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Road Engineering and Construction Practices for Cold Regions

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COTR: Richard J. Barrows, P.E., Geotechnical Engineer, FHWA WFLHD
Advisory Panel Members: Richard J. Barrows, P.E.; Gary L. Evans, P.E.; Amit Armstrong, Ph.D., P.E.
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16. Abstract

Road Engineering and Construction Practices for Cold Regions CD includes multimedia presentations that describe and explain the principles of science and engineering related to road engineering and construction for cold regions. The contents are presented on 275 pages accessible sequentially or in any order through the use of a sophisticated navigation system. The text is augmented by 159 photographs, 248 figures, PowerPoint® slide shows, clickable Internet links, downloadable software, and 175 complete reference documents. Guest speakers describe cold regions problems and solutions in the "Expert Speaks" series of twenty audio clips and fifteen video clips.

This presentation may be appreciated at several interest levels. Readers with limited cold regions experience can achieve a basic overview of the field by simply reading the text, perusing the photographs, and watching the videos. Professionals seeking in-depth understanding can study the figures, read reference documents, listen to audio clips, download and use software, and explore Internet resources. Continued exposure to the fundamental principles underlying engineering and construction practices will improve one's ability to successfully complete engineering projects in cold regions.

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Road Engineering and Construction Practices for Cold Regions

Technology Deployment Program
Western Federal Lands Highway Division
Federal Highway Administration
610 East 5th St.
Vancouver, WA 98661

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised March 2003)

Foreword

Road engineering and construction practices for cold regions have an evolutionary history. Cold regions are centered around the poles, perhaps down to the 40th parallel; regional exceptions are the northwest coasts of North America and Europe. Common definitions of cold regions are:

- Average temperature of coldest month is below 0° C
- Average temperature of warmest month is above 0° C but not above 10° C
- 150mm (0.5 ft) to 300mm (1 ft) depth of frost penetration
- Communities that spend a substantial amount of money on snow removal

Altitude has a marked effect on the occurrence of a cold region, primarily as it affects climate. Seasonally and permanently frozen grounds are characteristic of cold regions.

The cold regions of the United States and the world represent a unique challenge for engineers. Temperate zone engineering and construction practices may not be applicable. Issues relating to the fundamental principles of heat transfer and the response of unfrozen or frozen ground to cyclic freezing/thawing or a single episode of thawing must be considered.

Over the past several decades design and construction procedures have evolved from relatively empirical approaches to moderately complex applications of engineering science principles and construction techniques. Early road building efforts in cold regions typically involved construction of embankments from the most immediately available material that could be placed. Embankment stability, ground settlement, frost action, and permafrost degradation were not a concern. Coarse-grained materials were available in some locations, but where fine-grained cover deposits were used trafficability, particularly during spring breakup and wetter summer periods, was a frequent problem.

To insure satisfactory performance of roads in cold regions three characteristic modes of distress must be carefully considered. First, distortion (movement) and faulting of roads may occur due to frost heave and thaw weakening in the active layer and also due to thaw degradation of underlying permafrost. Second, cracking may occur in paved roads related to both traffic loading and the cold environment. Finally, disintegration and wear can occur in paved roads due to raveling, moisture susceptibility of the mix, and studded tire traffic loading.

Specialized knowledge is required to successfully complete a project with significant cold regions engineering and construction issues. While it is possible to acquire this knowledge through self-study or short courses, the modern engineering professional may find these modes of information transfer very time-consuming or rigid in presentation structure. The key to successful information transfer for the modern professional is access to knowledge in a user-friendly format.

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Federal Highway Administration
610 East 5th St.
Vancouver, WA 98661

For more information or additional copies
contact:
Amit Armstrong, Ph. D., P.E.
Phone: 360.619.7668
Fax: 360.619.7846
Amit.Armstrong@fhwa.dot.gov