masonry as well as panel and frame type structures, and strengthening requirements and methods. The code has no requirement for quality control leaving it to the government agency to implement such control. Although the code was officially issued in 1995, the reconstruction program administration had followed closely the development of the code, and its requirements were generally incorporated in design and construction. Prior to this date, drafts of this Code were circulating for review in design offices and universities. Visiting Professors at the American University of Armenia, among whom was Professor Vitelmo Bertero, had reviewed the draft of the Seismic Code, and they had made their recommendations. Generally, the code specifies earthquake resistance levels 30 to 40% higher than the old Soviet Code.

TYPES OF CONSTRUCTION

Buildings are monolithic reinforced concrete structures 1 to 5 stories high, and are of the large panel type. This design had been developed as one of the standards of the Soviet Union, and it performed well during the earthquake, unlike the frame and lift slab types that collapsed or were damaged beyond repair. The large panel type is the only one allowed for the reconstruction program, and its design is based on the new Armenian Code that has been enforced since April, 1995.

QUALITY CONTROL

Another criterion that is being enforced is that developed for quality control. On a competitive basis, the PIU selects consulting companies and charges them with the task of supervision of quality. The competing organizations are state or private design or research firms that have relevant licenses for supervision and inspection. In addition, the contractor is required to assign an engineer whose sole task is the supervision of the quality of construction. This is the first level of control. At the second level of control, the consulting company provides its supervision. The constant presence of the consulting

company's assigned quality control engineer on the job site is mandatory. His work includes visual as well as instrumental control using non-destructive methods in the field and laboratory testing of materials in the laboratory. There is also a third level, and that consists of the PIU specialists. In addition, from time to time, the World Bank representatives visit the construction site.

CONCLUSIONS

1. The debate on relocation versus in-situ reconstruction had started during the International Seminar on Spitak-88 Earthquake that was sponsored by UNESCO and held in Yerevan in May, 1989. The advocates for relocation won the argument, but it turned out that the population would have preferred to rebuild on the site of their ancestral homes.

2. Seismic strengthening would have involved major financial commitments, because practically all buildings that did not collapse needed upgrading. Repair alone would not protect the buildings from future earthquakes because, due to poor quality construction, most damaged buildings needed strengthening. Since the government had decided for relocation, the question of whether or not to rebuild after demolishing or repairing the damaged buildings did not become a major issue.

3. International aid to the devastated region, humanitarian as well as reconstruction, was essential for the population to survive. Although poor living conditions continue to this day, such international assistance prevented epidemics, famine, and complete deterioration of the region. It is estimated that international assistance amounted to \$500 million. What was needed was \$3 or 4 billion. The cost of reconstruction of brick and mortar is only a small part of the need for economic revitalization of the region.

4. The Spitak-88 earthquake prompted the scientists and engineers of Armenia to work on the development of a seismic code based on current knowledge of the geology of the country and the dynamic response requirements of structures. A review of codes used in other countries and studies of local conditions led to the adoption of a building code that divides the country into seismic zones and defines the corresponding applicable design forces and deformations.

5. A new mechanism was developed for quality control during construction. The new mechanism was a departure from earlier practice where design, construction, and quality control were all state supervised and executed. An independent supervision of quality was introduced.

6. The local engineering profession and construction industry showed unusual ability to mobilize itself after the collapse of the Soviet Union. The delays in the resumption of the reconstruction effort were mainly due to financial difficulties and the political unrest in the region. The World Bank loan has given a new impetus to the reconstruction program.
