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Permafrost & It's Effect on Engineering Structures and Climate

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Abstract: In geology, permafrost is defined as ground including rock's or soil at or below the freezing point of water 0°c for two or more years. Permafrost accounts for 0.022% of total water on Earth and exist in 24% exposed land in Northern Hemisphere. Most Permafrost is located in high latitude (in and around the Arctic & Antarctic region).In India Permafrost is located in Tibetan Plateau , Hindu-Kush Himalayan Region , Kullu , Leh region in Jammu & Kashmir . The Permafrost is found in elevation of 2,400 – 2,800 m, in Himalaya is thawing mainly due to global warming, which contributes to river flood in down-stream area. A collaborative Indo-Swiss research on Permafrost has thrown new light on these rarely studied component of the Indian Himalayan cryosphere. Overall 9 %(420 sq.Km) of land area in Kullu is classified as Permafrost terrain. Hence Permafrost is classified as significant. Permafrost is not only affected by climate change but eventually will affect climate change itself by releasing the greenhouse gases it stored. More than 50% of modelled permafrost land area in Kullu is characterised by slopes less than 35°, a threshold commonly used to distinguish debris-covered slopes from steeper bed rock. Thawing of permafrost in such regions is a potential hazard that could lead to debris instabilities and increased sediment load in water ways and reservoirs. Thawing of permafrost may destabilizelakes, dams and rock-fall or debris flow from surrounding slopes may cause overlapping waves or block outlet channels. If high northern latitude warm significantly permafrost will thaw, allowing organic matter within the permafrost to decompose which release carbon into atmosphere and thus temperature increase. In past 50 years the temperature has increased by 1.3°c, 3 times the global average this resulted in 82% retreating of ice covers and 10% degrading of permafrost. Permafrost has crucial effects on environment and Civil structures, because when permafrost melts the land above it sinks or changes shape and the shifting ground could potentially damage building and infrastructure such as roads, Airport, water and sewer pipes. Thus to have spotlight on such crucial topic it is necessary to study permafrost.

Keywords: Permafrost, Qinghai-Tibet Railway, Cooled Road, Thermosyphon.

I. INTRODUCTION

Permafrost is described as an essential climate variable by the world meteorological organization, which is defined as ground including rock or soil, at or below the freezing point of water i.e 0^0c or 32^0F for two or more years. Permafrost accounts for 0.022% of total water on Earth and exists in 24% of exposed land in the Northern Hemisphere. In other words permafrost is soil, rock or sediment that is frozen for more than two consecutive years. In areas not overlain by ice it exists beneath a layer of soil rock or sediment which freezes and thaws annually and is called as active layer. Permafrost has layer, of which frozen ground is just one portion.

Fig – 1. Idealized Permafrost cross section

1) The active layer is ground that is seasonally frozen typically lying above the perennially frozen permafrost layer. Talik is unfrozen ground that lies below the permafrost and between the active layer and permafrost.

II. PERMAFROST AND CLIMATE CHANGE [EFFECTS OF CLIMATE CHANGE ON PERMAFROST

As result of climate change, permafrost is at risk of melting releasing the stored carbon in the form of CO_2 and methane, which are powerful heat trapping gases.

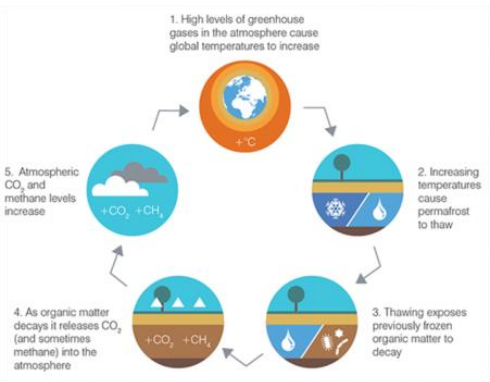

Fig – 2. Permafrost Feedback loop [cycle]

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III. STUDY AREA

• **The most effective example of study area for permafrost is Qinghai – Tibet Railway.**
Qinghai- Tibet Railway an Engineering Miracle.

Fig – 3. Tibet Railway

International experts simply stated that the Qinghai-Tibet Railway could not be when china announced the plan of building the track on the Tibetan Plateau. with its extremely harsh climate and geographic conditions it was no doubt, an arduous task.
Both economic and geographic difficulties were encountered in the construction of this most elevated railroad. As is well known, such a feat of engineering must require huge investment, which was a big challenge for China at that time. But, the biggest challenges lay in the harsh geographic conditions on the high Plateau. The fragile ecosystem on the Qinghai-Tibet plateau, and also the lack of oxygen at the high altitude, and the permafrost were major problems which made the history of the Qinghai-Tibet Railway specifically eventful.

Solution to Permafrost (perennially frozen ground)

Fig – 4. Solution to Permafrost

There are many technical difficulties for such a railway about half of the second section was built on barely permanent permafrost. In summer, the uppermost layer thaws, and the ground becomes muddy. The heat from the trains passing above is able to melt the permafrost even small change in temperature.

It troubled Engineers over the world, but they successfully figured out ways to solve the problem, and ensure roadbed stability in permafrost regions by gravelling embankments and vent-pipe roadbed techniques.

Permafrost area was avoided as possible, by building bridges instead of railroads. Building bridge over permafrost, though expensive, has least impact on the area. The 11.7km Qingshuihe Bridge is the world longest bridge built on permafrost.

The most important solution to permafrost are stone embankments – a layer of loosely piled chunks of granite about the size of baseballs, that allow enough space between the rocks for air to circulate freely.

In some places, the engineers buried ventilation pipes in the ground. The pipes simply allow the cold air to circulate underneath the rail-bed. In other spots, though, a pipe called there thermosiphon was sunk 5m (15feet) into the ground and filled at the bottom with ammonia.

In India the permafrost is found in Tibetan Plateau Hindu-kush Himalayan region, kullu and leh region in [Jammu & Kashmir] The permafrost found at an elevation of 2,400 to 2,800m in Himalayan is thawing mainly due to global warming which contribute to river flood in downstream area.

IV. PERMAFROST IN INDIA

[Hindu-kush Himalayan Region]
The study in Himachal Pradesh is expected to provide crucial data in a little-studied area of climate change. Part of an Indo-swiss science and technology initative the study will took if global warming is thawing the permafrost that is typically found at elevation of 2,400-2,800m in Himalayas.
The only indication of possible extensive presence of permafrost in the Himalayas comes from a global study by Stephan Gruber of Carlton university of Canada. He did the study when he was in the department of geography, university of Zurich, Gruber analysed mean annual temperatures at various heights along slopes.

V. IMPACTS OF MELTING PERMAFROST

• **Physical and Ecological:**
Permafrost is not only affected by climate change, but eventually will affect the climate change itself by releasing the green house gases it stores.
Permafrost stores an immense amount of carban and methane (twice as much carbon as contained in atmosphere) In a warming environment, permafrost is expected to degrade and these gases which have been in storage will be released a third of earth soil carbon is found in the frozen organic matter. If the high northern latitude warm significantly, permafrost will thaw, allowing

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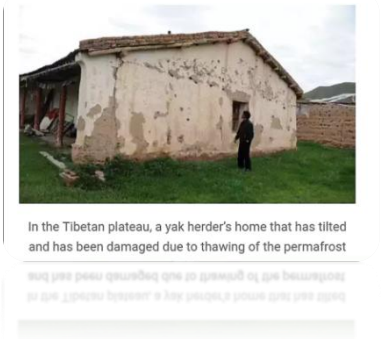
the organic matter within the permafrost to decompose. The decomposition will release carbon into the atmosphere this already happens within active layer each summer. Researchers at the national snow and Ice data centre estimated that by 2200, 60% of the Northern Hemispheres permafrost will probably be melted, which could release around 190 billion tons of carbon into atmosphere. This amount is about half of all the carbon released in industrial age. The affect, this will have on the rate of atmospheric warming could be irreversible.

In moist area, most of the emissions will be of methane. A green house gas that has 20-25 times more warming power than carbon dioxide. As ground warms, methane will eighter be released directly into atmosphere or bacteria will break it down into carbon dioxide, which will then be released. Now this two gases carbon dioxide and methane when release into atmosphere acts as solar trapper which ultimately increases the overall temperature of earth due to which melting of permafrost occurs. Melting of permafrost would contribute to river floods in downstream areas. As the frozen permafrost acts as an underground binder, with soil, humus and disintegrated rock particles when this permafrost melts it leads to debris flow and erosion of ground.

- **Structural impact.**

As we know that construction of any civil Engineering structure demands the land which is firm. Stable even and capacity to sustain the loud of structure.

When permafrost melts, the land above it sinks or changes shape and the shifting ground could potentially damage building and infrastructure such as Roads, Airports, and water and sewer pipes. It also causes landslides, slope collapse.



In the Tibetan plateau, a yak herder's home that has tilted and has been damaged due to thawing of the permafrost

Fig – 5.

VI. PREVENTIVE MEASURES

The various preventive measures that can be used to prevent melting of permafrost are as follows :-

i) Reduce, Reuse And Recycle:-

Reduce garbage by choosing reusable products. If it is something that can't be reused, try to purchase products with minimum packaging. Recycle paper, plastic, glass, newspaper & aluminium.

ii) Save gas / fuel & walk more:-

When you save a gallon of gas you can help keep 20 pounds of Co_2 out of the atmosphere. You can also get lots of benefits by walking to the office, school or grocery store.

iii) Plant a tree :-

Plant's absorb Co_2 & produce oxygen. Planting a tree can balancing the increased percentage of Co_2.

iv) Eat green :-

How much of the food in your grocery store is imported from across the word? Transportation is a major contributor of green-house gasses. Eat locally grown food to reduce transportation emissions.

v) Use less heat & air conditioning:-

Use less air conditioning & heat, or just keeping your house 2 degrees lower in winter or 2 degrees higher in summer can make a big difference.

vi) Save electricity:-

Turn off the lights, television, PC, or any other electrical devices when not in use.

vii) Inform others:-

Inform family, friends, & colleagues about how they can reduce their carbon foot print by following the tips above.

VII. CONCLUSION

- Meting of permafrost leads to liberation of carbon dioxide and methane in to the atmosphere which ultimately leads to global warming.
- Under the global warming scenario the "cooled Roadbed" approach must be use for road design and construction in "warm" and ice rich permafrost. This approach changes the design philosophy from using passive insulation to proactive cooling.
- The use of crushed rock layer as "Thermal semi-conductor" in the constriction of Qinghai-Tibet Railway has proven successful. This cooling measure is highly recommended for various. Engineering constructions, because it is efficient. Easy to deploy, cost effective and environment friendly.
- Crushed rocks ventilation ducts thermosyphons, and dry bridges have all been used in the Qinghai Tibet railway Engineering and have proved to be successful in lowering ground temperature and ensuring roadbed stability.
- Thus the study of permafrost is important in ecological and structural point of view.

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