



DESIGN AND OPERATION OF ICE ROADS

**Ice Roads Research Project
NTICC – TRB AME30
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**U.S. Department of Transportation,
Federal Highway Administration**

Importance of Ice Roads to Alaska Villages



Why are **Ice Roads** so important?

- No overland roads or bridges to many villages.
- Trails on land usually limited to snow machines.
- Airplanes are expensive for people and freight.

Ice Roads can provide economical & dependable access:

- For Medical services, freight, mail, cultural activities, substance fishing & hunting;
- May reduce cost of goods to villages.



Design And Operation Of Ice Roads Manual

Chapter	Title
1	Introduction
2	Framework
3	Background
4	Hazards
5	Design
6	Construction
7	Signage
8	Vehicle Control
9	Monitoring and Maintenance
10	Uncrewed Aircraft Systems
App A	Use of Uncrewed Aircraft Systems
App B	Examples of MUTCD Signage
App C	References



Chapter 1: Introduction

Section	Title
1	Purpose
2	Background
3	Organization of Manual
4	Limitations
5	Safety Considerations

Philosophy

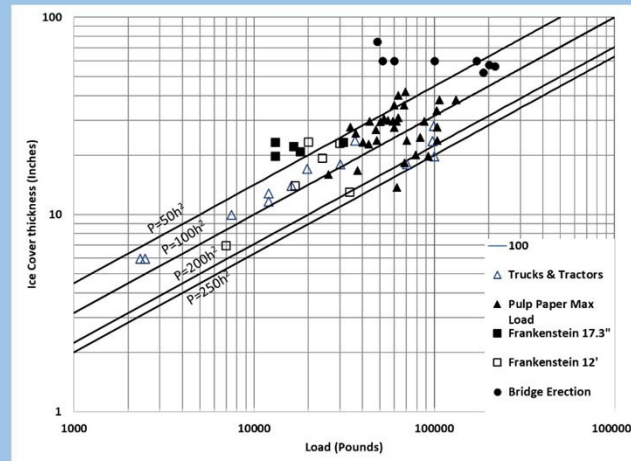
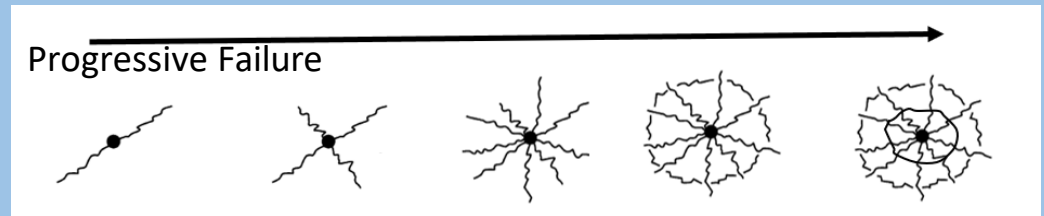
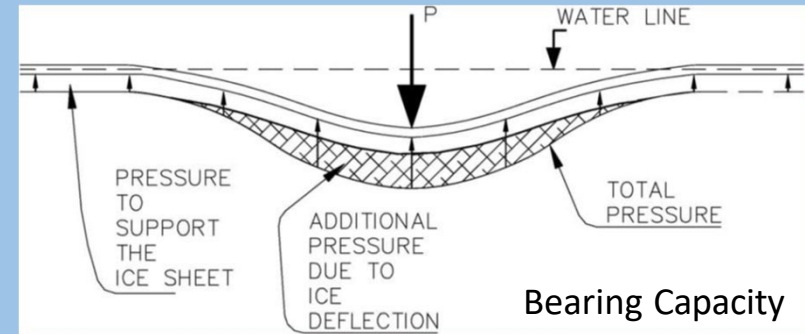
An in-depth development of the principles of ice mechanics is not presented here.However, an overview of the principles required to operate an ice road are provided so that the practitioner has a basic understanding of the performance of an ice sheet under traffic loadings

Chapter 2: Framework

Phase		Main Activities	Tasks	
Pre-Season	The open water period before freezeup	Planning	Route Planning	
			Select Operations Level	
			Determine Signage Requirements	
			Determine Equipment Requirements	
Pre-Construction	Freezeup to Construction	Surveying	Manual Surveying	
		Route Selection	GPR Surveying	
Construction	Begins when the ice thickness is thick enough to allow safe transit of the construction vehicles.		Ice Road Establishment	Route Selection
		Signage		Access Points
				Monitoring
			Maintenance	
		Administration		
				Shutdown
Ice Road Operation	The Ice Roads and crossings are opened for public use.		Monitoring	
		Maintenance		
				Administration
			Shutdown	
		Shutdown		
				Shutdown
			Shutdown	
		Shutdown		
				Shutdown
Shutdown	Safety			
	Shutdown	Training		
		End of Season	The public use of Ice Roads and crossings are ended	Shutdown

Chapter 3: Background

Section	Title
1	Introduction
2	Bearing Capacity
3	Flexural Rigidity
4	Flexural Strength
5	Stationary vs. Moving Loads
6	Creep
7	Progressive ice cover failure
8	Gold's Formula
9	Ice Types
10	Multiple ice types in the ice column



Gold's Formula

$$P = Ah^2$$

Chapter 4: Hazards

Section	Title
1	Introduction
2	Crack Types
3	Causes of Crack Formation
4	Blowing Snow
5	Warming Periods
6	End of Season

Crack Types

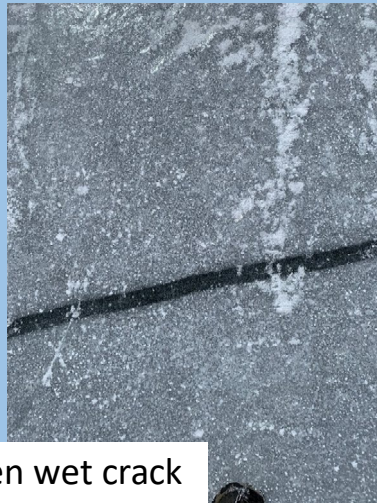
Dry Cracks: Do not penetrate through the ice cover.

Wet Cracks: Penetrate the ice cover.

Causes of Crack Formation

Vehicle Induced	Excessive Loads
	Moving Loads
	Multiple Loads
	Frequent Loads
	Long Term Loads
	End of Season
Ice Road Geometry- thickened ice in the road itself and bounded by snowbanks on either side	
Environmentally Induced	Thermal – rapid air temperature changes
	Pressure Ridges
	Water level changes

dry and re-frozen wet cracks



Re-frozen wet crack

Chapter 5: Design

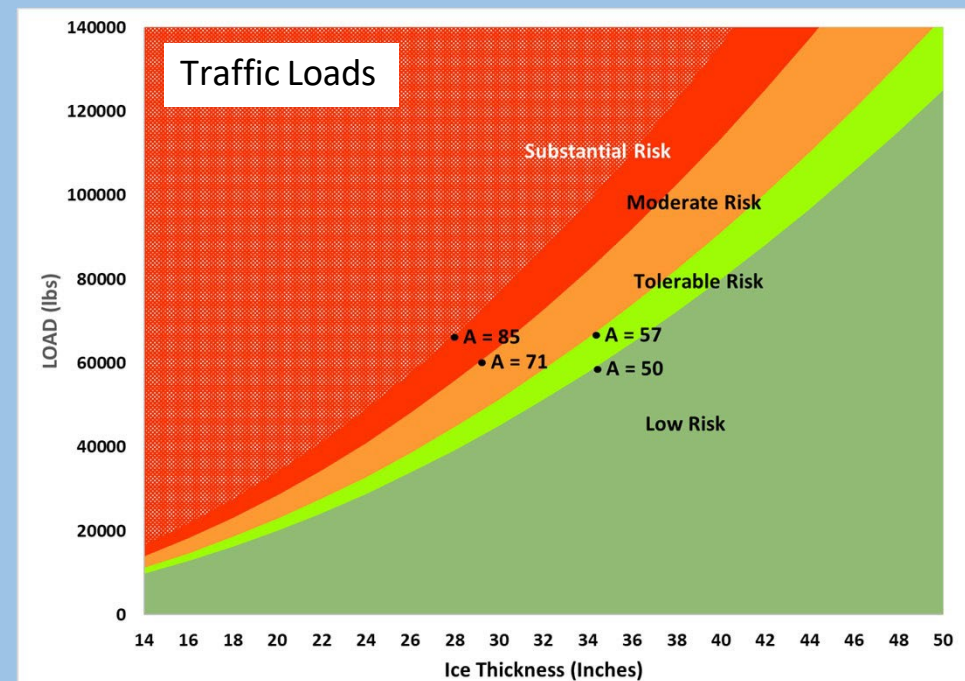
Section	Title
1	Introduction
2	Route selection background
3	Widths and channel bank offsets
4	Route selection for ice roads following rivers
5	Route selection for ice roads crossing lakes
6	Route selection for river crossings
7	Required ice thickness
8	Effective ice thickness

Extreme Loads.

Extreme loads are those over 140,000 lbs. A professional engineer should provide recommendations for required ice thickness and procedures for these loads.

Effective ice thickness requirements for lighter loads

Load/Situation	Estimated Weight (lbf)	Minimum Ice Thickness (Inches)
Person walking	260	4
Snowmobiles (machine + rider)	< 1100	7
3/4-ton 4x4 vehicles	GVW < 11,000	15



Chapter 6: Construction

Section	Title
1	Ice thickness surveying
2	Pre-Construction
3	Construction
4	Suggested equipment
5	Safety features



Pre-Construction
 Surveying the ice thickness during Pre-Construction can be the most dangerous period of the winter season due to the relatively thin and unknown ice conditions.



Road Widths

Operating Vehicles	Cleared width - Between snowbanks	Driving lanes - Total width	Channel Bank Offsets on each side
Light vehicle traffic (11,000 lbs)	65 ft	32 ft	32 ft
Construction (50,000 lbs)	82 ft	50 ft	50 ft
Super B Train (140,000 lbs)	100 ft	65 ft	65 ft

Chapter 7: Signage

Section	Title
1	Purpose and Intent
2	Design
3	Application

Appendix B: Examples of MUTCD Signage

Design

Ice road are considered Low Volume Roads as defined by the MUTCD. Ice road signage shall be designed in accordance with the provisions contained in Part 5 of the MUTCD, "Traffic Control Devices for Low-Volume Roads", and where required, in other applicable parts of the MUTCD.

Application

- Construction Signs
- Entry Signs
- Regulatory and Advisory Signs



SUGGESTED SAFE MAXIMUM WEIGHTS FOR GOOD BLUE ICE			
Safety of ice is not guaranteed Crossings are made at your own risk			
ICE THICKNESS	MAXIMUM GVW WEIGHT		
CM's	INCHES	KG's	LB's
40	16		
45	18		
50	20		
55	22		
75	30		



ATTENTION: WHEN CROSSING WITH HEAVY LOADS
1. Maximum speed 15 km/h
2. Do not pass other loaded vehicles
3. Vehicles to travel at least 1 km apart
4. Max 8 km/h within 1 km of shore to minimize wave action under the ice approaching shore
FOR MORE INFORMATION PLEASE CALL :
1-306-953-3262 - ATHABASCA AREA OFFICE
1-888-335-7623 - HIGHWAY HOTLINE

Examples of Entry Signs Information

- Whether the road or crossing is open or closed
- Maximum allowable Gross Vehicle Weight
- Maximum Speed limit
- Minimum distance between vehicles
- Phone number to call for road information
- Services available on the road, if any
- Advisory on tire chains and survival gear
- Distance to next community

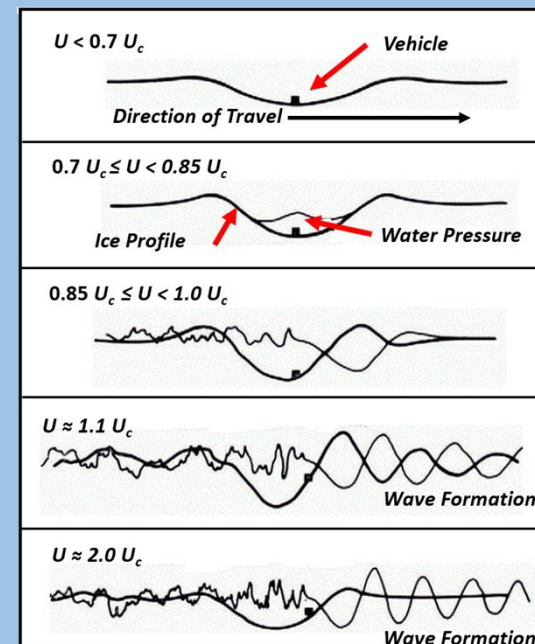
Chapter 8: Vehicle Control

Section	Title
1	Introduction
2	Maximum Speed Limits
3	Minimum distance between vehicles
4	Stationary Loads
5	Load Management

Minimum Distances	
Vehicle Weight	Minimum Distances
Vehicles < 11,000 lbs	660 ft (200m)
Vehicles > 11,000 lbs	1,640 ft (500m)

Stationary Loads:
Stopping or parking of loaded trucks on the ice is always prohibited

Maximum Speed Limits	
Vehicle Situation	Maximum Speed Limit
Vehicle operating at the minimum ice thickness for its weight	15 mph (25km/h)
Vehicle operating at 2 x minimum ice thickness for its weight	25 mph (35km/h)
Approaching or leaving shore access points	5 mph (10km/h)
Meeting oncoming vehicles	5 mph (10km/h)
Passing work crews	5 mph (10km/h)
GPR Profiling	5 mph (10km/h)



Chapter 9: Monitoring and Maintenance

Monitoring Program

A Value	Level of Risk	Visual Inspection	Surveying
50	Low	-At least once every three days, checking of ice quality	Manual measurements every 10-14 days
57	Tolerable	Regular Ice quality monitoring program	Program of regular manual ice measurements
71	Moderate	Daily Ice quality monitoring program	Daily program of regular ice measurements or program for regular GPR ice profiling plus manual ice measurements
85	Substantial – Special Procedures		

Maintenance Program

A Value	Level of Risk	Maintenance
50	Low	- Repairs and maintenance as needed
57	Tolerable	
71	Moderate	- Regular program of repairs and maintenance
85	Substantial – Special Procedures	-Daily program of repairs and maintenance

Conservative estimates of bearing capacity can result in lower allowable loads but require fewer resources for monitoring, maintenance, and administration.

More aggressive estimates of bearing capacity can result in higher allowable loads but require more frequent monitoring and maintenance, and more active administration of the ice road.

Chapter 10: Unmanned Aircraft Systems

Section	Title
1	Benefits and limitations of UAS for monitoring ice roads
2	Open water
3	Freezeup
4	Solid ice
5	Breakup
Appendix A: Use of Uncrewed Aircraft Systems (UAS)	
A1	Types of Small UASs to Support Ice Road Monitoring
A2	Sensor Payloads and UAS Data Products to Support Ice Road Monitoring
A3	UAS Flight Requirements, Operational Considerations, and Recommendations
A4	UAS Flight Operational Considerations
A5	Data Management
A6	Conclusion on UAS for Ice Road Support

Multi-Rotor



VTOL



Fixed wing



Comments?
Questions?





Contact & Program Info

Todd Brockmann- FHWA TTP Tribal Coordinator
(360) 619-7905
email: todd.brockmann@dot.gov

FHWA Office of Tribal Transportation (OTT):
<https://highways.dot.gov/federal-lands/programs-tribal>

Save the Date! November 8-9, 2022
Bethel, Alaska

Ice Roads Symposium



Yupiit Piciryarait Cultural Center



For more information contact:
bgconnor@alaska.edu or vgwolf@alaska.edu