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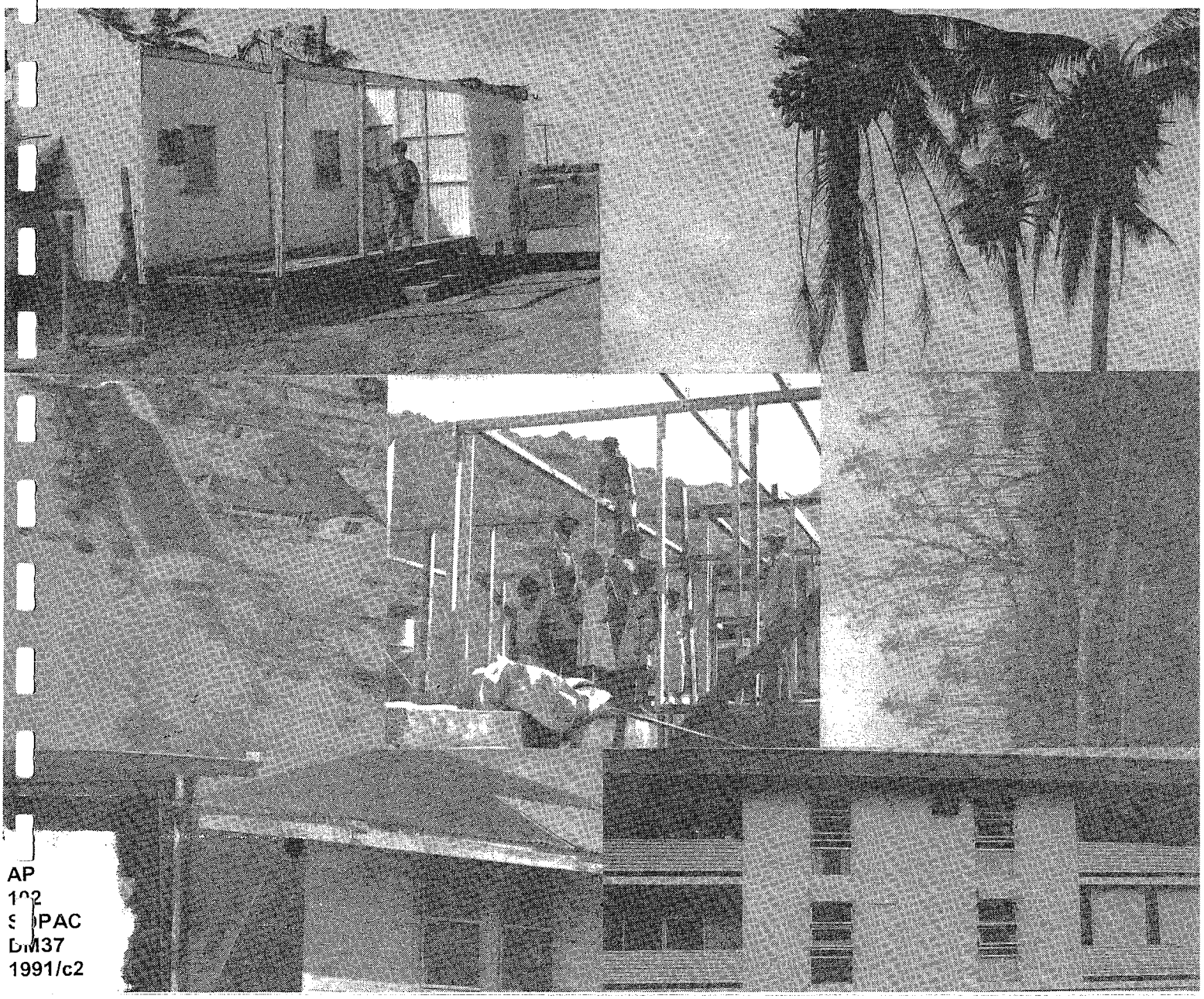
South Pacific Programme Office

Mission Report

Disaster Management and Mitigation Possibilities and Insurance Aspects



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Office of the United Nations Disaster Relief Co-ordinator (UNDRO)
South Pacific Programme Office

MISSION REPORT

Disaster Management and Mitigation Possibilities and Insurance Aspects

UNDRO/SPPO
Suva, Fiji, July 1991

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Preface

The significant role that insurance can play in disaster management is of considerable interest to governments of Pacific island countries as well as to the private sector. The threat of disaster, either natural or man-made, is of constant concern and recent disasters have incurred huge costs. In 1983 and 1985, for example, cyclones devastated the urban centres of Fiji's Western Division, and this prompted insurance companies and brokers to insist upon conformity to new building standards to be a prerequiste for insurance cover. In Fiji, this use of insurance as an incentive for property owners and investors to secure their investments has already proven to be an important strategy in mitigating against cyclone damage. Insuring against losses can also act as a means of managing risks by spreading their costs.

This detailed study of ways in which insurance could be involved to mitigate the impact of natural disasters is the result of a request made by the Fiji Government to the Office of the United Nations Disaster Relief Co-ordinator (UNDRO), during its 1990 mission to assess disaster mitigation needs in Pacific island countries.

The study was conducted by Dr Herbert Tiedemann, Engineering Consultant to the Swiss Re Group, and a leading authority on the subject. Dr. Tiedemann worked extensively in Asia on mechanical, electrical and civil engineering projects before joining the insurance community. He has developed analytic risk assessment and optimization methods in the field of engineering insurance, hydrology, climatology, seismology and volcanism. Dr Tiedemann is a member of the Seismological Society of America and of the Earthquake Engineering Research Institute, has been nominated as a representative of the Swiss Government to the Ad Hoc Committee of Experts on Earthquake Research at the Council of Europe, and is a former member of the European Seismological Commission. He also has published a substantial number of papers and special publications in related fields of science. He currently assists the UN and various governments as a senior adviser and as a leader of international teams of experts.

UNDRO South Pacific Programme Office wishes to thank the Fiji Government for facilitating this study and acknowledges the assistance provided by the Department of Rural Development, the Underwriters Association of Fiji, Fiji Master Builders Association, the Commissioner of Insurance, the Ministry of Infrastructure and Public Utilities, the Department of Mineral Resources, the Fiji Sugar Corporation, the Housing Authority, the Ministry of Tourism, Forum Secretariat and those individuals and organisations which assisted Dr Tiedemann during his visit.

DR. HERBERT TIEDEMANN

ENGINEERING CONSULTANT
TO THE SWISS RE GROUP

Report on Mission to Fiji, 18th March to 3rd April, 1991: Disaster Management and Mitigation Possibilities and Insurance Aspects

INTRODUCTION

The purpose of this report is to present a concise holistic discussion of disaster management, mitigation and insurance issues. The reason for such an integrating approach is that the many problems cannot be solved by attending to the different problems in isolation, like disaster management or insurance. Moreover, a segmented treatment is liable to produce an incomplete picture leaving many gaps. The consultant has proposed a project to UNDRO on April 14 and explanations hereto on 30th June 1991 describing how the many problems resulting from the present exposure to natural disasters and the respective general situation can be solved in an economic way in order to achieve short-term, medium-term, and long-term benefits.

This report deals with the most important exposures, viz. windstorm, flood, earthquakes, and tsunami. It will illustrate the potential impact of the various hazards referring to the main groups of elements at risks. Direct and indirect consequences will be considered.

In a special chapter we will analyse whether and in which way insurance can be involved to mitigate the impact of natural disasters, allowing for local and international market conditions, insurance models, funds required, reinsurance, and which prerequisites must be met to achieve economical insurance solutions.

A glossary has been added at the end which describes important technical terms used in the report.

GENERAL ASPECTS

The discussion with the many parties, departments and sections showed that so far no comprehensive study has been prepared which allows for all natural disasters and their potential effect on the various sectors of industry, commerce, and society. In particular, hazards like earthquake which can deal a devastating blow to the economy have not received adequate attention.

Quantifying probabilistic studies are, however, much needed because disaster management, mitigation, and insurance can only be applied successfully and economically if such data is used. This report will try to bring out the main issues, more details have been included in the proposal mentioned earlier. Moreover, the references quoted in this report contain very detailed information on several issues.

The following is an overview of the available information and data and of the principal requirements:

- In the field of disasters due to windstorm (cyclone, hurricane) past observations have been collected by the Meteorological Office. More research is, however, needed to establish the probability of specific wind velocities as precisely as possible.These windforce probability distributions must be correlated with the vulnerability functions of the various elements at risk.

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- In addition to flood studies concentrating on few specific regions, general probability studies are required which show the correlation of depth of rainfall to probability to aid in developing various hydrographs and exposure scenarios which allow for the vulnerability of the different elements at risk. For the urbanized zones risk maps should be developed in view of the high concentration of values. Such maps should form the basis of future developments.

- Earthquake maps have been prepared by the Department of Mineral Resources. What is required is information on the probability of certain intensities and magnitudes in the different parts of Fiji and research into the question of potential seismic gaps. Moreover, these data must be correlated with the respective vulnerability functions, and disaster scenarios must be developed. For the most densely populated areas microzoning should be developed.

- In the field of insurance detailed studies must be made which correlate the results of the research described above (mainly event probability and vulnerability) with the spatial distribution of elements at risk which are and which may be insured in order to arrive at a proper rating and to assess the exposure of the insurance industry. Moreover, it is necessary to study in detail general and specific conditions which are to be met and which covers and funds are needed in connection with disasters of different magnitudes.

- To enable the assessment of exposure as precisely as possible, and in view of the catastrophic magnitude potential a high degree of certainty is desireable, stocktaking is required which produces a picture of the geographical distribution of the different important elements at risk, their value and vulnerability. If the results of this study is combined with the respective probabilities of the different perils disaster scenarios can be calculated which form the basis of efficient disaster management.

Without such more detailed studies, that is, if deliberations are based on the general data as available today, the uncertainties are very substantial and disaster management is bound to be incomplete. This implicitly means that efficient and economic risk mitigation, management, and insurance is not yet possible at this stage, at least for some of the hazards considered here. It is obvious that large safety factors are required if the uncertainty is considerable and this intrinsically means adding to the cost in an unnecessary way. Reliable and efficient cost-benefit considerations are only possible if the probability and impact of disasters is as accurately known as is possible at the present state of the art.

WINDSTORM RISK ASSESSMENT AND MITIGATION

The consultant prefers not to use expressions like gale, cyclone, or hurricane in a qualifying manner in this report. These words carry a specific and different meaning in various countries, and using such words to describe events of different wind velocities only adds to the confusion. Moreover, what counts as regards risk are the forces exerted by winds of certain velocities.

The data available at present to indicate annual probabilities or return periods for certain wind velocities are inadequate for precise risk assessment. For the time being it will be necessary to draw on experience collected in other comparable regions of the world in order to render probability estimates possible. Due to the paucity of measurements in the past one must try to augment the situation by installing a suitable grid of recording stations. It must be stressed that the cost of adequate recording and research is a small fraction of the disaster potential. On the other hand, properly guided and utilized research can reduce the cost of natural perils very much.

The windstorm probabilities and velocity distributions used by the consultant hereunder should be taken as examples only. The actual figures may be quite different from the values used. Moreover, we add at this place that trends in the climatology must also be considered as they can change future exposure in a dramatic way not only because of increased wind speeds but due to increased frequency which also adds to the risk of multiple occurrences. As the useful lifetime of most elements at risk (e. g. ordinary buildings, hotels, factories, but also forests) amounts to several decades this issue is important.

Fiji has been ravaged by tropical storms repeatedly during the past years and this has increased the risk awareness in this field. The consultant could not collect more than general data on the losses caused by the different events and therefore the following illustration is only of an indicative nature in particular as probability aspects of specific wind velocities are still an open question.

We estimate that an insured windstorm damage of $ 10,000,000 has a return period (R) of approximately 5 years and that ten times as much damage, viz. $100 million can occur once every 25 years. As these figures only represent insured losses the total loss would be substantially larger. This is also supported by Information Sheet No. 84 of the Fiji Meteorological Service which states that two to four cyclones per decade cause severe damage in Fiji.

We can correlate these estimates with Fig. 1 which represents a region on the southern hemisphere with similar cyclone conditions. The R = 5 years - event would correspond to a sustained wind velocity of approximately 100 km/hour or slightly more because return periods apear to be shorter for Fiji, or 210 km/h or somewhat more for R = 25 years. This appears to be reasonable.

The consultant has obtained a list of "Fiji Cyclones" starting in 1840. If the number of cyclones is plotted against time (Fig. 2) in a cumulative manner the following general information can be tentatively extracted.

1. Reporting does not appear to be reasonably complete before about 1870.

2. Between 1870 and 1985 approximately 1.2 cyclones have been observed per year (R = 0.83 yr). As the definition of a cyclone requires a wind speed of at least 33 knots (abt. 60 km/h) a correlation with Fig. 1 indicates that return periods in the region of Fiji may be somewhat shorter than shown in Fig. 1.

3. The graph can be approximated by a tangent representing the average frequency of occurrence. After 1960 the observations (which are probably more complete during this time than earlier) appear to drop off somewhat. This could indicate a trend but it appears to be too early for such conclusions.

4. Between 1875 and 1985 there were seven years with four cyclones or more per years, i. e. approximately once every 15 - 16 years. This alone points at the grave risk of multiple disasters during one year. Moreover, a careful analysis of Fig. 2 shows an effect of clustering, i. e. an abnormally high number of cyclones within a sequence of, for instance, three years. 7 - 9 cyclones or more have occurred, for instance, six times during 3 consecutive years, i. e. on the average once every 18 years. This shows that the recovery of society and economy can be affected quite seriously if several severe hurricanes devastate sensitive regions.

It should be noted that these are preliminary results. A more detailed analysis is, however, warranted once more research into this field has been done.

As a further cross-check we may calculate what damage of $ 100 million means if we convert it to a per capita basis. Assuming a population of about 200,000 people in the area affected by the windstorm a per capita loss of $ 500 is derived. According to experience collected in comparable regions such a loss must be considered a lower limit for a strong hurricane, because losses which are three to four times higher have been recorded. For an extremely strong hurricane - a so-called PML-event (possible maximum loss) - substantially higher losses are to be expected. We add at this place that all direct and indirect effects of a windstorm must be taken into consideration, viz. wind damage, salt spray, storm surge, wave damage, indirect damage as a consequence hereof including business interuption, loss of clients and of markets, etc.

As regards indirect losses we will give only one example which has been selected because of its importance and relatively easy risk optimization. Tourism earns about $ 300 million per year which represents 20% of the foreign exchange earnings. The indirect losses (loss of profit) from a one year

interruption of approximately one third of the tourist facilities - which is not a high figure in case of a very strong windstorm - would cost the country about $ 100 million. Tourist facilities can be retrofitted to withstand much higher wind forces than now, reducing the probability of considerable damage very much.

It is mentioned in passing that the largest foreign exchange earner, the sugar industry, is also very exposed because cane is very vulnerable the way it is planted today. The consultant is of the opinion that this exposure can be reduced significantly. Sugar accounts to 60% to 70% of Fiji's export earnings. Therefore any substantial reduction of the loss potential will protect the foreign exchange earning capacity of the country. As a detailed treatment of the methods which may be exploited to reduce this hazard is beyond the scope of this report, it is suggested to include it in the detailed programme which was proposed by the consultant. The same holds mutatis mutandis for pine forestry.

Reverting to the general exposure to windforces, i. e. to all elements at risk, the following details should be considered:

- The exposure related to the different regions.
- Topographic effects.
- Roughness of landscape and its effect on exposure.
- The general damage parameters for each category of elements at risk.
- The present proposals for building codes should be carefully checked and revised to achieve the minimization of vulnerability more economically.

This list is not complete but contains only some of the most important parameters. For instance, it is also recommended to streamline disaster mitigation taking detailed account of:

- Damage parameters related to buildings [shape, height, quality (material, workmanship, implementation), design (code requirements, but considering relative vulnerabilities and importance), elements of buildings (foundation, support, floors, walls, roof structure, roof cladding), external parameters (trees), other vulnerable items, rockfall, and slides]. The presently proposed codes are certainly a very valuable step in the proper direction. A perusal by the consultant, however, showed that they should be better adapted to local conditions to render risk optimization less costly.
- Damage parameters of other elements at risk [utilities, life-lines, communication, transport facilities (road & rail, water, aviation), agriculture (sugar cane, forestry)]. These issues received very little or no attention so far.

FLOOD AND INUNDATION RISK ASSESSMENT AND MITIGATION

To be able to assess the exposure more correctly data must be compiled giving information on event probability aspects. These are, for instance, records covering the full spectrum of precipitations from "normal" rains to record rainfalls.

Moreover, information on infiltration, run-off, hydrographs, topography, and capacity of storm sewers are needed (1). Risk maps and zoning maps controlling development must be developed (2).

Attention must be paid to vulnerability aspects, in particular in densely settled or urbanized regions. The mean damage ratio (MDR) of dwellings exposed to flooding can be 25% of their value and it can reach and even exceed 75% as regards damage to contents and merchandize. It must be kept in mind that the MDR of flood losses is in general much higher than windstorm damage (1, 3). This risk is presently underestimated.

A short list of elements at risk which are generally exposed is given hereunder and in each case the damage parameters must be considered carefully.

- Roads (embankment, culverts, shoulder protection, overtopping, slides).
- Bridges (return period used in design, scouring, endangered elements, debris).
- Agriculture (siltation, scouring).
- Buildings & factories (return periods, scouring, wasting away, water damage to buildings and content, siltation).

In particular the exposure related to the last group of elements at risk has increased much for a number of reasons and the total loss can assume gigantic proportions.

CLIMATOLOGY, METEROROLOGY, AND HYDROLOGY: TRENDS

In connection with the perils discussed so far trend parameters and exposure resulting herefrom [rain, flood, windstorm, drought (crop failure, fire risk to pine plantations, etc.)] must be considered as such trends can shift (aggravate) the event probability distribution in a significant manner. These trends may also influence the probability of multiple events and specific exposure herefrom. Recurring events like "El Niño" (Southern Oscillation) can in addition to long-term trends pose additional problems. Here one must not only study its influence on rains, floods, and windstorm, but on drought which may not only be a direct menace but enhance the fire risk, e. g. in pine forests.

Moreover, trends in general parameters which influence the exposure (demographic, economical, and vulnerabilty) must be allowed for. The last aspect is more important than is generally recognized.

EARTHQUAKE RISK ASSESSMENT AND MITIGATION

A number of good reports on the general seismicity of the region have been prepared. For the purpose of disaster management, disaster mitigation, and insurance, probabilistic information is, however, required.

The following brief discussion on the earthquake probability in the region is based on the SIM-method and the corresponding risk maps developed by the consultant (4-6). According to this method it can be estimated that for places in Fiji the return period of an intensity equal to MM VIII or greater is approximately 600 years if no corrections for seismic gaps or trendy are applied and only 150 years for MM VII.

It is stressed that a substantial number of modern buildings seen by the consultant in Suva, for instance, are very vulnerable because of their asymmetry and/or a soft ground floor or their support by short columns, or due to window bands (cf. Figs. 3-6).

Normal buildings of the general strength seen in Suva but not showing the negative parameters mentioned above generally sustain a mean damage rate (MDR) of about 25% to 30% of their new replacement value if exposed to MM VIII (Fig. 7). Considering direct and indirect damage and losses one should be prepared for a per capita loss of about $ 10,000 or more (cf. e. g (5). This level was observed after the Newcastle, NSW, earthquake of December 1989 although its magnitude was only M 5.5 and the epicentre not near to the town. This signifies that a large shallow earthquake under Suva can cause a much more severe loss.

Correlating $ 10,000 per inhabitant with the population of Suva it is seen than a total loss in excess of $ 1,000 million can be caused by a strong earthquake. In fact, because of the smallness of Viti Levu and because of the probability of quite large events with a shallow hypocentre, a much larger number of people can be affected and the total loss can therefore be even higher (cf. 5, 6).

It should be noted that there is the possibility of a seismic gap in the region of Viti Levu and it is therefore possible that the present probability of a devastating earthquake is much higher than indicated by the average return periods indicated above.

Also in the case of the proposed earthquake building code modifications are recommended which would permit achieving a good degree of safety more economically than by following the present proposal. In particular the important damage parameters must be allowed for and not only base shear (cf. 5).

It is beyond the scope of this report to discuss vulnerability aspects related to the different elements at risk and allowing for direct and indirect damage and losses. This must be left to a detailed report and programme as mentioned at the beginning. Moreover, the consultant presented information in his paper presented for the conference in Suva (7).

TSUNAMI RISK ASSESSMENT AND MITIGATION

In view of the exposure along some coasts of Viti Levu, in particular where the concentration of values and of human settlements is high, a detailed study is recommended. The consultat has included some useful information in his paper prepared for the conference in Suva (7). Detailed information is to be found in (6). It is mentioned in passing that the bathymetry off the southern coast of Viti Levu is such that the risk should be studied carefully. Other coastlines appear to be better protected by shallow water offshore or islands, but this should be studied more closely.

The Mineral Resources Department mentions in Report 62 that eleven tsunamis in Fiji are listed. The three largest had an amplitude of two metres. One of them was caused by a major earthquake in 1877 in the region of Chile. The latter tsunami fortunately occurred at low tide but still three times the waves reached far above the high water mark. It is important to note that general tsunami observation in Fiji since 1911 and for tsunamis generated by earthquakes near the coast of South America since much earlier are bound to be incomplete. This is due to global seismic trends (cf. 5 & 6). Since 1911 and for the region of Peru and Chile since much earlier, the number of great earthquakes (of M 8 and above) has been abnormally low, leading to the development of substantial seismic gaps. If this trend is reversed one day some of the great earthquakes expected along the western coast of South and Central America may cause destructive tsunamis in Fiji.

INSURANCE OF NATURAL PERILS

The purpose and the general principle of insurance is risk-spreading. Put simply, this may either be achieved in such a way that premium income and losses paid in a large region are balanced to such an extent that the surplus from several regions is adequate to compensate a severe loss at one particular place. It may also operate in such a way that in a region which is not large enough to spread premium income and exposure sufficiently, spreading or balancing of income and losses over a number of years may be attempted. In the latter case a severe loss in one year is recovered from the profits during profitable years.

It becomes evident that if such prerequisites are not met no balanced portfolio can be developed. Such a situation will sooner or later lead to considerable difficulties or even to a collapse of the system. Moreover, it is extremely important to realize that even a balanced system where losses are met by adequate premium income may not represent an economic solution for a society. Losses after all still remain losses even if they are paid for by insurance. One only shifts the losses from the society in general to a segment of it. Therefore losses amount to wasted investments. Moreover, much money must be accumulated to pay for them. This money is not available for other projects and/or developments.

Therefore also here a detailed cost-benefit analysis must be employed to show to which level elements at risk must be improved to reduce the drain of capital and wasting of national resources and to make insurance economically feasible. We will revert to these general problems in a more specific manner after discussing insurance models.

Models of Insurance:

The most common approach is an open and unrestrained insurance market. In this case insurance companies are only bound in the most general way, e. g. by an insurance act but are free to offer insurance or to refuse certain covers. The main advantages of this model is that is offers maximum flexibility, because many insurers are competing in a market. This is in general - but not always - an advantage for the insureds. If risks are, however, insured for inadequate premiums substantial premium adjustments become necessary after large losses which are the rule in connection with natural disasters. It may even happen that insurers cease to write such business or withdraw from a market or country with the result that insurance may be difficult to obtain or no insurance at all may be available after very severe losses. In fields where large losses are the rule and where expertise as regards scientifically founded rating and underwriting is in short supply, this possibility should not be discounted, in particular if local insurers are influenced by results in other markets. In the latter case severe losses in one country may influence the insurance conditions in a different one.

The opposite of a free insurance market described above is compulsory insurance. In this case strict control forces all proprietors of certain elements at risk to take out insurance.This does, however, not signify that any type of risk is or can be insured. Although there appear to be a number of advantages, like no aquisition cost, low administrative expenses because of large portfolios and therefore relative cheap insurance rates, this system harbours a number of disadvantages.

In general people resent being forced to insure. Moreover, such a system incorporates the tendency to equalize insurance rates with the result that the "good risks" persistently pay for the "bad ones". This does not only increase frictions between all parties involved but it demotivates people to optimize their risks. If everybody pays about the same rate why should one bother and spend money to build better? The outcome of this is detrimental to the interest of the country. Moreover, such systems tend to be sluggish.

Government insurance schemes are operated in several countries to cover natural perils. This third alternative is a variant of the second one. Its prominent general disadvantages is the lack of differentiation in the approach, its slow adaption to changing requirements, and often the failure to induce the insureds to reduce the risk on their own. This is a drawback for any economy. Moreover, it should not be overlooked that providing and managing insurance and to settle the large number of losses after a disaster requires many well-trained people - and most of them only rarely. The result is a costly administration.

Combined systems have been discussed in several countries the main reason being that insurers may not have adequate funds to cover a large disaster. It should be mentioned at this place that the accumulation of sufficient funds is often prevented by taxation. Governments do not appreciate that the annual premiums collected in the fields of insurance covering natural perils are not profits but are needed to build funds for the rare catastrophic event.

The problem is particularly severe in a setting where a catastrophic disaster may cost as much as the GNP of the country and this is unfortunately true for Fiji. In such a case it becomes evident that insurance can only play a secondary role. This is best illustrated by considering the issue with the help of modern rating, the funds available and the solvency. In order not to complicate matters too much we will only discuss the rating of a single event. It must suffice here to state that to cover several events during the useful life of an elements at risk two to three times the premium must be collected (for details cf. (6)).

The risk rate (X) in permille (%o) can be calculated for a single event using the following formula.

$$X = \frac{LE \times f \times u \times P \times 1{,}000}{R \times V}$$

That is, the risk rate X in %o (per mille) **for a single event** is the product of the Loss Expected (LE) times the overhead factor (f), times the uncertainty (u) which can be considered a safety factor, times the period of exposure (P = years), and divided by the return period (R in years) and the value at risk (V) which should be the new replacement value.

To perform such a calculation one must be able to establish the damage probability distribution, i. e. the correlation between the various damage levels and their respective probability and the corresponding return periods. This shows that more is needed than the vulnerability function. Moreover, the event probability distribution must be known, i. e. the correlation between event magnitudes (wind velocities, floods, earthquakes, etc.) and the respective return periods. In addition the uncertainties in these assessments must be established because it would amount to an error of catastrophic magnitude not to allow for proper safety factors when assessing disaster potentials.

We shall calculate one example each for windstorm, flood and earthquake to illustrate the use of the formula. The parameters and figures employed must be seen in the light of what has been said in the earlier sections.

1. Windstorm example

We assume that an ordinary house is to be rated for a very strong windforce which has a return period of approximately 50 years. According to Fig. 1 this would be a wind speed of about 280 km/h. Moreover, it is assumed that the house has no particular weakness and that therefore only some significant damage to the roof, to some windows and appurtenances must be expected. Finally, we assume that the water damage from rain associated with the hurricane is not severe. In such a case the LE will be about 15 % and R is 50. For a discussion of "f" & "u" cf. (3 & 6). Therefore

$$X = \frac{15 \times 1.5 \times 2 \times 1 \times 1{,}000}{100 \times 50} = 9 \text{ \%o, i. e. } 0.9\%$$

2. Flood example

We assume that a shop selling sensitive equipment is located in a region of Suva or Nadi which will be flooded in case of a very severe rain which happens only once in 100 years. The LE of the building and fixed equipment of the shop is assumed to amount to 20%. The risk rate is:

$$X = \frac{20 \times 1.5 \times 2 \times 1 \times 1{,}000}{100 \times 100} = 6 \text{ \%o, i. e. } 0.6\%$$

The rate for the sensitive equipment suffering a total loss (LE = 100%) would be identical (i. e. 6 %o) if only one fifth of it would be in within reach of the water. If the depth of water should however be one to one and a half metre the rate required could be in excess of one percent in spite of the long return period of 100 years.

3. Earthquake example

We assume that the modern building to be rated is only moderately asymmetrical and founded on medium-hard alluvium. In this case the LE would be about 30 % (cf. Fig. 7). The return period for MM VIII is (without any correction for gaps and trends) approximately 600 years. Therefore

$$X = \frac{30 \times 1.5 \times 2 \times 1 \times 1{,}000}{100 \times 600} = 1.5‰, \text{ i. e. } 0.15\%$$

The total risk rate for each individual case would have to consider smaller, albeit more probable damage from events of a smaller magnitude plus the rate required for even more catastrophic events having longer return periods. Moreover, the rates from all perils covered by the insurance policy must be added.

The simple examples show that the rating levels presently applied are in general not compatible with the exposure - even if the above assumptions should be too pessimistic. Therefore no balance will be reached in the long run and insurance of natural disasters is likely to meet colossal problems as soon as an abnormally severe disaster or several smaller ones occur.

This conclusion is also reached when approaching the problem in a different way, viz. extrapolating from past experience.

In 1985 Fiji was first affected by Eric, the first of two tropical cyclones which occurred within 48 hours, the second one was called Nigel. Two more cyclones, viz. Gavin and Hina, occurred within the total space of two months. The total damage caused by these cyclones has been estimated at $ 80 - 90 million of which about $ 66 million was the cost to the Insurance Industry.

The Net Loss Ratios to insurance in that year in those branches which included some element of windstorm cover were approximately:

All Risks	265 %
Contractors All Risks	102 %
Fire	904 %
Houseowners	224 %

If we consider the overall underwriting gains and losses in General Insurance as such, i. e. all general branches which normally tend to balance large losses due to perils of nature to some extent, we find that in the six years from 1981 to 1986 four years produced a gain of $ 3,250,356. The loss in 1985 was, however, twice as much, viz. $ 6,569,878. If the underwriting loss in 1983 is added the picture becomes even more bleak.

It must be stressed that of the approximately $ 66 million 50 million dollars were paid by overseas reinsurers, which shows the considerable reliance of the insurance market of Fiji on external support in case of natural disasters. This, however, underlines as well the considerable dependence on the goodwill of such parties. This external support should not be taken for granted and the reasons may not only be bad results in a market like Fiji but bad results in other markets, i. e. an accumulation of problems.

The total fire premium (the branch where most of windstorm, flood, and earthquake insurances are written) of insurers in Fiji amounts to approximately $ 10 Million. This indicates that the total gross income of six and a half years - i. e. without any losses or administrative expenses - are needed to compensate a year like 1985.

It must be stressed that 1985 was far from a Possible Maximum Loss (PML) scenario, which shows that insurance would have great difficulties to cope with such an event. The maximum sustained winds of Eric (which caused about $ 40 million damage) was 120 knots (abt. 220 km/h). This is well

below the maximum velocity in tropical cyclones. The force of the wind, however, grows with the square of the velocity. Hina, the fourth event in that season, was potentially one of the worst hurricanes with 10-minute average winds of 120 knots but gusts of 160 knots (abt. 292 km/h). Hina, however, fortunately changed its course so that the most destructive winds passed over the open sea to the west of Viti Levu and Kadavu. It has been pointed out that a large earthquake can produce losses approaching the GNP. Therefore, even if the level of rates were raised dramatically and even if taxation was changed to permit insurers to accumulate funds more liberally they would be far from sufficient to meet such calamities.

Considering now the solvency of General Insurers (i. e. excluding Life Assurance) we find that the total market or real assets in Fiji were approximately $ 25 million, less than half of the total cost of the windstorm damage in 1985, a small fraction of a PML-event of this sort, and a very small fraction of the damage which may be caused by a PML-earthquake. The consolidated balance sheet shows assets of $ 27,539,985. This leaves no doubt that in the field of natural disasters insurance cannot be the salvation, at least at present with the loss potential overwhelmingly larger than all assets. It is noted here that assets may be badly affected by windstorms and floods and in particular by a very destructive earthquake.

All this shows that the only safe and economic way to "manage" disasters, more correctly to reduce their impact, is to pay far more attention than hitherto to risk optimization, that is to reduce the loss potential. The proposal made by the consultant to UNDRO on 14th April, 1991 has been drawn up on these lines in order to reduce the exposure in the most economic manner possible. It also aims at transferring at the same time as much expertise as possible to those participating in the project.

The earlier discussion does not signify that there is no place for insurance in handling disasters. Quite to the contrary well trained inspectors of insurerance companies can provide much assistance in implementing safer concepts of design and construction and help assuring that the execution follows the intentions of the design. To achieve this also modern assessment and rating tools must be introduced. At any rate, in order to make insurance one of the important and reliable pillars of disaster management the level of exposure must be reduced to such an extent that attractive insurance rates result. Once this has been achieved local and foreign insurers and reinsurers will feel confident to risk considerable sums for rare to very rare events, i. e. for the residual risk.

Applying rates which are commensurate with the exposure is an important tool to motivate people to reduce exposure thereby protecting the wealth of the country. Moreover, well trained insurers can assist engineers, contractors, builders, and owners in arriving at economic solutions. We shall illustrate this with a very simple example.

Doubling the strength, i. e. halving the vulnerability of a normal building, for instance, does in general not require an additional investment of more than about 3% to 4% of the value of the building. This additional resistance will, however, protect the building against a windstorm and earthquake the return period of which is at least twice as long as that of the storm and earthquake which endanger the building which has not been strengthened. Quite frequently very considerable improvements can be achieved at no or very little extra cost (1% of the value of the element at risk), for instance by avoiding certain dangerous designs or manufacturing methods (cf. e. g. 5).

CONCLUSIONS

It has been shown that successful and economic disaster management in the widest sense must be supported by several pillars. These pillars are the development and use of event probability functions, of vulnerability functions, and the employment of all engineering and economical skills to reduce the exposure, i. e. the loss level caused by natural disasters. Such measures which should be based on detailed, skilled cost-benefit analysis will protect national economy in the most efficient manner. If properly motivated and trained, the insurance industry can assist in achieving this aim and in covering the residual risks which still remain in spite of all risk optimization, and at economic rate levels.

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GLOSSARY

Note: This is not intended as a detailed scientific/technical glossary but as a short explanation of terms used in the report.

annual probability = The probability of the occurrecnce of the event, etc. within one year. A 1% annual probability of a windstorm, for instance, signifies that this storm will occur on the average once in 100 years.

base shear = The strength of a building against a horizontal force acting at its centre. It is generally expressed as percent of gravity (% g). A building designed, e.g. for 3%g is supposed to sustain a horizontal force equal to 3% of its weight.

bathymetry = Information on depth of water, here in the ocean

clustering = The occurrence of events in groups, i. e. in one or within few years, although the individual return periods are very much longer

cost-benefit study = A study which weighs the cost of steps (improvements) against the gain in order to find the most economic solution

damage parameters = Factors or criteria which influence the damage, like weak material, bad workmanship

disaster scenario = Assuming an event of a certain magnitude and affecting a selected area and calculating the consequences hereof

earthquake intensity = A description of the effects of an earthquake according to one of the many scales, like Modified Mercalli (MM)

earthquake magnitude = The instrumentally determined size of an earthquake, like Richter magnitude (M), surface wave magnitude (M_S), body wave magnitude (m_b), etc.

earthquake maps = The most common maps are those showing epicentres of past events

El Niño = A particular meteorological/oceanographic condition in a particular part of the Pacific Ocean (which can also influence the weather at distant places)

hydrograph = A graphic representation of the time-history of a flood and of flood levels

hypocentre = The focus of an earthquake, i. e. its place below an epicentre

infiltration = The amont of rain water infiltrating into the ground and therefore not available for the generation of floods

insurance portfolio = Generally all the business written by an insurance company in one branch

life-lines = Term used in earthquake engineering for utilities (water, gas, power) but also pipelines, roads, and bridges

loss ratio = Generally the losses expressed as a percentage of the premium income

mean damage ratio = The Mean Damage Ratio (MDR) is the amount of damage expressed as a percentage of the new replacement values of a homogeneous group of elements at risk. For individual elements = Damage Rate (DR)

microzoning = Subdivision of a zone, for instance, a seismic zone, into subzones according to certain parameters permitting a more precise definition and subdivision

multiple disasters = The occurrence of several disasters, which may be of a different nature, within a short span of time (cf. clustering)

possible maximum loss = The maximum loss deemed possible from one event

probabilistic studies = Assessment, for instance, of the occurrence rate or the loss using the tools of statistics or stochastics

probability distribution = A mathematical distribution, e. g. of magnitudes or losses according to their probability

reinsurance = Cession of part of the insurances written by insurers to reinsurers to reduce the exposure of a portfolio = spreading of risk

return period = A different form of indicating event probability, i. e. the average time between similar events

risk maps = Earthquake, flood, or windstorm, etc. zoning maps

risk optimization = Steps taken to reduce the exposure, i. e. to reduce the loss caused by an event of a certain magnitude

roughness of landscape = Factor controlling the wind velocity near to the ground due to the resistance (interference) the roughness offers

run-off = That part of the rainwater which does not infiltrate into the ground. The larger the run-off the higher the flood risk

seismic gap = Region where no earthquakes have occurred although past experience and tectonics tell that they should have happened. As earthquakes are due or even overdue in seismic gaps the risk there is much higher than indicated by the average occurrence rate.

seismic trends = Global seismicity is not random but shows phases of relatively low seismicity which are followed by phases of higher and even much higher activity

seismicity = The seismic activity of a region (earthquake frequency)

shallow earthquakes = Earthquakes occuring in the upper layer of the crust and therefore close to the elements at risk

short columns = Columns of short length supporting houses or at window bands

soft ground floor = A ground floor of a building with no or few stiffening walls leading to high loads on the columns and signifying high to extreme vulnerability

storm surge = Increase of water level due to low air pressure and wind forces piling up the water

topographic effects = Landform interfering with windstorms enhancing or reducing the effect

trend perameters = Factors which have a trend-like influence, e. g. like increasing construction and/or repair cost on the cost of disasters.

tsunami = A train of waves generated by an earthquake under the floor of the sea or near to the coast. These translational waves are extremely damaging.

useful lifetime = The average commercial life of, e. g. a building, say 50 years

utilities = Facilities generating and distributing electric power, water, gas, etc.

vulnerability = The sensitivity of an element at risk to damage, e. g. by windforces

vulnerability function = The mathematical function correlating vulnerability with the intensity or mangnitude of an event

window bands = A line of windows in a wall without wall sections between the windows (due to the absence of stiffening walls a weak zone)

8th July, 1991

Dr. Herbert Tiedemann

Fig. 1. Correlation between wind velocities in tropical storms on the southern hemisphere (km/h) and return periods R in years). On the right side the wind pressure is indicated which grows with the square of the wind speed. The graph must be used quite carefully as probability distributions are affected by a considerable number of uncertainties, last but not least by the inadequate observational sample. Moreover, one has to differentiate between sustained speed, wind velocity during 5 or 10 minutes, or in gusts. Damage may also be influenced by directional properties and vortices.

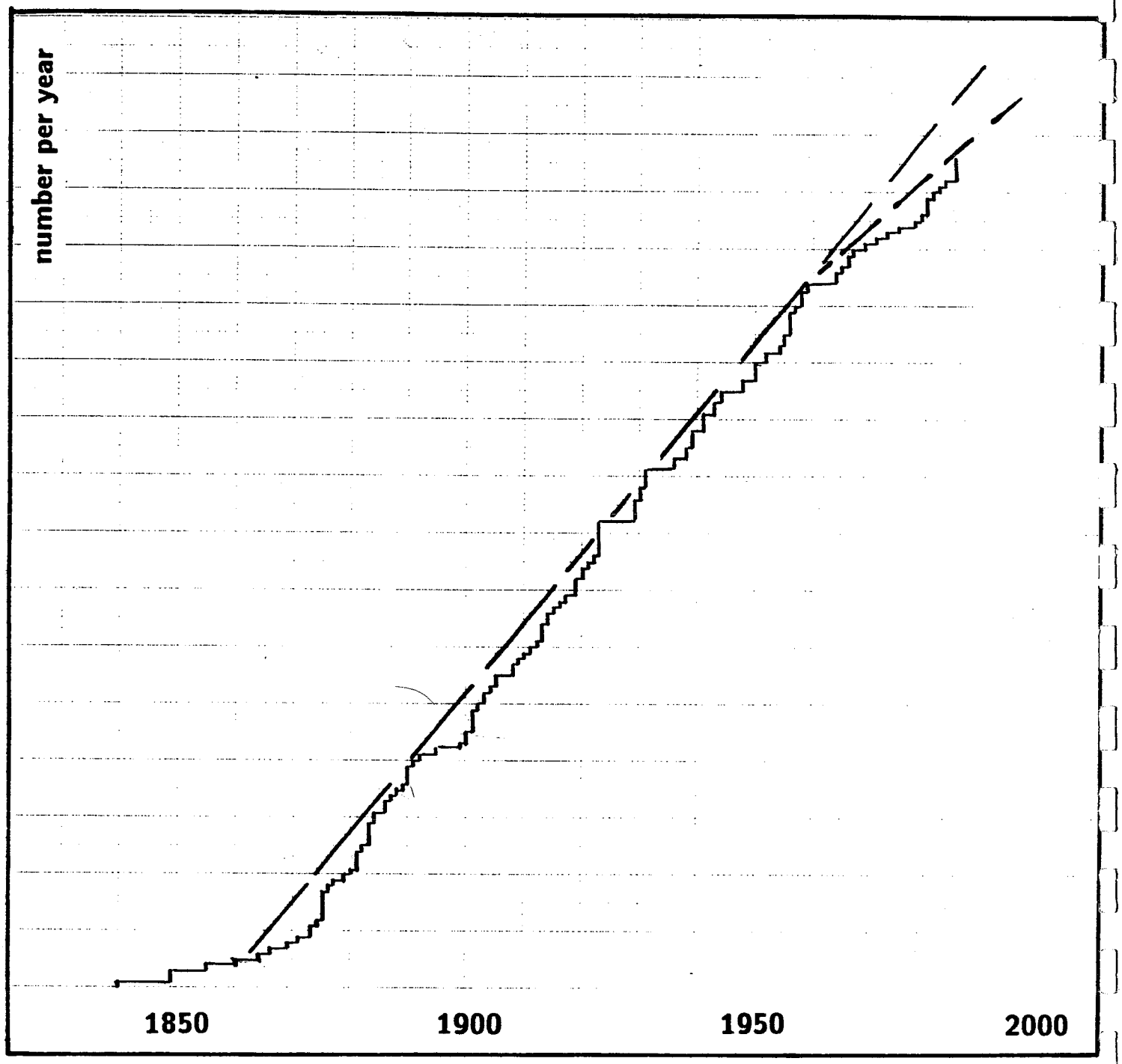


Fig. 2. The "Fiji Cyclones" known since 1840 have been entered per year in a cumulative manner. One notices that the record is incomplete before about 1870. Thereafter the record appears to be approximately consistent as a tangent can be fitted to it. Since 1960, however, the incidence of cyclones appears to have been lower as a less inclined tangent can be fitted to this section. This must, however, be interpreted with great care and it would be very wrong to jump to conclusions. A sequence of "windblown years" like during earlier clusters of cyclone-laden years or even worse can reverse such apparent trends rapidly. At any rate there appear to be sequences of years with above average cyclone activity. It is stressed that this graph only provides the number but not the "magnitude" of cyclones.

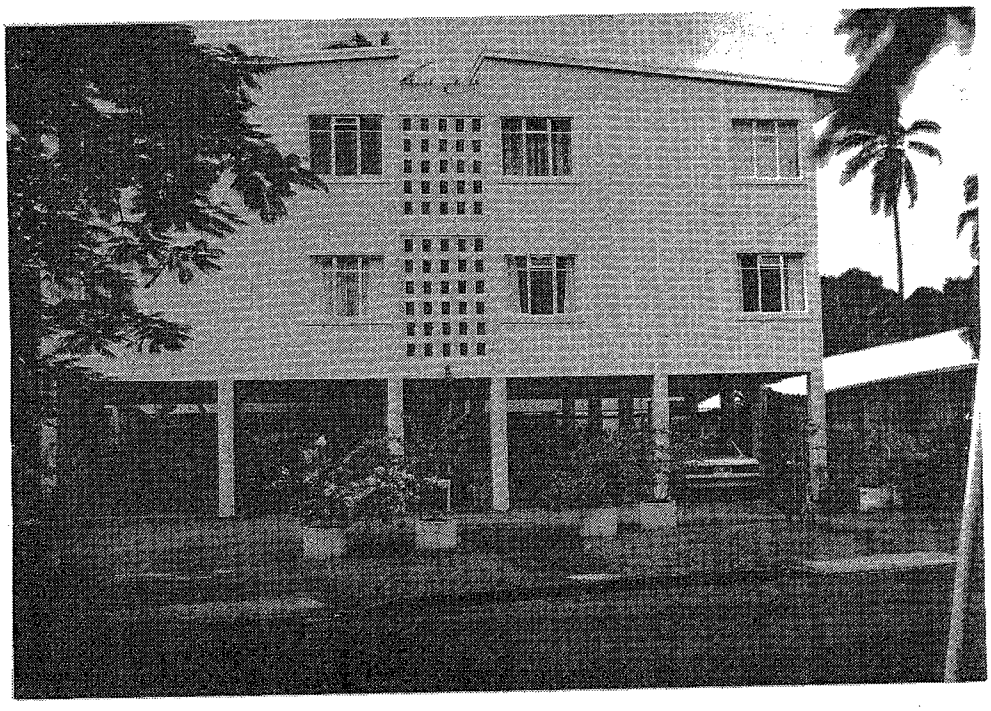


Fig. 3. House in Suva, Fiji, with a soft storey. Such buildings are extremely vulnerable because their base shear is lowest in the region where bending moments are highest. Moreover, as such buildings also have a long period there is a considerable likelihood that they react strongly even to the low-frequency shaking of strong distant earthquakes. Therefore such buildings - which may become death-traps - incorporate a much higher probability of being affected by earthquakes than similar structures with walls in each storey.

Fig. 4. In this building two negative parameters combine. It does not only have a soft ground floor but also asymmetrical stiffness because of a stiffening wall only at its rear. This introduces additional torsional loads.

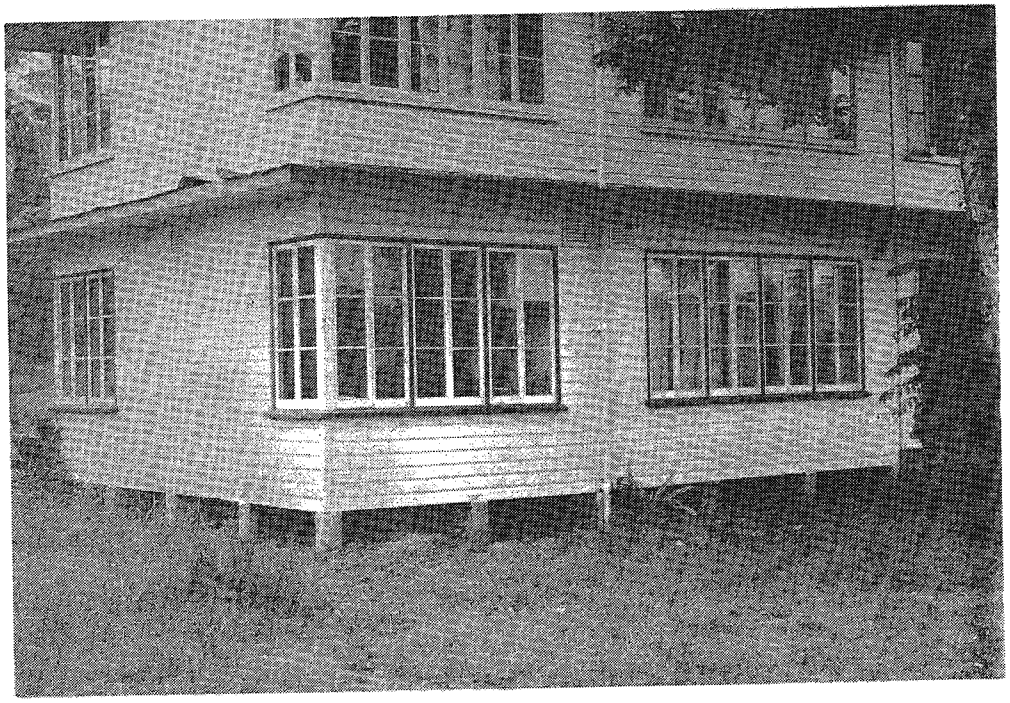


Fig. 5. Short columns are very vulnerable because they tolerate only little deflection without failing. Therefore this wooden building which is as such comparatively earthquake resistant must be considered very vulnerable because of the short columns supporting it. Adding concrete walls between the columns at the corners and in the central sections of the outer wall would reduce the exposure very much and at very little cost.

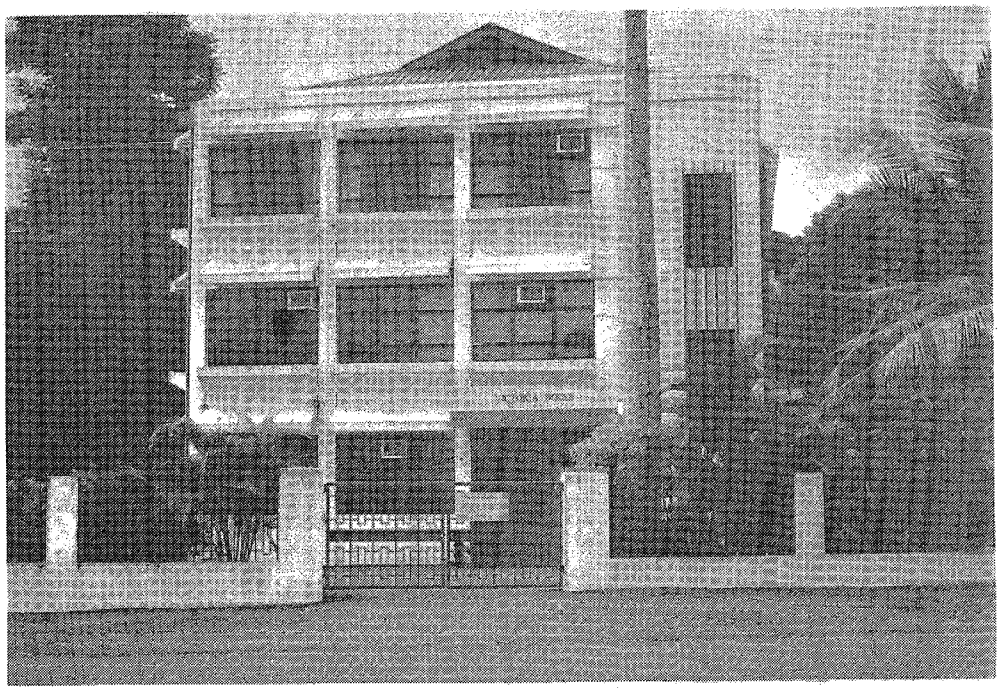
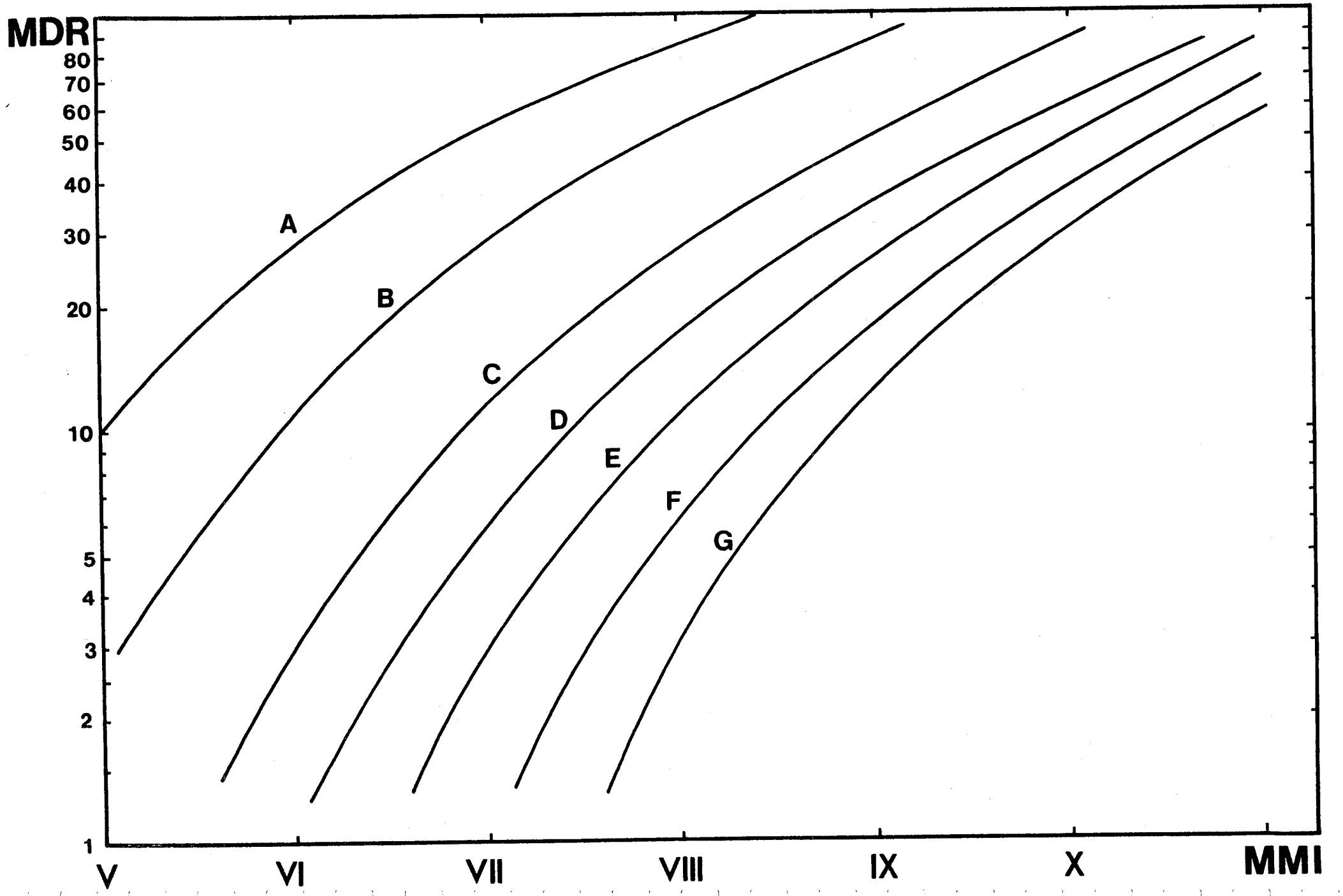


Fig. 6. This building has extensive window-bands in at least one wall. As windows lend no lateral support to the columns such buildings are vulnerable.

Fig. 7 . The graphs show the mean damage ratio (MDR) in percent of the new replacement value depending on the earthquake intensity (MMI) and the building quality. The intensity is given according to the Modified Mercalli scale (MM 31). The MM intensity can be converted to other suitable scales like MSK and JMA using the conversion tables found in the literature. The quality of buildings of reinforced concrete is stated as base shear: C = 2 - 3% g, D = 3 - 4% g, E = 6% g, F = 12% g, and G = 20% g. Graph A represents buildings of adobe and frail rubble masonry, graph B is for unreinforced brick buildings having solid, i. e. not cavity walls. The graphs are valid for medium-hard alluvium, i.e. a bonus must be allowed for harder subsoil and a malus for softer. Liquefaction requires special consideration as discussed in the main text. The graphs are valid for buildings which are only moderately asymmetrical and for different buildings Reference (5 & 6) give additional information. The graphs can also be used, for instance, for improving designs which are exposed to orientational sensitivity and for assessing damage/vulnerability relations of other structures and items (cf. (5). If, for instance, the MDR of an element at risk can be estimated with reasonable precision, e.g. 50%, 10%, or 1% at MM VIII, one of the curves shown in this graph or a new one fitting their general characteristics can be used. This approach is possible because we have learned from the analysis of very large numbers of different elements at risk that the damage or loss distribution is very much determined by the MDR; in other words, irrespective of the kind of the element at risk and the hazard causing loss or damage, one will find that the distributions are comparable if MDR's are similar.


MDR
80
70
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A
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C
D
E
F
G
V
VI
VII
VIII
IX
X
MMI