THE IRAN EARTHQUAKE

Four of the 20 highest fatality earthquakes this century have been in Iran, but the earthquake that hit Manjil in June 1990 far exceeded previous disasters both in the death toll and the scale of destruction. Here we report on the findings of two UNDRO missions in the impact of the tragedy on buildings in rural areas, and the priorities for reconstruction.

The earthquake that struck north-western Iran on 21 June 1990 was the sixth most lethal in the world this century and the largest ever in Iran. The official death toll announced on 27 June was 36,898, and an estimated 60,000 were injured. The losses were greater because the earthquake struck at 31 minutes past midnight local time, when most people were asleep.

Destruction to buildings and property was on an unprecedented scale. Four towns with a combined population of 50,000 were devastated and an area of 30,000 square kilometres was affected. A total of 1,600 villages were damaged; in some village areas, 60–90 per cent of the houses collapsed.

The earthquake occurred in a valley between two mountain ranges, one of which borders the south-western margin of the Caspian Sea. The zone of destruction included the three towns of Manjil, Rudbar and Lowshan – all in Gilan Province. Manjil took most of the impact of the earthquake, but the effect was just as devastating to Lowshan, which is one of the fastest industrializing areas in Iran, growing at 11 per cent a year. The majority of the buildings in the towns were damaged beyond repair. But 83 per cent of the houses destroyed and most of the losses were in the thousand or so neighbouring villages, where most of the affected population live.

The provinces hit by the earthquake – Gilan and Zanjan – are distinct in climate, culture and buildings. Gilan, located towards the Coast of the Caspian Sea, is densely populated, temperate in climate, and well-cultivated with rice, wheat and tea plantations. The traditional building type in this area is two-storey timber framed construction with wattle and daub infill on a masonry plinth. Their pitched roofs are of clay tiles, thatch, corrugated iron sheeting and corrugated cement fibre sheeting. Modern housing is mainly of similar form, using steel framing members and fired brick masonry with cement mortar. Modern roofs are pitched, of timber construction, covered by corrugated iron or asbestos cement sheeting.

In the mountainous area of Zanjan – one of the poorest provinces of Iran – the landscape is dramatically different. It is relatively sparsely populated; villages are located about 30 square kilometres apart in sheltered positions in the valleys or south-facing hillsides, around springs, in pockets of irrigated land in an otherwise barren landscape. The traditional housing in the region is single storey, of rubble or adobe masonry, with flat roofs made from compacted earth and rush matting. Some of the older traditional rubble masonry houses also have horizontal timbers near the top of the walls, to add strength to the unsupported masonry. Modern housing in the area is mainly fired brick with horizontal reinforced concrete ringbeams.

The Government of Iran announced that a Master Plan for reconstruction would be prepared before the end of September 1990, and asked for all international aid to be channelled through the United Nations Development Programme and for a small international
2. Houses in the mountain villages of Zanjan are typically of rubble or adobe masonry, with flat roofs. Regular maintenance has reduced the buildings' vulnerability.

3. Modern non-engineered house in Gilan. Timber and masonry houses such as this one stood up reasonably well.

The first mission by UNDRO took place from 22 June to 6 July. It reported that in the towns of the worst affected area, where buildings were mainly one or two storey brick masonry on steel frames, collapse resulted primarily from rupture of poorly welded connections in the steel frame, and from the heavy weight of the ceilings, especially roof masonry. The mission also reported that mud and reed roofs in the village houses had offered very low resistance to the earthquake.

The Reconstruction Programme Formulation Mission from UNDRO went out to Iran on 28 July 1990. This second UNDRO mission, consisting of a six-man team of advisors and led by Dr Andrew Coburn, a director of Cambridge Architectural Research Ltd., set out to investigate more fully the technical impact of the earthquake and make recommendations for reconstruction, focusing on housing.

As a framework for assessing the performance of the different types of dwelling, the team distinguished not between rural and urban housing but
between engineered and non-engineered buildings. Non-engineered housing may be of steel frame or mud construction, and constitutes a very large proportion of the building stock in both towns and villages. It is typically built by the Mimar (master builder) or Bano (village builder) under contract to a household, who also provide much of the labour. In the epicentral region, around 75–80 per cent of these non-engineered buildings suffered collapse (ie more than half of the primary bearing members of the roof were dislodged) while most of the other buildings suffered from partial destruction or heavy damage.

The team highlighted the rapid proliferation throughout the towns and many rural areas of the country (and particularly in Gilan) of steel framed buildings. Several of these were non-engineered buildings, whose frames were held together by simple spot welding. While steel elements are expensive, they are used because they can be erected quickly (a two-storey frame can be erected in two days), and they require a low level of skills. The problem of the failure of the welds had been exacerbated by the construction of floors by jack-arches: shallow arches of fired brick masonry with steel joists about a metre apart. When the welds failed, the masonry fell into the structure. The Mission also noted, however, that some of the simple welded frames remained standing even in the severest conditions at the epicentre; it appears that these structures are less likely to suffer total collapse than other building types.

Problems of construction were also identified in non-engineered reinforced concrete framed buildings with weak mixtures of concrete steel often poorly arranged within the concrete and columns and undersized.

In unreinforced masonry structures –
including those of adobe, rubble stone masonry in mud mortar and unreinforced fired brick in cement mortar – the variation in the strength of materials and quality of construction, affected how they fared in the earthquake. In several cases, damage was found to relate to weaknesses such as cracks and other defects present before the earthquake. A major problem identified by the team was structural separation between load-bearing and non-loadbearing masonry walls, which had in several cases led to collapse of the roof.

The minority of buildings in the affected region which have horizontal reinforced concrete ringbeams, performed substantially better than other masonry, but, again, were sometimes prone to weaknesses of materials and construction. Some intact ringbeams also showed a disparity between the strength of the ringbeam itself and poor brickwork below it.

The team found that both old and recent timber framed buildings, seen in many of the villages in Gilan in the valleys down to the Caspian Sea, fared well compared with other structures. Very few of these timber framed houses were badly damaged in the earthquake. Composite structures of masonry on the ground floor and a timber framed upper floor often showed more damage to the masonry than the timber. The few collapses seen were mainly where the ground on which the structures were built had fallen away, bringing the structure down with it. Scarcity of timber would prohibit its extensive use in reconstruction; but the Mission Report advises that where structural timber is available, it should be encouraged.

Andrew Coburn, Team Leader, emphasizes that the problem is not lack of adequate seismic building codes, but the fact that very few of the buildings were constructed to the code requirements. The priority, as he sees it, is in making improvements in the quality of building construction without stifling the building production of much-needed new housing. Even more important, he stresses, is mitigation of future losses in the region, by establishing a building process of stronger structures, for the next generation of building.

The reconstruction programme is divided into an urgent first phase to provide temporary winter shelter, for completion before the end of 1990, and a second phase for completion by the onset of winter 1992.

The main reconstruction activities will be co-ordinated by the Housing Foundation in Iran – a highly competent operational organization, with almost a decade of experience working on the war reconstruction. As Akbar Zargar, advisor to the Foundation, points out, eight years of war has also created a strong community network (organized through the mosques), through which the local population are involved in the building task.

The Housing Foundation have already provided each family with the emergency provision of a tent, and are providing thousands of pre-fabricated structures as emergency measures. The objectives of the Housing Foundation for the reconstruction programme include maximum participation of the affected population and reliance on locally available raw materials for the production of the construction materials. The Housing Foundation’s Reconstruction Programme also states that the technology of converting raw materials into the final product must not be complex, so as to make possible their preparation by local inhabitants; that the choice of materials must take into account economical considerations and that the production of these materials must not have a detrimental effect upon the environment.

The United Nations Expert Mission are currently making recommendations on suitable materials for short and long-term building. In the short term, the advisors have recommended that the emergency housing for the winter take the form of one or two rooms built by the householders on the site of their previous house to form the core of an eventual reconstructed dwelling – or a store-room which can later be used alongside it. They also emphasize the short-term need for expansion of the existing small-scale
7. A well crafted village house of rubble stone masonry. The stones are neatly wedged together and smaller stones are used towards the top.

8. Detail of the horizontal timber reinforcement in a masonry wall – a traditional way of increasing stability.

Opposite: A master mason begins reconstruction of a house in Zanjan.

Concrete block production for building winter shelter.

Recommendations by the UNDRO mission for the long-term reconstruction include the training of village builders by master craftsmen from the region, in techniques of good quality masonry and concrete making, using rural technology. The proposed goal is to train 2,000 builders in 18 months. The team also recommend that the UN and the Housing Foundation work together in appointing resident Iranian architects who would be responsible for the town reconstruction.

Coburn stresses that the biggest bottleneck in reconstruction will be supply of materials. There is a severe shortage of building materials nationwide. The UNDRO mission anticipates the exploration of appropriate materials of domestic origin, such as reinforced fired brick masonry, lightweight concrete blocks and stabilized soil.

The reconstruction in Iran takes place against the backdrop of an expanding population (growing at around 2.3 per cent) – which is also currently receiving an influx of 30,000 former prisoners of war from Iraq. However, as Coburn points out, the technical capabilities of Iranian national institutions is high, building research is of international standard; and there is an impressive spirit of cooperation and enterprise among the people, who are already actively involved in rebuilding their homes and their lives.

Notes
2. The mission team consisted of the following: Dr Andrew Coburn, Team Leader, University of Cambridge, UK; Professor Jakim Petrovski, Skopje University, Yugoslavia; Dr Danilo Ristic, Skopje University, Yugoslavia; Dr Ignacio Armillas, United Nations Centre for Human Settlements (UNCHS – Habitat); Dr Niels Biering, United Nations Industrial Development Organization (UNDRO); Giovanni Verese, Office of United Nations Disaster Relief Coordinator (UNDRO).

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