Alternate Methods of Supplying the Oregon Coast with Construction Aggregates

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ALTERNATE METHODS OF SUPPLYING THE OREGON COAST WITH CONSTRUCTION AGGREGATES

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INTRODUCTION

Impending shortages of high-quality aggregates in areas along the Oregon coast have forced users to search for new sources of supply. A number of feasible methods exist for supplying the affected areas. Three of these alternatives are: (1) importation, either by truck, rail, or barge; (2) the use of good-quality dredged rock; or (3) the use of abundant supplies of low-quality or marginal aggregates, including low-quality dredged materials combined with admixtures to improve performance.

This report evaluates these alternatives in terms of energy, economics, and environmental consequences. Advantages and disadvantages of each method and cost comparisons are included as an aid to planning and decision making.

METHODS OF SUPPLYING AGGREGATE

Importation

The shipment of bulk materials over short distances is normally by truck. The existence of an extensive roadway network gives truck transport a major advantage over other modes: the ability to dispatch small tonnages of materials to widely dispersed geographic points.

A major disadvantage of truck transport is its high energy intensity. Energy intensities for the transport of bulk materials by truck, rail, and barge are given in Table 1. Transporting bulk material by truck consumes

Table 1. Energy intensity by transport mode

Transport mode	BTU consumption per route-ton-mile
Truck	2500
Rail	430
Barge	481

Source: Reference 1

five times as much energy as rail or barge. At the present time, significant quantities of aggregates are being imported to coastal areas from sources in the Willamette Valley. As a consequence, large amounts of fuel are required to transport these materials. Table 2 shows estimates of the amounts of

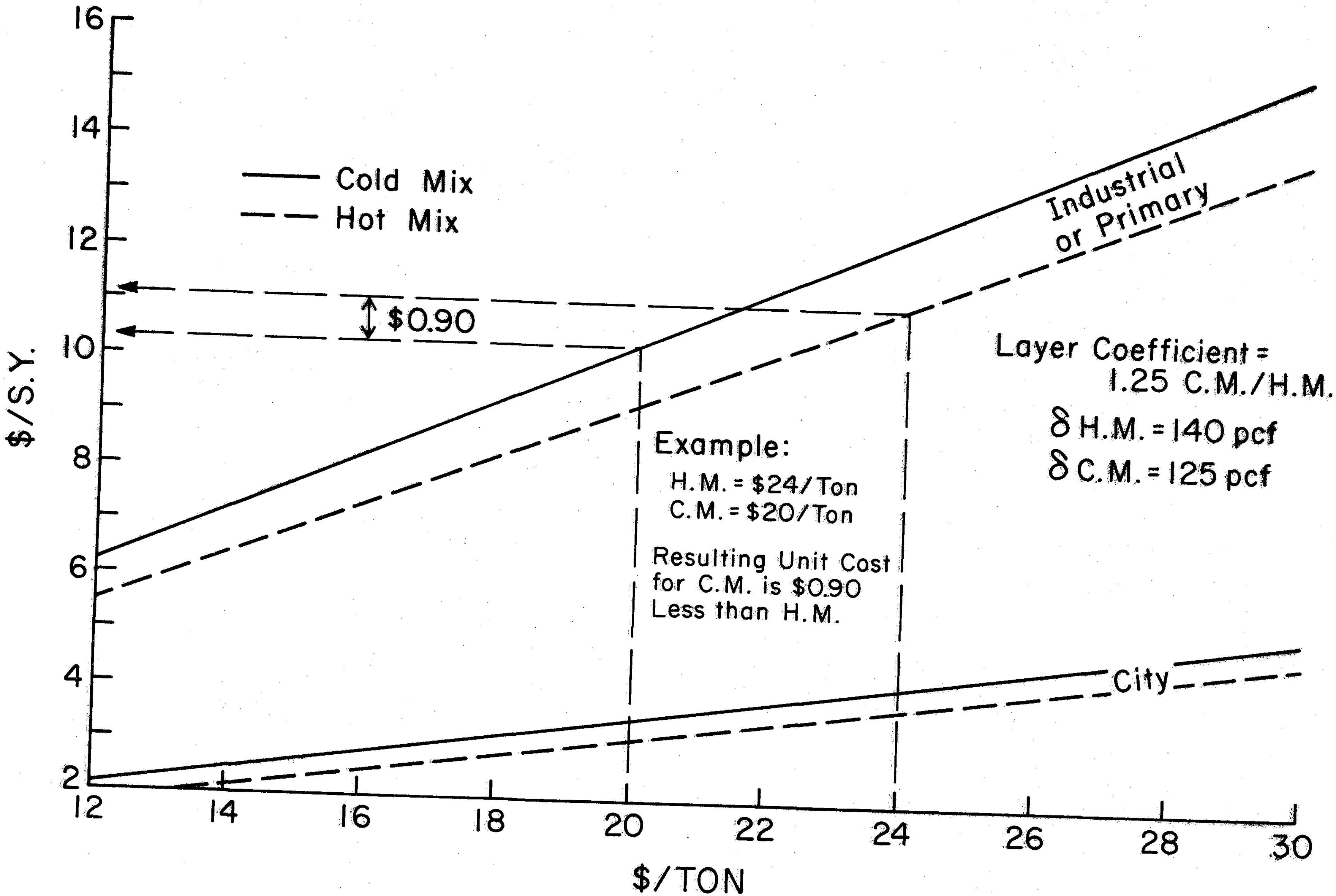

Figure 3. Comparison of Unit Costs for Hot Mixed Asphaltic Concrete and Open Graded Asphalt Emulsion.

aggregates imported, and the associated fuel consumption, for areas along the Oregon coast.

Rail transport is commonly employed to transport large amounts of bulk materials over long distances. A major barrier to rail transport in areas along the Oregon coast is the lack of an extensive rail system. Figure 1 depicts the present Oregon rail system. It can be seen that the system is not sufficiently developed to provide adequate distribution to most areas along the coast.

The determination of haul rates for goods transported by rail has evolved into a complex task. A multitude of factors may enter into the determination, including origin, destination, haul distance, class rating, topography, type of equipment, number of rail lines involved, turnaround time, and percentage of empty backhaul. Typical haul rates for the transport of aggregate from Portland to coastal counties are shown in Table 3. These are not specific;

Table 3. Rail rates on rock, sand, and gravel from Portland(1)
(Source: Reference 3)

To: County	To: Representative railhead	Miles (2)	Rate (3)	Min. weight (lbs)	Revenue ($)	Cents per ton-miles
Clatsop	Astoria	100	61	80,000	488	12.20
Tillamook	Tillamook	121	67	80,000	536	11.07
Lincoln	Toledo	152	74	80,000	592	9.74
West Lane	Swisshome	173	78	80,000	624	9.02
Douglas	Roseburg	198	81	80,000	648	8.18
Coos	Coos Bay	245	92	80,000	736	7.51
Curry			No railroad			

(1) Rail rates based on Class 13, 80,000 lb-min UFC 13 + NPCFB/PSPB Freight Tariff 1016.

(2) Distances based on SP Tariff 420.

(3) Rates in cents per 100 lbs.

a rail haul rate can be established only by a request from an individual railroad company. A comparison of truck and rail haul rates for aggregates

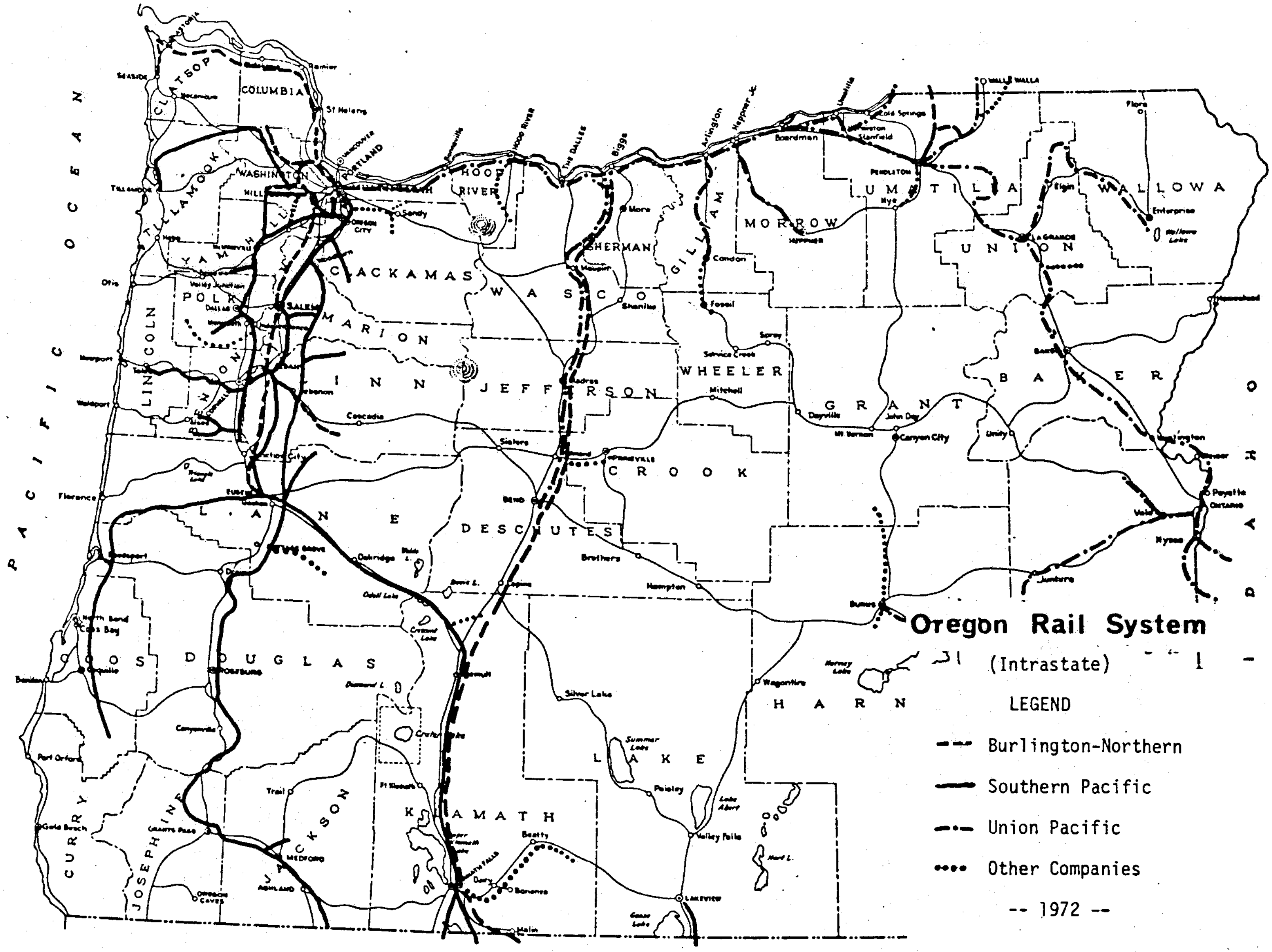

Figure 1. Oregon Rail System. Source: Reference 6.

over selected routes is provided in Table 4. The haul rate for rail transport is favorable for only the longest routes.

Barges offer the most efficient means of transporting bulk materials to areas that are close to navigable waterways. The principal disadvantage is that both loading and distribution points must be on waterways. Barge transport is normally combined with another mode to provide the required service because producers and users are rarely both located near docking facilities. Favorable weather conditions are required for the safe transport of barges, and their movement is generally slower than other modes. Another disadvantage is a lack of flexibility needed to adjust to rapid changes in output.

Advantages of barge transport include low energy intensity, relatively high manpower productivity, and low cost of service per unit of commodity carried. Barges have the potential to move very high tonnages of material. The size of the barge that can be used depends on the size of the locks and towing restrictions of the waterway used. For example, the locks at Oregon City limit the barge payload to 750 tons (2). Rates for commodities (such as aggregate) are determined by the barge company on the basis of the nature and quantity of the material, the points of origin and destination, distance, whether the haul is upstream or downstream, lock and channel limitations, and any applicable local regulations. Barge transport costs range from $0.0006 to $0.015 per ton-mile or higher (2,4,5). These relatively low haul rates may be offset to some degree by the multihandling costs incurred when interfacing with another transport mode. Large investments may also be required to provide modern storage, loading facilities, and vessels.

Increasing environmental concern has restricted the development and use of new and existing aggregate sources along the Oregon coast. This concern has also generated some important considerations for the transport of aggregates. Trucking, the dominant mode of aggregate transport, generates the greatest number and range of environmental complaints. Principal areas of concern include public safety and inconvenience, noise and vibration, air pollution, and visual obstruction. Environmental concerns associated with rail transport include safety, noise vibration, and dust. The primary environmental disadvantages attributed to barge transport are a result of activities affecting river and shoreline areas because of the construction and maintenance of river channels and lock facilities. Activities such as dredging channels, construction of dikes, and channelization can all have significant adverse effects on river and estuary environments.

Dredging Quality Rock

Dredging operations are performed either to create or maintain navigational waterways or to mine bottom material for commercial use. The Umpqua River is the principal source of good-quality dredged rock used for commercial purposes supplying the central Oregon coast. The Rogue River is also considered a potential resource for significant quantities of good-quality aggregate. Other sites lack either the quantity or the quality of aggregate required to foster their development for commercial purposes. However, low-quality materials dredged to improve navigation offer a potential use for

Table 4. Comparison of truck and rail haul rates for rock, sand and gravel

From Portland to	Distance: Railroad (miles) (1)	Distance: Highway (miles) (1)	Rail class rate (¢ per ton-miles)	Truck rate (¢ per ton-miles) (2)	Rail haul rate ($ per ton)	Truck haul rate ($ per ton)	Difference in truck rates from rail rates (% per ton)
Astoria	100	95	12.20	5	12.20	9.50	2.70
Tillamook	121	74	11.07	5	13.40	7.40	6.00
Toledo	152	121	9.74	5	14.81	12.10	2.71
Swisshome	173	147	9.02	5	15.61	14.70	0.91
Roseburg	198	177	8.18	5	16.20	17.70	-1.50
Coos Bay	245	212	7.51	5	18.40	21.20	-2.80

(1) Source: Oregon official highway map.

(2) Developed from these operating costs:

Rural: ($40/hr)(trip/26 tons)(hr/25 miles) = $0.05/ton-mile.

Urban: ($28/hr)(trip/14 tons)(hr/15 miles) = $0.13/ton-mile.

road construction if upgraded.

Upgrading Marginal Aggregates

In addition to low-quality dredged materials, there are several other types of marginal aggregates found in abundant supply along the Oregon coast that can provide satisfactory performance if upgraded. The most important are marine basalts, sandstones, and sands. Each of these aggregates have quality deficiencies that preclude their use under normal design circumstances. The problems associated with these aggregates are summarized in Table 5. For a more thorough examination of these problems, see Construction Aggregates Available Along the Oregon Coast, Oregon State University Extension Service Special Report 614.

Table 5. Marginal coastal aggregates and associated problems

Type of Aggregate	Problem
Marine basalt	Low resistance to chemical degradation
Sandstone and siltstone	Low resistance to mechanical degradation
Sand, beach, and dune	Low stability because of poor gradation environmental restrictions
Low-quality dredged materials	Poor gradation Possibility of high organic content

Various methods are used to upgrade marginal aggregates (see Upgrading Marginal Aggregates for Road Construction Along the Oregon Coast, Special Report 615, hereafter Upgrading). The most important is admixture stabilization, a process in which small quantities of a second material are mixed with the aggregate to improve road construction performance by increasing the strength and the volume stability. Table 6 summarizes recommended stabilization methods for Oregon's coastal aggregates. For discussion of treatment levels and methods for upgrading marginal aggregates, see Upgrading.

Table 6. Summary of recommended stabilization methods for Oregon's coastal aggregates

Material	Stabilization method
Marine basalt	Asphalt emulsion Portland cement
Sandstone and siltstone	Portland cement
Sands	Asphalt emulsion Portland cement Lime-pozzolan
Low-quality dredged materials	Portland cement Lime, lime-pozzolan

COMPARISON OF SUPPLY ALTERNATIVES

Environmental Consequences

The use of marginal aggregates would achieve favorable environmental impact both by reducing the need for transporting aggregates over long distances and by slowing the growth in demand to develop new aggregate sources. Supplies of these aggregates are available in existing rock quarries, but they have not normally been used because they do not meet minimum specification requirements. Low-quality dredged materials are currently either dumped at sea or used as landfill. Using these dredged materials would eliminate the costs and adverse environmental consequences associated with their disposal.

Economic Comparison

The cost of transporting aggregates over long distances (50 miles or more) can be a significant portion of the overall cost of constructing the pavement. The cost of constructing pavements that use cement-treated bases made with marginal aggregates versus those constructed with a regular base section of quality aggregate is shown in Table 7. The pavement section constructed with the regular base is the least expensive option. However, if transportation is required to supply the quality aggregate, this option is less attractive. Figure 2 depicts the increase in unit cost attributable to the marginal cost of transporting the aggregate by truck over various distances. By combining this information with the data given in Table 7,

Table 7. Unit pavement costs for C.T.B. and regular base

Aggregate type	City street					Industrial or primary highway				
	Thickness			$/S.F. 100,000 ft^2	$/S.F. 10,000 ft^2	Thickness			$/S.F. 100,000 ft^2	$/S.F. 10,000 ft^2
	A.C.	Base	C.T.B.			A.C.	Base	C.T.B.		
Quality	3"	9"	-	0.96	1.10	6"	26"	-	1.75	1.78
Ocean Lake quality basalt	3"	-	6"	1.06	1.14	6"	-	14.5"	1.97	2.06
Eckman Creek marginal basalt	3"	-	6.5"	1.10	1.18	6"	-	15.5"	2.03	2.12
Marginal sandstone	3"	-	6"	1.06	1.14	6"	-	14.5"	1.97	2.06
Dredged materials	3"	-	7.5"	1.18	1.27	6"	-	18.0"	2.19	2.28

Source: Reference 6

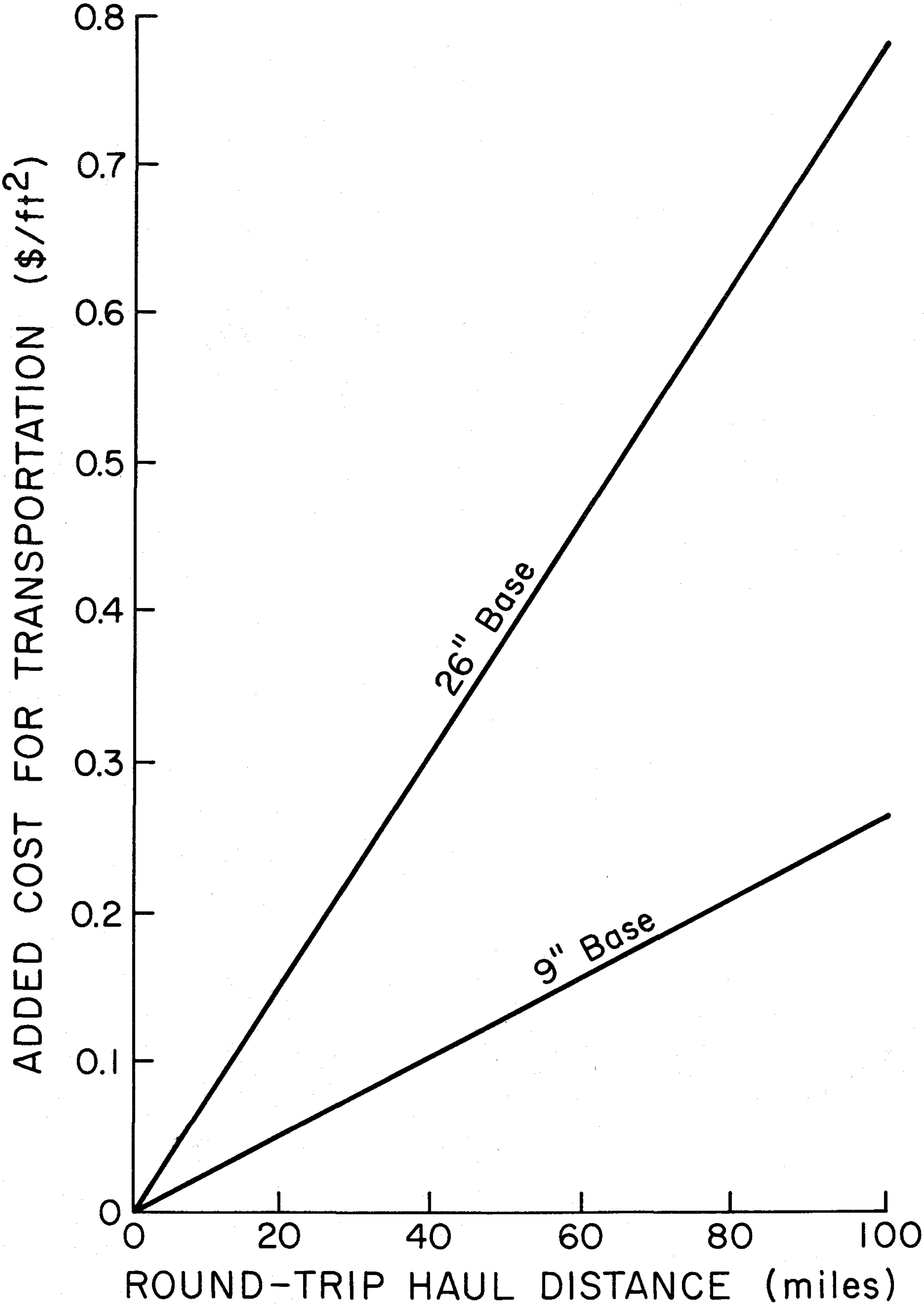

Figure 2. Truck Transportation Costs.
(Source: Reference 6)

Table 2. Analysis of number of trips, amount of fuel consumed in importing aggregate along the coastal area

County	Source	Distance (miles) (1)	Type of materials imported	Amount (tons)	Number of trips required		Approximate fuel consumption of average speed of 30 mph (miles/gallon)	Approximate amount of fuel consumed per trip (gallon/trip)	Total amount of fuel consumed (gallon)	
					Dump truck (2)	Truck with trailer (2)			Dump truck	Truck with trailer
Lincoln	Corvallis to Newport	54	Asphaltic concrete	40,000	2857	1538	6	9	25713	13842
			Sand and gravel	80,000	5714	3077			51426	27693
Western Lane	Eugene to Florence	61	Asphaltic concrete	15,000	1071	577	6	10-17	10892	5868
			Crushed rock	45,000	3214	1731			32686	17604

(1) Source: Oregon official highway map.
(2) Based on 14 tons per trip for dump truck and 26 tons per trip for truck with trailer.

total unit costs can be determined for various pavement sections and haul distances. For example, a 100,000 sq. ft. area of pavement constructed for a primary highway using a good-quality aggregate on a regular base section (26") with a round-trip haul distance of 28 miles will have a unit cost of $1.97/ft (1.77 + 0.20). This cost is just equal to the cost of a pavement section constructed using a marginal basalt on a cement-treated base. For the design conditions described above, the pavement section constructed using the marginal aggregate will be the most economical choice if the haul distance for the good-quality aggregate exceeds that for the marginal aggregate by 28 miles or more. Similar calculations can be made to evaluate the economic feasibility of using local supplies of marginal aggregates.

Marginal aggregates (basalts) can also be used in open-graded, asphalt-emulsion pavements (see Upgrading). Transportation costs are reduced if local materials are used in the pavement, as demonstrated in the above example. In addition to the savings resulting from reduced transportation costs, asphalt emulsion (or cold mix [C.M.]) pavements are generally more economical than hot mix (H.M.) pavements. Prices vary depending on the job, but cold mix prices range as low as $6/ton less than hot mix. Cold mix also has a lower unit weight than hot mix (125 pcf vs. 140 pcf.). The lower price per ton and unit weight of cold mix is partially offset by a higher layer equivalency: cold mix has a layer coefficient of 1.27 when compared with hot mix (7). Figure 3 demonstrates the resulting costs per square yard when all three of the above factors ($/ton, unit weight, and layer equivalencies) are combined. For the example cited in Figure 3, cold mix costs $0.90/S.Y. less than hot mix when prices for cold mix and hot mix are $20/ton and $24/ton, respectively.

SUMMARY

Three methods of supplying aggregate to the Oregon coast are available: (1) importation, (2) dredging quality rock, and (3) upgrading marginal aggregates. These methods exhibit various advantages and disadvantages when compared on the basis of energy, economics, and environmental considerations. Alternatives that require a minimum of transportation and that use existing supplies of aggregate will hold an undisputed advantage over other methods.

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