ROAD HEATING SYSTEM UTILIZING NATURAL ENERGY, A WAY IT SHOULD BE

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1. Preface

The Kagosaka Pass of the General National Road No. 138 is close to the border between Yamanashi-pref. and Shizuoka-pref. This pass is within the Fuji-Hakone-Izu National Park. Because the Kagosaka Pass is in the snowy and cold area, weather conditions in winter are extremely severe. Additionally, since the road linear formation is complicated, this situation interferes with the winter road traffic considerably. Therefore, this research was conducted by aiming to smoothen the winter road traffic and to improve safety while making use of natural characteristics of the area. Value was given to the regional features within the national park (Mt. Fuji) which represents Japan. The target is set to put into practice this road heating system utilizing solar energy being kind to environment.

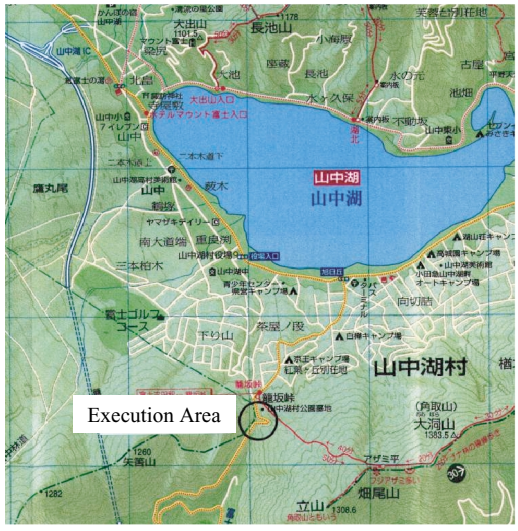


Fig.1 Execution Area Location Map

2. Winter Road Traffic Condition around the Kagosaka Pass

Road conditions around this research area are as indicated in Chart 1. The vertical gradient is 5% in average (maximum 8.5%), and the minimum curve radius is 10m. Structure is complex as a whole. At the same time, this area is the one which shows difficult road linear formation. Therefore, if daily snow accumulation reaches around 10 cm, vehicles cannot climb the slope. They stop and tend to cause traffic congestion.

As in Fig. 2, the number of time when daily snow accumulation exceeds 10 cm per year is four times in average, so traffic jams take place every year. Furthermore, Fig. 3 reveals that the number of winter traffic accidents is on the rise, and 6 accidents happened in the fiscal years 1998 and 1999. Thus, traffic congestion and accidents tend to occur easily around the Kagosaka Pass as mentioned above. Therefore, it is hoped to have policy to secure smooth winter road traffic.

3. Research Outline

To investigate the technical method for winter road surface countermeasure reflecting the local characteristics, weather data (daily snow fall, daily lowest temperature, wind velocity) of the past 10 years were collected. Required energy volume was calculated as well.

In addition, usable natural energy for melting snow around the Kagosaka Pass was examined. By comparing constructive aspects, economy, snow melting capacity and environment concerning the snow-melting method using such energy sources, the snow-melting method, which fits this research area, has been selected.

Chart 1 Road Conditions in the Construction Subjected Area

Road classification	General National Road No. 138
Structure standard	Third Class Second Level
Traffic style	Facing traffic
Regulated speed	40km/h
Traffic amount	14,000 cars/day
Vehicle road part width	Approx. 6.5m
Average vertical gradient	5% (maximum 8.5%)
Minimum curve radius	R=10m

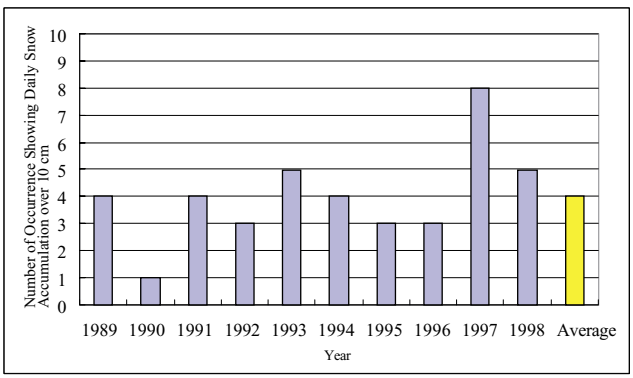


Fig.2 Annual Occurrence of Daily Snow Accumulation over 10 cm

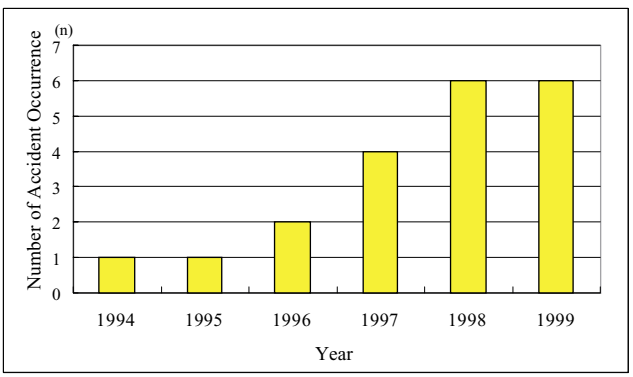


Fig.3 Number of Winter Traffic Accident Occurrence (Dec.- Mar.)

4. Research Results

4-1 Calculation of Required Value to Melt Snow

The set values indicated in Chart 2 are decided by the weather data. Calculated necessary heat value for melting snow per unit area becomes 250W/m^2. However, it is intended to leave as little snow as possible because a lot of vehicles pass by putting on ordinary tires. Besides, this research area is close to Shizuoka-pref. which is not a snowy and cold area.

Chart 2 Weather Condition Values and Required Heat Values for Melting Snow Used in Designing

Snow Fall Intensity	2.5cm/h
Temperature	-7.9℃
Snow Density	60kg/m^3
Wind Velocity	1.6m/s
Required Heat Value for Melting Snow per Unit Area	250W/m^2

4-2 Investigation of Snow Melting Facilities Installation Area

In the investigation of snow-melting facilities installation area, summarizing curve radius from the point of view on road structure and sorting out the problems with bottleneck areas occurring traffic congestion. As the result, snow-melting facilities have been installed, by appointing approximately 790m^2 as indicated in Fig. 4.

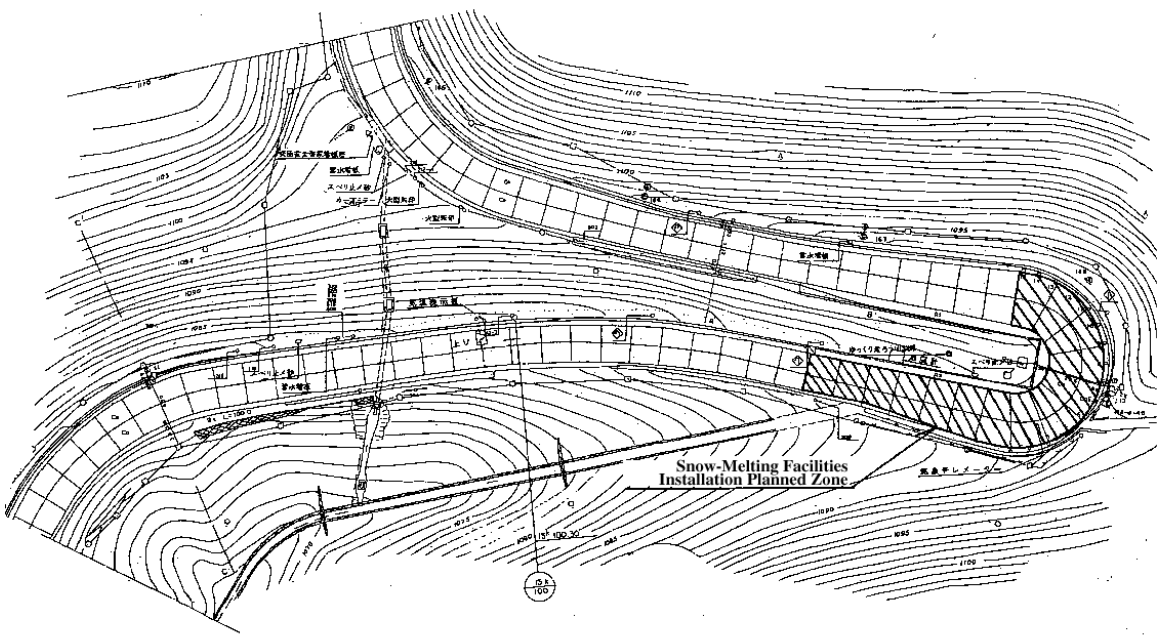


Fig.4 Snow-Melting Facilities Installation Planned Zone

4-3 Construction Technology Selection

Perform extraction of snow-melting heat source. Investigation was done on the possible potential energy source to melt subjected 790m^2 area around the Kagosaka Pass. Then, a selection was made on construction technology.

4-3-1 Extraction of Snow Melting Energy Source

As for the heat source, there are largely three kinds: natural energy, local energy and fossil energy. The heat source classification list is indicated in Chart 3.

Chart-3 Heat Source Classification

1. Natural energy (Energy existing in the nature surrounding the planned area) • Air temperature • Underground water temperature • Geothermal temperature • Solar energy (heat accumulation) • Solar energy (generation power) • Wind power • Sea water heat
2. Local energy (secondary emitted energy) • Hot spring heat • Urban heat emission temperature
3. Fossil energy (energy majoring around fossil energy) • Fossil energy (kerosene, fuel, etc.) • Gas • Electricity

4-3-2 Investigation of Usable Heat Source

Usable heat source to melt snow in the assigned 790m^2-snow melting zone was examined. The snow-melting technical method indicated in Fig. 5 was judged possible.

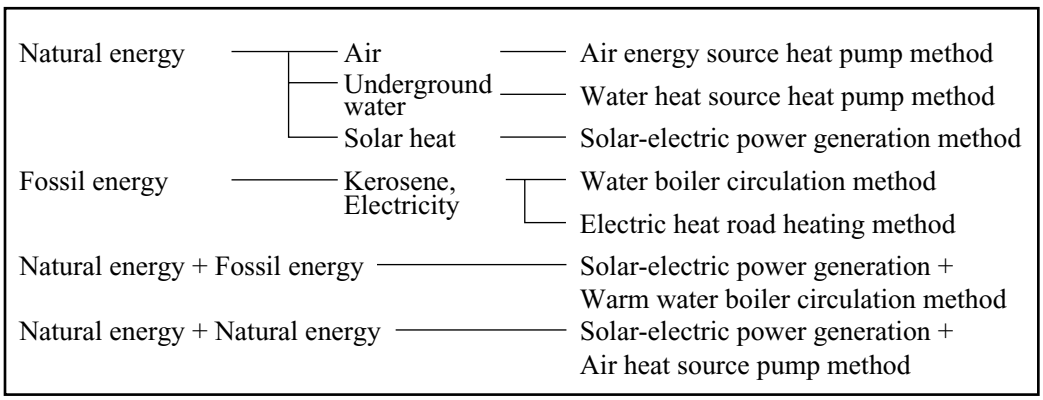


Fig. 5 Usable Potential Energy

4-3-3 Technical Method Selection

Comparison of snow-melting technical method was made regarding each item; constructive aspects, durability, environment, snow-melting effect, maintenance management and cost. Finally, certain technical method was selected.

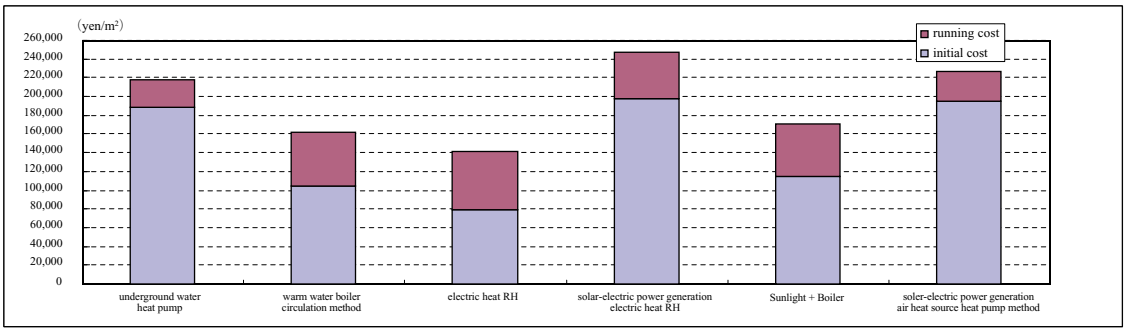
As for this construction site, the total cost of the electric heat road heating method is the cheapest. Running costs are cheaper with underground water heat source heat pump method and soler-electric power generation air heat source heat pump method.

Soler-electric power generation air heat source heat pump method is the one which applied sunlight as the energy source of the heat pump.

Chart 4 indicates a cost comparison graph.

In terms of environment, CO_2 is the worldwide problem at present. But by using solar

Chart-4. Snow Melting Technical Cost Comparison Graph



batteries as a source, it becomes possible to decrease the amount of CO_2.

The comparison of CO_2 generation amounts is indicated in Fig. 6.

Even though the natural environment of this snowy and cold area, the focus is on the fact

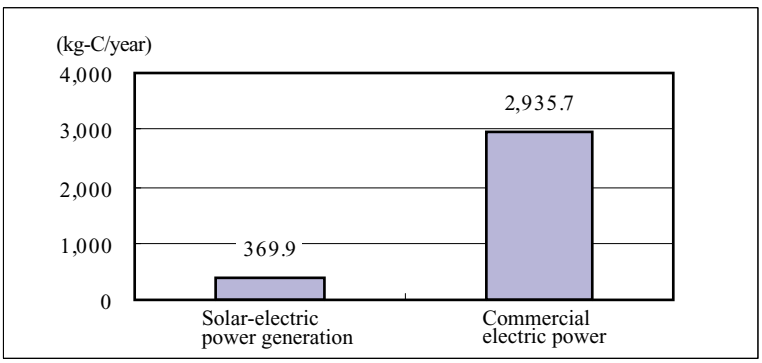


Fig. 6 Comparison of CO_2 Generation Amounts

※ CO_2 emission source unit 76g-C/k Wh
(Values of The Tokyo Electric Power Co., Inc. in 1998)

that the Pacific climate (with much sunshine) is available. Accordingly, to facilitate the plan to use solar energy, solar-electric power generation air heat source heat pump method road heating was chosen. This is the suitable technical method for this research area by evaluating maintenance fee and environmental items.

Snow-melting technical evaluation point is indicated in Chart-5.

Chart-5 Snow-melting Technical Evaluation Points

Items	Water heating HP (underground water)	Boiler (kerosene)	Electric heat RH	Solar-electric power generation electric heat RH	Sunlight + Boiler	Solar-electric power generation air heat source heat pump RH
Constructive aspects	×	△	○	○	△	○
Durability	○	○	△	△	○	△
Environment	○	×	△	○	×	○
Snow-melting effect	△	○	○	○	○	○
Maintenance management	○	△	○	○	△	○
Initial cost	×	△	○	×	△	×
Running cost	○	×	×	△	×	○
Evaluation points	7 points	5 points	9 points	9 points	5 points	10 points

○…2 points　△…1 point　×…－1 point

4-4 Outline of Solar-Electric Power Generation Air Heat Source Heat Pump Method Road Heating Facilities

Solar-electric power generation heat source heat pump method road heating is the system which electric power uses generated by solar batteries to circulate an antifreezing solution heated by a heat pump. Power generation by solar batteries amount in winter is few, and power generation is expected at night. Therefore, commercial power is connected and supplement is provided in case snow-melting electric power lacks by purchasing electric power. Decreasing the running cost is possible by not practicing road heating or selling surplus of electric power which is generated in summer. Solar-electric power generation air source heat pump method road heating outline diagram is provided in Fig.7.

Road heating facilities utilizing sunlight

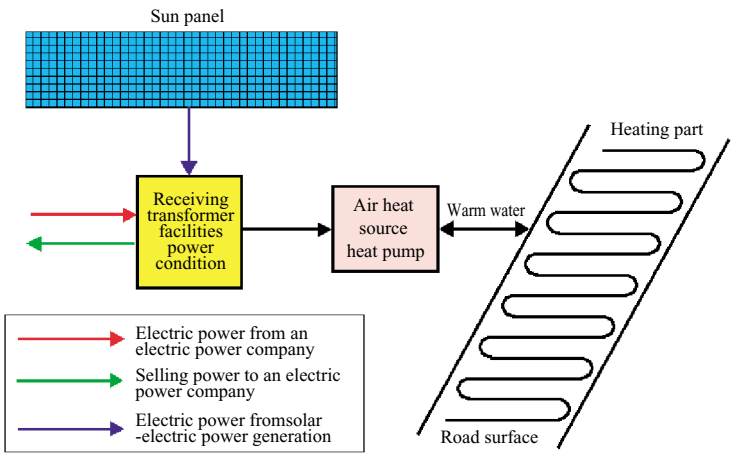


Chart-7 Solar-electric power generation air heat source heat pump method road heating outline chart

5. Conclusion

Solar-electric power generation air heat source heat pump method road heating was selected as the snow-melting facilities suitable for construction site in this research. Basic plans for facilities installation plans were made accordingly. After installing facilities, follow-up research will be conducted over solar-electric power generation and snow-melting conditions. Practical efficiency of facilities are expected to be provided. Furthermore, it is hoped to investigate road heating systems utilizing natural energy, which take the environment into consideration in the future.