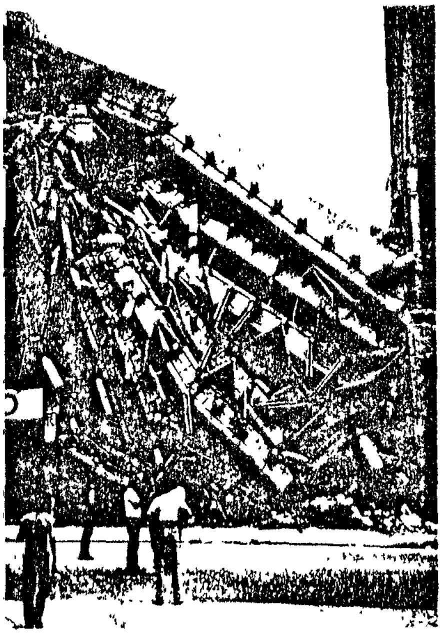

INTERNATIONAL RESEARCH AND TRAINING SEMINAR ON REGIONAL DEVELOPMENT PLANNING FOR DISASTER PREVENTION

APPLICATION OF RESEARCH FINDINGS IN EARTHQUAKE DISASTER PREPAREDNESS PLANNING AND MANAGEMENT

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NOTE

APPLICATION OF RESEARCH FINDINGS IN EARTHQUAKE DISASTER PREPAREDNESS PLANNING AND MANAGEMENT

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INTRODUCTION

There is no region in the world where earthquake problem can be completely neglected. But differness are recognised both in the intensity of ground shaking as well the frequency with which earthquakes recur in different areas of the world. Commonly speaking, earthquakes are included in the list of 'natural disasters' alongwith cyclones, floods, drought, landslides etc. Studies on the 'causes' and 'effects' of the so called natural disasters have led to the increasing awareness that they are in fact natural events which are converted into disasters due mainly to the acts of man either through ignorance or neglect. The report "Prevention Better Than Cure" of Swedish Red Cross, 1984, rightly states that "The term natural disaster is misleading". The ground motion during earthquakes is rarely directly responsible to cause deaths or injuries to people. It is the collapse of unsatisfactory constructions which leads to disaster. Besides the forces of nature released during these natural events, such as earthquakes, the major factors leading to disastrous consequences are poor land use, the structural weaknesses in the handiworks of man such as houses, buildings, bridges, lifelines etc., and neglect about the secondary chains of disastrous events which can result due to the failure of a major structure like a dam, a chemical or industrial plant or an Atomic Power Station. Fire can result due to short circuiting of electric wires, rupture of gas pipes or falling objects getting burned in kitchen fires due to earthquake shaking. In the developing countries the disastrous effects are further pronounced by lack of awareness and education, concentration of population in seismically very weak houses, lack of communication and transportation facilities, deficient financial resources, etc. In fact, the poorer the population, the more vulnerable it is to the natural disasters. Hence the earthquake disaster mitigative measures must be the most economical and cost effective so that they could be afforded and accepted. This calls for research not only in scientific and technological aspects of the earthquake problem which may be more of global nature but also in socio-economic and management situations which are usually of local character.

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'Hazard mitigation' usually means taking those actions before an event which will minimise the impact of that event on the society. The losses to the society will be in the form of loss of lives, loss of property, loss of production, reduction in income of the people and their assets, increase in liabilities and expenses, etc. For an earthquake, mitigation would mean, such actions that would protect the existing structures, lifelines, etc., and build new ones in such a way that they should suffer little damage and remain functional during the earthquake. This ideal is, however, far too high to achieve due to serious constraints in most countries as stated above. Hence 'preparedness' for anticipated effects and after-effects of the hazard becomes one of the strategies for reducing the impact on the affected community. Here also a number of questions have to be answered:

where and for whom to prepare, what to prepare, best way to prepare, and so on ?

Some time, because different types of professional and management persons are involved in mitigation and preparedness phases, the two measures are artificially separated by drawing a sharp line. This is detrimental to the cause of the society which both the measures intend to serve, since as stated earlier, Prevention is Better Than Cure. Therefore the preparedness measures must include guidelines for implementation of mitigation measures by the people themselves as well as some minimum measures as part of Preparedness for it to become effective in reducing the misery of the affected people. Research has helped in answering the questions related to effective mitigation and preparedness measures at minimum cost.

PREPAREDNESS ACTIVITY

Preparedness phase is directly related with the anticipated emergency situation that may arise just after the earthquake which will include the following:

maintenance of law and order, preventing loot and theft;
evacuation of people;
recovery of dead bodies and their disposal by cremation or burial;

medical care for the injured;

supply of food and water and restoration of water supply lines;

providing temporary shelters;

restoring lines of communication and information, controlling rumours; restoring transport routes;

quick assessment of damage and demarcation of damage areas according to grades of damage;

cordoning off severely damaged structures liable to collapse during after shocks;

temporary shoring of precariously standing buildings to avoid collapse and damage to adjoining buildings; and

immediate action to prevent certain chain reactions which could develop during a severe earthquake e.g.

controlled release of water from the reservoir of a dam which may get damaged and found dangerous,

control on leaking toxic gases,

treatment of environment to prevent spread of disease, etc.

Opportunity should be utilized to learn lessons from the event for the future benefits by damage survey in a scientific manner, collecting instrumental and other field data from the effects of the earthquake like after-shock records, effects on well and spring water, changes of levels and distances, rockfalls and slips, fault ruptures, etc. It is useful to mention that much of present scientific learning about earthquakes owes it to the keen observations made by professionals as well as the public on what happened during the damaging earthquakes. There has always been something new to learn from each such happening. As a result of such observations through the ages, human ingenuity developed, based on locally available materials, such construction techniques which made the buildings adequately earthquake resistant. Examples can be cited of braced and brick-nogged wood frames in Jammu and Kashmir, Dhajji wall construction in Himachal Pradesh and Assam type Ikra construction in north-eastern region of India. Even sun-dried brick, adobe and rammed earth constructions had been so well strengthened by use of buttresses and wood elements in Himachal Pradesh in India and regions in Yemen Arab Republic that they have lasted for centuries under seismic environment. These techniques with further improvements brought about by modern research efforts(1) can effectively be used to build safe small tenements in the rural and semi urban areas in various seismic intensity zones.

COMPONENTS OF DISASTER PREPAREDNESS

For cost effective preparedness against a natural hazard the following are visualised as the important components of preparedness:

i) Seismic Zoning and Microzoning of the country or the region is essential so that the need and level of seismic safety required can be established. Basically for seismic zoning, data will be needed an earthquake occurrences and the geologic framework and tectonic set up of the region. For microzoning, additional data on topography, local geological and soil conditions, level of water table, strong ground motion records etc., are required. Study of precursory phenomena helps in predicting an impending earthquake in terms of probable location,magnitude and time of occurrence. Whereas seismic zoning will help in establishing long term needs of mitigation and preparedness in various zones in a graded manner, micro-zoning and prediction will indicate where more concentrated and urgent preparedness is necessary.

ii) Societal data in the identified seismic regions is necessary in terms of population density, prevalent building types, presence of vulnerable structures, and life-lines, socio-economic conditions, etc., so as to determine not only the vulnerability of the man-made structures under the probable earthquake but also the capability of the community to respond and absorb the effects of the shock. This will also help in fixing the targets of protection in a priority--wise manner for cost effectiveness of the resource inputs.

iii) The data from the above steps can be combined to carryout vulnerability studies of the regions, subregions or urban conglomerates. These will greatly help in planning and management of the mitigation and preparedness activities according to the realistic needs and not in a haphazard manner. It should also provide the basic inputs to the promulgation of governmental decrees and municipal bylaws and guidelines for land-use planning of settlements, special construction features, rating of existing buildings for earthquake resistance and protective requirements, etc.

RESEARCH FINDINGS

Study of seismological observations, strong ground motion records and effects of earthquakes on ground and structures has provided insight regarding earthquake sources, spacial and temporal variation of earthquake occurrence in such sources, severity and variation of ground motion at various distances from such a source during earthquakes, behaviour of ground, performance of man-made structures and facilities located on different soil and rock conditions in different situations of geomorphology and hydrology at various distances from the earthquake source; and other natural phenomena such as surface faulting, regional uplifts and subsidences, fires, and inundations from tsunami and floods resulting from failure of valley fills from landslide and avalanch debris, embankments and levees during earthquakes. The research findings related to components of disaster mitigation and preparedness are briefly summarised in the following paragraphs.

EARTHQUAKE SOURCE

Major earthquakes which result in damage on the ground occur due to ruptures and fractures in the lithosphere (say within 70 km depth below ground) in regions where crustal deformations are actively taking place in the present tectonic regime and evidences of Neotectonism are observed. Boundaries of lithospheric plates, mid-oceanic ridges, the circum-Pacific island arcs and subduction zone, and Alpine - Himalayan mobile belt constitute the major earthquake belts on a global scale. Boundary of crustal blocks on a regional scale, and areas lying within the lithospheric plates show reduced order in terms of size (magnitude as well as intensity) and frequency of earthquake occurrence. Great earthquakes (say magnitude $M \geq 7.8$) occur along and close to the lithospheric boundaries and other major seismotectonic belts. Identification and demarcation of seismotectonic features and characterising the activity as 'line-source' or 'planar source' along their various segments will provide the basic information on location of probable earthquake sources in future for evaluation of earthquake hazards. Use of geologic data provide a long term assessment of potential of earthquake occurrence in future and defines the character of earthquake sources, as in many situations data characterising contemporary earthquake occurrence may appear to be unrelated with known or inferred capable faults.

A region with similar earthquake hazard at all places is defined as 'seismotectonic province'. Earthquake occurrence unrelated with seismotectonic structure, that is, the capable faults and other active tectonic lineaments, are classified as 'floating sources' in a seismotectonic province. Remote sensing can be usefully employed in demarcation of active tectonic lineaments in a region wherein evidences of Neotectonism and Recent movements have been observed on the ground.

EARTHQUAKE SIZE

The amplitude of seismic waves (e.g. body waves and surface waves, recorded at a place), the parameters of the earthquake source (viz., stress drop and seismic moment), and the area affected by shaking felt by people, indicate the size of rupture zone at the earthquake source. The size of earthquake referred as Richter's magnitude is computed from near field ground motion records. Body wave, surface wave and moment magnitudes are also utilised to indicate size of earthquake. Magnitude is expressed by Indo-Arabic numerals such as 7.8. The longer is the length of fault rupture at the earthquake source the higher will be the magnitude. Though originally defined as an open ended parameter, the magnitudes determined from recorded amplitudes of seismic waves of various periods of vibration show saturation indicative of an upper limiting value, probably controlled by deformation and rupture strength of the lithospheric rocks. Earthquakes of larger size beyond such a limiting value may indeed result in longer duration of motion due to larger size of the earthquake source. Higher the magnitude of the earthquake, longer will be the duration of strong ground motion and larger will be area affected by the earthquake. The rating of the effects of an earthquake at a place or an area is done in terms of Intensity scale, the more common ones now are Modified Mercalli Intensity scale and the MKS Intensity scale.

STRONG GROUND MOTION

Free field strong ground motion depends on the mechanism and size of rupture at the earthquake source, seismic wave attenuation characteristics of the intervening medium from the source to the place of observation and the local influences of topography, depth of soil and other deposits overlying base rock, and ground water conditions. Soil - foundation - structure interaction effects influence the recorded ground motion close to and at the foundation level of structures. Strong ground motion in earthquakes with Richter's magnitude $\leqslant$ 5 is restricted within a small area and has relatively **short duration** hence in general has little damage potential. The severity of motion increases with higher magnitudes. In the magnitude range 5 to 7, it attains a high value close to the earthquake source and attenuates away from the source with distance. But the severity close to the earthquake source does not show a significant increase for earthquakes with magnitude greater than 7 although the area affected goes on increasing. The extensive damage during such earthquakes affecting large areas is the result of longer rupture length and duration of strong ground motion.

The time history of strong ground motion around an earthquake source is characterised by the rupture mechanism and size of rupture that is the earthquake magnitude. More or less similar motion occurs on the two sides of the rupture in a 'strike slip' mechanism. Significant differences in the ground motion are observed in the hanging and footwall sides in 'dip-slip' and 'thrust' mechanisms. Isolated peaks of small duration, larger than the effective average amplitude of strong ground motion result from rebound in thrust mechanism or high stress drop in ruptures of significant asperities along the failure surface. Surface shear waves and Rayleigh waves constitute the bulk of the strong ground motion which adversely affect the stability of the ground and the man-made structures, and the severity is seen to reduce with depth. At an approximate depth of 30 m or more, the severity reduces to half of that at the ground level. The long period surface waves attenuate with distance less rapidly than the short period body and Rayleigh waves. This understanding regarding nature and severity of strong ground motion is a significant advancement in the engineering applications for safe design of various structures and systems.

EARTHQUAKE HAZARD

Earthquake hazard at a place or an area, within a given time interval, expresses the probability of occurrence of a visible adverse effect such as damage to buildings and structures, ground failures (fissures, landslides, avalanches, lurching, differential settlements, liquefaction, etc.), surface faulting, uplifts and subsidences, inundation and fires. The severity and duration of strong ground motion govern the damage potential based on the dynamic characteristics of the buildings and structures, earth slopes and dams, etc. Displacements along the rupture surface at the earthquake source spreading upwards towards the ground cause surface faulting, uplifts and subsidence, and if such ruptures cut across structures, very severe damage can take place. It will not be feasible to restrain displacements along active faults. Therefore seismically active faults extending to the ground surface should be avoided while locating structures. But avoiding may not always be possible, as in case of long tunnels and other lifeline structures. In such casses measures should be adopted in design for localising and minimising damage without loss of function and load carrying capacity. Alternatively, adequate flexibility to absorb the displacement (or self healing material as in earth and rock fill dams) should be adopted.

Tsunamies are generated by excitation of large water masses of oceans by major earthquakes often resulting in inundation of coastal areas, and as their development can not be prevented, construction at appropriate elevations in coastal regions and network of observation and warning system are the main mitigation measures for safety against such sea waves.

Floods could be caused due to failure of dams retaining large reservoirs. Rupture of electrical wiring, gas pipelines and contrainers of inflammable liquids and gases can lead to fires, which under certain condition can develop in conflagrations.

GROUND FAILURES

Slopes with critical stability can undergo irreversible displacements when subjected to strong ground motion, resulting in landslides and slips. Stress waves impinging on ground surface in mountainous terrain result in scabbing of rocks on steep slopes and hill tops, and sliding and over turning of rock fragments and boulders initiate movements of surficial material cascading downwards forming surface runs, debris fall and avalanches, carrying with them buildings, roads and other structures down to the valley base. Local slides and rock fall in such terrain block transportation routes and retaining and breast walls on roadsides are damaged. Rock mass volumes, when excited through interaction with predominent periods of ground vibrations in the epicentral tract, will develop fissures and dislocations along the weaker planes and zones. Unconsolidated strata in river valleys and alluvial plains, on similar excitation, produce fissures, mole tracks and lurching, that is, sliding and overturning of soil blocks converting an alluvial plain into a hammocky ground. Dynamic pore water pressure is caused due to seismic vibration in saturated loose cohesionless soils in alluvial plains and coastal regions and similar loose cohesionless material inter-bedded with cohesive material which results in loss of shear strength of the soil and with significant duration of strong ground motion, causes its liquefaction. The liquefied soil flows in underground openings, and where the fluid pressure exceeds the overburden loads, the liquefied soil ejects out on the surface, rupturing through fractures and fissures in the soils cover above ground water table, forming sand fountains and flows on the surface. Craters of sand fountains and layers of sand flowing from fissures cover the ground resulting in soil polution. Settlement of soil takes places in the process, which in the coastal regions often results in inundation by water from the sea. Buildings, structures and objects located on liquefied soil undergo subsidence and tilting, and under-ground pipelines, septic and storage tanks and other structures suffer ruptures, distorsions and uplift. Ground breaks resulting from displacements along the rupture surface follow well defined tectonic lineaments. The trend length of area covered by fractures, and the horizontal and vertical offsets on the two sides of such ground breaks provide data for confirmation of earthquake source mechanism and fault plane solutions obtained from analysis of seismological records. However such ruptures should be discriminated from fissures resulting from ground failures.

Researches in soil dynamics and rock dynamics have brought out significant results regarding the above phenomena and the properties of soils and rocks affecting the observed behaviour in relation to the intensity and frequency contents in strong ground motion. Thus potential land slide areas can be mapped and analysed and the liquefaction potential of soil deposits can be worked out by laboratory testing and analysis. Methods have also been developed for improvement of site conditions for preventing land slides and slope failures and appropriate compaction of soils to avoid their liquefaction.

BEHAVIOUR OF MAN-MADE STRUCTURES

The behaviour of buildings and structures is controlled by their strength, the dynamic characteristics, interaction with the predominant periods of ground motion and the behaviour of the soil on which they stand. The greatest deformation and stresses which the structures standing above ground undergo are governed by the dynamic amplification of ground motion over the range of their structural frequencies and the inherent damping. Underground structures surrounded by soil or rock mass follow closely the displacement of the ground. Damage and failure of structures during an earthquake result from development of strain beyond yield, excessive displacements and rotations along joints and supports and development of plastic deformations and hinges in the structural framework. Failure and falling of non-structural elements in buildings such as glass panes, false ceilings, ornamentations, clading and partition walls, etc, cause injuries to people and account for very large portion of the economic losses. The degree of earthquake resistance that the different structures should have, depends on their importance and permissible damage, which is to be based on their desired performance during the maximum credible earthquake. Various levels of earthquake force can be specified for different structures for design within working stresses utilising ductility and energy absorption capacity of the structures so as to have adequate safety to remain functional after the earthquake. Well designed and appropriately constructed structures are less susceptible to damage than poorly designed and deteriorated structures. Earthquake resistant design and construction methods of different types of residential and industrial buildings attempt to optimize the cost-benefit ratio and at the same time avert the collapse of structure and loss of life, taking into consideration available construction materials and quality of construction as limited by the economic resources of the individuals and the country. Community buildings such as schools, cinema halls, theatres, multistoreyed office and commercial complexes, and other structures for large gatherings and occupation of people, service buildings including hospitals, police and fire stations, telephone exchanges, radio and television stations, etc. and lifeline structures, that is structures for electricity, water supply, and transportation systems demand higher earthquake resistance in relation to ordinary residential buildings to reduce larger loss of life, provide rescue and relief to the affected people and prevent dislocation of essential supplies and services for the people. If dams impounding large quantities of water, water and gas pipelines, structures for transport routes like bridges and tunnels, structures for storage of inflammable or poisonous fluids and explosive materials, and nuclear reactors and facilities suffer serious damage or failure during earthquake, they will accentuate the disaster. Such structure require detailed and judicious study for evaluation of earthquake hazards, analysis and design to have safe or fail-safe construction. Research has led to methods and techniques of analysis and design to achieve the desired safety levels of various types of structures for stipulated earthquake ground motions and resulting forces.

HUMAN RESPONSE

In general there is lack of awareness in most communities about earthquake hazards and mitigation measures to reduce earthquake risks. The earthquake events are considered by the common people as insurmountable natural phenomena, as fated events or an act of God or gods. The fact that earthquakes, can neither be prevented nor reliably predicted, has inhibited to develop a safety consciousness against earthquake hazards in the society, specially in developing and under-developed countries. Due to ignorance about mitigation and preparedness measures, any forecast or prediction for an earthquake results in fear and panic in the people leading to social problems and turmoil in the region. On the other hand, in the prevailing socio-economic conditions in most cases, individual owners prefer not to have earthquake resistance incorporated in the construction of their own buildings, as in their belief the chances of the dwelling being destroyed by earthquake during their own lifetime is not large. The individual is also not motivated to adopt earthquake resistant provisions as his neighbours have not done so nor do the local authorities so specify. Such provisions are also not made even in many public buildings for want of suitable bye-laws or guidelines. Information on good construction practices, reduction of earthquake damage where such practices have been adopted, vulnerability of existing structures, seismically safe construction methods on hazardous ground conditions etc. needs to be disseminated to the people in severe seismic regions so that a safety culture is developed.

APPLICATIONS OF RESEARCH FINDINGS

Where

As stated earlier, the first question to be answered is which are the regions, areas, or locations in a country where mitigation and preparedness measures should be taken in order of priority ? Earthquake occurrences in the past, systematically catalogued for as long a historical period as feasible provide the first indicators. Paleoseismicity research helps in extending the evidence backwords in history. But in view of the limitations of such records, a good statistical average frequency or return periods of particular magnitudes of earthquakes is not reliable. Hence this information is further supplemented with identification of probable earthquake sources, that is, active or causative faults and use computational algorithms to arrive at probable future seismic activity.

Another area of research is establishment of attenuation laws which will reliably determine peak ground accelerations in the region of interest. Results show that local geological, topographical and soil conditions play crucial role and make them region/location specific.

Based on the research studies as stated here above, the earthquake hazard can be evaluated with adequate confidence and seismic zoning with respect to expected intensities on MM/MSK scales, and peak ground accelerations with corresponding probable return periods can be developed. For specific locations of certain major projects and critical facilities or urban conglometrates situated in these zones, detailed microzonation can be worked out.

For whom

The second question is 'for whom is the disaster preparedness required ?" The answer is provided by seismic risk evaluation. The seismic risk is a function of the earthquake hazard in the tectonic province, the location of the place relative to the earthquake source, the vulnerability of the constructions at the place and the prevailing socio-economic conditions. Larger the hazard, nearer the source, weaker the constructions and poorer the population, larger will be the seismic risk to life, limb and livelihood. Based on the relevant seismic and societal data and the available results of researches regarding levels of earthquake resistance and vulnerability of man-made structures and systems, appropriate seismic risk models can be developed which will differentiate between the high risk to low risk locations, structures and system, thus bringing out not only the needs of mitigation and/or preparedness measures but also the order of priorities in such actions. Needless to mention that vulnerability of natural slopes to slides and slips, that of soils deposits to partial or total liquefaction must be included in the vulnerability and risk analysis.

It must be realized that it is almost impossible to mitigate against all impacts of earthquake on the society. Hence not only the poorer communities but even those which are economically better off need to be selective in choosing the targets for protection. There seems to be a consensus now on the following priority list:

i) Hazardous Structures

Those structures whose failure can lead to extensive loss of life and property to population at large, such as dams posing danger to areas downstream of the reservoir, nuclear power plants posing radiation hazard, containers of toxic gases, and the like, will require safety under the maximum credible earthquake which is likely to impinge on them. New ones must now be adequately designed and existing ones need to be strengthened where required. Preparedness should include these protective actions besides other actions like flood zoning of the downstream of vulnerable dams and areas surrounding the other hazardous structures, and warning and evacuation of populations likely to be affected in good time.

ii) Lifeline Resources

These would include essential services (water, power, sanitation, telephones and telegraphs), all emergency medical services, police and revenue offices, planning offices dealing with the disaster, etc, and transportation links viz., railway, important link roads and airports.

iii) Key Economic Activities

This refers to those industries or markets which if destroyed during an earthquake will result in great economic hardship to population due to loss of means of livelihood over a considerable length of time.

iv) Places of Public Assembly

These should naturally take precedence over individual houses in view of possible concentrated loss of life (as it happened due to the collapse of a mosque and madrassa in the earthquake of Dec. 1982 in Yemen Arab Republic) and will include schools as the first choice, cinemas, places of worship, community halls, etc. They are important since they also serve the emergency purpose of providing shelters to the people in distress after the disaster.

v) Cultural Monuments

Those buildings or structures to which the communities attach a high value need to be protected by prior action.

vi) Individuals

Whereas the above five categories will usually require action by public authorities, the individuals have usually to fend for themselves. Awareness and educational programs through mass media and extension services will help create the culture of self-help and cooperative action for mitigation as well as preparedness, and their involvement in preparedness for emergency action will be the most crucial factor in the implementation and success of the plan.

Nature and Extent of Preparedness

The next question relates to the nature and extent of preparedness. These will naturally depend on the scenario that emerges from the seismic risk studies and the resources available in terms of funds, man power, technological knowhow and skills, relative importance of disaster mitigation with respect to other social-economic needs of the people, the awareness of the risk, and the political will to plan and implement the mitigation and preparedness measures. If one looks at the situation in most seismic countries and regions of the world, it will be found varying from no preparedness at all as in most developing countries to very high level of mitigation activities as part of preparedness for receiving a magnitude 8.0 earthquake as in Japan, where effective measures have been conceived and implemented against spread of fire as well as tsunami inundation. These states of affairs can be visualised as shown in Figs. 1,2 & 3.

Figure 1 shows the general situation after a damaging earthquake occurrence where no preparedness existed. There will be many differences in details in various countries. But in general the situation becomes rather chaotic, the response of the people is random-mostly of despair and rarely of hope, mostly negative and seldom positive. Rumours abound and criticism of the administration builds up into a cry even as evacuation, relief and rehabilitation proceed through the Government and voluntary agencies. Then as time passes, and the aftershocks die down, life limps back to normal, the earthquake event is forgotten, the disastrous act of nature or the gods is over. All remains peaceful until the next one comes after a few decades or a century, and history repeats itself.

Figure 2 shows a more enlightened situation where the lessons learnt in the earlier events created enough recognition of the problem resulting into actions regarding seismic zoning and preparedness for the emergency situation. Here the various activities become systematic, actions become swift and coordinated, the population feels involved resulting in a positive attitude and mutually cooperative, voluntary agencies perform tasks as visualised and assigned, and wastage of precious resources is minimised. Also valuable information of scientific, engineering and socio-economic interests is generated by professional teams for future planning and implementation.

Figure 3 presents a mix of disaster mitigation and preparedness measures taken for implementation in the earthquake prone area likely to get the next damaging event. Due to effective mitigation measures undertaken, the disastrous impact of the earthquake is very much reduced hence all emergency operations should become easier leading to the community life fast returning to normal.

The results of research which are already, available as stated earlier in the paper find obvious applications in the different activities brought out in these figures. Hence knowledgable institutions and sceintific and professional personnel should be fully involved in planning and implementation of the mitigation and preparedness measures should not be left to the generalist administrators and revenue officials alone.

A TYPICAL OUTLINE OF PREPAREDNESS MANAGEMENT

As stated earlier earthquakes cause havoc, as they occur without any warning and create widespread damage in a very short time. As a consequence people panic, which aggravates the situation. It is therefore necessary to evolve well thought out measures in a planned manner, so that the local population becomes alive to the problem and is prepared to meet the hazard with cool courage, discipline and determination.

The object of the contingency plan should be to organize disaster relief measures covering both the urban and rural affected areas. A 4-tier preparedness management setup needs to be worked out at the following levels:

i) Village Council

It is the lowest functional unit. Each village council should have an Advisory Committee to coordinate and implement different functions.

ii) Sub-Divisional Unit

This has its nucleus in the subdivisional headquarters to help, coordinate and implement the programs undertaken by the village councils and also look after the work in affected sub-division towns. It could have sub-units at Block levels where area to be covered is large as in India.

iii) District or Province level unit

This is the highest unit in a State or Province and is required to keep a close liaison with the Central Government. This unit will help review and coordinate the activites of the lower formations in the state and also formulate and disseminate the policy dicisions.

Action is required to be taken on the following at three different stages:

i) Before Disaster

Enrollment of volunteers and their training, assessment of magnitude of problem likely to arise, demarcation of responsibilities of official and non-official agencies, resources evaluation-manpower, equipment, transport, shelter, hospitals etc.

ii) During Disaster

Visit to place of occurrence, ascertaining damages, prompt operational decisions, report to higher authorities, assessment needs, arrangement of proper services to victims.

iii) After the Disaster

Procurement of transport, setting up of centres for information, shelter, field hospitals, restoration of essential services-equipment and stores, repair/replacement of damaged equipment, returning of materials procured on loan and release of volunteers.

Coordination and control of the work to be carried out by the various services during a calamity is essential and hence the measures undertaken could be grouped under the following heads of services:

Relief Operations:

i) Technical services

Fire fighting, rescue of casualties, salvage of property, debris clearance, emergency demolition and repairs, restoration of essential services, maintenance of law and order.

ii) Medical and Health Services

First aid parties, first aid posts, innoculation and vaccination veterinary services.

iii) Welfare

Evaluation, emergency feeding, sheltering and clothing, information centres, publicity, psychological first aid, and prevention of panic.

Head Quarters Services

The Administrative officer in the area will act as Ex-officio Assistant Controller, Civil Defence in his Block area and shall be located at Block head-quaters and the same will be used as the Disaster Relief Control Centre for the Block.

Communication Service

All available means of Communication Services besides telephones, such as Police wireless/runners/trained messengers, etc., shall be used in the Disaster Relief Control Centres.

Warden Service

During disaster, the services of persons of influence, media-coverage and personality with sound knowledge of the locality will be necessary to advise and help the affected people, and to serve as a link between the public and the authorities To provide this, the Warden's service is organized, whose duties shall be to enlist volunteers and relief parties, to assess damage and report to the control centre, assist and guide relief services, prevent and control panic and counteract rumours, render shelter to homeless people, arrange temporary pyres or morgues, inform people.

Veterinary Service

The extension officer (veterinary) will be in charge of this service in the concerned block who will assess the requirement of veterinary services to be undertaken in the affected areas. During and after disaster, the following are required: Alerting of subordinate and field staff, arrangement of personnel, stores, equipment and vehicles and the program of relief work. Assistance to public in taking preventive measures against any epidemic among livestock, vaccination, distribution of feed and fodder, taking steps for repair of damaged veterinary buildings and restoration of equipment and stores, etc.

Rescue Service

The primary object of the rescue services will be the rescue of the living persons entrapped in the debris, and recovery of the dead bodies at a slightly later stage. The junior engineer possessing a sound technical knowledge will be in charge of the rescue service in a Block and his duties will include: enrollment, training and demonstration of the services and maintenance of records. Preferably, personnel for rescue work should be from Home Guards, and they should be trained in first aid. Medium and heavy rescue work will be done by the Public Works Department and Assistance from Army units and other security forces may be taken.

Welfare Service

In the event of a severe disaster, many become homeless, and a large population need food and clothing. The problems resulting from death, injury, loss of home, etc., would be handled by the welfare service. The victims will have to be supplied with essential items immediately, but should also be encouraged in self-help. The availability of such facilities can play a decisive role in not only raising public morale, but also in rehabilitating the population. The functions of the welfare service in general, are supply of information, care for homeless and evacuation.

The plan broadly indicates different services with organizations responsible for implementing it in the field. These services will be organized by the different Departments in a coordinated manner at the District as follows:

1. Casuality Service (Health and Family Welfare Department)
2. Comunication Services (State Police/Radio Organization)
3. Fire Fighting Service (Fire Service Organization)

4. Welfare Service (Education & Social Welfare Dept./ Public Works Dept./ Public Health Engineer)
5. Wardens Service/Local Leaders Service (Local Administration)
6. Corpse Disposal Service (Local Administration)
7. Veterinary Services (Animal Husbandry & Veterinary Dept.)
8. Rescue Service/Medium Rescue/Flood Relief Service / Salvation Army/ Home Guards Organization/Public Works Dept.)
9. Salvage Service (same as number 8)
10. Training Service (same as number 8).
11. Supply Service (same as number 8)
12. Depot and Transport Service (Community Development Dept.)

The breakdown of the financial requirements in the matter of organizing the services on the basis of the overall contingency plan will depend on the earthquake affected area of the State and prevailing cost structure, and must be worked out in each case after the seismic risk studies. It may also be mentioned that much local level research will be needed to make the services truly effective. Some of the research areas can be mentioned , e.g., ascertaining damages, shelters, disaster medicins and corpse disposal, rescue operations, fire fighting etc.

CONCLUSIONS

In order to be able to take appropriate preparedness measures for meeting the emergency situation created by a damaging earthquake effectively, there are no short cuts to the sustained research efforts which must be made to identify and delineate the seismically active regions, to determine the potential of seismogenic features to generate major earthquake, to understand the behaviour of local constructions under strong ground motion, to learn how to build new ones which will be safe and how to protect and existing ones by retrofitting, and so on. Preventive action is not only safer than cure but also very much cost effective. Preparedness devoid of mitigation measures will be much less efficient than when they are included. For successful implementation of any preparedness plans, a management system going down to the village level and involving the local volunteers must be established, otherwise it will be reduced to a pious wish on paper.

REFERENCES

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2. "Earthquake Resistant Regulations-A World List" Pub. by International Association for Earthquake Engineering, Tokyo.

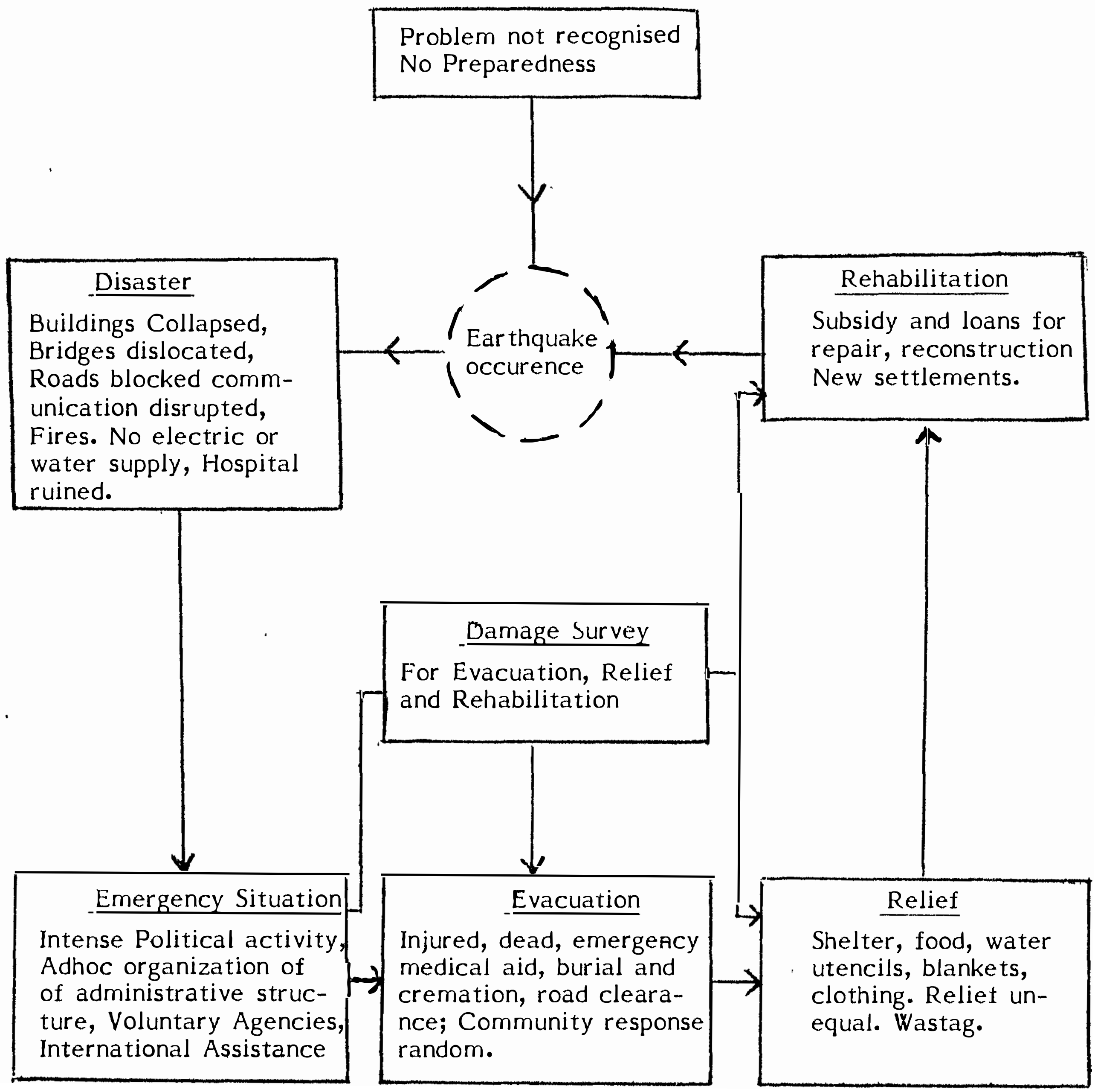

Fig. 1 Sequence of Events in an Unprepared Situation (Disastrous and Costly)

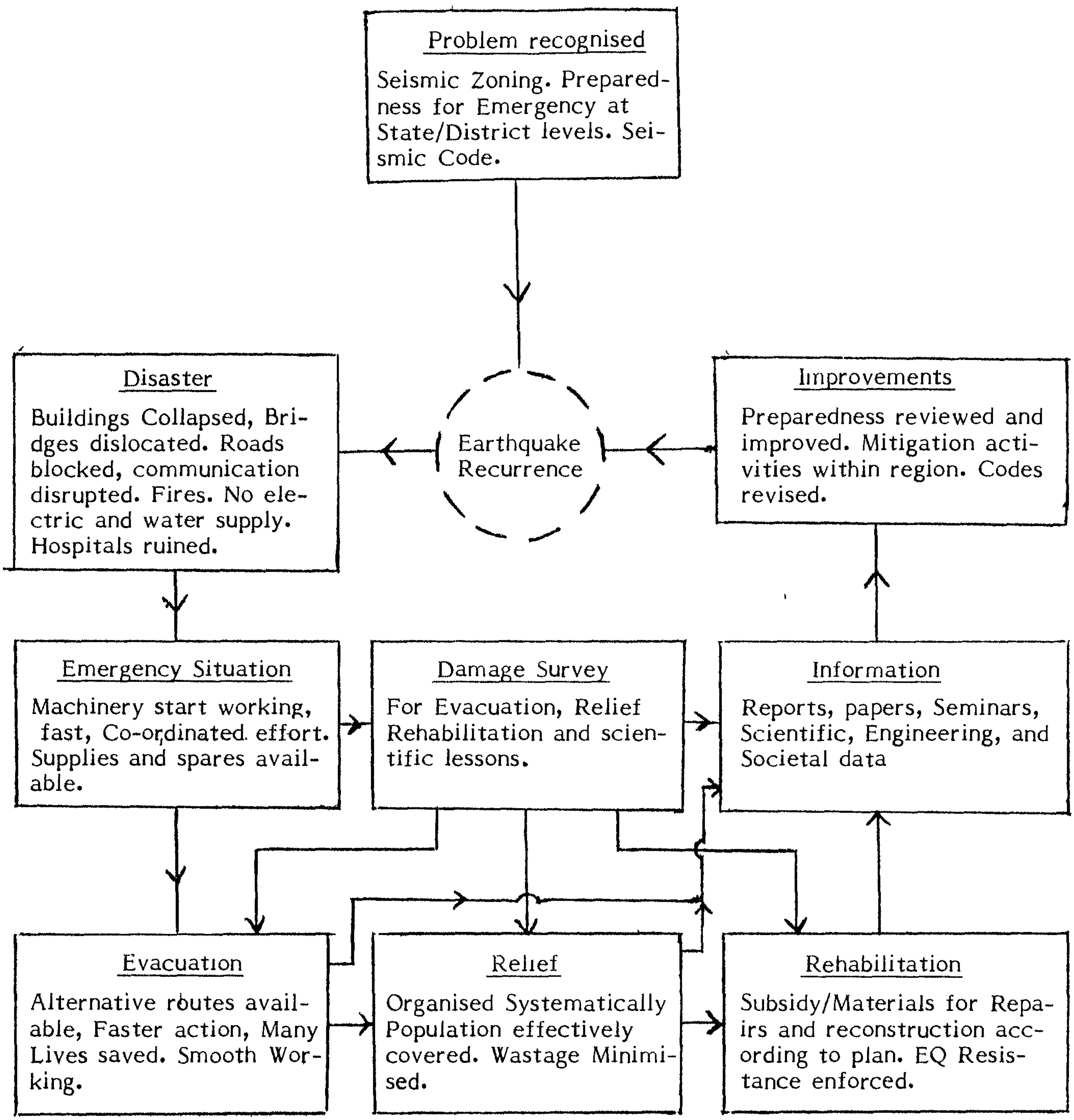

Fig. 2 Improvements where Preparedness for emergency through Contingency Plan Implementation Agency exists. (Better Relief to Population, but are Costly).

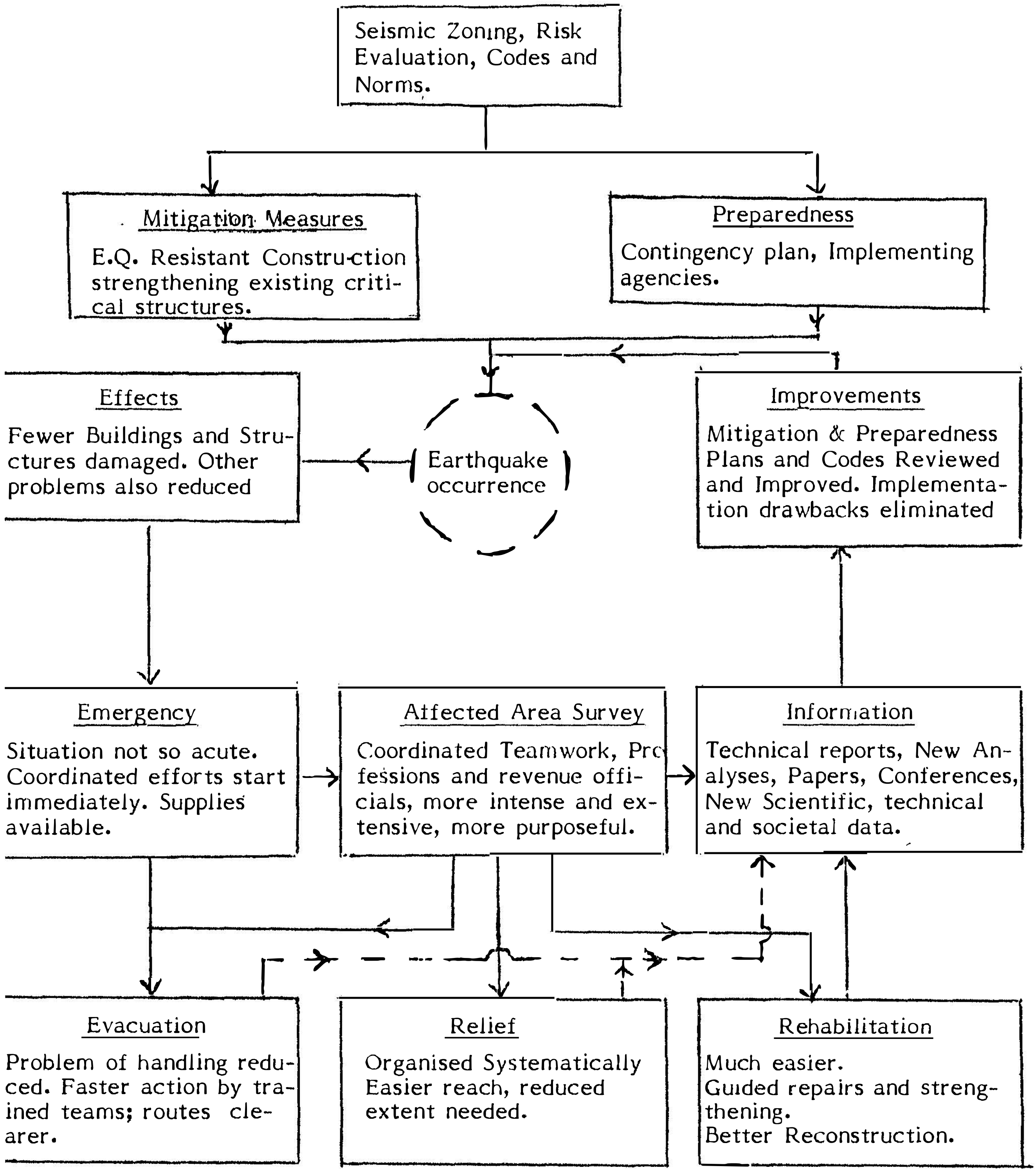

Fig. 3 Mitigation and Preparedness Activities Combined (Reduced Disastrous Impact, Cost Effective).