RAILROAD ENGINEERING
UNDER SUB-ARCTIC CONDITIONS

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Railroad Engineering, whether it be in Alaska or Alabama, is divided into three classifications, namely; location, construction and maintenance. Each phase of these activities involves different techniques and during the heyday of railroad expansion (1890 to 1910) there developed almost three distinct classifications of railroad engineers.

PHASE I - LOCATION

The basic and prime importance of a good location needs particular emphasis because the other two phases are dependent upon the engineering decisions made during the original survey and selection of the route.

There are many ways of doing things, usually each person learns only one way and is, to some degree, intolerant of any deviation from the one method he knows. Particularly is this true on the selection and location of a railroad route. Engineers, seemingly without exception, when moved to new and far off locations are prone to locate railroad routes that could be constructed and maintained economically only if the climate and other factors they have previously contended with were duplicated in the new areas.

Generally speaking, the railroad locating engineering has a definite pattern to guide him, as the ideal railroad connecting any two points would be a straight and level line. In all but rare and very exceptional cases such a route could be constructed only at a prohibitive cost, yet the locating engineer must never lose sight of this ideal. He must continually realize that the further he diverges from it the more inferior and inoperable his railroad becomes.

Another factor, and one not so recognizable, is that each feature of work in each geographical location presents separate construction and maintenance problems. Particularly is this true in railroad location in sub-arctic areas where the climate and drainage problems vary so extensively from those encountered in warmer latitudes.

The common practice of establishing grade lines on new construction so that the cuts will equal the fills can no longer be followed. It usually takes several years of experience before an engineer gets acquainted with sub-arctic drainage and snowdrifting conditions and becomes competent in avoiding or overcoming their associated difficulties. If possible, he must "fill everywhere" for drainage and more drainage are the stablizing factors of any roadbed. Such drainage not only involves the creation of artificial channels for the outlet or diversion of rivers, creeks, springs or bank seepages; but also includes the selection and placement of self draining materials required for grade embankments and track ballast.

One of the least recognizable hazards in sub-arctic locations, and one which the engineer is usually unfamiliar with is the prevailing low temperature of running water. Along the northern tier of states, just south of the Canadian boundary, the average temperature of ground water varies from thirty seven to forty two degrees fahrenheit, but north of the Alaska Range, in the Yukon Valley, the temperature of ground water, even in the summer, rarely exceeds thirty four degrees and during the winter only a fraction of a degree above freezing. Under such conditions, especially if the temperatures of the atmosphere are below zero, water readily turns to ice thus blocking its flow channels and causing no end of trouble.

Before any location line is run, the purpose of the line must be defined. If it is to be used as a haul road for ore or coal from the interior to a sea port, or serve as a feeder to Military installations in the interior, or even if it is to be used as a service route for tourist travel, it is essential to know the purpose of the line because the grades should be established in harmony with the direction of the payload haul. An estimate of the train speed likely to be required is also a prime requisite in establishing maximum curvature.

If the route is to be used exclusively for a one way haul, it is obvious that much steeper raising grades can be operated on in the direction of the empty haulage, and the initial construction cost of the line reduced considerably by such pre-planning. A subsidiary study and selection of the most economical limitation of the greatest degree of curvature must also be arrived at. Where ruling grades must also be considered in conjunction with curvature, a reduction in elevation of 0.04 ft. per degree of curvature for each 100 ft. of such designed curvature must be made to compensate for wheel flange resistance on uphill hauls. If, for example, a ten degree curve has been selected on 2.2 per cent grade line, the grade should be reduced to 1.8 percent through that 10° section.

One of the greatest hazards to railroad location in sub-arctic areas is the overlying non-drainable mass of semi-decayed vegetation, commonly referred to as "Tundra" that covers at least 90 percent of the entire area of Alaska. Its blanketing mass which varies in depth from one to ten feet, is not confined to flat ground. It can be found on fairly steep hillside slopes and, because of its putty like texture, is undrainable and has exceptionally low embankment bearing qualities. It is astounding to note that so many of our government maps and drawings give no indication or information on the presence and location of this wet and unstable blanket. North and west of the Alaska Range, a great portion of this tundra muck remains frozen. Summer sunshine, though lasting twenty hours a day, only thaws the top layers to a depth of one or two feet. The locating engineer must try to avoid the selection of a route where the tundra problem is intensified. The use of caterpillar bulldozer for investigating its depth and prospecting for suitable borrow material to make those "fill everywhere" embankments is an essential tool of the sub-arctic railroad locater.

In mountain passes, which invariably act as spillways for cold masses of air seeking equalization between adjacent valley areas, there is likely to be one side of a pass that is less subject to snowslides or snowdrifts.

When selecting a railroad route through a pass it may be necessary to follow through on one side at a slightly higher elevation than the top or middle of the pass, which should be avoided if possible because of snowdrifts being more prevalent in a central location.

As most location work is done during the summer when snowslides and snowdrifting conditions cannot be observed, the locating engineer and his assistants must be on the alert for after signs of same. Patches of late and retarded vegetation growth indicate that snowdrifts have lasted late in the spring. Usually in snowslide country where there are small trees and brush, there will be patches of ground where unthawed slide deposits have retarded vegetation growth and left telltale deposits of dead leaves, small rocks, twigs and dry grass which show where the drifts or slides thawed out and left their winter gatherings.

Usually the paths of snowslides from high mountains can be readily observed, except the jump type, which occurs where a long steep snow covered slope has a slight uprise near its base which hurtles the fast traveling snowslide out and farther down the slope like a skier making a long distance jump. During the gold stampede to the Klondike in 1898, a large group of fortune seekers camped one night in an open clearing at the foot of a steep snow clad mountain. They felt quite safe in this camp location as a thick line of high old growth trees and dense foliage rimmed this clearing between them and the toe of the mountain, indicating to the inexperienced that no slides had ever occurred there or the trees, many of which were over two hundred years old, would have been knocked over by the avalanches. But next morning when the sun thawed the snow on the high mountain slope, a huge slide occurred, the outer fringe of which jumped out and over the tree tops burying and killing over eighty stampeders in the clearing below. In mountainous country, the locating engineer must investigate the reason or cause for any bare or spruce growth areas he encounters.

Subsidiary to avoiding snowdrifts and snowslide locations, the locater must also avoid placing the line where small bank glaciers are likely to form and cover it during the winter months. Usually such icing occurs where grade benches have been cut in the solid rock along the toe of a steep mountain and where small seepage channels in the rock are exposed to the winter atmosphere. The constant cost of ice removal at such locations must be avoided if possible by locating the line on a fill away from the toe of slope.

Cluverts and cross drainage facilities that have a limited flow capacity should be included sparingly in the location plans. Instead 4 bent 3 span pile trestle bridges should be installed on original construction where the ultimate flow of the streams cannot be observed. By the time these small bridges need replacing sufficient flood flow observations should have been made to enable the maintenance engineer to select a culvert size sufficient for all emergencies. In valley locations where such bridges are required across the tributaries to large rivers subject to spring ice jams, the engineer must select a location for same as far up from their junction point as possible. The backflow of upstream action of damming ice from the main river can easily push aside any piling bents and destroy such bridges. Special studies must also be made for bridge locations at each major river crossing. The elevation of the highest high water mark must be obtained at each bridge location.

In mountainous country the locating engineer will encounter places requiring tunneling. A careful study for likely snow or rock slides at each tunnel portal location is required. It must also be noted that, unless the proposed tunnel location is through a well drained rock ridge, there is a big possibility of tapping rock seepages that drip from the tunnel roof or ooze from its sidewalls causing no end of icing trouble.

The constant maintenance expense of removing tunnel ice, or heating the tunnel to prevent its forming, plus the cost of employing doormen and the expense of building and operating heating plants for at least six months each year, needs deep consideration. The engineer must try to avoid, even at a much larger initial expenditure of money, such wet tunnel locations.

PHASE 2 - CONSTRUCTION

Actual construction under sub-arctic conditions that embrace the movement of earth, gravel or rock quantities is generally confined to the one hundred and thirty frost-free days between the end of May and the middle of October. As almost constant daylight prevails during this same period, double 10 hour shifts can be worked each day to great advantage. Considerable preparatory work such as the hauling and distribution of equipment, tools and supplies, also the building of camps and access roads can be done during the preceeding months.

Associated with the seasonal limitations of actual construction activities caused by cold weather, are further retarding factors of non-accessibility to the work sites. Most of the existing railroad routes in North America, including those in sub-arctic locations were built by hand labor. It was comparatively easy, once the line was located, to distribute men with the then light construction and camp equipment along its route. The rapid results of such widely distributed labor can not be equaled, except at a prohibitive cost, in this modern age of elaborate camp facilities and the use of heavy duty construction equipment.

The rugged living conditions endured by the workmen, and their corresponding accomplishments on the construction of The Alaska Railroad from 1915 to 1923 deserves special mention and recognition. Tents without floors, pole bunks covered with wild hay for mattresses and no bedding (you packed your own) were the accommodations then available. There was no smiling camp steward to direct the new arrivals to their quarters. The new arrivals generally had to provide and build their own. At some locations along the access winter trails or tote roads, crude log houses chinked with moss were hastily constructed. Roofs on such houses were made of strong poles laid with very little pitch or slope, then covered with birch bark, hay and moss and capped with an overall covering of two or three feet of top soil or earth. Door hinges were ingeniously made out of bent nails or leather from old boot tops, and homemade wooden latches held the doors shut. Alaska was then a land without locks or policemen. Empty flour sacks covered the openings where windows should have been. Such trail accommodations were a combination store, cookhouse, dining room, social hall and bunkhouse.

The bunks were built out of poles like honeycomb cells at both ends of the building, similar in arrangement to postoffice boxes. They were usually four feet square and eight feet in depth and were aptly called "Muzzle Loaders". The extra two feet of depth was for duffel storage. Two coal oil lamps suspended from the ceiling provided illumination to the travelers gathered around the central heating stove or who climbed up and down the crude ladders to their muzzle loading bunks. One should not claim to be an Alaska Railroad pioneer unless he has spent at least one night in a "Muzzle Loading" bunkhouse.

Though the greater part of The Alaska Railroad was built on top of tundra covered ground, there were many miles of heavy rock work excavation and tunneling. The construction of the 30 miles of grade between Kern and Potter along the shoreline of Turnagain Arm during the work season of 1917 was an achievement of hand work which could not be done in the same time today with modern machinery. During the five month work season, over four million cubic yards of solid rock were hand drilled and hand excavated at an average cost of $1.35 per cubic yard. One shudders to think of the amount of the contract bid that would be tendered today for the same work if it were required to be completed in the same short period under similar difficult transportation and inaccessible construction conditions.

It is revealing to know that the men who did this station contract work were mostly European immigrants who had not yet obtained U. S. Citizenship status. The major railroads built across the American Continent were the products of the Irish Shovel Stiffs. In a similar manner, it was the Scandanavians, the Russians, Greeks, Italians and Slavonians - yes, and the Irish, who with axes, mattocks, hammers, drills, spike mauls and track gauges, did the real actual work of building the Railroad in Alaska.

Associated with, and by no means a minor factor in the overall Alaska Railroad construction program, was the problem of bridging the numerous streams and rivers that had to be crossed. It is astounding to realize that of the 420 miles of main line extending from Seward to Fairbanks, eight and one-half miles are still on bridges.

Most of the original spans were wood structures, though the major river crossings, such as Gold Creek, Hurricane, Riley and Tanana Rivers, required especially designed steel structures. These steel bridges, built between 1917 and 1923, are still in service and are monuments to the ingenuity of the men who designed and erected them.

On many miles of the original construction, where fill material was not readily available to make the required embankments across deep swamps or long hollows, temporary pile trestles were built out of native lumber obtained from the forests near the jobsites. These trestle sections were later filled by train hauling the required embankment material from convenient borrow locations. Pile driver and bridge erection crews were exceptionally competent in those times. Scotty Parks and a crew of ten men with a pendulum lead type, 4200 lb. drop-hammer pile driver drove and capped 16 5-pile bents, totalling 80 pilings in one single 8-hour shift. All piles were driven to refusal with an average ground penetration of 10 feet. One third that amount of work today with the same number of men, plus modern and improved pile driver equipment would be considered an exceptional day's work.

PHASE 3 - MAINTENANCE

The engineering problems on the maintenance of a railroad bed and its associated structures under sub-arctic conditions are invariably intensified by the original poor selection of embankment materials. No intensification of roadbed drainage or stabilization work can thoroughly correct such original errors. The Alaska Railroad has spent many millions of dollars in such efforts because the original grade builders made no attempt to clear away the tundra and gumbo muck before placing fill or embankment materials. On many sections of line they succeeded only in laying the ties and rails on top of these deposits by placing miles of corduroy or puncheon. The maintenance of a roadbed superimposed on such foundations has, and will be, a continuous source of expense.

It has been found that the normal winter penetration of frost in ordinary pit run gravel having 25% air voids is from three to five feet deep depending on its structural compaction and the back infiltration of muck or moisture from its underlying or adjacent deposits. Where the tundra and glacial deposits of muck and clay lie within the region of frost penetration, frost action expands them in proportion to their water contents. As the expanding action is always irregular and upwards, the overlying railroad tracks become warped and buckled, necessitating the insertion of wood shims between the cross ties and the base of rails to level up the track for the safe passage of trains.

Two solutions have been found for the elimination of frost heaves: (1) Dig out the underlying deposits of tundra or glacial muck, backfill with clean gravel and provide such backfilled sections with ample drainage. (2) Raise the track on clean gravel or other voided material two to three feet, or sufficient to prevent the winter frost from penetrating to the underlying water saturated deposits. This last method has been found most practical because it permits extensive action over a long stretch of track and automatically improves drainage and snow removal problems. The dig out and backfill method can best be used on isolated short sections of frost heaving, or where the ruling grade line cannot be raised because of overhead tunnel clearance or other reasons.

Another constant sub-arctic maintenance factor in the nature of track settlement is caused by the underlying deposits of permafrost and associated ice lenses thawing out after the natural insulation of dead grass, leaves and matted roots have been removed. On The Alaska Railroad from Healy to Fairbanks where the winter temperature sometimes reaches 72° below zero, and 25° below zero is considered a fairly warm winter's day, the line passes through rolling valley country most sections of which are underlaid with permafrost and ice lenses. The average depth of the summer thaw on tundra covered ground is only one or two feet; consequently embankments of gravel placed on top of these permanently frozen areas are always thawing and settling during the hot summer season when the thermometer climbs to plus 98° or better. Such gravel embankments warm up under the almost constant summer sunshine and act like a hot poker laying across an ice cake. Hundreds of thousands of cubic yards of backfilling and grade raising material have been used and the settlements of the tracks partly stopped on the 112 mile section of line.

A somewhat different form of settlement has been occurring on the ten mile section of track through the Nenana River Canyon between McKinley Park and Healy. In this area the grade bench foundations have been thawing out since the original excavation, in 1917, removed the natural insulation and altered the established drainage pattern. In several places, especially in gumbo filled hollows or draws, the entire slope for half-mile or over, both above and below the tracks, has slid, sometimes at the rate of six inches per day, down and outward toward the river. Such settling and sliding action only occurs during the frost-free period of the year. No permanent solution within economic limitations for stabilizing these areas has yet been found. Rail traffic at reduced speed can be maintained only by constantly adding ballast and raising and relining the tracks. Ditchers or similar excavating machines must also be used to "cast over" the slides from above the tracks.

Also allied with track heaving and distortion of the rolling surface of the rails is the lifting effect deep frost has on bridge abutments and piling. Although every attempt is made during construction to get the foundation of bridge piers, piling bents and abutments into the ground as far as possible, the process of frost penetration plus frost adhesion, lifts them out. When the first frost occurs it forms a top crust that unites with the piers or piling. As the crust gets thicker and the freezing ground below it expands upward, the crust attached to the piling or concrete structure has such gripping power that the bridge bents and abutments are lifted off their original foundations and the bridge surface consequently distorted. Piling and telephone poles set in ground that freezes to any great depth are lifted up from four to six inches annually by such subterranean frost expansion. Some prevention of such heaving can be done by backfilling against the piers or abutments with screened gravel whose rounded particles, when frozen, do not adhere strongly to the concrete.

Snow removal from the tracks and subsidiary facilities also contributes to sub-arctic maintenance problems. Through the Broad Pass which, because of its width (5 miles) and its low elevation (2,363 feet), acts like a spillway for the heavy cold masses of air that collect north of the Alaska Range in the Yukon Valley. The periodic winds that blow in this section drift the snow in long ridges. Winter temperatures range from 10 to 60 degrees below zero in this section. Spreader type plows have to be operated almost constantly during most of the winter to keep the line open. Even small drifts, 8 to 10 inches deep, if allowed to remain on the tracks soon become almost as hard as solid ice. Small pellets of snow, as they are jostled and blown around with the wind, collect static electricity. When the pellets are drifted along, some of the most supercharged ones find catch places and immediately weld themselves to the mass below and around them. Heavy locomotives have been derailed by such hard drifts that appear so small and of no consequence.

Another hazard to sub-arctic train operations on The Alaska Railroad has developed with an increase of the moose herds. These wild animals, some of them weighing 1200 pounds, get onto the snow cleared railroad tracks and refuse to leave them on the approach of trains. It is assumed that the moose, whose prime enemy is the wolf, gets the impression that the big snorting locomotive is of the same breed and that his only chance to get away from such a ferocious wolf is to outrun him where the running is good. Mr. Moose knows from long experience with wolves that if he gets into deep snow where his leg action is hindered he is playing into the wolf's hand, so he naturally tries to outrun him in the area clear of snow where he has a chance to use his feet. Numerous attempts, without results, have been made to give the moose escape paths by bulldozing runoffs through the adjacent snowbanks. Bridge decks have been covered over with metal plates to prevent the moose from getting their legs down between the bridge ties. Such installations seem only to lengthen the chase. During last winter, over 350 moose were killed by The Alaska Railroad trains and no end of expensive delays and traffic interruptions were caused by these animals. It is not possible to fence them out. Ranchers in the Matanuska Valley state that moose are totally oblivious to the highest barbed wire or metal fences. They invariably walk right through them.

Associated with the extreme cold and winter maintenance conditions is the consequent reduction of locomotive traction power in proportion to the falling of the thermometer. No reduction of haul tonnage for cold weather is made down to zero. From zero to 20° below, the load must be lightened by 15%; to 40° below, 20%; and when the thermometer registers to 60° below, the load must be reduced by 40%. Other retarding factors caused by sub-arctic conditions must be noted. Maintenance of way workmen, I mean those section hands who keep the switches and road crossings clean of snow or who patrol and shim the tracks and replace the broken rails, have to bundle up to protect themselves from the cold which reduces their working efficiency. Oil, in extremely cold weather, fails to flow freely and lubricate the machines; all metals become more brittle and consequently break more readily. Daylight is only for a few hours around mid-day. The problems of locating, constructing and maintaining a railroad under such conditions are both numerous and expensive.

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2/26/64
(Re 4/28/67)