CABINET OF MINISTERS OF TURKMENISTAN

DEPARTMENT FOR THE TURKMENISTAN STATE COMMISSION
FOR EMERGENCY SITUATIONS

# NATIONAL REPORT: WORK AND RESEARCH IN TURKMENISTAN IN CONNECTION WITH THE INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION 1990-2000

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GENERAL

Turkmenistan attaches great importance to the International Decade for Natural Disaster Reduction proclaimed by the United Nations. Efforts to reduce the risk of natural disasters constitute a vital aspect of international cooperation and participation in them is very important for us.

Turkmenistan, which is situated in Central Asia, has an area of 488,000 $km^2$ and a population of 4,520,000. On the west it is washed by the Caspian, while the eastern border, which is with Uzbekistan, consists largely of the Amudarya river. The Kara Kum desert occupies almost the entire northern two thirds of the country. To the south, Turkmenistan is bordered by the high Kopetdag mountains. The climate over much of the country is markedly continental.

Turkmenistan, like all other regions in Central Asia, is prone to natural and man-made disasters. These affect the inhabitants, agriculture and industry, and it will clearly be a long while before we can nullify the consequences of natural disasters or reduce them to a tolerable level.

Its position at the boundary between the young and growing Kopetdag range and the vast Kara Kum desert predisposes Turkmenistan to mudflows from the mountains and to hurricanes and violent sand storms.

Under certain circumstances (mostly in spring/summer), there is extensive flooding of the Amudarya, one of Asia's most powerful and least predictable rivers, which runs through the lowlands of south-west Turkmenistan. This causes heavy damage both to towns and to farm land.

Major problems are now emerging as a result of the steady rise in the level of the Caspian, which scientists predict will continue for the next ten years.

In addition, Turkmenistan contains natural breeding grounds of a number of extremely virulent infectious diseases, including cholera, plague and Siberian plague. Some work is being done on preventing epidemics of these diseases.

There are in Turkmenistan some 30 especially hazardous industrial facilities. These include the Krasnovodsk oil refinery, the Mary power station, the Cheleken chemical works, the Nebitdag iodine and bromine works, etc. The civil defence and emergency relief authorities are working together with works managers and the relevant ministries to evaluate the risks at potentially hazardous industrial sites, especially those handling highly toxic substances. Careful attention is being paid to the experience of the Russian Federation, Belarus and other industrially developed countries in this respect.

Since most of Turkmenistan is a seismically active zone, attention in the present report focuses on the problems of investigating seismic phenomena and devising effective means of mitigating the potentially disastrous consequences of major earthquakes.

The area covered by Turkmenistan is one of the most seismically active portions of the Eurasian Alpine-Himalayan mobile belt. It has suffered numerous earthquakes, some of them catastrophic, in both ancient and modern times. Among the destructive earthquakes during the present century have been the Termab earthquake of 1929 (the first Ashgabat earthquake), the Kazandzhik earthquake of 1946, the Ashgabat earthquake of 1948 and the Kum-Dag earthquake of 1983.

RISK ASSESSMENT

Rise in river levels

Hydrological statistics show that water levels in Turkmenistan's rivers rise principally in spring/summer.

The spring/summer swelling of the Amudarya in 1992 occasioned critical water levels on the Kerki-Chardzhev-Darganata stretch and the consequent erosion of banks and dykes and flooding of floodplains, infrastructure and farm land. While this is rarer, there has also been flooding because of bad icing, as was the case during the winter of 1969, when two thirds of the city of Chardzhev was inundated. In 1991, 1992 and 1993, the rivers Terghap and Tedzhen crested at three times their normal levels, inundating floodplains and other areas, washing away dykes, railway lines and roads and destroying bridges, irrigation structures and human settlements, so causing substantial damage.

During flash floods on the River Etrek, water levels can reach the danger mark, causing damage and flooding in surrounding areas. A flash flood in August 1963, for example, carried away a protective dyke, flooding the village of Gyzyletrek. This settlement has since been moved to the higher, main bank of the river.

Flash floods occur in spring and in summer. The highest to date came on 21 July 1982, when maximum discharge downstream of the confluence of the Sumbar and the Etrek was 1,500 $m^3$/sec. Flash floods posing a threat to dykes and irrigation systems recur every 3-5 years.

Mudflows

The foothills of the Kopetdag range and the Kugitangau mountains are known to contain some 180 channels where mudflows occur. As a result of the dryness and continentality of the climate, the sparsity of the vegetation, the prevalence of readily erodible sedimentary rocks and the occurrence of surface runoff because of the intensity of the rainfall, erosion processes in the catchment areas of watercourses are strong and so occasion mudflows. Such flows are commonest in April-May, but rapid flows (up to 6-7 m/sec) of enormous destructive potential are also frequent in June-August. Peak discharges can range from 10-15 to as much as 1,000 $m^3$/sec (Adzhider).

In the past three decades, the worst years for mudflows have been 1963, 1969, 1972, 1981 and 1986. The worst affected regions are the eastern Kopetdag from Chaacha to Annau and the central Kopetdag from Annau to Archman. The worst affected streams are the Chaacha, Meana, Archinyansu, Kazganchai, Sekizyab, Arvaz, Nokhur, Sumbar and Kyzylarvat and a major watercourse, the Adzhider, where maximum discharge on 8 September 1963 amounted to 1,088 $m^3$/sec.

High winds (hurricanes, squalls)

These can occur throughout the country and at any time of year. They cause substantial damage.

For example, wind speeds can reach 40 m/sec on the Kopetdag plain and in the Kopetdag mountains and foothills and 50 m/sec in the Pulikhatum region of the Tedzhen valley. Similar wind speeds have been measured in the Murghap basin (Tagtabazar) during periods of "misbehaviour" by the Murghap cyclone - usually between December and March, but also in April-May.

Particularly high winds, accompanied by abundant precipitation, can occur in the event of regeneration or development of the cyclone or of activity on an arctic front when the precipitation associated with this front and that associated with the cold front of the cyclone merge into a single vast zone.

In such circumstances, a combination of natural disasters can occur: hurricanes, storms and floods. They affect the valleys of the rivers Murghap, Gushga and Kashan, causing considerable damage.

Tornadoes, some of them destructive, occurred in the Amudarya valley in 1963, 1965, 1967 and 1987. The wind speed in the destructive tornado in the Darganata region in 1967 was 60 m/sec. The wind speed in the destructive tornado in the Dzhev region in 1987 was 70 m/sec (according to indirect estimates made using the official scale for the intensity of tornadoes employed by the National Weather Service of the United States of America).

Turkmenistan, particularly the Kopetdag plain, is also affected by atmospheric depressions from the north of the Arabian peninsula. These manifest themselves as severe dust storms coming from the Arabian deserts and as heavy haze when the depression is inactive. They are accompanied by hurricane-force winds in the Kopetdag range and the Kopetdag plain. The wind speed at Ashgabat and in its environs and the mountains can measure 40 m/sec with virtually zero visibility.

The worst hurricanes occurred in 1953, 1968, 1975 and 1985. Storms of this kind cause heavy damage, bringing down power and telephone lines and damaging other facilities in the city, villages and the mountains. They disrupt (or completely halt) both life in the city and villages and traffic.

Rise in the level of the Caspian Sea.

The Caspian Sea is the world's largest enclosed water body; it has not outlet to an ocean. It covers an area of some 398,000 km, measures over 1,200 km from north to south and has an average width of 320 km. It holds close to 80,000 $km^3$ of water and the total length of the shoreline is in excess of 7,000 km. The waters of the Caspian wash the shores of five States: Turkmenistan, Kazakhstan, Russia, Azerbaijan and Iran.

In terms of relief and hydrometeorology the Caspian is divided into the Northern, Central and Southern Caspian. The northern part of the Caspian is the shallowest, with a smooth, undulating bottom and a depth that is mainly in the range 4-5 m. The Sea is fed in the proportion of 88% by stream flow, most of it into this northern section.

The Central Caspian is considerably deeper. Depths here are as much as 600-700 m.

The southern part of the Sea is the deepest of all and also has a deep shelf, particularly in the west and the south.

Precipitation averages 200 mm/yr, but is very unevenly distributed. Thus, precipitation on the south-western shoreline is as high as 1,700 mm/yr. Evaporation from the water surface averages 1,000 mm.

In recent decades, the climate in the Caspian Basin has become somewhat milder than before: winter temperatures have risen and summer temperatures fallen. This has had the effect of increasing precipitation and reducing evaporation from the surface of the Sea.

The waters of the Caspian fill a deep tectonic depression and the water level is significantly below that of the world's oceans: over the past two millennia, it has varied within the range - 25-32 m relative to this datum level. Such wide variations in sea level - which have a substantial environmental impact - are basically of tectonic and hydrometeorological origin. There has been no complete study of tectonic activity in the Caspian region: fragmentary information exists, but not a full description or assessment of the geological processes shaping the immense Caspian Basin. Consequently, determining the influence of tectonics on the water level in the Sea is largely a matter of guesswork.

It is far easier to assess the role of hydrological factors, such as stream flow, precipitation and evaporation.

The figures for the level of the Caspian over the course of the current century show that between 1900 and the end of the 1970s it fell from - 25.8 m relative to the datum to - 29.2 m. During the same period, stream flow declined from 330 $km^3$/yr to 240 $km^3$/yr and precipitation over the Sea amounted to slightly more than 70 $km^3$. So far this century evaporation loss has tended to decline; during the period under review it amounted to between 360 and 380 $km^3$/yr. Hence, the debit side of the water balance for the Caspian has outweighed the credit side, and that in turn has led to a fall in the level of the Sea.

Beginning from the end of the 1970s the level has risen: by 1993 it stood at - 27 m. This is entirely attributable to an increase in stream flow: over the past 14 years, the latter has averaged 307 $km^3$/yr and sometimes exceeded 400 $km^3$. The average volume of precipitation falling on the surface of the Sea has also risen, to 86 $km^3$. Evaporation loss has been of the order of 340 $km^3$. Also on the debit side of the Sea's water balance with evaporation is discharge into the Karabogazgol Gulf, which is within the borders of Turkmenistan. This discharge has varied between 4 and 20 $km^3$, depending on the year, and has had some influence on the water level in the Sea. The values of these components of the water balance are shown in the table below:

| Period | Credit, km³ | | Debit, km³ | | Credits - debits, km³ |
|---|---|---|---|---|---|
| | Stream flow | Precipi-tation | Surface evaporation | Discharge to Karabogazgol | |
| 1900-1929 | 330 | 70 | 389 | 16 | - 5 |
| 1930-1941 | 269 | 73 | 395 | 13 | - 66 |
| 1942-1969 | 285 | 74 | 356 | 13 | - 5 |
| 1970-1977 | 240 | 88 | 375 | 6 | - 53 |
| 1978-1991 | 307 | 86 | 343 | 0 | - 50 |

The damage resulting from the present rise in the level of the Sea is unimaginable. During the period when the Sea was shrinking, people moved onto the newly uncovered land, establishing towns and villages, industries and transport infrastructure. New patterns of life developed. Now all this is being drowned as the waters rise: Turkmenistan alone has already lost 15 population centres, 9 km of wharves, 30 km of utility lines, sewage plants and an oil depot in Turkmenbasha, and large parts of its oil and gas fields. The cost of the damage already runs into the billions of roubles. The measures being taken to keep back the rising waters include building dykes and raising shorelines. The Karabogazgol Gulf, which was closed off in 1980, has been reopened and now 16-18 $km^3$ of Caspian water are flowing into it. Despite all this, the Sea continues to rise.

The seismicity of the region

The first two earthquakes to have been officially recorded in Turkmenistan occurred near Ashgabat (the Nisa of antiquity) in approximately 2000 B.C. and 10 A.D. and had an intensity of 9-10 points (M 7.1). There was another earthquake of the same intensity at Nisa 10 centuries later, in 953.

During the period 1876-1893 earthquakes affected the area along the Caspian. Two, in particular, stand out: the Turkmenbasha earthquakes of April 1876 and November 1892, which measured 6 and 7 points respectively.

There were especially strong earthquakes in 1893 and 1895, three of them catastrophic. These included the two earthquakes at Quchan, on the far side of the Kopetdag range; they occurred in November 1893 and January 1895 and measured 10 and 9 points respectively, with the shocks felt in Turkmenistan measuring 4-6 points. The propagation zone covered some 150,000-200,000 km$^2$.

The third catastrophic earthquake was that of July 1895 at Turkmenbasha, the intensity of which at the epicentre, which was on the shore of the Caspian, measured 10 points (M 8.2). The tremors were felt over an area of 3 million km$^2$.

There followed, in the period up to 1925, some 80 earthquakes, most of them of an intensity of as much as 6-7 points.

After this came a period of relative calm. The next major earthquake did not occur until May 1929. It measured over 9 points at its epicentre, which was situated west of Ashgabat, in Iran, and 9 points in Turkmenistan itself. The aftershocks continued for four years.

The next historic earthquake occurred in 1946. In the night of 4-5 November there was a catastrophic earthquake which had its epicentre in the area around Kazandzhik. It caused considerable destruction and loss of life.

One of the most destructive earthquakes in the history of Turkmenistan was the Ashgabat earthquake of 1948. At its epicentre, 25 km south-east of Ashgabat, it had an intensity of 10 points on a 12-point scale, representing a magnitude of 7.3.

Because its epicentre was so close to the city, its consequences were horrendous: every house, school and administrative building and all the hospitals, cultural facilities, industrial structures, restaurants and shops were razed. Even multistorey brick buildings and reinforced-concrete structures - built until 1940 and from 1943 to withstand earthquakes measuring 8 and 7 points respectively - were heavily damaged. Fewer than ten buildings were left intact in the entire city. In a few seconds, the city was reduced to a heap of rubble cut off from the world by the severing of all its communication links.

The social and economic consequences of this subterranean tragedy were enormous.

Prior to the earthquake, Ashgabat had some 132,000 inhabitants. Even according to the official figures, which were undoubtedly reduced, the casualties numbered in the tens of thousands. Press reports spoke of 35,000, 70,000 and even 110,000 dead. What is certain is that, of those killed, 37% were children, 47% women and 16% men. Starting from statistical averages and assuming the population to have comprised 30% children aged below 16, 45% women and 25% men (the unusually low proportion of men being a reflection of the post-war conditions), G.L. Golinsky has calculated the probable number of persons killed at 47,850 (see table).

| | Population | | Fatalities | |
|---|---|---|---|---|
| Composition | % | Number | % | Number |
| Children below 16 | 30 | 39 600 | 37 | 14 650 |
| Women | 45 | 59 400 | 47 | 27 920 |
| Men | 25 | 33 000 | 16 | 5 280 |
| Total | 100 | 132 000 | 100 | 47 850 |

The above figures take no account of the members of the military garrison, hotel guests, railway passengers, etc. If they are included, the number of dead can be put at 52-56,000.

The economic consequences of the earthquake were catastrophic. Over 600 million roubles' worth of industrial equipment, raw materials and finished goods were buried beneath the rubble and over 200 enterprises of republican or all-Union importance were affected. The earthquake is estimated to have cost the economy a total of US$ 5-6 billion.

The Ashgabat earthquake also caused substantial damage outside the city, in the Gekdepin and Ashgabat farming districts. It also affected adjacent areas of northern Iran. Damage was particularly heavy in the north-eastern part of Khorasan, south of the Turkmenistan locality of Chaacha: 30 Iranian villages were totally destroyed and over 3,000 people were killed. Hence, Turkmenistan can be considered a zone of high earthquake risk, with tremors of a magnitude of up to 9-10 points and a magnitude of over 8.0.

In the 45 years since the catastrophic earthquake of 1948, there have been more than 35 earthquakes of magnitude 4.0 or greater in Turkmenistan.

The past ten years have been marked by powerful destructive earthquakes in western Turkmenistan (1983, Kum-Dag, intensity 8 points, magnitude 5.7; 1984, Burun, intensity 8 points; 1986, Caspian Sea, intensity 7 points, magnitude 6.6; 1991, Gaurdak).

On 28 November 1992, at 2.09 a.m., a 6-point tremor was felt in Ashgabat; its focus was 130 km to the south-east. There were no casualties or destruction, but more than 35 buildings, most of them schools and hospitals, suffered slight damage to expansion and earthquake joints.

ACTION TO MITIGATE THE CONSEQUENCES OF NATURAL DISASTERS

Our action to mitigate the consequences of disasters is appropriate to the natural and man-made phenomena described above.

Regarding hydrometeorological phenomena, attention will be focused on setting up and developing a system for the monitoring of atmospheric phenomena and the related flooding, large mudflows, hurricanes, heavy frosts, and dust storms.

Applying this system and experience in short- and long-term forecasting, it will be possible to plan ahead and take measures to forestall the possibility of damage.

The next group of activities will concern the financing of the building of hydraulic structures to minimize damage from rises in water levels on major rivers, the controlling of runoff and dredging.

Stocks of seedlings are being built up in order to boost the planting of food crops and cotton.

Measures to protect livestock include:

Development of reliable long-term forecasting of severe and unusually snowy winters;

Development of reliable short-term forecasting of heavy snowfalls and blizzards with sharp temperature drops;

Building in welayats, etraps and farms of warm shelters and enclosures.

As regards the steady rise in the level of the Caspian Sea, the Turkmenistan Government is studying the possible damage and means to develop a special programme to contain it. Implementing that programme will require a substantial input of funds.

We feel there is a need to set up a warning centre to provide information in the event of the emergence of exceptional or environmental situations that pose a threat to the Caspian region in general or to individual Caspian States.

The level of the Caspian Sea is governed by a multitude of tectonic, hydrometeorological, human, environmental and other factors, each of them important, complicated and far from fully studied. There are many natural phenomena and processes that extend over decades, perhaps centuries, and therefore all factors must be taken into account. Unfortunately, the present level of research is inadequate to support the accurate and fully and scientifically substantiated long-term forecasting that is required.

There is a need to analyse both the information that is already to hand and the information which has yet to be collected. That means not only continuing the present series of observations, but also supplementing them by augmenting the network of observation points and increasing the number of parameters being monitored. The countries concerned must institute a continuous exchange of information on the Caspian Sea, for the Sea is one and its shores recognize no frontiers.

Turkmenistan is now intensively engaged in developing its industrial potential.

This is occasioning serious safety problems at industrial facilities now under construction or already in operation, and particularly at sites handling highly toxic chemicals. Work to assess the risks at potentially hazardous enterprises has recently begun and is being conducted in accordance, inter alia, with the recommendations of the International Labour Office and the UNEP/ILO/WHO International Programme on Chemical Safety. Guidelines have been drawn up for what plant employees should do in the event of major accidents. New chemical industry facilities are being designed and built in accordance with the current international directives and safety standards. A system for the State regulation of the commissioning of industrial plant of this kind is under development. Realizing that the problem of safety at potentially hazardous industrial facilities is a complex one, Turkmenistan's specialists are attentively studying the experience of the advanced industrial countries and would be interested in international cooperation in this field.

ACTION TO MITIGATE THE CONSEQUENCES OF POWERFUL EARTHQUAKES

To ensure efficient decision-making and planning to mitigate the consequences of these natural phenomena, action must, we feel, be concentrated in these three main areas:

1. In-depth scientific study of the phenomena themselves; drawing-up. on the basis of such study, of seismic-risk maps for use in the designing and erection of earthquake-proof buildings; long-term prediction of seismic activity; from the accumulation of knowledge and the processing of a broad range of statistical information, achievement of the prerequisites for

reliable short-term forecasting; drawing on specialist experience, establishment on the basis of a network of seismograph stations of a national service for the provision of information on recorded or expected earthquakes;

2. Establishment of an efficient national service for coping with the effects of earthquakes, including ensuring prompt evacuation, rescue and medical assistance and care for the homeless;

3. Natural-disaster preparedness training for the public, training of rescue teams, training of authorities to take effective management decisions.

In order to concentrate the available human and other resources and ensure the pursuit of a coherent policy as regards seismology, Turkmenistan plans to set up a National Centre for Seismic Studies and Earthquake-proofing.

In our view, the most important requirement is for proper planning and conduct of research in the areas of seismology and earthquake-proof construction. Meeting this requirement will entail large inputs of money and equipment.

The 1948 Ashgabat earthquake was a turning point in the development in Turkmenistan and elsewhere in the world of earthquake studies and efforts to predict seismic events. It brought recognition of the need for substantial intensification and expansion of work in the areas of seismology and earthquake-proof construction. A seismograph station was opened in Ashgabat literally two weeks after the 1948 earthquake, and other stations followed: at Mary in 1959, Kyzylarbat in 1950, and Bayramaly and Vanovsky in 1952. In 1953-55, with a view to identifying the precursors of earthquakes, the first work was done in Turkmenistan on the study of electromagnetic processes in the soil and atmosphere and, through measurement of physical fields at the Earth's surface, of deformation processes.

Thanks to further expansion of the network of seismograph stations, it is now possible to determine epicentral coordinates to ± 25 km and to study the both the regional peculiarities and the general characteristics of seismic activity in Turkmenistan and neighbouring areas. This is of great importance for seismic zoning and the creation of a basis for the assessment of the earthquake hazard in connection with urban and infrastructure development in Turkmenistan.

A systematic approach has been followed to seismological and geographical investigations in Turkmenistan, with work in these areas: study of the physical processes connected with the nature of earthquakes and taking of instrument readings in connection with the study of the dynamics of the Earth's crust; integrated study of the structure and dynamics of the Earth's crust and upper mantle in seismically active zones; elaboration of earthquake predictions from a combination of geological, geomorphological, geophysical and geochemical data, determination of the degree of earthquake hazard in the country.

In 1982 the studies of seismic activity, crustal structure and dynamics and geophysical fields were used to prepare earthquake-risk and seismic-zoning maps for the country as a whole. There are three seismogenetic regions in Turkmenistan: the Nebitdag-Krasnovodsk and Kopetdag regions, where earthquakes can have an intensity of 9 points or more, and the Gaurdak-Kugitang region, where the intensity measures 7-8 points. Within these the maps identified new seismic zones and gave more precise locations for zones already known: the Kopetdag-Bolshebalkhan, Tedzhen, Murghab, Amudarya, Elbrus-Bakharden and Kushka-Charshanga zones, where earthquakes of magnitude 6.0-8.0 can occur. There was discovered to be a possibility of earthquakes more powerful than those already known in the Nebitdag-Krasnovodsk zone and south-west of Ashgabat.

On the basis of studies of the geology, hydrogeology and seismicity in the individual seismogenetic regions and special work to determine the earthquake hazard, seismic-microzone maps have been made of Turkmenistan's principal industrial cities: Ashgabat, Krasnovodsk, Chardzhev, Bezmein and so on. These maps pinpoint the areas where seismic activity can have an intensity of 7,8 or 9 points or more and have been used as a basis for the elaboration of city master plans and the designing and building of housing and industrial facilities.

Currently, the main normative document for such construction is the 1:5,000,000 "Seismic Zoning Map of the USSR (SR-78)", which dates from 1978. It is based on instrument readings made over a relatively short period of time and on inadequate information about the history of large earthquakes in Turkmenistan; it also fails to take fully into account the influence on the earthquake hazard in Turkmenistan of the adjacent seismically active regions in the Islamic Republic of Iran and Afghanistan. Since the map was drawn up, new seismological, geological and geographical information has been published, methods of earthquake-hazard assessment have improved, new approaches have emerged to regional and engineering seismology and new discoveries have been made concerning earthquakes and the geological and geographical circumstances of their occurrence. A fresh look is therefore required at the seismic zoning of Turkmenistan.

This review needs to be conducted in the context of modern thinking about seismic processes and bearing closely in mind the efforts to monitor the seismic situation in the region. With the setting-up of a national seismological service and national earthquake prediction institute, the technical and methodological basis will very soon exist for the making of the first seismic-zoning map of independent Turkmenistan. It is planned to carry out the research for, and compilation of this map in cooperation with specialists in Russia and the neighbouring countries of Kazakhstan, Uzbekistan and Iran.

WARNING SYSTEM

The basis has been laid for a national seismological service in the form of a regional network of fixed seismograph stations at 24 points in the Republic. The country has also established the Ashgabat seismological centre, where complex predictive readings are made by a total of 19 methods, and arrangements have been made for a centre at Nebitdag. Information has been obtained about the structure of the Earth's crust in seismogenetic zones and about geophysical processes in the build-up to tectonic earthquakes and there has been trial long-term and medium-term prediction of seismic events in the Ashgabat and Nebitdag seismic zones. In addition to the national seismic-zoning map, large-scale zoning maps have been drawn up for a number of towns and industrial sites. These are of great value in forecasting the general earthquake hazard and in assessing the threat to, and the likelihood of survival of housing, industrial plant, power stations and transport infrastructure.

The structure and staffing of the national seismic service will be consistent with the concept of seismic monitoring developed in Turkmenistan.

The main component of the service will be the prediction centre, which will have powerful computers and efficient algorithms for the processing of seismological data so as to assist a panel of experts in reaching conclusions as to the seismic situation and predicting earthquakes. The information coming from the centre must be good enough to enable Turkmenistan's presidential Committee on Emergency Situations to reach accurate decisions on ways of reducing possible damage from seismic events.

A procedure chart has been drawn up in relation to seismic surveys in Turkmenistan for 1992. The fundamental element of the procedure is consistent compression of the raw data with minimal loss of its information content. This first-level data provides the information necessary for determining the spatial distribution and energy levels of earthquakes.

The next step, representation of the data for the purposes of analysis of the space/time structure of seismic activity, is based on a catalogue format: a software package enables the data relating to the subject of enquiry to be displayed in the form of graphs, histograms and seismic parameter maps. The process of building up a meaningful display is an interactive one in which the computer user can select the information he considers to be important.

Through this process of identifying the spatial and time patterns in the region's seismic activity and displaying them in any of the available standard forms (graph, table, histogram, map, etc.) it is possible to analyze the earthquake hazard and also to delineate the zones with the greatest earthquake potential and pick out the danger periods. A standard graphics package displays the information in the form of a catalogue of plot files, with an indication of the nature and forms of data representation (including the necessary statistical information on the source information being used).

Thus, thanks to the systematic saving of the results of processing, there is no need to repeat the entire computation process when seeking final output and time is saved when an urgent assessment has to be made of the earthquake situation.

The indicators of seismic activity must be chosen bearing in mind the scale factor (segment, province, region, local region) and will require a combination of observation methods. The latter must be such that the typical time scales TI and the typical space scales LI and the combination of methods (TI, LI) cover a sufficient range of potential seismic events.

For mitigating the consequences of powerful earthquakes it is important to have adequate construction standards and to promote the construction of earthquake-proof housing and public and industrial buildings and structures.

In the 1988 earthquake in Armenia, poor-quality building work, designs and materials, inadequate site investigation and the absence of reliable information on seismic zoning, together with the errors made in many projects, were the main causes of the widespread destruction of buildings and infrastructure and of the earthquake's serious consequences.

Work is currently in progress in Turkmenistan on the detailed seismic zoning of industrial areas and the seismic micro-zoning of towns. This includes the updating of the existing zoning maps.

New design standards are being drawn up for construction in areas liable to earthquakes with an intensity in excess of 9 points and guidelines are being prepared for construction in seismically active areas in general.

Better training, including refresher training, is being provided for building workers.

Building work, including construction by families of their own homes, is now subject to closer inspection.

Improved designs making extensive use of local materials and in-situ casting of concrete and offering greater durability and resistance to earthquakes are steadily being developed both for buildings and for other structures.

As far as is currently known, the seismicity of Turkmenistan is as follows:

1. Earthquakes with an intensity of 7-8 points are possible in eastern Turkmenistan;

2. Earthquakes with an intensity of 9-10 points are possible in the central Kopetdag.

This classification is being borne in mind in the construction of residential, public and industrial buildings now in progress. In addition, a programme is being drawn up for the inspection and seismic strengthening of existing buildings.

INTERNATIONAL COOPERATION IN SEISMOLOGICAL STUDIES

Under agreements between the Turkmenistan Academy of Sciences and the IRIS Corporation, the United States Seismic Survey Center, Pacific-Sperra Ration, a private company, the University of San Diego, California, Indiana State University and the Lamai Observatory of the University of Colorado, a teleseismic station, a local network of seismograph stations and geophysical observatories to apply new geophysical monitoring techniques are now being established.

The aims of the proposed research are deeper study and reliable prediction of the natural phenomena concerned.

In accordance with the programme of action for IDNDR, the Turkmenistan Academy of Sciences is preparing a general framework for national seismic-hazard assessment, drawing up a new national seismic-zoning map and setting up a seismic-hazard assessment centre in pursuance of the international programme on the "Global Seismicity of the Earth".

The principal prerequisites for the execution of these programmes are, of course, funding and the provision of equipment, including the supply of modern apparatus incorporating the latest technological advances. This matter can be successfully resolved within the framework of IDNDR.

We see a need and opportunities for international cooperation in the following areas:

1. Improvement of communications and creation of modern communications networks for the real-time transmission and prompt pooling of information on earthquakes and the timely dissemination to national authorities of the information they require for the taking of effective management decisions. Creation of opportunities for the exchange of information with neighbouring and interested countries;

2. Coordination of national, and participation in international research programmes in the complex field of seismology. Exchange of experience regarding, and assistance in the procurement of seismic instruments and state-of-the-art computer and laser technology for earthquake prediction;

3. Exchange of experience regarding, and assistance (including through exchange programmes) in the training of researchers and technicians;

4. Exchange of experience regarding, and cooperation in the development of standards for construction in earthquake zones and of new technology for the building of earthquake-proof residential, administrative and industrial buildings. Exchange of experience regarding the surveying and strengthening of existing buildings;

5. Assistance in the elaboration of national programmes for the reduction of casualties and damage in the event of powerful earthquakes.

We are confident that our active participation in IDNDR and the Yokohama conference will lead to effective solutions to many of the above issues.

Since Turkmenistan is only just establishing itself as a sovereign State, we should be grateful if a large part of the cost of attendance at the Yokohama meeting could be borne by the United Nations department whose humanitarian mission it is to coordinate activity in connection with IDNDR.