

Earthquakes: The Vulnerability of Traditional Buildings in the Yemen

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The recent earthquake has shown the vulnerability of the traditional buildings and has raised questions concerning the future of building in the Yemen. This paper describes the alien influences arriving after the revolution of 1962. It compares the traditional buildings with thick walls and roofs, suited to the climate, with the imported thin-walled versions. The philosophy of the United Nations Development Programme (UNDP) at that time is stated, and the efforts of the UNDP personnel assigned to the Ministry of Public Works to adopt a more sympathetic approach is described. The earthquake disaster is bringing in bilateral aid, but if the wrong types of rapid-aid programmes are introduced, it could be the end of the Yemeni traditions. This paper suggests criteria for taking account of the climate and the traditional patterns in building new structures, for allowing public participation and for encouraging self-reliance. The longer-term aim must be in the improvement of traditional techniques together with the application of appropriate technology. Only in this way will the Yemeni tradition survive.

Need for re-appraisal

The Yemeni people have created a unique architecture based on their deep cultural roots. In spite of the fact that alien influences have lately been suggesting design solutions that are not in accordance with these values, it is still a fact that the Yemeni people, who are proud of their architectural traditions, would like to continue building in hand-cut stone, rubble, as well as burnt brick, sun-dried blocks and rammed earth. These methods and materials have advantages from many points of view.¹ However, a new element has suddenly appeared: the need to re-appraise traditional building methods in the light of the events resulting from a recent and unexpected earthquake in the Dhamar province. There is a possibility that a rapid-aid programme



Sana'a, Yemen Arab Republic.

Photo: C. Little/Aga Khan Awards.

with bilateral assistance, if of the wrong sort, might irretrievably damage the balance of the use of local materials and building methods, causing immense harm to the cultural heritage.

The earthquake occurred on the 13th of December 1982, with a magnitude of 6 on the Richter scale, and of about 45 seconds in duration. The epicentre was located approximately 15 km north of Dhamar, and about 2 km west of the village of Risaaba. A second earthquake with a magnitude of 4 and about 3 minutes in duration occurred on the 30th of December 1982.² Some 1150 villages and settlements in an area of about 4000 sq. km around Dhamar were destroyed in this disaster. About 1500 people are said to have died, including many women and children who were at home or at school. It has been estimated that at least 300,000 people were left homeless; 42,000 houses became uninhabitable, of which 15,000 were completely wrecked. In addition, mosques, schools, water-supply facilities and wells, and government buildings were destroyed.³

Rural buildings in the Yemen are constructed with thick walls and roofs, a method having advantages from the climatic point of view. In the highland zone there is a large diurnal range of temperature (about 15° to 20°C.) so that a heavy structure can "store" the heat of the day, allowing restitution at night, and thus providing a stable indoor temperature without any need for heating or air-conditioning.⁴ However, from the point of view of earthquake risk, these are the most dangerous structures.⁵

Earthquake risk

Earthquakes have not been expected in the Yemen, and precautions have so far not been taken. Indeed, a recent World Bank project was made on the following basis: "there will be no special consideration taken to seismic conditions or hurricanes".⁶ The Yemeni government as well

as the UNDP were not of the opinion that earthquake risk existed. The existence of so many ancient minarets and high buildings throughout the country seemed to confirm their view. However, historical accounts show that earthquakes have been felt in many regions of the Arabian peninsula, but the accounts lack detail and have limited value other than showing the area is seismically active. The entire land mass of Arabia is a tectonic plate surrounded by evidence of the epicentres of earthquakes. The Yemen is situated in an area where major or minor intensities may be expected.⁷

The detailed area around Dhamar is characterised by the presence of old lava fields and volcanic rock. There is evidence of a large volcanic crater rimcrest approximately half-way between Dhamar and Sana'a.⁸ The local building stone named "trap" is of volcanic origin.⁹

It is known that the Yemen has been subjected to earthquakes, but data does not seem to exist before the thirteenth century. Al-Khazaji, living in the thirteenth and fourteenth centuries, has recorded the following earthquakes: AD 1258, in many places west of the Yemen; AD 1387, near Aden; AD 1394, near Mokha. An earthquake was recorded in Sana'a in AD 1666. In the last century, several earthquakes were recorded by the Yemeni historian Abdelwassii. There was an earthquake at al-Hayma, west of Sana'a, in 1873-74, and another, near Mokha, in 1896-97, and a third at Waylan, near Sana'a in 1909.¹⁰ Within living memory, some say there was an earthquake in Sa'ada in 1944.

Attitudes towards Yemen: architecture

Until the establishment of the Republic in 1962, the Yemen had remained a largely unknown country. It was at that time that the United Nations and its specialised agencies came forward and set up a development programme. The UNDP office in Sana'a issued Information



Wadi Dahr, Yemen Arab Republic. Architectural harmony is achieved in this settlement of old buildings through the use of natural materials and the free repetition of simple design elements.

Photo: C. Little/Aga Khan Awards.

Papers in order to "put the Yemen on the map". One of these dealt with "Housing in Sana'a".¹¹ This paper set out the main considerations upon which UN policy was to be shaped in relation to the future physical planning and construction in the Yemen. The fundamental points were: architecture in the Yemen is of the highest standard; and housing has adapted in an outstanding way to local conditions of climate, locally available craftsmanship and low-cost building materials. Architectural design was developed in the past 2000 years so ingeniously that today we find many aspects of functional design belonging to the most recent stages of the art of architecture.

It is therefore deeply to be regretted that in a sense of falsely-understood "progress", certain circles wanted to be "modern" at any price, and despised the outstanding features of traditional



Sana'a region, Yemen Arab Republic. New construction has followed many of the design practices of traditional building.

Photo: C. Little/Aga Khan Awards.

Yemeni building culture, and attempted to introduce reinforced concrete buildings. It is a fact that these foreigners came mainly from developing nations and not from industrialised countries. They spoke of cutting broad avenues through what they described as the "slums" of the Old City. Yet it is certain that no slums exist in Sana'a. It is clear that construction in the style of the Abdul Mogni Street (with its reinforced frames infilled with thin cement blocks) should be discontinued.

It is well known by those who have to live in these modern concrete houses that they are much less comfortable than the traditional buildings with thick walls and roofs. The modern structures are hot in summer and during the day, and cold in winter and during the night because of the thin walls and roofs. They also require expensive maintenance because their facades do not have naturally weathering materials.

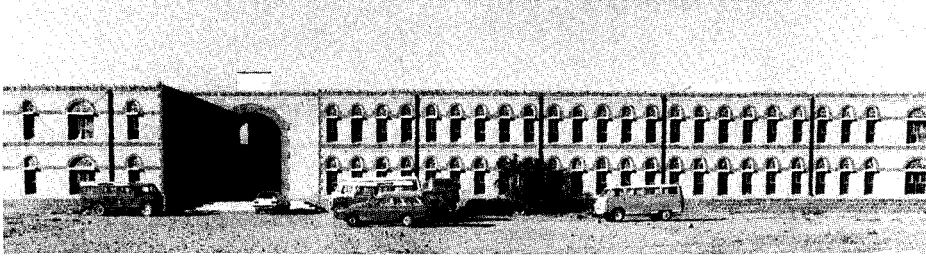
The UN Food and Agricultural Organisation tried to be "modern" and "fast" by importing prefabricated houses for the UNDP/FAO Wadi Zabid Project. It took a full 19 months (September 1968 to May 1970) for these prefabricated houses to be erected. They proved to be a nightmare of inconvenience during the hot season. About 60 per cent of the total cost (\$240,000) would have been sufficient if the project had been built with local materials and labour. Similar considerations apply to some new school buildings erected in an alien style and method. In both cases, a large proportion of the cost goes into the pockets of a few contractors, with only about 25 per cent remaining in the country. If we expect rural communities to participate in self-help for construction, then care must be taken to ensure that the money collected will remain in circulation within the community itself, in order to create an incentive and feed-back for such local develop-

ment as agricultural inputs (fertilizers, seeds, tools) and for constructing rural water supplies and feeder roads, etc. By recognising the high values of traditional Yemeni architecture, use may be made of these values in order to promote rural development economically.¹²

One result of this UNDP project was the successfully reversing of the trend of indiscriminate building with unsuitable imported materials. It became official government policy to construct all public buildings in Yemeni stonework, using highly skilled local craftsmen. This ended the mere copying of foreign building styles, and stimulated the growth of a modern Yemeni architecture, blending well with its environment.

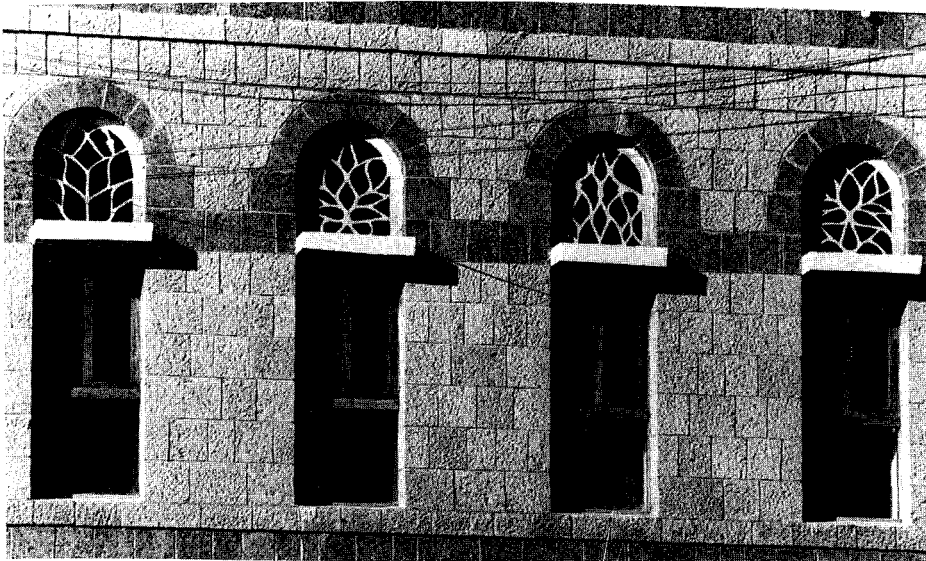
The value of Yemeni architecture and the concept of harmonious use of local traditional skills and materials in modern buildings has now become widely accepted. The architectural assistance to the Design Section of the Ministry of Public Works in Sana'a was being continued by the UNOTC architect (the author) who arrived in April 1972, and fully supported the basic principles of these policies. Continuous alertness remains essential so as to prevent aberrations by individuals, ministries, and bilateral aid donors. Vigilance is necessary, since there is still a tendency amongst local contractors (who originate from Ta'izz or Aden where traditional architecture and skills of the Sana'a level do not exist) to inflate their estimates on construction in local materials, because their profit margins in concrete construction are higher.¹³ A major break-through occurred when the government Guest House in Sana'a was constructed in solid load-bearing masonry. It then became a requirement for new official buildings to respect Yemeni traditions, both from an economic and aesthetic point of view, and the Design Office in the Ministry of Public Works fully subscribed to this policy and implemented it.¹⁴

Another important landmark appeared in 1971, previous to the Guest House, when



National Institute of Public Administration, Sana'a. South elevation.

Photo: courtesy D. Miles.



National Institute of Public Administration. Stonework detail.

Photo: courtesy D. Miles.

the government decided to build the new offices for the Ministry of Foreign Affairs in local hand-cut stone instead of the reinforced concrete-framed structure filled in with thin cement blocks, then more usual. This decision was due to the efforts of the UNOTC Planner and architect Alain Bertaud. Following this, and according to the same philosophy put forward as the UN policy, many other projects were undertaken including hotels in Hodeidah and Sana'a,

extensions to the small hospital in Sa'ada, and fish processing plants in Hodeidah and Mokha.¹⁵ Several major public buildings were designed and constructed in local materials through the Ministry of Public Works, including the National Institute of Public Administration, the Health Manpower Institute, and the Ministry of Justice. The former Palace, Beit 'Ali, was converted into Al-Hamd Palace Hotel, with extensions at roof level in traditional style and building

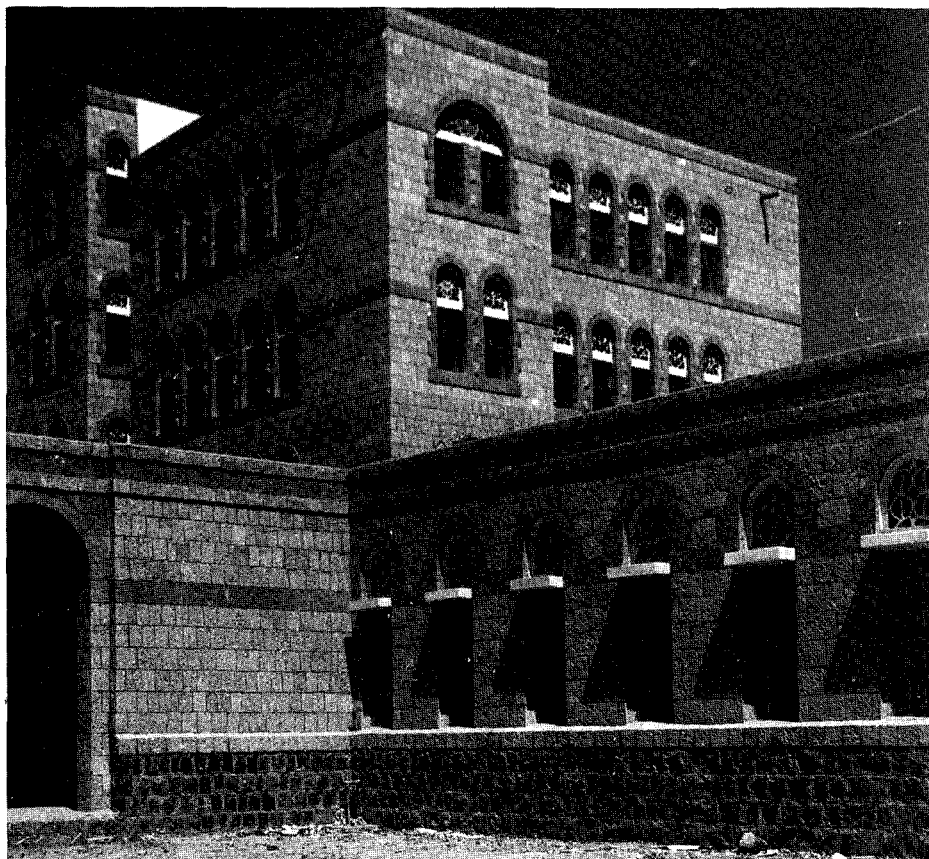
method. Other projects successfully completed included the International School, a School of Nursing in Ta'izz, the second phase of the Health Manpower Institute, and the Provisional Health Centre and Hospital, with staff housing at Dhamar. The World Bank Education Project followed the same precepts.¹⁶

Documentation

Whereas rural building, and even low-cost work in the towns, was still being carried out with local materials, it was thus proved that sophisticated work can also be done in the same traditions.¹⁷ The structural improvements since proved to be adequate in avoiding undue damage in the recent earthquake, and having good stability resistance.¹⁸

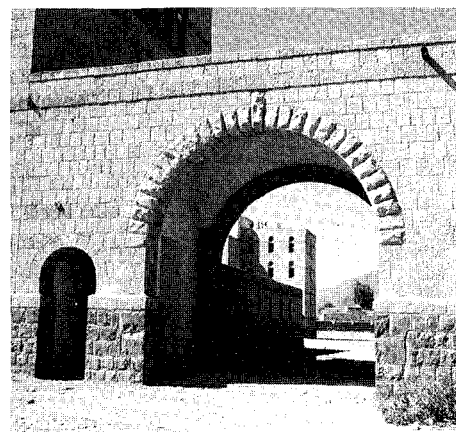
The principle has been summed up in a film by Vladimir Bibic and Derek Matthews for the UN Conference on Human Settlements held at Vancouver in 1976. The film describes the failure of attempts made in the Yemen after the revolution of 1962 to introduce western-style building methods using thin walls and unnecessary reinforced concrete framing. It shows the alternative of using local materials as far as possible, which respond to the needs of development, and at the same time conserve the harmony of the architectural heritage. It illustrates important economic advantages, for when local materials are used, the benefits are spread over the population at large, whereas if an imported system is used, the local building industry does not benefit, and the profits flow out of the country. An inferior product results, for the inevitable thin walls do not have sufficiently high performance standards to satisfy local conditions.

The content of the film was used together with other material as a basis for a large exhibition entitled "Building in the Yemen" which showed by means of photographs, etchings and lithographs the architecture, landscape, people, and the



Health Manpower Institute, Sana'a. Internal Courtyard.

Photo: courtesy D. Miles.



Health Manpower Institute, Sana'a. Entry adjacent to administrative block.

Photo: courtesy D. Miles.

building materials and traditions of the country.¹⁹

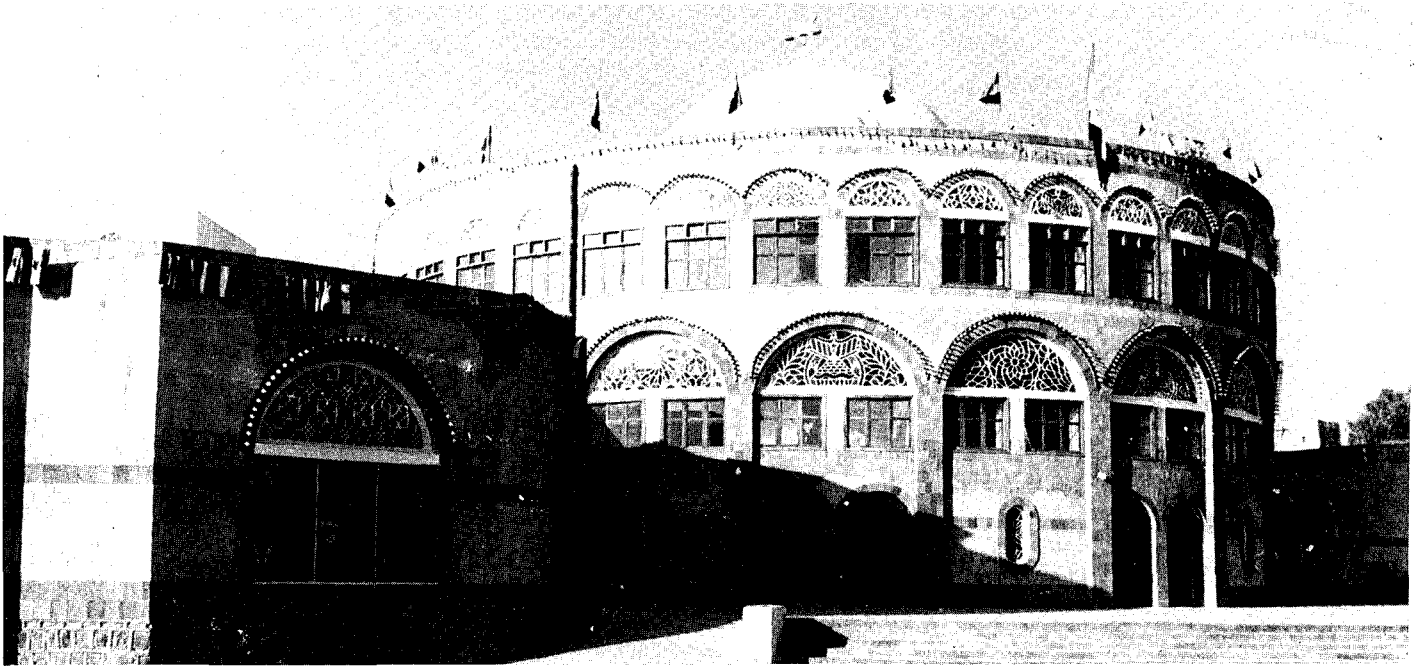
The film drew attention to the fact that there has never been an acute housing problem in the Yemen, and the people have had the skill to satisfy their needs. Housing in the villages is carried out by families, who also help each other. Rural housing, such as that which has been destroyed by the recent earthquake, is entirely of the "self-help" category, and it does not come under any description of public sector housing, nor that of private developers. Every Yemeni is a natural builder and a mason. The unique architecture is a product of the involvement of the people themselves.

Proposals

Schemes now being proposed to rebuild after the earthquake damage must take into account the fact that so-called "turn-key projects" are explicit examples of the wrong approach. The local people must be involved at every stage of the decision-making process, and especially in the execution.²⁰ It follows that certain criteria, such as the following, must apply: to use local materials, skills and technology, and even labour-intensive methods; to ensure the saving of energy; to respect traditional patterns; to respond to climate; and to encourage public participation and self-reliance.²¹ In setting up a

programme for rebuilding after such a disaster, the first decision to be made is to establish how much protection from earthquakes can be provided. Clearly it is possible to construct houses that will withstand any intensity, but this is not feasible on a large scale for reasons of cost. In the words of a UNESCO mission, "The purpose of earthquake-resistant design is not to prevent all damage by severe earthquakes, for such an objective would result in unreasonably expensive structures. The aim is first to ensure against loss of life or injury, and then to balance the cost of additional measures against the probable cost of repairing damage during the expected life of the structure". It should be added that where money is very scarce, then the main object must be to prevent the collapse of buildings and consequent loss of life. One must expect buildings to crack, and the need to repair them if there is a major earthquake.²²

When making proposals for rebuilding, it is not sufficient only to be concerned with structural stability. Not only must the structure be strong enough to withstand an earthquake, it must also have the ability to satisfy climatic requirements, so as to provide conditions in the

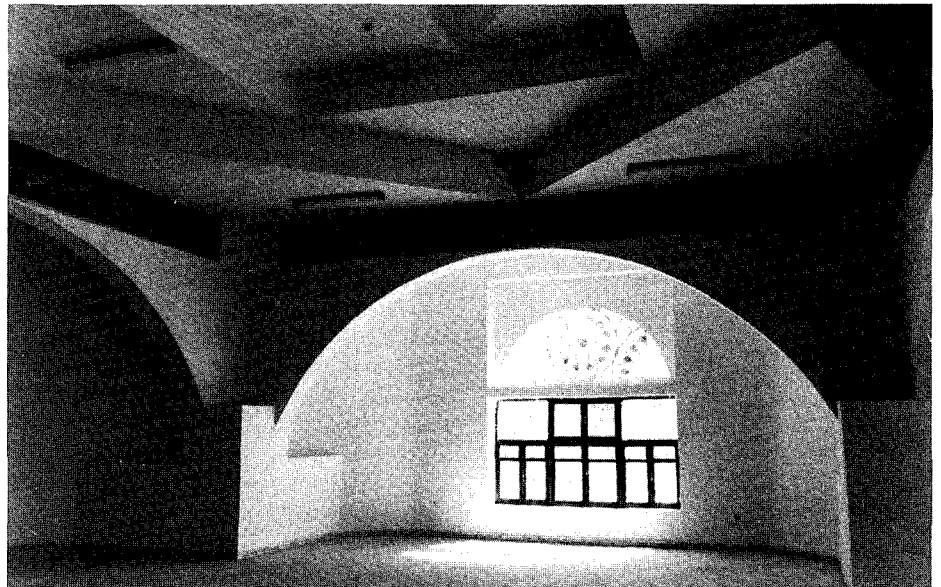


Ministry of Justice, Sana'a. Main entrance.

Photo: courtesy D. Miles.

new house as comfortable as those in the structure which it has to replace. Some proposals using thin walls do not satisfy this need. The problem here is that heavy walls and roofs are prone to extreme damage.

There is a short-term problem at present in the Dhamar area, the immediate requirements to help those who have lost their homes; for the long term, the need is to ensure self-reliance. In considering the former, rapid-aid programmes are now being proposed using mass-produced components. It is known that the government might favour systems with pre-cast elements, but not complete prefabrication. Some bilateral donors are, of course, suggesting systems which have the emphasis on strength against earthquakes, but which ignore climatic requirements and comfort conditions inside the houses, as the proposed wall thicknesses are inadequate.



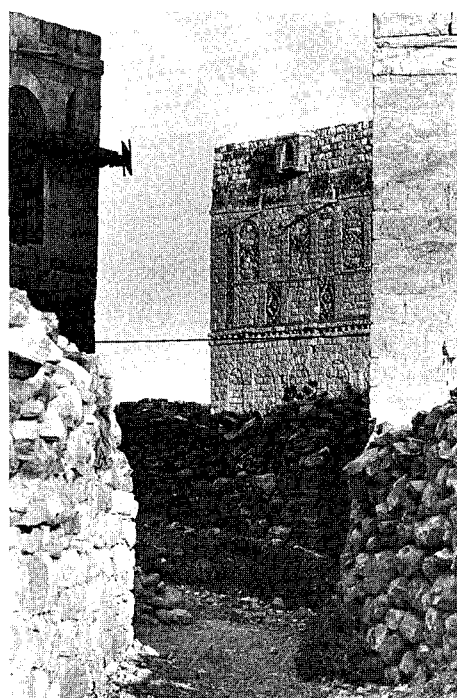
Ministry of Justice, Sana'a. Interior of Hall.

Photo: courtesy D. Miles.



Detail of exterior stone wall with projecting wood beams.

Photo: C. Little/Aga Khan Awards.



Kawkaban, Yemen Arab Republic. Stone building walls with horizontal wood coursing.

Photo: C. Little/Aga Khan Awards.

Because most of the damaged settlements are in areas inaccessible to heavy transport, only building elements that are light-weight, and of limited size, strong enough to be transported in a small truck, can be considered as practicable.²³

They should be of such a nature that the people can use any elements themselves as part of a "do-it-yourself" method. Proposals must also be in accordance with traditional ways of life, and should not require any radical changes in life-style and culture. The new structures should blend into the natural landscape.

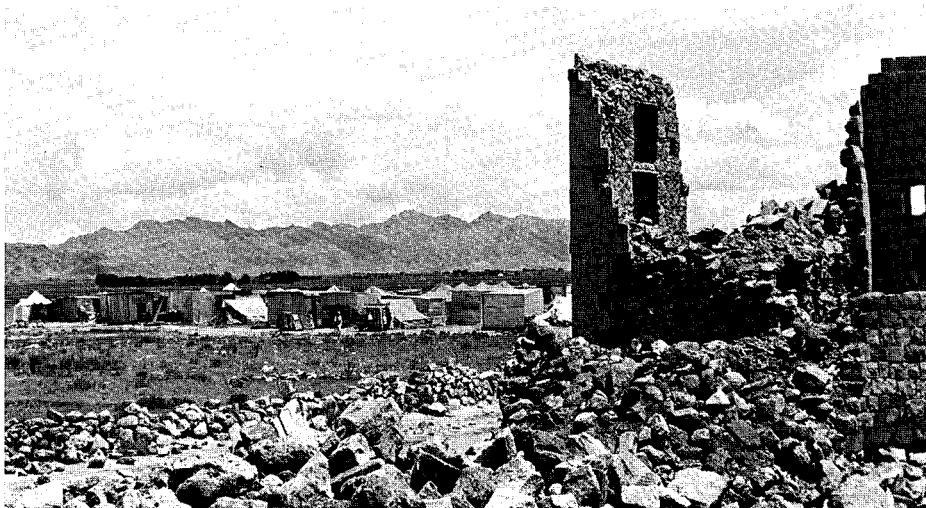
Any rapid-aid programme should take into account the need for such items as have been listed above under essential criteria, including the maximum use of local skills and appropriate technology.²⁴ The short-term solution for providing immediate shelter must be seen in relation to the long-term requirement for improving local methods and techniques, thereby bringing new structures into the category which will not collapse and cause loss of life if another earthquake occurs.

To improve traditional building, it is necessary to diagnose the types of destruction that occur during an earthquake. Field surveys show that the commonest type of failure is the breaking off of the four top corners of buildings. Cracking of the wall begins at roof level where vibration is strongest. The wall then cracks and the whole of the corner shears off, and the roof falls in. The first severe shock usually does not last long enough to bring down the levels of the building below the top storey. A second shock may continue the process. The extent of cracking, of shear and collapse, depends on the strength of the materials and their bonding, which is in turn affected by maintenance. Other conditions may cause a building to collapse throughout its full height. This may be caused if the foundations move because they are badly designed and constructed, or if they move due to ground conditions, steep hillsides, or fill. Some ground con-

ditions, such as tipped shales, magnify the transverse waves of the earthquake. A house can also be pushed over by the vibration of a cliff against which it is built, or by vibration from the collapse of neighbouring houses.²⁵

Some solutions to strengthen traditional methods of building include consideration of the shape of the basic structure, the quality of materials and workmanship, and additional constructional strengthening. Detailed information on these aspects can be found in manuals.²⁶ Briefly, Razani's statement is true: "Save the lives of the residents by preventing the seismic collapse of the roofs. Do not worry about property damage; the houses can be repaired or rebuilt later."²⁷ Such techniques were already known to traditional builders, including those in the Yemen.

Techniques for strengthening walls have been practised since antiquity. The Monastery Church of Debra Damo in Ethiopia is a case in point.²⁸ The walls consist of tile-like stones set in earth mortar, strengthened with longitudinal beams which are themselves fixed to the walls with cross-pieces, projecting and known locally as "monkey-heads". Such a method of construction has been used as far apart as Crete, Asia Minor and Tibet. It seems to have been the normal constructional method at Axum. K.A. Cresswell states that the construction of the Ka'aba in AD 608 with alternate courses of stone and timber was the result of the employment of an Abyssinian named Baqum.²⁹ That strengthening of walls is a technique that was also well known to traditional builders in the Red Sea area. In Suakin, Jeddah, Hodeidah, Mokha, Luhaya, it is usual for longitudinal timbers to be built in at vertical intervals of about 1.2 metres for stability.³⁰ It is not unusual for timber also to be built into walls in other parts of the Yemen, particularly in the sophisticated houses of Sana'a and other towns. Possibly the shortage of timber has led to this strengthening being abandoned.



In the background, post-disaster housing in an earthquake struck village in the Dhamar area.

Photo: C. Little/Aga Khan Awards.

To conclude, therefore, long-term solution to achieve earthquake-resistant housing has to be based on the use of local materials and methods. This is particularly important in the case of the Yemen where many buildings are in rural areas, that are difficult to reach by motor transport. Moreover, as we have seen, traditional building techniques have incorporated means of strengthening walls so as to prevent the collapse of buildings during earthquakes. With further technical improvements, structures can be made sturdier, allowing thicker walls and heavy roofs which are necessary to obtain comfortable internal condition in the highland climate. Meanwhile, a short-term disaster relief is needed to provide shelter for the 300,000 homeless people in the Dhamar province. Yet, any rapid-aid programme that ignores the climate, traditional patterns of living and the necessity of public participation will be doomed to failure. It is certain that traditional techniques of building in the Yemen possess the potentialities needed to achieve adequate structures that at the same time continue in the mainstream of Yemen's cultural heritage.

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