CHARACTERISTICS OF AVALANCHE ACCIDENTS IN WESTERN HIMALAYAN REGION, INDIA

Ashwagosha Ganju *, Naresh K Thakur, Vijay Rana
Snow & Avalanche Study Establishment

ABSTRACT

Avalanches caused considerable damage initially to the inhabitants of Himalayan belt but lately only a small proportion of the original inhabitants of Himalayan region have suffered due to avalanche menace. The inhabitants, after initial suffering settled their dwellings at safe places through logic as well as trial and error method. The hazard, however, increased with the movement of persons in the inner belts of Himalayan region. The movement this time was not for the settlement but for carrying out the various tasks in the high altitude snow bound regions.
The paper analyses the evolution and progress of avalanche accidents in Western Himalayan region. The cause of some of the major avalanche disasters was found to be unprecedented weather situation that caught people off-guard. The authors opine that with the increasing population and increased activity in the Himalaya belt like winter sports, adventure tourism, refuge in hills etc., the threat is likely to assume greater proportion in near future. While avalanche forecasting models are being refined and fine-tuned and better equipment are being developed for safe travel through avalanche terrain, emphasis in the Western Himalayan region should also be given to awareness and quality education programme. This will help the pedestrians to take adequate precautionary measures while negotiating avalanche slopes.

1. Introduction

Avalanches, a well-known threat in snow bound mountainous terrain, is dreaded for its destructive potential. Thousands of people have lost their lives in avalanches so far. In comparison to the other natural hazards, snow avalanche is a relatively less known, on account of the remoteness of the scene of disaster away in the mountains. Nonetheless, they have rocked the mountains and claimed the toll of lives and property winter after winter. In comparison to earthquakes where destruction can go up to thousands or even up to millions, avalanches are relatively less destructive forces. Tangshan earthquake of 1976 killed quarter of million people (Clifford, 1989). The famous avalanche disaster in Switzerland in 1951 and in Himalaya in Mar 1979 killed only 98 persons and 200 persons respectively. However, as per WMO nearly 5000 people have been killed by avalanches in the world during 1947-1980. The incidents are likely to increase in future is deduced from the fact that more than 60 million visitors spent a night in Alps in winter in 2000 as against 13 million in 1980 (New Scientist 1999). With increasing demand for winter sport, skiing, patrolling the interaction with avalanches is likely to increase manifold.
The necessity of movement (Skiing, patrolling, winter sports etc.) and the poor knowledge of the nature of snow pack on mountains makes backcountry travelers vulnerable to avalanche menace. The risk of death in avalanche (once caught) is 100 times the risk for people caught in ordinary mountaineering, (McClung et al, 1993). The backcountry people, in the past, choose safe dwelling locations through trial and error method or through basic reasoning. However, the safe movement through the avalanche terrain was not given much of a thought and as a result some of the major accidents in last two decades or so took place while people were on move.
In the Indian region, especially in Western Himalayan region, only a miniscule population (approximately 3% of the total) lives in avalanche prone areas. Notwithstanding, avalanches have proportionally killed more people in the past. While civilian people generally confine to the four walls during winter months, carrying out very restricted movement in the avalanche prone areas, the chances of their getting caught in avalanches has been found to be higher than in any other European country having similar avalanche terrain. In Western Himalaya, while every fifth person traversing through the avalanche terrain is caught in an avalanche, in Europe every twentieth person crossing an avalanche terrain is caught in an avalanche.
Snow avalanche fatalities in India till late seventies have been low except one odd event, for example; during the winter of 1829-30 when sixty odd persons got killed in avalanches in Trilokinath area of Lahaul & Spiti district of Himachal Pradesh. Majority of accidents till then, are assumed to have taken place due to the wrong siting of villages. By early seventies villagers resettled their dwellings at fairly safe locations. However, the subsequent increase in avalanche fatalities from late seventies to late eighties was the result of increasing movement of people through the avalanche terrain. Though there has been significant drop in the causality rate due to avalanches since nineties, the trend is likely to

**Corresponding author address:* Ashwagosha Ganju, Snow and Avalanche Study Establishment, Research and Development Center, Him Parisar, Plot No 1 Sector 37 A Chandigarh, India; tel 0091-172-699805; fax: 0091-172-699802; email: ashwa85@yahoo.com

increase in future as the activities like winter sports, tourism; vigilance etc. is on increase now.

2. Problem Definition

To start with it is important to understand why avalanche accidents take place. Avalanche accidents in the past are understood to have taken place as a result of ignorance and fatalistic attitude of the people towards avalanche phenomenon. The present day accidents are more related to casualness and ignorance. Today pedestrians' etc. moves with known amount of risk factor as in the case of motor driving. However, more often, out of ignorance, the risk taken by them in moving through the avalanche prone area is more. The problem of uncertainty associated with avalanche phenomenon is unique and the accidents as a result bring more agony and are not generally acceptable.

Assessing avalanche danger at any one time is difficult as behavior of snow as a material is still being investigated. Hence, pedestrians travelling in avalanche prone area always run a risk, which of course is also unique to other natural hazards. Besides that, the pedestrians repeat the same mistakes as committed earlier in traversing through the avalanche terrain. The accidents generally take place immediately after the cessation of snowfall when people venture out in clear day weather situation. Since most of the movement in Indian Himalaya is generally through the valley bottom region, most of the accidents took place in the run-out-zones of avalanches. Very recently some movements have started taking place in the middle and formation zone of avalanches also but the number is still very small. Since daytime or early morning movement is preferred while traversing through avalanche terrain in India, most of the accidents have taken place during the daytime.

From the foregoing the cause of avalanche accidents can be addressed to the following:

(a) Interaction of man with nature may cause accidents.

(b) While past avalanche accidents were the result of lack of knowledge and fatalistic attitude, the present day accidents are involved with high risk that a pedestrian is ready to take.

(c) Avalanche accidents cannot be totally eliminated; however, awareness can be generated to help people take calculated risk while venturing in avalanche terrain.

(d) The people who are likely to get involved in avalanche accident need to be identified and a scheme evolved to minimize the avalanche mishaps.

3. Materials and Methods

The avalanche areas of Himalayan region lie along the northern part of Jammu & Kashmir, Himachal Pradesh, hills of Uttaranchal, extending up to Sikkim in the eastern region. These areas, due to communication difficulties and remoteness from the rest of the country, are very thinly populated and underdeveloped and hence a lot of incidents of avalanches in these areas go unnoticed.

In fact due to lack of communication, backwardness of the areas and security reasons, very little is reported in the news regarding avalanche accidents. In India, an average of 30-40 human lives is lost and assets worth millions of rupees are destroyed every year, in the snow-bound regions due to avalanches. There is no systematic record available of the years before 1970 and very little attention was paid to archive the data in proper format.

The present study comprised collection of information that was already available in the archives of SASE. SASE had in early eighties conducted survey based on a questionnaire on avalanche accidents in various areas of J&K, HP and Uttaranchal. This information was further verified through newspaper reports. A fresh set of questionnaire was sent in 2001 to various organizations and feedback on avalanche accidents was collected. Data thus collected over last two decades on the avalanche accidents and damages is thus in no way complete. Actual figures are likely to be many times higher since a number of incidents go unreported.

4. Results and Discussions

The analysis and discussion in the subsequent paragraphs shall be covered to find out as to what caused avalanche accidents in the past.

4.1 Avalanche terrain and accidents:

Himalaya has a very rugged terrain. Generally the slopes are quite steep and barren of any vegetation except in a few areas, which sustain forest line maximum up to 3000m.

4.1.1 Distribution by Slope Angle

Majority of avalanche releases that killed people has taken place from slopes between 30 to 45 Degrees. Of these, the slopes of $31\text{-}35^0$ have killed the maximum (33%). The data tallies with the analysis given by (McClung, 1999). Small to medium sized avalanches from slopes between $46\text{-}50^0$ have killed about 9% of the people. Small proportions of the accidents (4%) from slopes between $25\text{-}30^0$ are the cases of wet snow avalanches. Together, the slopes between 31 to 46^0 have claimed the maximum avalanche casualty in the past in western Himalayan region. (Fig 1)

4.1.2 Distribution by Slope Aspect

Avalanche accidents have taken place from all types of aspects in the Western Himalayan region in the past. However, northerly, southeasterly and

southwesterly slopes have taken the maximum toll constituting about 50% of the total accidents recorded so far. (Fig 2)

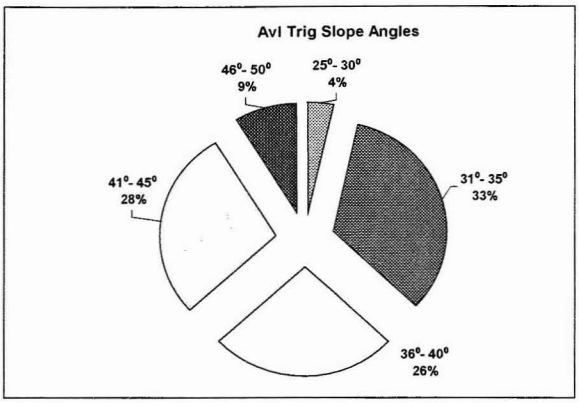

Fig 1. Distribution of avalanche accidents on slope angle

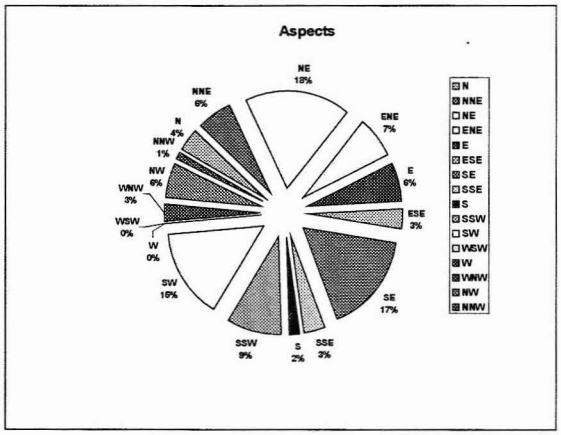

Fig2: Distribution of avalanche accidents on slope aspect.

This is understandably the consequence of wind loading and sunshine. Southerly slopes receive maximum sunshine and immediately after each snow spell release avalanches, which has been seen many a times coinciding with the movement of the people. Northerly slopes remain in unstable state for longer duration and as such 13% of the total accidents are from northerly slopes. Snow accumulation due to drift snow takes place on certain preferred slopes depending upon prevalent wind direction and valley orientation. The accidents due to accumulation of additional drift snow have not been investigated.

4.1.3 Distribution by Mountain Range

Pir Panjal receives maximum snowfall, which is generally moist. As a result the settlement of snow is fast. Majority of avalanches in this range takes place either during snowfall or immediately after the cessation of storm on clear sunny days. The snowpack, thereafter, shows a trend towards stability. However, the complex snow structure with weaknesses evolves over Great Himalayan Range (Depth hoar and Surface Hoar formation). The most accident-prone place also happens to be Great Himalayan Range. The distribution of accidents that have taken place in different mountain ranges is given in (Fig 3)

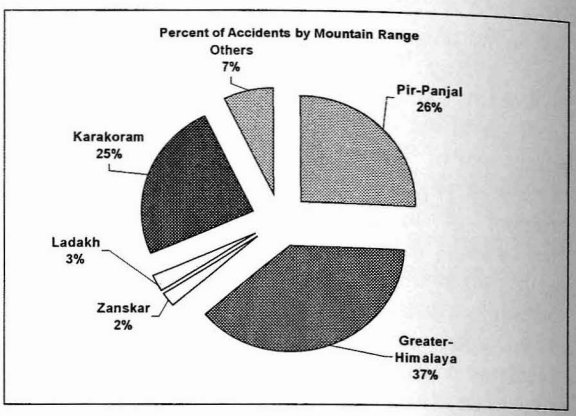

Fig3: Distribution of accidents according to mountain range.

4.2 Accident Trend

The year wise fatalities of both civil and army personnel from 1829-30 to 2000-01 is given in (Fig 4)

The earliest record of avalanche accident available with SASE is of 1829-30 winter. The data, however, is regular from 1970-71. In these records also, the data pertaining to army accidents is more or less complete than of the civil, which has often gone unreported. The period from 1978-79 to 1989-90 has, barring one odd year, produced maximum avalanche casualties in the history of Indian Himalaya. This increase in the avalanche accidents could be attributed mainly to the ignorance and ill equipped adventures taken up by army as well as civilians. The widespread avalanche activity of 1978-79, 1982-83 and 1987-88 made people to ponder over precautionary measures and safety measures. The years following 1990-91 have once again seen the steady decline barring the year of 1997-98 when 69 persons got killed in seventeen accidents. The ratio of the deaths to accidents is given in (Fig 5).

On an average about 5 to 7 persons lost their lives in each accident except during 1829-30, 1978-79 and 1987-88 when in an unprecedented weather situations, more lives were lost. The five years moving average of avalanche accidents, which has been low till 1977-78 increased steadily till 1991-92. Further beyond 91-92, there has been decrease in accident rate, which stands at 10-12 persons per year.

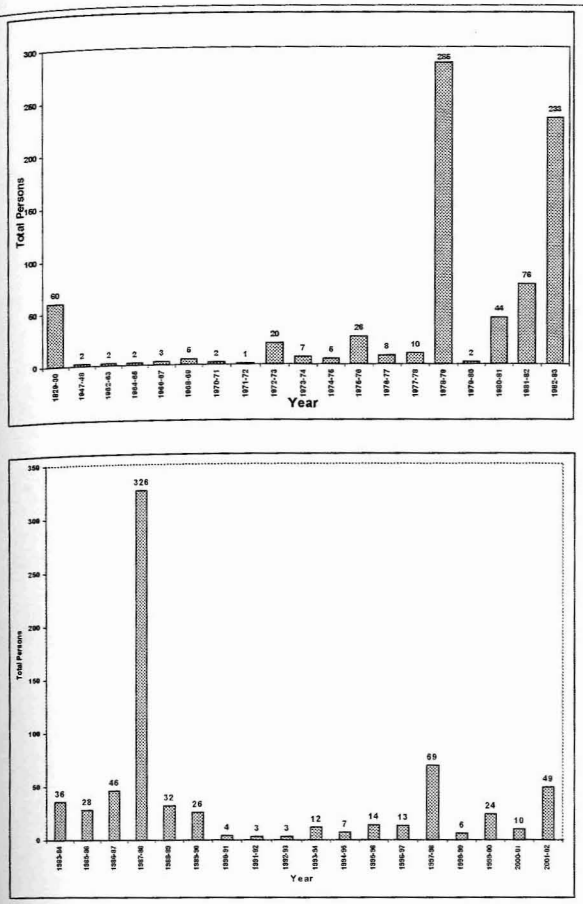

Fig4: Year wise fatalities of avalanche accidents in Himalaya

The current average stands at about 10 persons per year, which as per international norms is an exceptional accident average. The ten year moving average in clearly demonstrates that there has been a period in the history of avalanche incidents in western Himalayan region when a steady rise from 1977-78 culminated in a peak in 1987-88 followed by steady fall since then. The steady fall could be attributed to awareness programmes launched in last decade or so. Avalanche incidents is likely to increase in future, however, the fatal ones should show a downward trend.

4.2.1 Total accidents

Till date, out of 2344 persons who got involved in avalanche incidents, about 1452 people have got killed. Out of this the Army alone had 458 causalities and about 994 civilians lost their lives. The details of total army and civilian causalities are given in (Fig6).

4.2.2 Mobile and Static Accidents

In Western Himalayan region a considerable proportion (62%) of the total people killed due to avalanches the ones on move (Fig 7). In only one major disaster 29 percent persons were killed when they were static viz. in their houses, barn etc. Since majority of times the movement has been

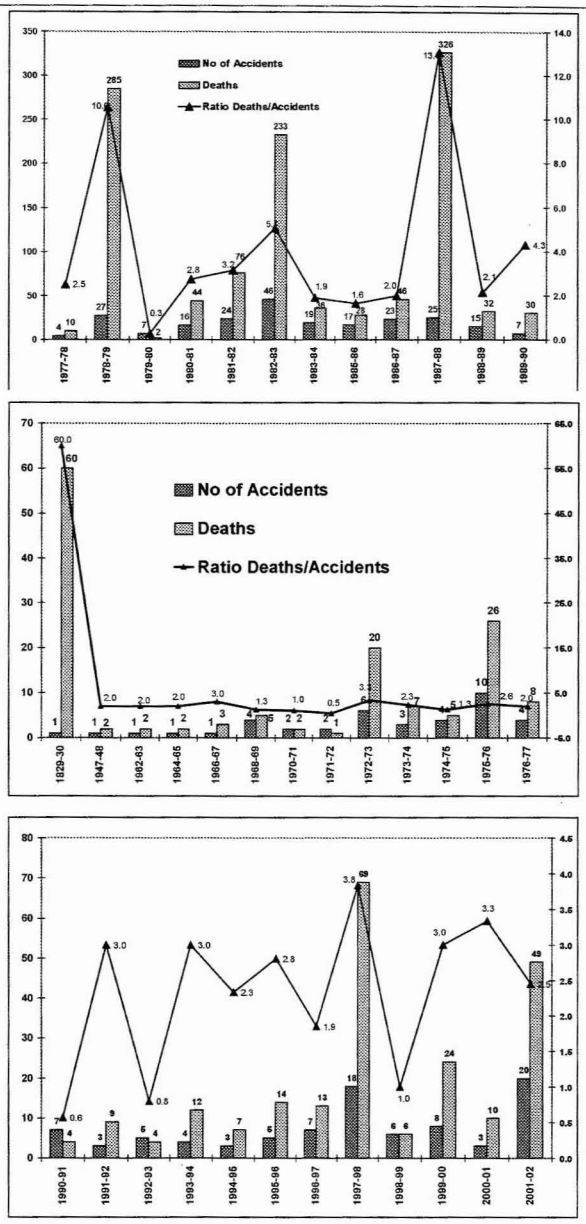

Fig 5: Ratio of deaths to avalanche accidents.

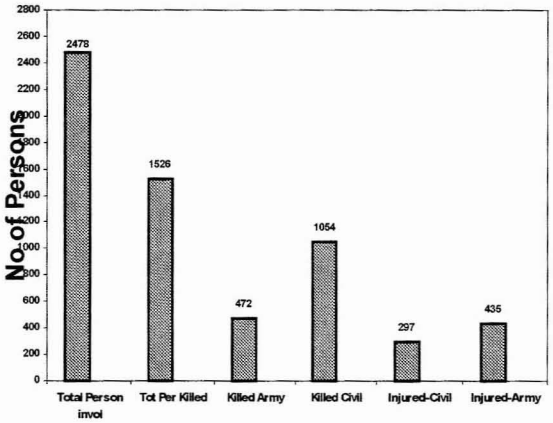

Fig 6: Total number of army and civilian persons killed in avalanche accidents.

through valley region, it is assumed the accidents have been from natural releases and not from the self triggered slopes. There has been about 200 percent increase in avalanche accidents from 1959-74 to 1974-89 while the people were in pursuit of recreation activities in Canada. In comparison there has been about 80 percent decrease in the accidents in buildings during the same period in Canada. In India also, the static accidents (viz. in buildings etc.) are on decrease and accidents while in pursuit of recreation activities or during vigil/ patrolling on border is going to increase.

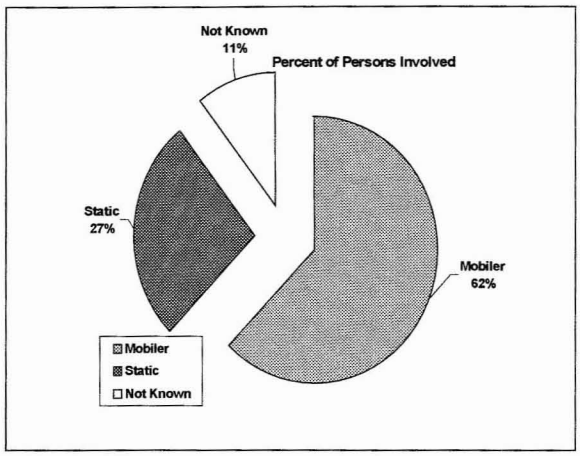

Fig 7: Percent of accidents while on move and in static mode.

4.2.3 Distribution by Month

The avalanche season and with that the accidents in Western Himalayan region starts from September and almost culminates in August. This trend is comparable to the trend observed in United States, Atkins et.al (2000). Whereas in Europe and United States, the peak of avalanche activity and the accidents have generally been reported in Jan or Feb, in India it has been in March touching a to about 36 percent of total accidents in different months (Fig8). The second most fatal months are Jan and Feb. Clubbing these three months, January to March constitutes the dominant 71% accident-prone months in Western Himalaya region (Fig8).

The maximum number of fatal accidents in March can be attributed to the commencement of movement of persons who after the hibernation of 3 to 4 months beginning from November venture out as the warming trend follows (Fig9).

While they attempt to venture out on snow laden slopes, the warming trend that sets in by then initiates moist slab avalanches.

March has also been observed to receive rain on snow events and wet snow ponding puts additional pore pressure and lubricates snowpack to release as wet snow or slush avalanches. The transient weather condition during this month has been seen to produce a few massive spells taking the pedestrians by surprise. The three months of Jan-March constitute the single most disastrous months when in the past nearly 1127 people got killed out of 1817 involved and left 545 injured.

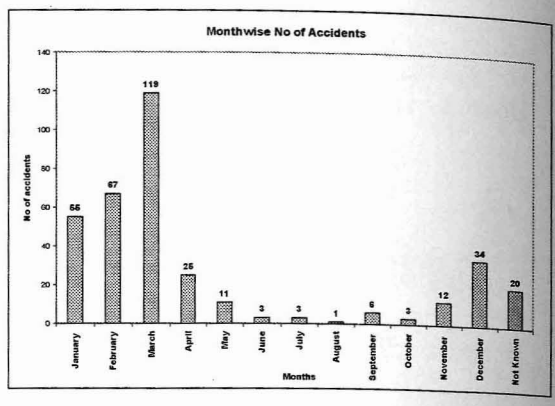

Fig8: Monthly distribution of avalanche accidents in Himalaya

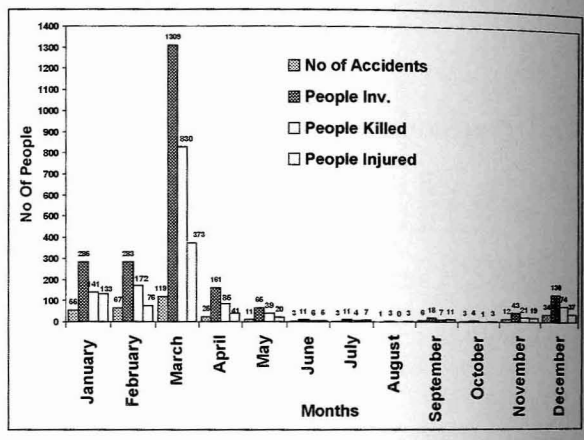

Fig9: Monthly distribution of avalanche victims.

4.3 Accident-Weather Situation.

Snowfall period constituted the dominant weather situation when avalanche accidents took place in the past. Of the total accidents, 46% took place during snowfall period followed by 23 % during cloudy conditions and 21 % during clear weather situation (Fig 10).

Accidents during rain events constitute about one percent only. The cloudy and clear weather situations when accidents have taken place are generally those ones, which were immediately preceded by snowfall.

4.3.1 Accidents within 24 h of the cessation of the storm.

Except in certain situation, the snowfall in Western Himalayan region is generally followed by absolute clear weather situation. The clear weather situation immediately after the cessation of storm has had about 64 % of the total accidents in the past. During cloudy conditions after the snowfall, 24 % accidents have taken place so far. (Fig 11)

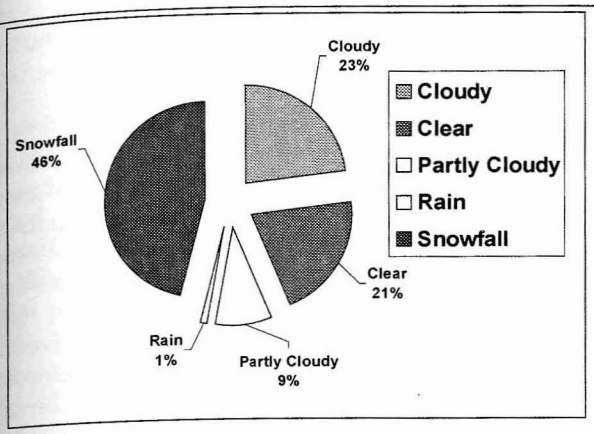

Fig 10: Weather during avalanche accidents

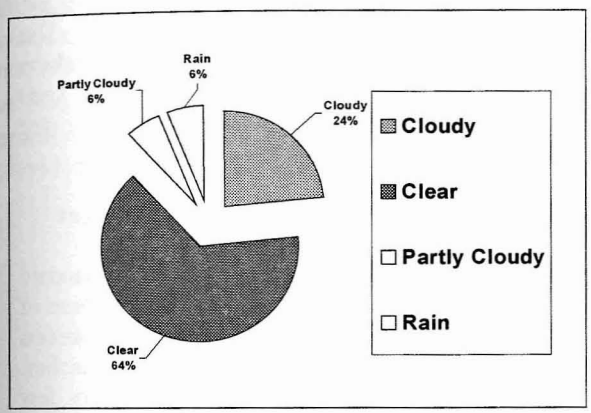

Fig11: Weather situation during accident within 24 h of the cessation of storm

All accidents during intermediate period (period between two storms, excluding the period of 24 h after the cessation of storm) have taken place during cloudy days (Fig 12).

4.3.2 Distribution by Type of Avalanche

Majority of avalanches in Western Himalayan region are massive snowfall related. This being more applicable in Pir Panjal Range where massive spells at high precipitation rate load the slopes rapidly to release loose snow avalanches. As a result, the maximum number of avalanche accidents (42%) are loose snow avalanche related (Fig 13).

A good proportion of accidents (17%) is due to the failure of soft slabs, which on 80 % of the occasions have been released by the pedestrians themselves. Soft slabs get formed in Great Himalaya and Karakoram ranges. Moist loose snow avalanches are dominant from Pir Panjal ranges. Air borne avalanches have been generally noticed in Karakoram ranges. A few airborne avalanches e.g. in Meenamarg, Sonmarg (J&K), Thangu Gantok (Sikkim), Gusikar (HP) and in Siachen have proved fatal and claimed many lives. In Alps and Canadian Mountains, generally dry slabs dominate

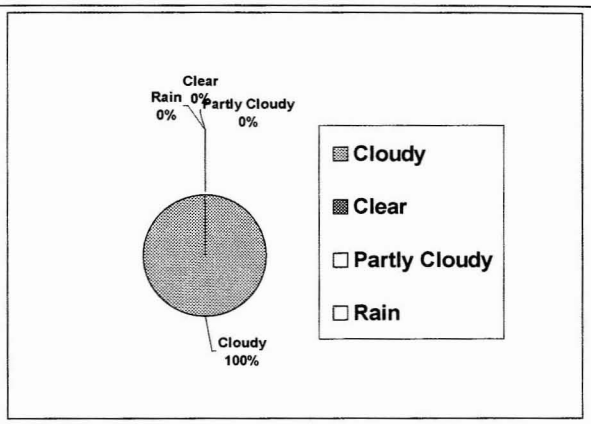

Fig 12: Avalanche accidents during intermediate period.

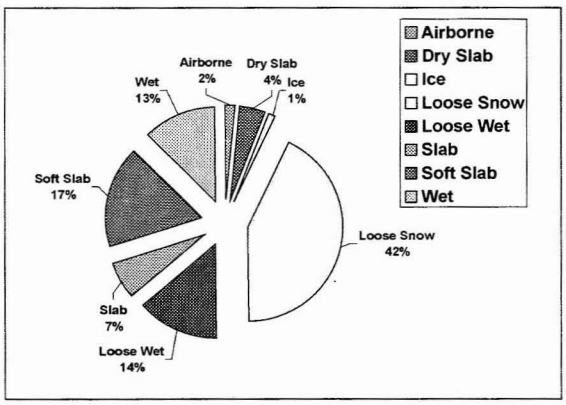

Fig 13: Type of avalanche activity reported during Accident time.

the avalanche accidents, since most of the skiers seek out for skiing on dry snow conditions.

4.3.3 Time of Accident

As already brought out majority of avalanche accidents in the past have taken place during daytime. Out of these, maximums of 41% accidents have taken place in the time slot of 1000-1500h. This is the time when people are generally on move or are about to reach to their destinations. The other major block time of accidents has taken place between 0600-1000h when about 31 % people got killed (Fig 14). This is the time when people are generally on move.

4.4 State-wise accidents.

The details of state-wise accidents are given in (Fig 15)

4.4.1 Jammu & Kashmir State has taken the major brunt of avalanche accidents in the past. Both civilians and army suffered major avalanche accidents in the Kashmir valley. Whereas the number of army persons involved is more, the deaths due to accidents in case of

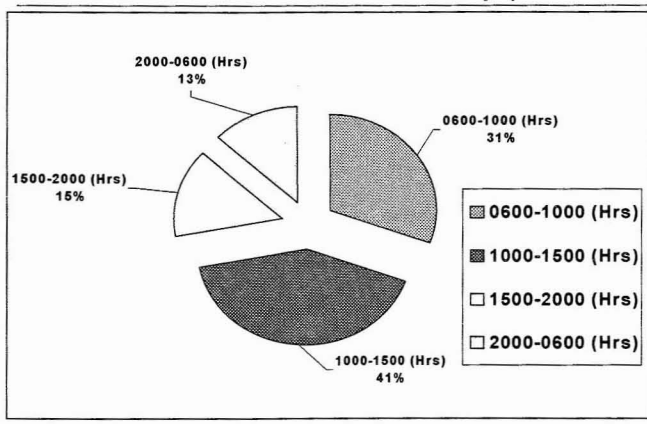

Fig 14: Timing of avalanche accidents in Indian conditions has generally been during morning movement.

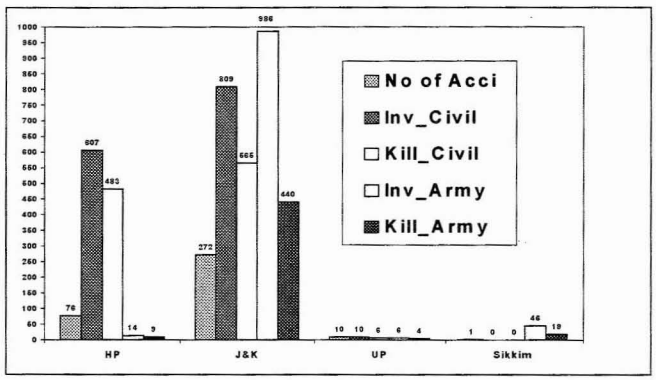

Fig 15: State-wise avalanche accidents show maximum causalities in J&K State

army as well as civil are comparable. The reason for such high avalanche deaths in this state is its proximity to international border, which runs all along the avalanche prone areas and has to be guarded all 12 months in a year. On occasions like the years of 1982-83 and 1987-88, maximum civilians lost their lives in unprecedented weather situations that brought massive avalanches. The calamity in both the cases took place when the persons involved in the accident were withdrawing from the avalanche prone mountainous terrain.

There has been a slight increase in the number of avalanche victims since 1989-90 in the State, primarily due the increased patrolling activity in the state. Frequent patrolling and insufficient knowledge of avalanche terrain has claimed many lives in the State.

4.4.2 Himachal Pradesh does share a small portion of its border with a neighboring country and the movement is predominantly of army personal. However, snowfall is generally sparse in the border area and as a result only a few avalanche incidents took place in the area. The high figure of 259 avalanche victims has been mainly due to the unprecedented weather of Mar1979 when massive avalanches hit the state at many places and a villages got buried in it

4.4.3 Sikkim and Uttaranchal had very few avalanche accidents in the past. In one odd occasion, 10 people lost their lives in avalanches in Uttaranchal and 19 in Sikkim. There may be severe avalanche activity taking place in Sikkim and Uttaranchal also, but the interaction with people, especially, during winter months is negligible.

4.5 Interaction with People.

In India, avalanches are of size 3 – 4, on Canadian scale. Massive avalanches in at least 3-4 waves in a season travel down the slopes at almost all the places in Western Himalayan region. The exceptions being the glaciated regions, where small loose and soft slab avalanches keep triggering throughout the winter. Only a few rare occurrences are of size 4 or 5.

4.5.1 Distribution by Release and Movement

Although a major portion of the available data (33%) does not signify the cause of the release of avalanches, however, a significant proportion (63%) does point to natural release of avalanches. In the context of Indian Himalaya, on very few occasions do pedestrians cross an avalanche path through its formation zone. Most of the time the movement has been carried out through the valley. Unlike in Europe where major accidents are related to the pedestrian's releases, Western Himalayan region has had avalanche causalities mostly due to natural releases. The only few cases of pedestrian release (4%) are that of army personnel who on patrol released it. (Fig 16).

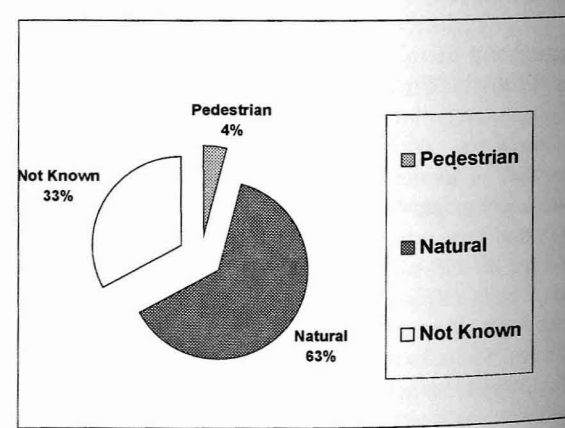

Fig 16: Nature of release of accident avalanches has in Indian context been generally natural.

4.5.2 Distribution during warning and non-warning period.

Civilian as well as Army personnel generally adhere to avalanche warring issued by SASE. However, due to some compulsions e.g. causality evacuation, patrolling, ambush, the army carries out movement with some precautionary measures. It has been found that the avalanche deaths on such occasions have taken place due to ignorance of the masses about snowpack behavior. (Fig 17) describes the status of accidents recorded during warning, non-warning and advisory period. Majority of accidents (about 45%) have taken place during warning period and on 22% cases no warning was issued in the past.

The failure to assess the stability of snow pack, which ultimately resulted in accidents, during non-warning periods, could be attributed to a number of factors. The non-receipt of timely data from forward observatories, or the lapses on the part of the forecasters/ practitioners who missed the finer details of the data provided to them could be some of the causes.

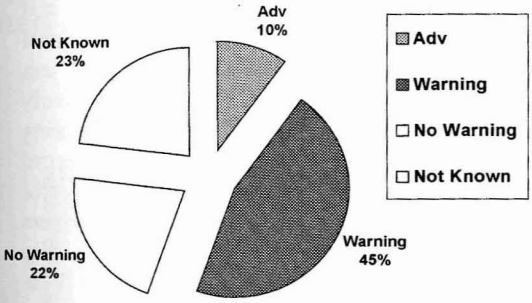

Fig 17: Avalanche accidents during warning or otherwise

However, on very rare occasions such incorrect assessments have been made.

The victims on the other hand, did at times ignore the vital clues, which indicated unstable state of the snowpack.

5. Summary and conclusion

Analyzing the causes of accidents, it has been found that the majority of accidents have taken place during or immediately after the cessation of storm. Ignorance of the behaviour of avalanche slopes has been the main factor for the avalanche accidents in western Himalayan region. The civilian populations either stops their movement, confining to four walls or if need be undertake movement without paying any heed to the warnings. With the growing interest in winter sports, the incidents are likely to increase. However, downward trend in fatal causalities is expected.

While avalanche forecasts are improving by leaps and bounds, it is too bad that people don't always act on them (New Scientist 1999, p 20-21). Any further improvement in avalanche forecasting can be expected now only through some technological breakthrough. Meanwhile, it is only through education and awareness that significant drop could be expected in avalanche fatalities.

While natural avalanches have been the main cause of concern till date, the scenario is likely to change soon when the recreationist and mountaineers would start going on to the slopes and release avalanches themselves.

There has been significant decline in the avalanche accidents of civilian people in the past decade or so. Among other factors, which could be attributed to the decline of accidents among civilians is general awareness, safe constructions and fairly dry weather conditions that have been prevalent during past few years.

Avalanche accidents will continue to take place in Himalaya, however, a proactive approach is required to be taken to mitigate the threat. While encouraging people to go to hills, enjoy winter sports, take tourism to new pastures deep within Himalayan ranges the avalanche accidents needs to be minimized. This can be achieved through awareness programmes, controlled release of avalanches, encouraging winter tourism industry to grow and bringing the fruits of basic research to the affected masses.

Awareness thus promoted will provide a survival strategy for people who are likely to be travelling in avalanche terrain. The strategy of making people take their own decisions by learning to do their own thinking (promoted by education) than to use someone's else's (provided by warning services) has been amply made clear by (McClung 1993).

Lastly having a good weather forecast, at least three days in advance would help in assessing the instability of snow pack better and forewarn the people of the impending danger.

6. Acknowledgement

The authors are thankful to Maj Gen SS Sharma, KC VSM for encouraging us in the preparation of this paper. We are also thankful to Indian Army in providing us some of the valuable information. Our sincere thanks is also due to the scientists and Technical Assistants of Avalanche Forecasting Group, SASE for contributing in one way or the other in compiling this information and analysis.

7. References

-McClung et al (1993). The Avalanche Handbook. p15

-Clifford Embleton (1989) Natural hazards and global change ITC Journal 1989-3/4 pp 169-178.

-New Scientist, Mar 1999; pp 20-21

-Atkins D and Williams Knox (2000). Proceeding ISSW 2000. pp 16-20