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TABLE I

Damage	*Flats* %	*Net Area* %	*Per capita* %
Collapse	8.2	7.0	8.5
Condemned	33.6	29.9	36.4
Repairable	36.6	39.9	30.6
Slight damage	19.0	19.8	20.3
Not damaged	2.6	3.4	4.2

TABLE II

Characteristics of the Skopje Earthquake

Date	26 July 1963
Origin Time (GMT)	04h 17m 11s
Epicentre (Instrumental) ...	42°00.5′N - 21°27.3′E
Epicentre (Macroseismic) ...	42°10 N - 21°26 E
Magnitude	6.0
Focal depth	4 km ± 2 km (Kövesligethy)
Epicentral Intensity	VIII ½ - (Modified Mercalli) - IX
Surface of perceptibility ...	70,000 sq.miles

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SEISMIC ENVIRONMENT THE SKOPJE EARTHQUAKE OF JULY 1963

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Summary

The Skopje earthquake of July 26, 1963, was a medium magnitude shock that occurred in one of the least seismic areas in the Balkans, causing damage to property of about £500,000,000 and killing over 1,000 people. Like many other cities in seismically suspect regions, earthquake risk was considered to be minimal in Skopje, and although there was evidence of past earthquake damage to the city no measures were taken to minimise the effects of a possible earthquake. In what follows, the Skopje earthquake, its aftermath, and a number of points concerning planning before and after an earthquake, are briefly described.

Introduction

Skopje, a city of 200,000 inhabitants and over 22 centuries old, is the capital of the Republic of Macedonia, Jugoslavia. It lies on a fertile plain, with the Vardar river running through it. The city was, and still is, the most important communication centre in Macedonia, and perhaps in the Balkans. To-day, several main arteries of communication and four railways converge upon it.

Skopje, in a latitude of 42° North has mean January temperatures well below freezing point, and despite its elevation (1,000 feet) the summer temperatures are well above 90°F. The rainfall is fairly well distributed throughout the year but May and October are the wettest months.

The mountains and uplands around the city allow for a notable development of livestock industry and the mineral resources are considerable. Coal, copper, silver-lead, chrome-ore, iron, antimony, all occur; also saltpetre and veins of pure magnesite

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are found in the district. One third of the economic potential of Macedonia is located in the Skopje region.

After the Second World War, Skopje began to develop very rapidly. In 1890, the population of the town was only 32,000; in 1931 it rose to 64,000 and it remained practically static until after the War (67,000 in 1939; 70,000 in 1945). In 1953 the population rose to 122,000; in 1961 to 172,000, and just before the earthquake the population of greater Skopje was estimated to be just over 200,000.

In 1963 the city occupied 2,300 acres in which lived 173,000 inhabitants in 34,800 dwellings. This exceptionally rapid growth in population was mainly due to immigration from the countryside and in early 1963 Skopje accounted for over 14% of the population of Macedonia.

Although Skopje by European standards is not an industrial city, in 1963 it had factories producing textiles, leather, paper, cement, glass, tobacco, beer and cement products. A new steel mill, with an output of one million tons of steel, employing 7,500 workers, was under construction in the outskirts of the city. Two gravity dams over 100 feet high situated 15 miles from the city supplied a part of the hydropower for the industrial development.

Within greater Skopje there is a considerable number of historical monuments, a few of which are the ruins of Skupi (518 AD), the monasteries of St. Pantelemon of Nerezi (1164 AD), and of St. Andreas (1389 AD), the mosque of Mustafa Pasha (1542), a 16th century aqueduct, and an early Turkish bridge.

The Skopje Valley has a rather long history of minor seismicity with a number of damaging, local earthquakes. The earliest known earthquake, in 518 AD, caused considerable damage to Skupi (old Skopje) and perhaps accounted for its desertion in 519 AD. The accounts of this earthquake as well as that of 1555 are rather confused and in all probability grossly exaggerated. Strong earthquakes occurred in 1890 and 1921 not far from Skopje.

In spite of the fact that the early seismic history of the Skopje Valley is not very well known, the available information shows that extremely shallow earthquakes (from one to ten kilometres deep) of medium magnitude ($M = 5$ to 6) were common. These shocks have a frequency of about one earthquake in Macedonia every 50 years, and always show a confined epicentral region.

The earthquake of 1963 cannot be said to have been unexpected. A proper seismotectonic study of the Valley, supplemented by the available historical data, should have proved beyond doubt, well before the 1963 earthquake, that the growing city was situated right on a young and growing tectonic graben whose movements can be seen on both sides of the Valley.

The 26th July 1963 earthquake

On July 26th, at 0517 local time, North Macedonia was shaken by a severe shock. It killed 1,070 and injured over 3,000 people. The shock destroyed or damaged beyond repair 40% of the houses in Skopje and about 2% of the houses in the neighbouring settlements. Damage to the total extent of about £75,000,000 was done among houses in the city having a total value of about £180,000,000, giving an average loss for the entire community of about 41% of their value (see Table 1).

The earthquake was a medium magnitude surface shock ($M = 6$) of the kind that in a sparsely populated region might have caused little concern. Unfortunately, the Skopje earthquake occurred in a densely populated area and it had appalling consequences. It literally destroyed more than 30% of the houses in the city without causing their collapse and caused damage valued at over 300 million pounds within an area not exceeding ten square kilometres. From the ground, some distance away, or from the air, it was practically impossible to detect any damage to the city. Like the Agadir earthquake of 1960, the unique characteristic of the Skopje earthquake was the extreme localisation of the destruction, a typical feature of a very shallow, medium magnitude shock that happened to occur very close to a city not designed to resist earthquakes.

The destructive movement of the ground was, for all practical purposes, of a shock type in the city directed from ESE to WNW. This movement being very violent but of duration less than 5 seconds subsided before there was time to produce total collapse of the majority of the damaged structures, which, after the earthquake, were left shattered and on the verge of collapse. So far, the results of the field studies show that the predominant ground acceleration, on the average, was very high and of a very brief duration, with resulting ground velocities of about 0,5 m/sec. Base shear coefficients for short period structures (0.2-0.3 secs) were found to be well over 48%, dropping off to very low values (8%) for structures of longer period (0.8-1.2 secs).

The earthquake was felt with an intensity equal to, or greater than, III on the Modified Mercalli Intensity Scale (MM) over an

area of about 70,000 square miles. The maximum intensity of the shock, assessed on a statistical basis by the writer, did not exceed IX (MM).

The earthquake in Skopje proved once more that ground accelerations during strong earthquakes can be very high. It also proved that the damage that these accelerations may cause depends on how long they will persist on a structure and on how long the total shaking will last. In other words, it is the rate at which the seismic energy is supplied to a structure that influences the degree of damage rather than the absolute magnitude of the ground accelerations.

In Skopje, the greatest part of the released seismic energy was spent in displacements of the ground in a powerful unidirectional shock of extremely brief duration. The analysis of the available seismological, geotectonic and damage data suggests that during the earthquake the city with its surroundings underwent a sudden mass movement, perhaps of considerable irreversible displacement, and that the destruction was brought about by a sudden re-adjustment of a number of tectonic blocks of the mosaic structure of the Vardar zone on a part of which Skopje stands.

The foundation strata in Skopje consist of alluvial deposits underlain by marls. The alluvium is generally gravel with sand and silts, and it is very well compacted. With a very few exceptions, Skopje had no foundation problems, its superficial geology being, for all practical purposes, quite uniform. The thickness of the alluvium within the limits of the city varies from a few feet to hundreds of feet, in some areas the gradients being very steep. The ground water level is about 6 to 30 feet below the surface and it varies seasonally, responding quickly to river fluctuations.

Tall reinforced concrete skeleton structures, modern engineering constructions such as factories, mills, bridges, dams, underground installations, highway embankments, railways, all of which had not been designed to resist earthquake forces, but had been well designed and constructed for normal operation conditions, suffered little damage. Two concrete dams near Skopje suffered absolutely no damage.

A few pipes of the water distribution system in the city and some underground telephone cables were damaged by the fallen buildings or by heavy débris. In other places only slight leaks were found, and in one place only a subsidiary main water pipe was damaged by the relative movement of its supporting structure where it crossed a ravine.

Buildings in Skopje may be divided into three categories: 1) Old adobe construction with or without timber bracing. 2) Load bearing brick wall construction supporting reinforced concrete or wood floors supported partly by masonry walls and partly by reinforced concrete columns and beams. 3) Reinforced concrete skeleton buildings with and without concrete shear walls.

There was also one roof structure of prestressed concrete and a few isolated cases where use of prefabricated prestressed or ordinary elements was made. There were no steel skeleton buildings in the city of any sort, with the exception of the new steel mill in the outskirts of Skopje.

Brick wall structures suffered more than any other type and accounted for the larger number of deaths. Mixed construction suffered considerably and although many of these buildings did not collapse they were left completely shattered, beyond repair. Old adobe constructions, particularly those with timber bracing, resisted the shock with some damage but behaved far better than the brick or the hybrid construction. Reinforced concrete skeleton structures suffered comparatively little damage and only two small structures of this type collapsed. Perhaps, tall skeleton structures, up to 15 storeys, performed far better because they were flexible but also because, being important engineering undertakings in Macedonia, they were constructed with more care and in some cases wind forces were considered in the design. Finally, a prestressed construction was totally destroyed after its supporting columns collapsed. The steel mill, which at the time was under construction, suffered only minor damage.

In general, the subsoil conditions at Skopje are intrinsically adequate and cannot be held responsible for the damage that the city suffered. Also, the design of modern structures, with the exception of the brick wall bearing houses, was in general adequate, although in some cases a little underdesigned and with considerable improper detailing. What was detrimental is that these modern methods of design were not followed up by equally advanced methods of construction and materials. The extremely variable quality in the building materials and in the methods of constructions was found to be more important than the lack of earthquake resistant design. Considering that structures were designed for static conditions and that the building materials and the methods of construction were admittedly below average, reinforced skeleton buildings performed rather well.

There are two interesting points that emerge from the study of the distribution of damage in Skopje. First, the area of the most severe damage correlates surprisingly well with the part of the city

that was flooded in November 1962, just nine months before the earthquake, and where intensive pumping from the basement of buildings resulted in producing a weakening of the foundations. As a matter of fact, after the flood, but before the earthquake, minor damage to structures in this area was noticeable mainly due to differential settlement of their foundations. Second, the central part of the city is situated on the thinnest layer of alluvium which dips sharply to great thicknesses east and west of the city. It is obvious that the seismic energy from either the east or west deposits of the alluvium had to be channelled through this thin layer of alluvium, with resulting intensification of the ground movements there.

After the earthquake

The account of the aftermath of the earthquake that follows should, in my opinion, be considered as a typical example of how the complex problems created by a destructive earthquake in a developing country can be controlled and overcome. This does not mean that all the actions of the Jugoslav authorities were perfect, but on balance one has to accept that the terrific problem posed by the Skopje earthquake of 1963 was successfully solved. A chronological review of the events after the earthquake will prove these points.

Friday, 26th July, 1963. The earthquake began at 5 hours 17 minutes and 11 seconds local time, on Friday 26th of July 1963. In about 5 seconds it was all over. The city was left shattered, covered with clouds of dust, and everything was in a state of confusion.

In a number of places transmission lines were short-circuited and the automatic switches of the electricity plants fell, leaving the city without eletricity. The telephone lines were also disrupted and the wireless stations were temporarily put out of action. At 10 o'clock, however, contact with the outside world was established and details of the disaster reached Belgrade. Prearranged emergency plans were automatically put into action throughout the country.

As a result of these plans, immediately after the earthquake a number of committees took action to coordinate the activities of the various working parties in the city. Drinking of tap water was forbidden until all leaks had been repaired and the army undertook to supply the city with over 300,000 litres of drinking water daily. Stray animals were being rounded up, killed and

buried to avoid rabies and other diseases spreading into the city. In the meantime, a small number of fires in the city were extinguished and rescue teams began their work. Organised teams of militia with citizens and miners rescued within the first day 325 people from the ruins, and the city was immediately cordoned off and all means of transportation were requisitioned. Looters were punished on the spot. A field hospital was set up from what was left of the destroyed hospitals of the city. In the first day, over 200 operations were carried out and over 1,600 cases were treated. An air-bridge established later in the day with other cities in Jugoslavia was used to evacuate 180 seriously injured people and medical supplies were flown back into the city. In Belgrade, the government appealed to countries abroad for help, and the League of Red Cross Societies was informed the same day and sent an appeal to all its national organisations.

Saturday, 27th July. Aftershocks continued throughout the first two days and from time to time ruins collapsed. Throughout the night rescue teams, which now consisted of over 9,000 people, continued a more organised search of the ruins, recovering another 300 bodies. Early in the morning, food supplies, mostly vegetables and fruit, were brought into the city by farmers from surrounding settlements.

The authorities were now concerned with the outbreak of disease and in spite of the stringent measures they had taken, they decided to evacuate all unable to be of help in the city. People were being vaccinated with the vaccines salvaged from the ruins. By mid-Saturday the evacuation of women with children began. These were followed by groups of children evacuated mostly to different parts of the country, where they stayed with families or in hostels.

The Jugoslav air forces were now mobilised and supplies by air began to arrive in the city. Not more than 36 hours after the earthquake, planes with blood-plasma, antibiotics, medical instruments, tents and blankets began to arrive from Bulgaria, Czechoslovakia, Denmark, East and West Germany, Italy, Norway, Poland, Sweden and the U.S.A.

A number of special groups were organising urgent repairs to the electricity lines and the water supply, and were also particularly concerned with the evaluation of the situation created by the earthquake.

The U.S.A. Army flew in a field hospital with 120 beds and 200 doctors, nurses and orderlies, from Germany. With the

second day after the earthquake at its end, 610 bodies had been found, and over 2,000 cases had been treated at the field hospitals. A special office was set up for the identification of the recovered bodies and for the issuing of death certificates.

Sunday, 28th July. The rescue teams continued their search for trapped people in the ruins, assisted by French rescuers equipped with sound-detecting equipment capable of picking up sound at some depth.

The evacuation of children between the ages of 7 and 14 continued, and considerable number of destitute families began to move out of Skopje on carts, trucks, or on foot. Some of them stayed in the suburbs of Skopje which suffered very little damage; others continued further, to settle temporarily in villages or towns allotted to them. These outgoing convoys created traffic jams as they moved through in-coming traffic of army lorries and heavy bulldozers, and caused considerable delays.

Airplanes began the spraying of the city with disinfectants, and the shanty district of the gispy population was kept under close sanitary control. More airplanes from France and Poland carrying supplies arrived and Red Cross lorries from Switzerland and East Germany arrived with medical supplies and equipment.

By the end of the day, parties of engineers had checked the leakage in the water supply system and this was restored late on Sunday. Other groups of engineers began the study of a systematic demolition programme for the wrecked buildings which had no historical or cultural value. National treasures, archives, and important historical documents were rescued from the ruins, cleaned and stored in safe places. Fortunately, none of the treasures was lost.

Monday, 29th July. By Monday, over 100,000 people had been led out of the city, and the traffic began to get out of hand.

Late on Monday it was decided that the ruins should be cleared away and those not already found should remain where they were and buried under the ruins. The wreckage was sprayed with strong disinfectants and the removal of the ruins began with explosives and bulldozers.

There was no urgent housing problem since the weather was very good, and over half of the inhabitants had departed. For those who stayed, temporary shelter in tents and improvised barracks was found for the moment. The public services were set up in the parks, sheltered under light roofs, and began to function by the end of the month. The work was carried out on a continuous shift system for 168 hours a week, and the work of assessing the situation created by the earthquake was given first priority.

Foreign aid in supplies and money kept pouring into the city and the authorities were trying to make the best use of it. Tents, beds, blankets, kitchen utensils, clothing, food, machinery, bulldozers, and medical supplies were all unloaded in Skopje.

August 1963. A special committee composed of civil engineers, architects, town planners and land surveyors began to examine all the structures within the epicentral area and to classify them according to their damage. All houses were marked with heavy lines of paint showing their structural condition. One red line indicated that the house was beyond economic repair (44.3%). One yellow line meant structural damage to the reinforced concrete skeleton of a house (1.3%); two yellow lines indicated structural damage to a brick-wall bearing house (20.8%). One green line designated no damage to the skeleton of a house but some damage to its brick work (0.6%); two green lines meant slight damage to a skeleton building (1.4%) and three green lines indicated slight damage to a brick building (14%). Finally, 11.4% of the total number of buildings, irrespective of size collapsed and 6.1% were not examined, being either slightly damaged or very small.

This classification was repeated in April 1964, using more realistic criteria, and a considerable number of yellow lines turned into green and some red into yellow. However, it is rather difficult to quote exact figures for the percentage of damage to various structures. In greater Skopje, it is safe to say that one third of the buildings were destroyed, one third damaged, but which can be repaired economically, and one third undamaged. The remaining ten percent of the buildings are on the bordelines of the last two categories.

Out of the 34,798 dwellings in Skopje, 9,217 survived the earthquake with minor damage, and late in August it was revealed that a better situation existed than had been thought.

The Jugoslav Corps of Engineers together with 450 military engineers from the U.S.S.R. with heavy equipment continued to clear up ruins.

Elements of the Jugoslav Youth Brigade arrived in Skopje early in August. Demolition work of light stuctures, salvage of usable materials and clearing of rubble were their tasks. Some hold that in their youthful enthusiasm they hindered as much as they helped.

The problem of providing shelter for at least 17,000 families before the winter created an extremely difficult situation. Most

of the factories in greater Skopje were not damaged, and from the factories in the Skopje area only 10% were out of action. Although by the end of the month Skopje received a total of six million pounds in money, materials and equipment from over 40 countries including Jugoslavia, its deficit was still colossal. For the economy of the republic not to collapse, men had to be asked to return to work, provided they could be housed with their families.

Early in August, missions of experts began to arrive in Skopje, some to help the authorities with their current problems and others to study the scientific side of the disaster. At the same time the Jugoslav authorities set up a commission for the scientific study of the earthquake and the work was divided amongst the six major Universities of the country. Each University undertook the study of a particular part of the city. The Geological and Seismological Institutes of the country began the study of the earthquake. The Town Planning Institute of Macedonia undertook the study of the redevelopment of the city. In all these activities U.N. and U.N.E.S.C.O. contributed by sending experts to help the planners with their problems.

The question of building the new city in a safer place arose early in the month. A study of the problem revealed that on the basis of the data available, there was no good reason for moving the city to a safer site. All sites in the Vardar valley have the same probability of occurrence of strong earthquakes. Moreover, Skopje was far from being totally destroyed, and its damage had originally been exaggerated to some extent.

September 1963. By the middle of the month the repair of damaged blocks of flats was under way and over 30,000 workers arrived in Skopje to repair 10,000 flats for the winter. Prefabricated house units also arrived from the northern parts of the country and from abroad.

The clearing up of the city continued. Ruins and buildings of no historical value, damaged beyond repair, were blown up and cleared away, much to the disappointment of those who arrived too late to study their engineering defects. Buildings of small value, hindering the redevelopment of Skopje, were also pulled down.

During the month, more experts arrived in Skopje, and more problems arose. The main problem now was how and where to accommodate the returning inhabitants of Skopje.

A legal authorisation of the State deferred payment of credits granted before the earthquake for people who lost their property,

and they also received new credits. A national loan with an interest rate for saving deposits was established and everybody was asked to contribute with a fair proportion of his income to facilitate the economy of Skopje.

The people began to return home slowly. The population of the city began to increase and workers returned to their jobs. Reconstruction and repair work were intensified and the plans for new Skopje were laid down by the town-planners and engineers, assisted by U.N./U.N.E.S.C.O. experts.

October 1963. Early in October the evacuated families started to return in larger numbers; there were now some 150,000 people in Skopje, as more than 80% of the industrial enterprises of the city had recommenced their activities. At the same time labourers from the surrounding country, mostly unskilled, poured into the city to find jobs in the repair of the damaged buildings. Business flourished again and life was eased. Schools reopened and lessons were given in tents or in the open air. Fortunately the weather was still fine.

In the meantime, repair and strengthening work continued to damaged building but without a definite building control. However, not all of the past errors in building materials and methods of construction were repeated, although in some cases building methods were still, and they will be for some time, far from adequate.

By the end of the month the weather changed and heavy rains caused the Vardar river to rise rapidly. Skopje was for a few hours in danger of being flooded again as had happened in 1916, 1935, 1937 and in 1962. The heavy rains inundated a number of camps and a few houses damaged by the earthquake collapsed. This event proved that there is no point in planning a new town and protecting it from earthquake hazards without planning simultaneously its protection from floods.

Throughout the month the construction of satellite units of prefabricated houses continued with an ever increasing tempo, and many hundreds of repaired, though most definitely not strengthened, buildings were handed over for habitation.

November 1963. The projected rehousing scheme for the winter had been completed. Small groups of temporary satellite settlements, with water mains, sewer or septic tanks and electricity lines, encircled the damaged city. Each settlement had a name, a sort of a shopping centre and transport facilities. The Univer-

sity of Skopje which was damaged, resumed normal tuition late in November. The State undertook the responsibility of school arrangements for the young people who had left Skopje after the evacuation and had not returned. For a few years to come the people of Skopje will necessarily live in satellite-villages of prefabricated houses around the damaged city.

Skopje had no definite building code and no regulations for the earthquake resistant design of structures. Also, building materials and methods of construction were far from adequate. The Jugoslav authorities began to study the problem of standardising their materials before the reconstruction stage. Better bricks, mortar and better workmanship had to be obtained. Also building codes based on the local conditions were studied and the rehabilitation of the homeless people in temporary shelters was planned in conjunction with the design of permanent housing so that the available funds could be utilised to their maximum efficiency.

1964-1965. The main events during the year following the earthquake were: the strengthening of damaged building, the preparation for a new master plan of the Skopje region, urban planning, training of local personnel in building trades, and the formation of an international board of consultants. A board of consultants was set up by the government with the assistance of the United Nations and of its specialised agencies to help in the planning and reconstruction of Skopje. The board included experts in urban and city planning (Yugoslavia, U.S.A., Holland, Hungary, Poland), seismology (Czechoslovakia, U.S.S.R.), engineering seismology (U.S.S.R., U.K.), building materials (U.S.S.R., U.S.A.), sociology and economics (Jugoslavia). The board meets every three months to consider the problems that arise as the plans advance.

Jugoslav engineers, architects and other scientists have been sent abroad for training in modern methods of construction and in the earthquake resistant design of structures. Late in 1964, an international seminar on earthquake engineering took place in Skopje under the auspices of U.N.E.S.C.O. and of the Jugoslav government, to review the scientific and applied aspects of the 1963 earthquake.

A Training and Research Institute for seismology and earthquake engineering was established at the University of Skopje and it planned to start tuition with the help of U.N.E.S.C.O. early in 1965. Jugoslav scientists trained abroad and international experts, together with the staff of the University, will compose the temporary staff of the Institute.

Planning after an earthquake

In three years after 1960, medium magnitude earthquakes hit with surprising precision the centres of rapidly growing cities in developing, though seismically rather inactive, countries (Morocco, Libya, Jugoslavia). These shocks killed about 14,000 people and caused damage equivalent to over £500,000,000. In all three cases, the epicentral regions did not exceed in surface a few square kilometres, and contained parts of the cities which were devastated. These earthquakes were all sharp shocks of terribly short duration, and showed abnormally high ground accelerations for their magnitude. The seismic energy they released, however, was only one thousandth of that released by the Chile earthquake of 1960.

Undoubtedly, the way in which the rescue, rehabilitation and the reconstruction of Skopje was handled is worthy of praise; particularly since the country was in a stage of rapid but extremely difficult economical development. One may argue that the destruction in Skopje was localised within 10 square miles only, and that the situation was easier to handle, or that the foreign aid was substantial. This is true, but Skopje was also the nerve centre of Macedonia and this was destroyed; but the life of the Republic did not collapse. As for the aid that Skopje received, this was not disproportional to the damage it suffered. It was undoubtedly better used than in other cases, although there will be critics with more spectacular views of how the aid should have been applied.

In the process of planning the new Skopje, a number of important points emerged, brought out from the experience gained in dealing intimately with the problems created by the earthquake.

Planning before an earthquake

Disastrous earthquakes seem to be the subject of widespread interest and concern, more on account of the loss of human lives than because of the economic chaos that they cause. It would seem fair to say that during the last 160 years the average number of persons killed by earthquakes every year is about 13,000, certainly smaller than the number of persons killed by cars every year in the United States alone.

On the other hand, for the same period, the annual damage caused by earthquakes seems to be of the order of £500,000,000, though the exact figure will never be known. This figure may be only a small fraction of the budget of a developed country, or many times the budget of a developing country. In certain parts of the world, an earthquake disaster may raise undesirable land

tenure problems or make the population of the affected area migrate in mass. An economic disaster of the order of £500,000,000 in most cases will have also political and social repercussions, immediate or latent, which may, and in most cases do influence other countries.

The effects of an earthquake disaster are more important, and will become increasingly so, for the economy of a developing country; particularly as the world population expands into seismically undocumented regions and as the wealth of new countries is centralised into big development schemes.

In order to minimise the damage that must be repaired after an earthquake, some form of Code or Regulations for building in earthquake regions should exist and also means of enforcing such a Code. This will require some organisation before an earthquake occurs; without it, any measures taken to minimise damage would be uncertain and will vary erratically.

Experience to be gained from half-measures taken by various governments to minimise damage, though valuable, will be of little use if applied without proper understanding of the local conditions by another government or in another country. Simple rules, no matter how well they may apply in one part of the world, may prove completely insufficient or even detrimental in another. Such rules should be intended as a starting point, they should be studied, and amended as need be in each country by a committee of professional men who are familiar with the problems involved. There is no way of producing rules-of-thumb which will be generally applicable, or effective, without adapting them to local conditions. This presupposes that each local authority should put some effort into adjusting the rules to fit its particular requirements. To provide standardised rules for countries which will not undertake to adjust them to their local conditions is a half-measure, which can in no way replace the results of a determined interest by the various local authorities.

Measures for restoring housing

After the earthquake it is found difficult to establish an effective central agency for the direction and control of the rehabilitation and reconstruction of destroyed villages, and much effort and funds are diffused in disparate activities. In some cases, rebuilding destroyed villages on new sites is essential. However, land tenure problems may arise which could be impossible to solve. In other cases removal of the débris from destroyed sites is not possible by mechanical means since valuables and food supplies are still under the

débris and their removal requires manual labour which, for various reasons, is not available. Above all, in some cases the populace shows a striking apathy towards restoring the damage. In many instances they refuse to help themselves or others, though not always without sufficient reason. They may not own the land on which they lived or the house they lived in. Fatalism, on the other hand, and lack of essential education often form barriers between themselves and those who want to help them. In other cases, the public apathy and the lack of cooperation on the part of the inflicted population results in half-measures which amount to patching up temporarily the damage caused by the earthquake, a pattern to be repeated in the future, only too often.

Short term and permanent housing after disastrous earthquakes in economically developing countries often follow a pattern detrimental to long term planning. After a short period of enthusiasm for ambitious restoring plans the interest in the application of various schemes begins to die out, as the available funds are found to be insufficient; some of them having been already squandered, and as the problems which rehabilitation poses become more involved and less exciting. The usual pattern is that as with time the interest of the authorities begins to decrease, many emergency or rehabilitation sites are left unfinished and poorly equipped with sanitary facilities, water, medical supplies and more emergency camps turn into slum areas. Villages and small towns turn into shanty settlements and their inhabitants begin to emigrate to the capital leaving the less active members of their community behind.

In some instances, the authorities at this stage decide to relieve the stricken area by issuing free building materials for repairs or they grant loans on easy terms. The results are invariably detrimental. What happens is that the materials are either misused, since villagers and townsfolk are far from able to do a proper job of repair, or they are sold. The loans often are used to finance a small business or to help members of the family to emigrate and settle in another part of the country.

Abuse of the available funds and improper design and construction carried out by incompetent building firms is also not uncommon. As supervision becomes more slack, abnormally high profits are made at the expense of funds raised for relief and rehabilitation. When there are no more funds to be spent, the stricken areas are abandoned and after a little while the earthquake and the destruction and death it brought are forgotten.

In some cases, domestic and foreign aid is not used to its full value. In some underdeveloped areas destroyed by recent earth-

quakes, a lot of money was spent in rebuilding villages after the European or American manner. Houses with flimsy walls and roofs were built disregarding the local climatic conditions, and meccano-type frameworks were used which were blown away by the first winter gusts of wind. In some cases, new villages were abandoned or totally altered by their inhabitants, while in other cases the villagers refused to occupy newly built houses. The reason for this was either that the houses were too hot in the summer and cold in the winter, with pitched roofs where the villagers could not dry their crops, or that there was not sufficient water. Newly built villages after recent earthquakes were still not occupied 18 months afterwards by their inhabitants, who lived in hovels nearby.

International Aid

In economically weak countries after a disaster there is always the difficulty of deciding on the spur of the moment how inflowing aid should be best used and what priority should be given to the innumerable needs of the area. Invariably, this problem is left to the local authorities to resolve without much deliberation and often a large proportion of the aid is abused. We should not expect them to be always right at a moment when everything around them is so confusing. There is room for criticism of the way in which the aid is offered. Tens of nations and hundreds of welfare bodies contribute independently with absolutely no central organisation. Even from the same country aid and relief actions are taken independently, so that part of the effort is wasted and the recipient confused. A lot of valuable time and badly needed money is wasted in spasmodic actions of a multitude of charitable bodies. It is appreciated that each of them wants to keep its independence; but could it not be possible for one central organisation to service their common interests in a coordinated manner ?

Such coordinated actions would avoid the useless repetition and waste of funds involved when well-meaning independent organisations contribute similar or even useless material (Tinned pork sausages sent to Muslim countries, tennis shoes to areas where the country is rugged and freezing, one-size or one-footed shoes are some of the extreme cases I have met with).

Technical Assistance

The same could be said about the work that the various teams of experts carry out in epicentral regions. Someone should

coordinate their activities once they are in the field. Some of them arrive not long after the disaster and others follow much later; many of them stay only a few days while others spend months in the stricken area. In most cases their valuable time is spent on trying to find their way about, cover as much ground as they can, ground already perhaps covered by others, and finally produce a not always factual report. These experts in most cases, have to face the language barrier, they have to appreciate the local manner of living, and moreover to be able to arrive at conclusions that could be useful to the country.

Temporary housing

The authorities in Skopje recognised immediately a vital point regarding temporary housing; if a house was eventually to be demolished as part of the reconstruction plan but at the moment could be repaired, they repaired it. They realised that to put the homeless in refugee camps would damage the country financially and administratively. Such camps can last for many years after the earthquake, endangering public health and morals. To put up prefabricated houses without proper planning, water supply, electricity and sewer system would prove equally detrimental. Granted, not all types of prefabricated houses that Skopje received or bought were suitable either for the climatic conditions of the country or for the purpose intended. However, by using all available to house people in an organised manner, many more families could resume a normal way of living and thus help to speed up the relief and rehousing of others. This tempted them to accept practically any type of housing. The same happened in Agadir, Iran, Barce, Greece and Turkey. If " banks " of the appropriate type of prefabricated houses had existed in numbers sufficient to cover the immediate needs in these areas, the situation could have been far easier. The lack of sufficient stores of different types of prefabricated houses held in various countries throughout the world can only lead to a repetition of the forced buying of sometimes unsuitable models. Buying a small factory to build such houses right where the earthquake occurred is an advantageous solution, as this will reduce local unemployment, cut down transportation cost and result in a productive investment of the relief funds.

Within the first year, Skopje bought 13,812 prefabricated units, of which only 2,549 were imported, the rest being manufactured in Jugoslavia. In Iran after the 1962 earthquake, only a fraction of the 21,300 required units could be provided, while in Barce and Greece only a few units out of the 9,200 required

were used. The main reason for this was the lack of sufficient numbers of prefabricated units, the unsuitability of the existing types and, in particular, the cost of transportation and time required for their delivery.

Population movements

After an earthquake, the feverish reconstruction activities and the relatively ample budget available for repairs and reconstruction of the damaged area attracts man-power from the surrounding countryside, or from the bigger towns. This artificial population increase, unless it is controlled, may create serious problems in the local economy. Where the earthquake damage is centralised, a temporary increase of the population by as much as 10% is likely. The population of Skopje by the end of 1963 began to exceed its pre-earthquake total, and late in 1964 reached a 10% increase.

Education

The relief of a country crippled by a natural disaster is largely based on the efforts of its inhabitants. In most of the economically developing countries the majority of the population is ignorant about the dangers that natural forces have in store for them, and those who do know have no idea of their causes or their effects. Superstitions, misinterpretations of well-known natural phenomena, and ignorance often lead to additional disasters.

It is not so much what one can prescribe for those affected by an earthquake as what one can achieve in the understanding of particular needs and the gaining of the cooperation of the inhabitant that is important. In a seismic country, the population must be taught about natural phenomena and their effects, at an early stage of their lives. Secondary school education must include such a study so that the absurdity of superstition may be brought out. Instruction about earthquakes should be given in the form of public lectures and of pamphlets.

Courses in earthquake engineering should be included in Technical University curricula. Moreover, modern ideas in earthquake engineering should be included and current design studies be discussed. In some university curricula a course in earthquake engineering does not always mean either that the course is given or that it results in an adequate interpretation of the subject.

Postgraduate research in earthquake engineering in universities is absolutely essential. Apart from attracting those who

wish to study the subject further, it gives an impetus to undergraduate education. It results in producing a nucleus of future research workers and lecturers on earthquake engineering and in advancing modern ideas about the subject.

For those who wish to pursue their studies further and to collaborate more closely with foreign workers in this field, training abroad in international centres on earthquake engineering should be made available, provided that strict rules should be attached to their terms of reference such as (a) an obligation to return to their own country and (b) upon their return, their appointment to the appropriate positions in lecturing or research for which they have been trained. So far, the majority of the trainees in international centres, upon their return home, have been mistreated, as a result of the unreasonable policy of their native universities, institutes or ministries.

It seems more reasonable for the foreign aid to be spent in advancing under- and postgraduate courses in earthquake engineering at a native university than for it to be spent in educating a very small number of trainees abroad. Apart from the language barrier that hampers the work of international centres, the latter form of aid distracts the trainee's attention from his task. So far there are very few encouraging signs to show that training at an international centre is effective when it is carried out in the form of undergraduate level courses. It seems that such centres would be ideal for the specialization and training in research of workers in earthquake engineering who have already had their basic training in their own countries.

Foreign assistance in either establishing or stimulating local training and research in earthquake engineerings hould be given with greater care. It is extremely important to know the potential and capabilities of the persons who are in charge of the local training and research activities.

January 1966.

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TABLE I

Damage	*Flats* %	*Net Area* %	*Per capita* %
Collapse	8.2	7.0	8.5
Condemned	33.6	29.9	36.4
Repairable	36.6	39.9	30.6
Slight damage	19.0	19.8	20.3
Not damaged	2.6	3.4	4.2

TABLE II

Characteristics of the Skopje Earthquake

Date	26 July 1963
Origin Time (GMT)	04h 17m 11s
Epicentre (Instrumental) ...	42°00.5'N - 21°27.3'E
Epicentre (Macroseismic) ...	42°10 N - 21°26 E
Magnitude	6.0
Focal depth	4 km ± 2 km (Kövesligethy)
Epicentral Intensity	VIII ½ - (Modified Mercalli) - IX
Surface of perceptibility ...	70,000 sq.miles

IMPRIMERIE ORANGHAMP - ANNEMASSE

SEISMIC ENVIRONMENT THE SKOPJE EARTHQUAKE OF JULY 1963

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Summary

The Skopje earthquake of July 26, 1963, was a medium magnitude shock that occurred in one of the least seismic areas in the Balkans, causing damage to property of about £500,000,000 and killing over 1,000 people. Like many other cities in seismically suspect regions, earthquake risk was considered to be minimal in Skopje, and although there was evidence of past earthquake damage to the city no measures were taken to minimise the effects of a possible earthquake. In what follows, the Skopje earthquake, its aftermath, and a number of points concerning planning before and after an earthquake, are briefly described.

Introduction

Skopje, a city of 200,000 inhabitants and over 22 centuries old, is the capital of the Republic of Macedonia, Jugoslavia. It lies on a fertile plain, with the Vardar river running through it. The city was, and still is, the most important communication centre in Macedonia, and perhaps in the Balkans. To-day, several main arteries of communication and four railways converge upon it.

Skopje, in a latitude of 42° North has mean January temperatures well below freezing point, and despite its elevation (1,000 feet) the summer temperatures are well above 90°F. The rainfall is fairly well distributed throughout the year but May and October are the wettest months.

The mountains and uplands around the city allow for a notable development of livestock industry and the mineral resources are considerable. Coal, copper, silver-lead, chrome-ore, iron, antimony, all occur; also saltpetre and veins of pure magnesite

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