Evaluation of Deicing Performance for Eco-Friendly Deicer

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Research Background

- The skid resistance is a very important factor in traffic safety on snowy and icy road.
- However, the ice and packed snow on the pavement surface in winter season can decrease the contact area of the vehicle tire and cause loss of skid resistance.
- The most important action in the winter road management is to remove the snow and ice from the road surface more efficiently and rapidly.
- In Korea, a pre-wetted salt (PWS) spreading method is currently being applied.

- Calcium chloride : Immediate effect with aqueous solution
- Sodium chloride : Continuousness

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Research Background

- Recently, the use of chloride deicer has been dramatically increased for driving safety.

- However, the excessive use of chloride deicer can induce the soil and water pollution, concrete structure damage due to the corrosion, and spalling of concrete pavement.

- It is necessary to develop a new deicer that minimizes the use of chloride and that maintains the melting performance at the level of existing deicer.

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Research Objectives and Experiments

- To evaluate and validate the performance of Eco-Friendly Deicer (EFD)

- Laboratory experiments
  - Freezing and eutectic point test
  - Ice melting test
  - Ice penetration test

- Field experiments
  - Friction (Skid Resistance) test

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Eco-Friendly Deicer (EFD)

- ❖ Developed using wastewater sludge and food waste
- ❖ About ten percent of organic acid was used, instead of chloride
- ❖ Advantage in preventing the corrosion of steel and damage to concrete
- ❖ Budget saved in winter road management with recycling of waste materials

Deicer	**NaCl**	**$CaCl_2$**	**KOH**	**CH_3COOH**	**CH_3CH_2COOH**	**H_2O**
EFD	○		◎	◎	◎	○
PWS	◎	○				◎

(◎: Major Component, ○: Minor Component)

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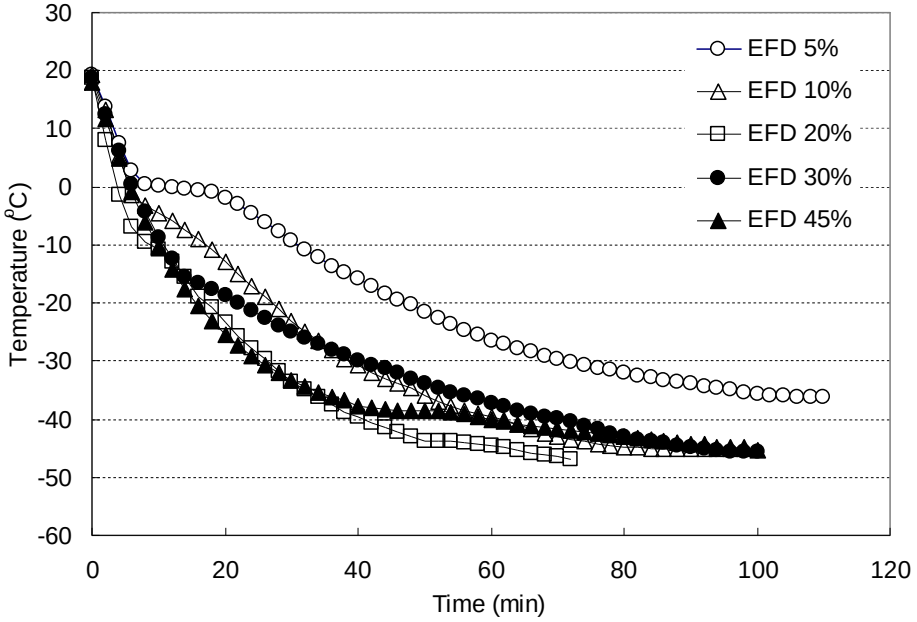
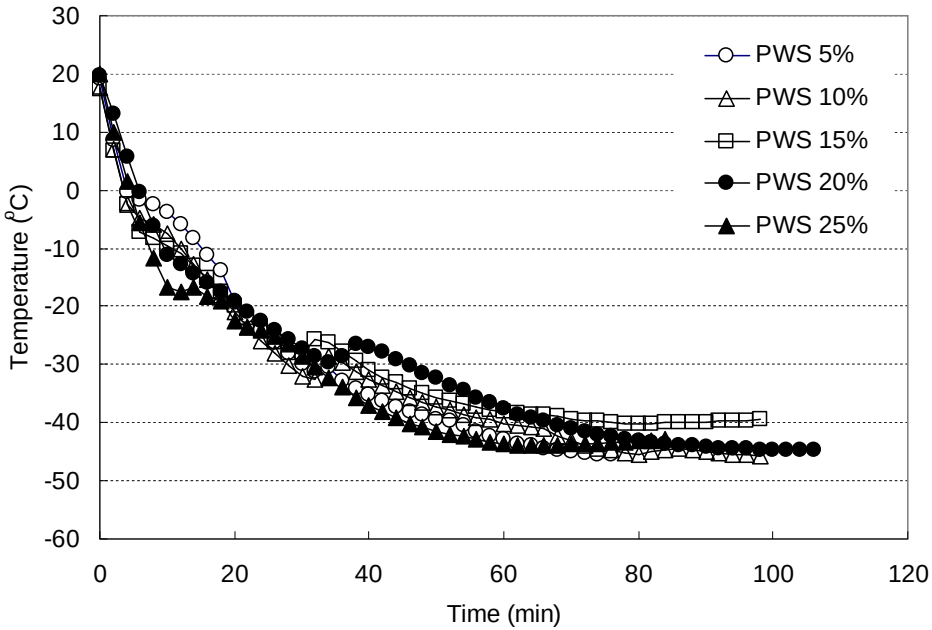
Freezing and Eutectic Point Test

- ASTM D 1177 “Standard Test Method for Freezing Point of Aqueous Engine Coolants”
- Temperatures of deicer solution was measured at two minutes by maintaining the ethanol temperature below -75°C using a dry ice.
- Concentration of deicer solution varied (5, 10, 20, 30, 40% etc).



(EFD)



(PWD)

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Freezing and Eutectic Point Test

- As the temperature of deicer solution gradually decreases and approaches the freezing point, the material state changes into solid condition.
- The state change of material induces the temporary increase or no change in temperature.
- The freezing point decreases as the solution concentration increases for both EFD and PWS deicers
- EFD with below -40°C of freezing point can be used in more extremely cold environment.

EFD	Concentration (wt%)	5	10	20	30	45	Avg. Eutectic Point
	Freezing Point (°C)	-0.5	-3.3	-10.7	-17.6	-38.5	**-44.7**
	Eutectic Point (°C)	-	-45	-44.2	-44.8	-44.9	
PWS	Concentration (wt%)	5	10	15	20	25	Avg. Eutectic Point
	Freezing Point (°C)	-1.8	-5.9	-8.3	-12.7	-16.7	**-27.8**
	Eutectic Point (°C)	-30.5	-28.5	-25.6	-26.6	-	

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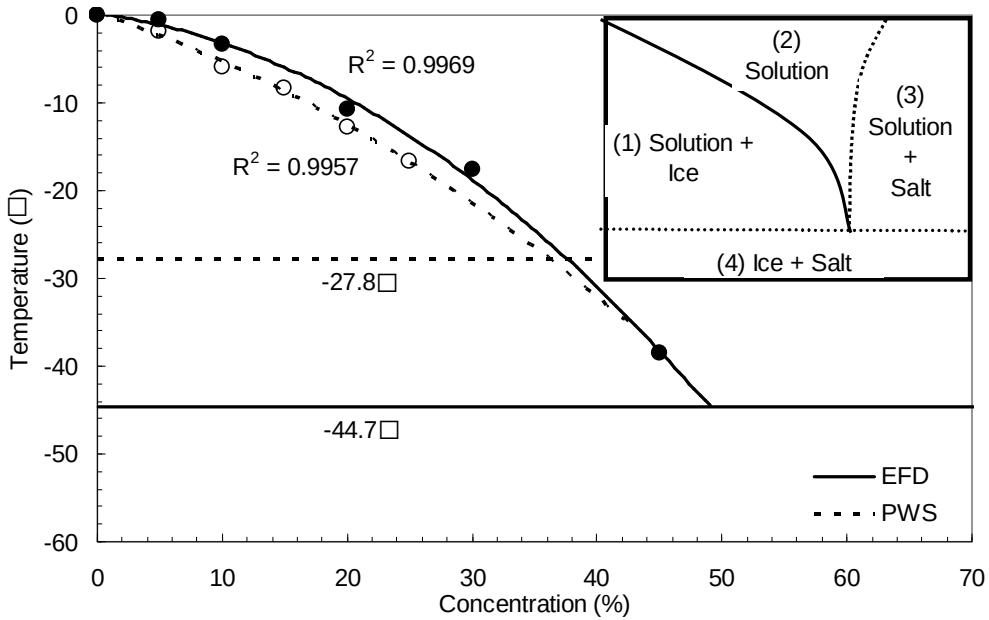
Freezing and Eutectic Point Test

- There is no region 4 when using the liquid type EFD deicer.
- Since the temperature is below the eutectic point in region 2, the deicer is self-iced and cannot be sprayed.
- To obtain the effective deicing performance, the temperature and concentration of deicer should be within the region 3.
- When approaching the region 1, the reicing can be occurred and additional spray should be needed to obtain the continuous deicing effect.



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Ice Melting Test

- SHRP H-205.1/2 “Test Method for Ice Melting of Solid/Liquid Deicing Chemicals”
- The weight of melting water was measured after the deicing chemicals was sprayed in a liquid state.
- The concentration of EFD solution was changed by 20, 30 and 45wt% and the performance was compared with that of PWS.
- Tests temperature was varied from -5°C and -10°C.

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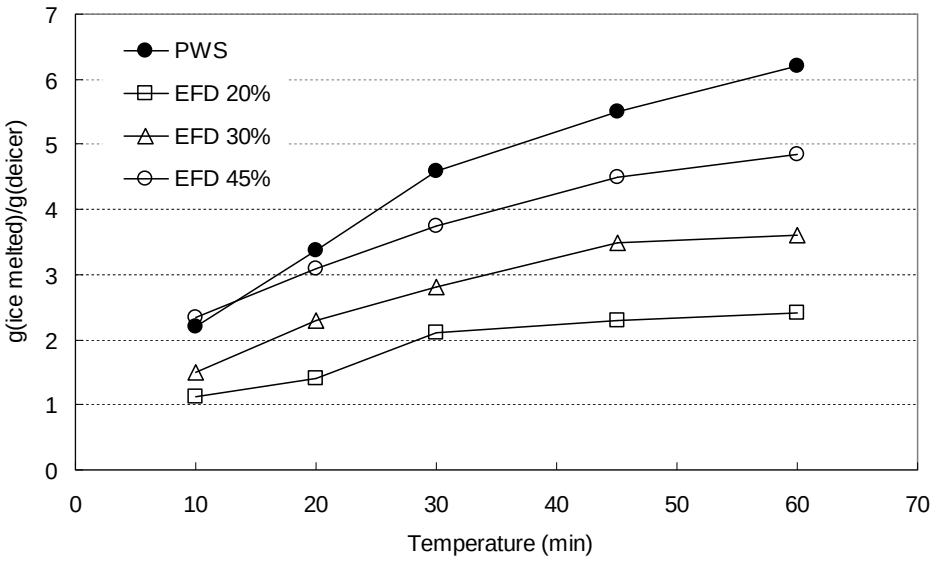
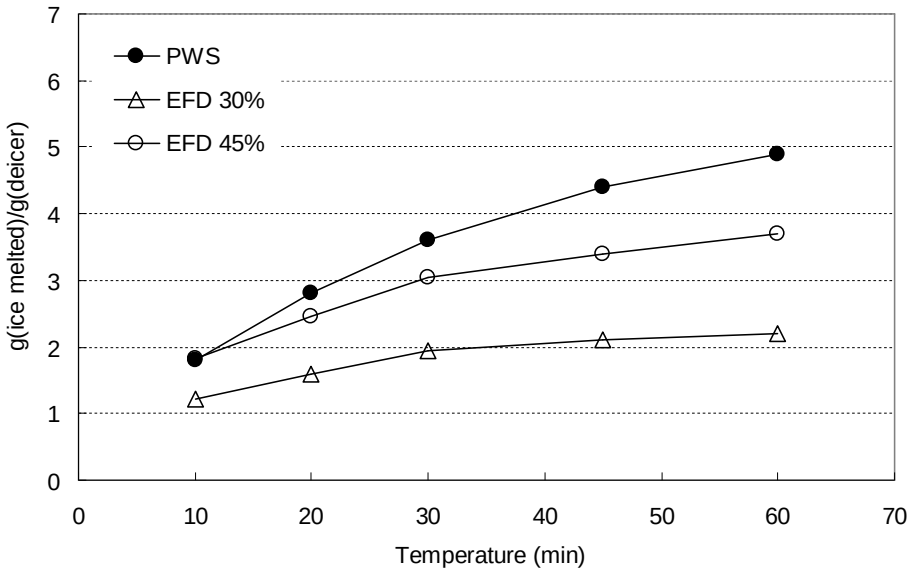
Ice Melting Test

- PWS has better melting performance than EFD
- The melting performance increases as the solution concentration increases.
- In case of a 45wt% solution of EFD, the melting performance from the initial to 10 minutes is similar to the PWS and tends to decreases with time.



at -5°C



at -10°C

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Ice Penetration Test

- SHRP H-205.3/4 “Test Method for Ice Penetration of Solid/Liquid Deicing Chemicals“
- After injecting the water in the grooves of penetration tester and icing using a freezer, the deicer is sprayed over the surface.
- The penetration depth of melting solution was measured with time.
- The solution concentration was similar to the ice melting test

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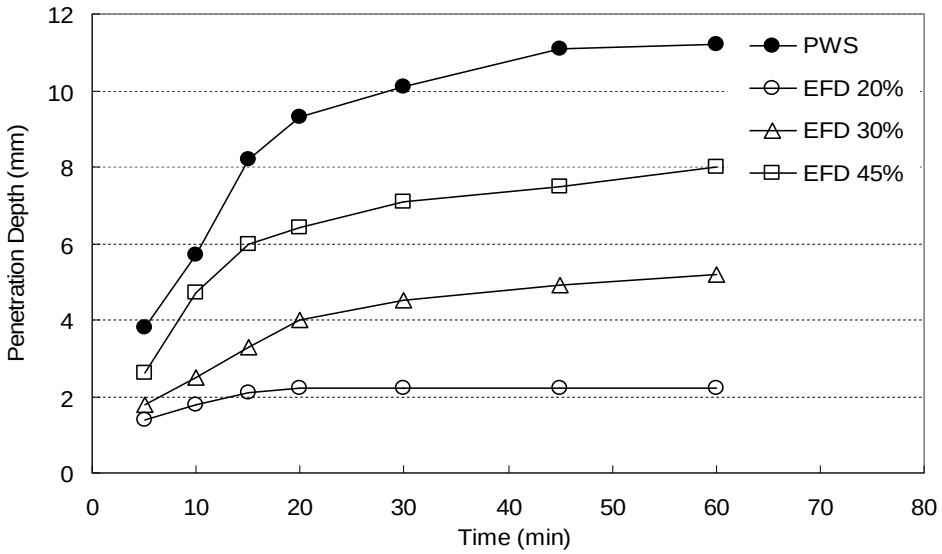
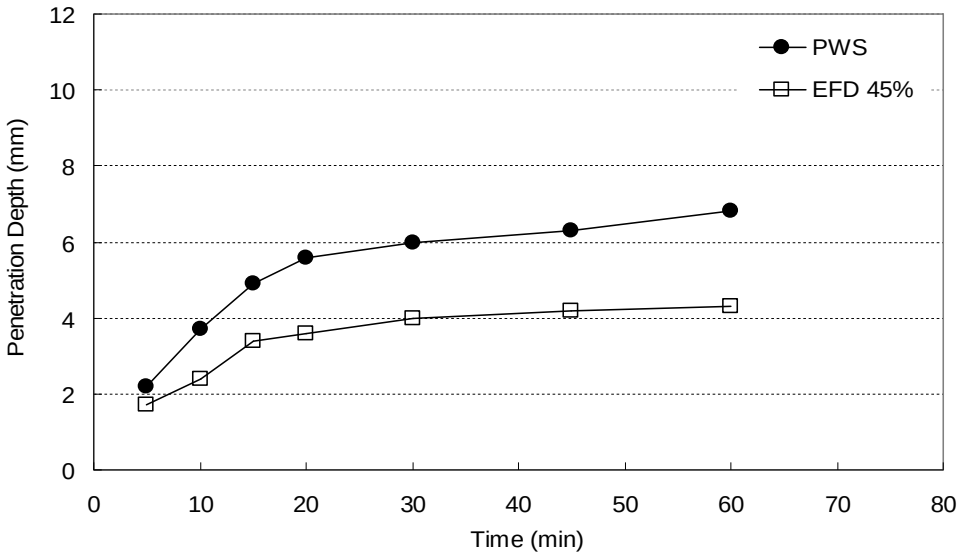
Ice Penetration Test

- ❖ At -5°C, 45wt% EFD has about 70~80% of PWS penetration performance.
- ❖ Similar to the melting test, the penetration performance of both deicers is relatively same in the initial ten minutes.
- ❖ The penetration depth did not increased after 20 minutes and re-icing for 20wt% of EFD was observed.



at -5°C



at -10°C

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Field Validation: Full scale skid resistance test

- The melting performance of deicer in the field can be affected by various factors so that it is necessary to evaluate the field performance of deicing chemical at different surface and climate condition.
  - temperature, wind speed, traffic passage, and surface condition etc
- The full-scale skid resistance testing was conducted using pavement friction tester (PFT) to evaluate the ice melting performance.
- EFD and PWS deicer were sprayed twice separately on the icy surface and compacted snow surface.
- The skid resistance for each section was measured and recorded every 15 minutes.

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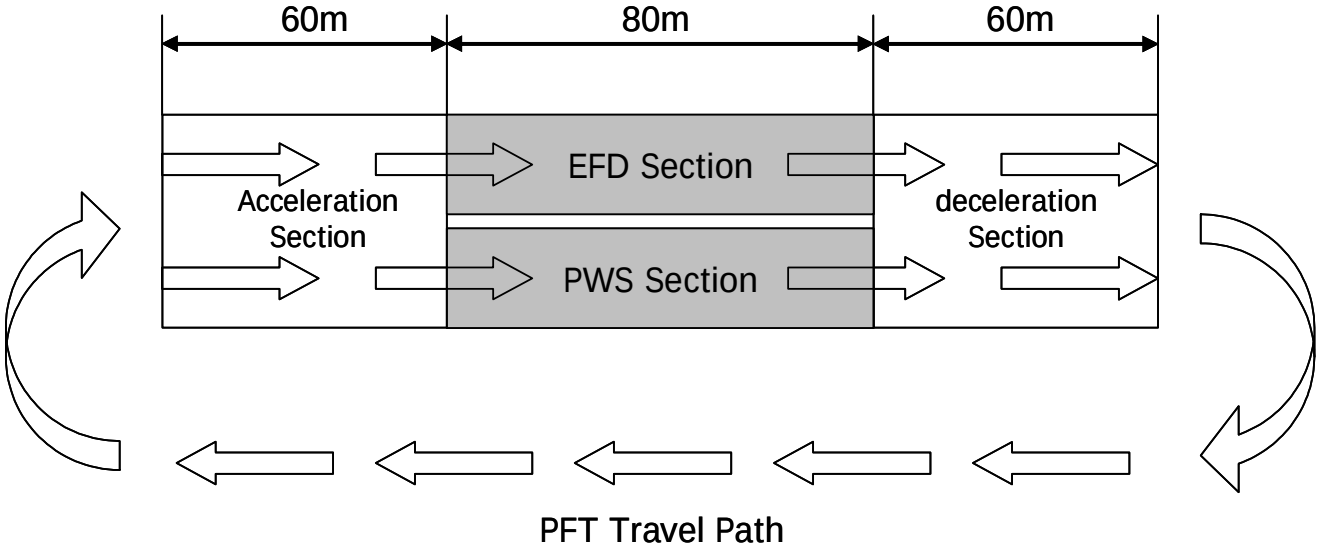
Field Validation: Full scale skid resistance test



Measured Content	1st	2nd
PFT Speed	40mph	
Surface Condition	Icy surface 2~4mm	Compacted Snow 2~3cm
Air Temperature	-2~-4℃	5~6℃
Relative Humidity	60%	77%
Surface Temperature	0~-4℃	1~-3℃
Wind Speed	7m/s	2.8m/s

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Field Validation: Full scale skid resistance test

- The skid resistance of icy surface recovered to original condition in 30 minutes after deicer spreading.
- In stead of the dropping of freezing point, the separation of interface between ice and pavement surface after deicer penetration into the ice increase the skid resistance on this condition.
- The physical action such as vehicle passage also helped increase the skid number of PFT.
- The effect of de-snow at early stage of deicer spreading and freezing point dropping affects the increase of skid resistance.

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Field Validation: Full scale skid resistance test

- Although the time to improve the skid resistance of PWS is slightly faster than EFD, there is not much difference in melting performance for two deicers.

- The SN40 value tends not to be increased after 60 which indicates about 60 values of wet condition is equal to SN40 value.

Measured Content		1st		2nd	
		EFD	PWS	EFD	PWS
Skid Resistance (SN)	Before Spray	**15**	**15**	**15**	**17**
	15 min	**42**	**48**	**19**	**18**
	30 min	**58**	**57**	**29**	**34**
	45 min	**-**	**-**	**46**	**51**
	60 min	**61**	**60**	**57**	**58**

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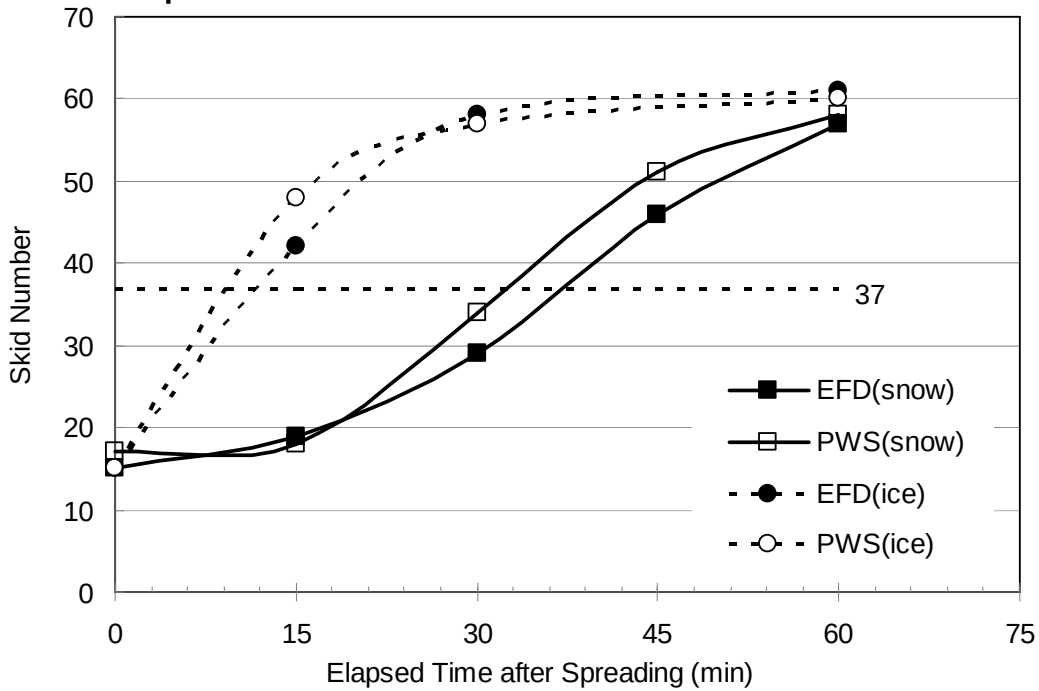
Field Validation: Full scale skid resistance test

- Regardless of deicer type, the time to recover the skid resistance to wet condition is about 30 minutes in the first test and 60 minutes in the second test, respectively.
- In case of highway with 80km of design speed, the minimum SN40 value is 37. PWS has three minutes faster than EFD in recovering the skid number to the minimum requirement.



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Conclusions

- Eco-Friendly Deicer was developed using waste food sludge and tested for freezing and eutectic point, ice melting and penetration and field resistance.
- The reduction trend of freezing point for EFD and PWS tends to be similar. However, the eutectic point of EFD is about 17°C lower than PWS indicating that the EFD can be used in wider range of temperature.
- The melting performance of PWS is slightly better than that of EFD.
- The melting performance of EFD is almost equal to PWS in the early stage of spreading indicating that the liquid spreading of EFD is capable of improving the melting performance.
- Based on the test results, the optimum concentration of EFD was found to be 45wt%.
- Field skid resistance test results showed that the time from snowy and icy surface to the original condition are almost same in both EFD and PWS.

Thank you for your attention !