Construction Aggregates Available Along the Oregon Coast

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CONSTRUCTION AGGREGATES AVAILABLE ALONG THE OREGON COAST

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INTRODUCTION

The natural reserves of high quality construction aggregates found along the Oregon coast are being depleted. The impending shortages are compounded by restrictions being placed on existing aggregate sources because of energy, economic, and environmental considerations, and zoning regulations. A current solution for the shortage is to import quality aggregate from areas that have more abundant reserves, such as the Willamette Valley. Figure 1 shows the amounts of aggregate imported to the Oregon coast from various sources, usually by truck. As this practice is both costly and energy-intensive, alternative sources of aggregate must be identified. As abundant supplies of lower-quality aggregates can be found near the Oregon coast, one alternative is to use these lower-quality, or "marginal," aggregates for construction purposes, particularly for road building materials.

The purpose of this paper is to identify the general types and extent of aggregates available along the Oregon coast. An evaluation of the important characteristics of the aggregates and the problems associated with their use in construction is also provided.

EVALUATION OF AGGREGATES

Evaluation of an aggregate can be accomplished in many ways depending on the material properties being characterized. Of interest to the road builder is the sample gradation and the mechanical and chemical durability of the aggregate.

A grain-size analysis is used to determine the gradation of an aggregate. Aggregate gradation affects the density and stability of the material.

Various durability tests for construction aggregates are in use in the Northwest today. These tests and typical minimum requirements for each are shown in Table 1. A good-quality aggregate will pass the minimum durability test requirements for any or all of these methods. Good-quality aggregates are often used for purposes where low-quality aggregates would be sufficient. When high-quality rock is not available, aggregate specifications can be written to allow acceptance of lower-quality, "marginal" aggregates. The use of the term marginal implies a range in acceptable values for durability falling below the normal minimum specification. Classification of an aggregate as marginal would indicate that special design considerations would be required for use on road construction. (See Upgrading Marginal Aggregates for Road Construction Along the Oregon Coast, Oregon State University Extension Service Special Report 615, hereafter Upgrading.)

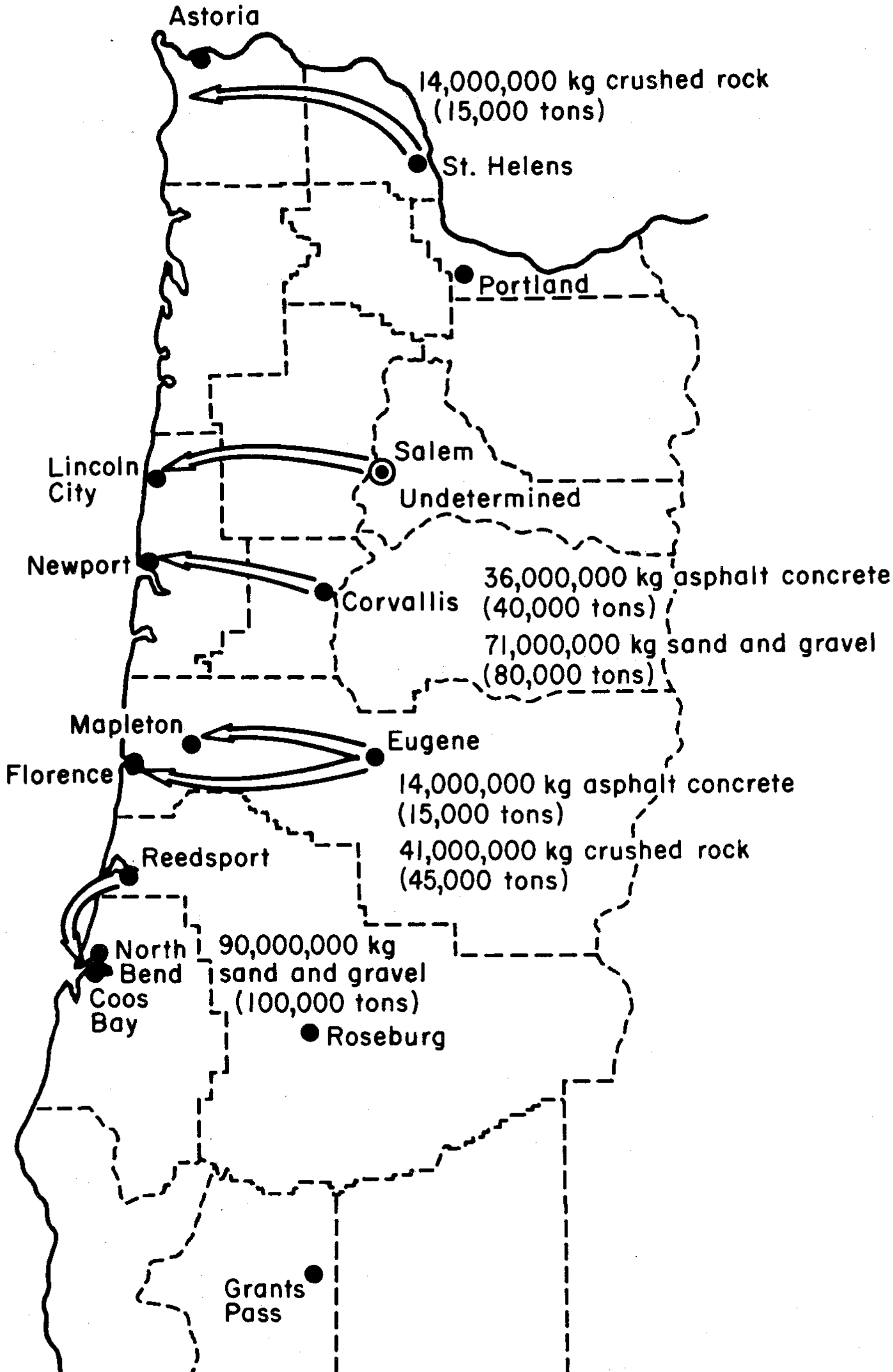

Figure 1. Annual Aggregate Importation to Coastal Oregon. (Source: Reference 1)

Table 1. Durability tests

Property	Test method	Typical specification
Mechanical degradation	(1) Los Angeles Abrasion (LAA) AASHTO T-96	35% maximum
Chemical degradation	(1) California Durability AASHTO T-210	35% minimum
	(2) Oregon Aggregate Degradation (OAD)	3.5 in. maximum sediment height 35% maximum passing the No. 20 sieve
	(3) Accelerated Weathering (Dimethyl sulfoxide or ethylene glycol)	Maximum of 4 failures out of 10 specimens

TYPES OF AGGREGATES AVAILABLE

The principal types of aggregate available to the Oregon coast include basalts, sandstones, dredged materials, and sands or gravels.

Basalts

Basalts are igneous rocks. Physical properties of basalts are largely determined by the location of the deposit of the parent magma, or lava. Basalts are classified on this basis as marine, aerial, and intrusive. Marine basalts were deposited in water, with subsequent rapid cooling. Aerial basalts were deposited over land, with slower cooling. Intrusives were deposited within the earth, with variable cooling rates. The rate of cooling determines the grain size that developed--and the quality of the rock, to some extent.

Marine basalts cool too quickly to form a distinguishable grain pattern. The substance formed under these conditions is termed glass. This glass is susceptible to breakdown and will alter to clay minerals through weathering action. If the clay minerals are expanding clays, degradation of the aggregate will occur. Marine basalts are normally considered poor materials for road construction purposes. However, this conclusion is not a general one. Certain quarry sites labeled as marine exhibit a wide range of durability values, from poor to good.

Recognition of the different types of basalts can sometimes be made at the quarry. A marine basalt is indicated by a spherical shaped mass, termed a pillow. These pillow basalts or pillow lavas result from rapid cooling of the flow when exposed to water. Pillows are composed largely of unstable glass on the perimeter.

Columnar formations usually indicate an aerial-flow basalt. Aerial flows are variable in thickness. They usually exhibit a porous broken top grading down into a more dense, coherent body. Columnar jointing is present, with joints perpendicular to the cooling surface. Glass is present chiefly in the broken porous top of the flow. The absence of any significant amount of glass indicates an aggregate of better quality.

Intrusive basalts result from solidification of the lava beneath an insulating rock cover. Such intrusive bodies may be lens-shaped masses of approximately uniform thickness. These are termed sills. They may also be tubular bodies that cut across the bedding of the intruded rocks, which are then called dikes. Vertical, pipelike conduits, or intrusive breccias form when intruding lava encounters water-saturated rock, causing rapid chilling and steam explosions that tear it apart. The breccias are much less common than flows, dikes, or sills.

Sands

Dune sands and beach sands are relatively abundant on the Oregon coast. These sands generally have a uniform gradation; consequently, they do not provide good stability when used for road construction.

Gravels

Some gravel is dredged from many of the coastal rivers. However, the only major sources of river gravel capable of providing a high-quality construction aggregate at the present time are the Umpqua and Rogue Rivers. Enough material could be mined from these sources to provide some export to other counties. Table 2 lists the amount of gravel removed from the Umpqua River for the years 1974 through 1979.

Table 2. Amounts of gravel dredged from the Umpqua River.

Year	Amount in tons
1974	441,399
1975	421,716
1976	310,702
1977	356,219
1978	476,219
1979	562,818

Source: Reference 7

Sandstone

The Coast Range and coastal areas of Oregon exhibit abundant quantities of sandstone interspersed with small amounts of siltstone.

Sandstone is composed of cemented sand grains. These grains are no different from the sand found on beaches or in dunes. The precipitation of mineral matter in the pores of the sandstone produces this cementation. The cementing material may be added from outside the rock by migrating solutions or may possibly result from the reorganization of mineral matter already present within the rock by solution from grains and precipitation within pores. The strength of the cementing agent determines the strength of sandstone. Unfortunately, this is not adequate for most road construction purposes.

Dredged Materials

Aside from the Umpqua River, dredged materials are relatively unused on the Oregon coast. Table 3 lists the material dredged from the major coastal rivers. Like dune and beach sands, these water-deposited materials exhibit relatively uniform grading. The material deposited by relatively slow moving water tends to be smaller; faster moving waters will tend to deposit larger-sized aggregates. As rocks are transported downriver, the weaker rocks erode more, leaving durable aggregates. Therefore, dredged aggregates can be expected to exhibit high durability.

Extent of Aggregate Resources

Figure 2 shows the availability of the various aggregates described above. Figure 3 depicts sources of river aggregate available in Oregon's coastal counties. Table 4 provides a summary of field interviews with county engineers to determine the extent of quality-aggregate shortages being experienced presently and future expectations for the respective counties.

Table 3. Location, type and average annual amount of dredged materials from coastal Oregon from the years 1973 to 1977 (dredging operations of the U. S. Army Corps of Engineers).

County	Location	Amount Cubic yards	Total Cubic yards	Total Cubic meters	Type of materials
Clatsop	At the mouth of the Columbia River Oregon and Washington	5,878,624	6,665,000	5,095,600	Sand & silt
	Skipanon Channel, Oregon	50,050			
	Tongue Point, Piers 7 & 8, Oregon	40,900			
	Columbia Slough (Operation Fore-sight)	26,310			
	Astoria Turning Basin	669,102			
Tillamook	Tillamook Bay and Bar, Oregon	24,701	133,000	101,700	Sand
	Wilson-Trask River, Oregon	108,163			
Lincoln	Depoe Bay, Oregon	12,437	652,000	498,500	Sand
	Yaquina Bay and Harbor, Oregon	639,165			
Lane	Siuslaw River, Oregon	237,654	238,000	182,000	Sand
Douglas	Umpqua River, Oregon	323,812	499,000	381,500	Sand
	Smith River, Oregon	174,941			
Coos	Coos Bay, Oregon	2,666,273	2,754,500	2,105,900	Sand & silt
	Coos and Millicoma Rivers, Oregon	35,851			
	Coquille River, Oregon	52,314			
Curry	Chetco River, Oregon	43,370	187,200	143,200	Sand
	Rogue River Harbor at Gold Beach, Oregon	106,282			
	Port Orford, Oregon	37,514			

Source: References 15, 16

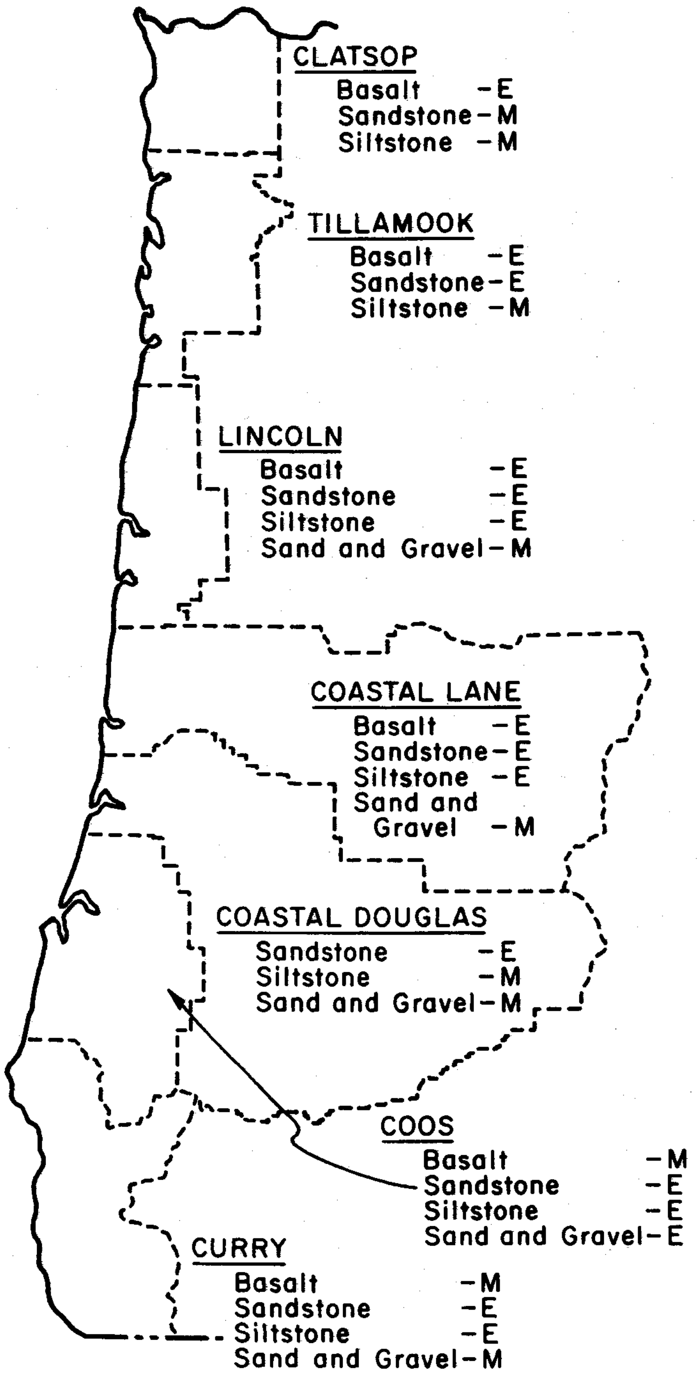

Figure 2. Availability of Land-Based Marginal Aggregate in Oregon's Coastal Counties. (Source: References 2,3,4,5,6,7)

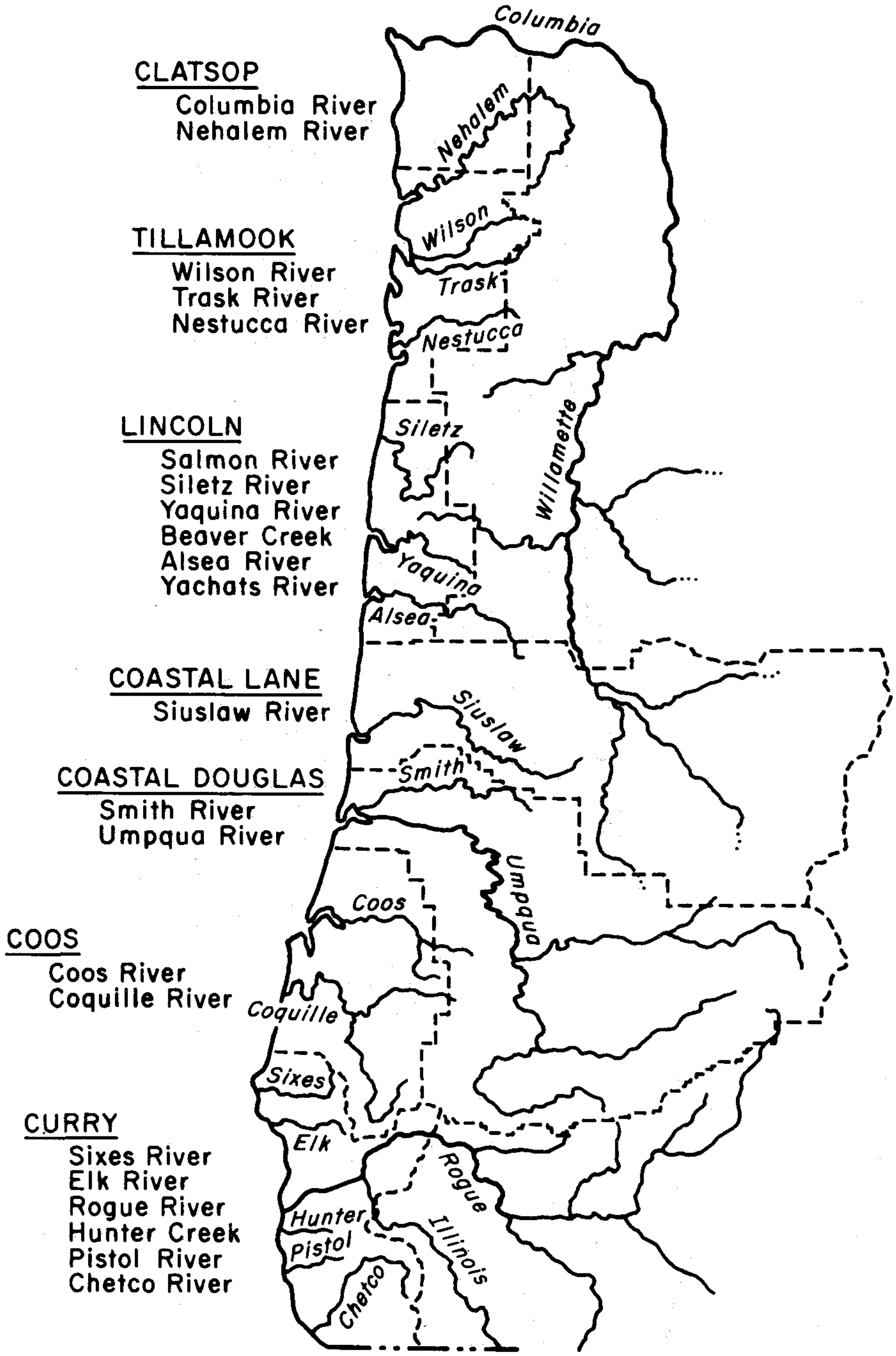

Figure 3. Availability of River Aggregate in Oregon's Coastal Counties. (Source: References 2,3,4,5,6,7)

Table 4. Summary of counties with quality aggregate shortages.

County	Field interview with county engineers	Evaluation from the interview
Clatsop	The main sources of aggregate used by Clatsop County are obtained from a rock quarry in Seaside, crushed gravel barged down the Columbia River (from Gable or St. Helens, Columbia County), and material taken from a gravel pit near the Big Creek River. In 1978, about 10,000 cubic yards of crushed gravel were imported from the Columbia River. Aggregate is also being purchased from a pit managed by the State Board of Forestry. The county owns two quality quarries; however, these are located in remote areas and cannot be economically used for most projects. Legislation currently prevents other quarries, such as Tongue Point and those owned by logging companies from being used in the county.	There is a trend to a shortage of quality aggregate in the county.
Tillamook	State Highway reports provided by the county engineer indicate that all of the materials in production are top quality. The county does not foresee any problems in obtaining aggregates for the next 20 years.	No problems with shortage of quality aggregate in this county.
Lincoln	The north part of the county uses rock from the Neskowin Pit (in Tillamook County), Ocean Lake Sand and Gravel (which consistently produces good quality rock), and a Forest Service pit on Widow Creek Road, called the Post Pit. The Post Pit material is marginal. The southern part of the county uses Siletz River run gravel, aggregate hauled from the Willamette Valley, good-quality aggregate from Yaquina Head, marginal aggregate from Eckman Creek and Berry Creek Quarry (in Lane County), the Alsea Lumber Company Pit in Benton County, and aggregate imported from the Umpqua River. The county expects to continue current trends such as importing from the Willamette Valley and the Umpqua River.	There is a shortage of quality aggregate in this county.
Western Lane	For the next 20 years, three main aggregate sources will be used: (1) marginal quarry rock located in Lane County, (2) aggregate trucked from the Umpqua River, and (3) aggregate from the Willamette Valley. It is suspected that more aggregate will be barged from the Umpqua River and the Willamette Valley in the future.	There is a trend to a shortage of quality aggregate in this part of the county.
Douglas	All of the quality construction materials currently used in coastal Douglas County's roads are dredged from the Umpqua River. Their prospects for aggregates for the next 20 years will be continued usage of the Umpqua River dredgings.	No severe shortages of quality aggregate in this county.
Coos	Aggregates come from rock quarries (namely Hervey, Sherets, Reed Bar, Broadbent, Eckley), and the Umpqua River. Of these sites, the Hervey Quarry is the only site that produces a substandard quality rock, and it is used extensively. Its usage is beneficiated by blending with other quality aggregates.	There is a shortage of quality aggregate in this county.
Curry	Curry County does not need to import aggregates. However, prospects for the next 20 years are poor. Local citizens groups have recently initiated a petition to close down sand and gravel operations by Tidewater Construction Company on the Chetco River. This petition failed to gain enough support for consideration, but it indicates future trends that will limit the availability of construction aggregate. Development in the Brookings area and the establishment of the Rogue River Wilderness Area near Agness have also restricted quality aggregate availability.	Currently, there is no shortage of quality aggregate in the county, but shortages of quality aggregate are expected in the future.

Source: Reference 1

PROBLEMS WITH USE OF MARGINAL AGGREGATES

Numerous problems result from the use of marginal aggregates in road construction. Table 5 summarizes the deficiencies of the various types of marginal aggregates available.

Basalts

Basalts, especially marine basalts, are high in mechanical strength but are susceptible to chemical weathering. Numerous accounts are available of road failures attributed to degrading basalts (9-13). It is generally concluded that the production of plastic fines in altered basalts is the principal cause of these failures. The presence of water will greatly accelerate the degradation process. Poor drainage conditions will cause a much more rapid failure of a road section made of marine basalt than a road section constructed of high quality aggregate.

Because of the relatively strong mechanical characteristics of basalts, efforts to improve their performance are warranted. Measures to reduce the potential for chemical degradation would require isolating the aggregate from water (see Upgrading).

Sandstone (or Siltstone)

Sandstones have a low resistance to mechanical degradation. Significant reduction in the grain sizes of a sandstone occurs during manipulation or loading. Field compaction and traffic loading result in dense gradations and a subsequent loss of permeability. The presence of water will then cause instability and failure.

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
Dredged materials	Poor gradation Possibility of high organic content

Efforts to improve the performance of sandstones requires increasing the strength of the cemented sand particles. This can be achieved by adding portland cement or asphalt (see Upgrading).

Sands

Poorly-graded beach and dune sands lack the grain interlock required to provide good stability when untreated. The addition of portland cement or asphalt can increase the stability of sands (see Upgrading).

Another factor restricting the use of dune and beach sands is the effect large-scale mining would have on the Oregon coast's scenic beauty.

Dredged Materials

Dredged materials exhibit relatively uniform grading. The problem of uniform grain-size distribution can be solved by blending with materials of a different grain size. Dredged materials will vary in grain size depending on the flow velocity of the water in the river section from which they were taken. A well-graded aggregate of high durability can be achieved by blending dredged material from different sectors of a river. Admixture stabilization can also be used to upgrade dredged materials (see Upgrading).

SUMMARY

Several types of "marginal" aggregates available on the Oregon coast could be used for construction. They offer a feasible alternative to the importation of quality aggregate. These aggregates include basalts, which are high in mechanical strength but susceptible to chemical weathering; sandstones, which exhibit poor mechanical strength characteristics; and sands and dredged materials, which require stabilization or blending to provide sufficient stability because of poor gradation. Special design considerations can help avoid the problems normally associated with the use of these aggregates. Upgrading Marginal Aggregates for Road Construction Along the Oregon Coast discusses procedures and considerations for the use of marginal aggregates.

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APPENDIX A

Tables A-1 through A-7 identify some of the aggregates presently available to the Oregon Coast and selected properties for these aggregates. Much of this information was obtained from the Federal Highway Administration, Region 10.

Table A-1. Summary of pit name and type of rock in Oregon coastal counties.

County	Pit	Type of Rock
Clatsop	No record of rock pit use in this county	--
Tillamook	Neskowin	?
	Bible Creek	Basalt
	East Line Quarry	Basalt
	Government Owned	Vesicular marine basalt
	Dovre Peak Quarry	Basalt dike
	Government Owned	Quarry rock
	Kostic Quarry	Gabbro/basalt
	Dovre Peak West	Intrusive, diorite
	Sand Dune	Dune sand
Lincoln	Yaquina Head	Basalt
	Siletz Quarry	Basalt
	Ocean Lake Sand and Gravel	Basalt
	Morris	Basalt
	Ocean Lake	Basalt
	Post Pit	Marine basalt
	Kaufman	Weathered basalt
	Willamette Industries	Gabbro
	Bureau of Land Management	Quartz diorite
	Bureau of Land Management	Andesite
	Gleneden Beach	Beach sand
	Eckman Creek	Basalt
	Siletz River	Gravel
	Hill Top and Roads End	Basalt
Lane	Berry Creek	Basalt
	Green Leaf Creek	Gabbro
	Nelson Ridge Quarry	Gabbro (diabase)
	Deadwood Quarry	Gabbro ledge rock
Douglas	Beckley Thomas Quarry (Tenmile Quarry)	Metamorphased volume
	East Roman Nose	Gabbro
	Wooley (Owner)	Gabbro
	Esmond Creek Quarry	Gabbro sill
	Little Wolf Creek Quarry	Sandstone
	Old Wolley Quarry	Sandstone
	Manasha (Owner)	Sandstone
	Bridge Creek Quarry	Sandstone and conglomerate
	Umpqua River	River gravel
Coos	Eckley Quarry	?
	Hervey Quarry	?
	Sherets	Bar run sand
	Reed Bar	Bar run gravel
	Broadbent	Bar run gravel
	Kenstone Quarry	Basalt
	"County Pit"	Basalt
	Kinchloe Quarry	Marine basalt
	Kasper Quarry	Marine basalt
	Indian Creek Quarry	Marine basalt
	Gray Quarry	Basalt flow (marine)
	Ansley Ranch Quarry	Columnar over marine basalt
	Boekelman Quarry	Columnar over marine basalt
	Woodward No. 2	Altered marine basalt
	Norway Rock Products	Submarine basalt
	Highway 42 Quarry	Submarine basalt
	Waterman Quarry	Metamorphic basalt
	Moon Creek	Sandstone
	Buck Peak	Sandstone
	North Fork Coquille	Sandstone
	BLM Pit	Sandstone
Curry	Langlois Quarry	Metamorphic
	Sullivan Ranch Quarry	Metamorphic

Source: Reference 14

Table A-2. Key to terminology used in Tables A-3 through A-7.

1. The pit numbering system as developed by the FHWA is described as follows:

35	-	29	-	0008
State (Oregon)		County (Tillamook)		Pit Number

County	Number
Tillamook	29
Yamhill	36
Polk	27
Benton	02
Lincoln	21
Lane	20
Douglas	10
Coos	06
Curry	08

2. Abbreviations

Sp. Gr.	Specific gravity
F	Fines
C	Coarse
D_c	Durability of coarse-sized aggregate
D_f	Durability of fine-sized aggregate
LAA	Los Angeles Abrasion
DMSO	Dimethyl sulfoxide
E.G.	Ethylene glycol
OAD	Oregon Aggregate Degradation
S.S.	Sodium sulfate soundness
PI	Plastic index
LL	Liquid limit
N.P.	Nonplastic
Man,mfg	Manufactured by laboratory crushing
A.R.	As received

3. Typical specification values for durability tests

Sand equivalent	35% minimum
California durability	35% minimum
LAA	35% maximum
OAD	3.5 in. maximum sediment height
	35% maximum passing the No. 20 sieve

Table A-3. Summary of aggregate tests - basalt.

Pit Name and Number	Type of Rock	Sand Equiv.	Sp. GR.	California D_c	California D_f	LAA	DMSO	E.G.	CAD	Other
Tobe Creek	Basalt	55		58	37	23		9		
35-02-0001		44		74	34	26		7		
		56		68	47	24		5		
		44			45					
		22(A.R.)		63	41	23				PI = 4
		27(moist)								LL = 26
			3.09/3.03	60	42					
		36		65	37	21				
		30	2.95	55	23	22	8	1		PI = 6
										LL = 27
										Wt. Ave.:
										DMSO 36.54
										E.G. 6.61
South Fork Alsea	Basalt	87	2.84	93	95	16		0		
Quarry		85		93	94	17		0		
35-02-0002		79		90	92	16		0		
Mary's Peak	Marine basalt		2.83		67	20				
Quarry			2.86	44	27	45				
35-02-0026		59	2.96F	31	30	67	10	0		
			2.83C							
		51	2.86F	37	27	25	10	3		
			2.69C							
		45			21					
		28(A.R.)								
		57(Man)								
		23(A.R.)								
		55(Man)								
Siletz Quarry	Basalt	37(Man)	2.60F	36	30	26		1		
35-21-0016			2.69C							
Kaufmann	Weathered basalt	68(Man)	2.84F	80	78	18		0		S.S. 8
35-21-0019			2.87C							Strip < 95%
Ocean Lake S & G	Basalt	66	2.85F	85	91	13		0		S.S. 5%
35-21-0027			2.89App							Strip < 95%
See pg. 14 for more										
Hill Top & Roads End	Basalt	70	2.73F	74	64	19				S.S. 9%
35-21-0028			2.70App							
Morris	Basalt	75	2.74F	58	43	16				S.S. 14%
35-21-0029			2.73App							
Kinchloe Quarry	Marine basalt			52	33	15		0		
35-06-0003				49	32	13	0	0		
Kasper Quarry	Marine basalt	68mfg	2.97F	62	60	26		2		
35-06-0011		77mfg	2.98F	70	48	23		0		S.S. = 12
		71mfg	2.99F	63	56	29		2		
		32(A.R.)		61	45			0		S.S. = 14
				52	26	29				PI = 7
										LL = 24
Gray Quarry	Basalt flow	31(A.R.)		45	40					S.S. = 32%
35-06-0016	(marine)			52	48	19				LL = 21
		38(A.R.)		48	46	17				S.S. = 8%
				58	47	15				
Indian Creek Quarry	Marine basalt		2.85F	34	30	23	10	3		
35-06-0017										

Source: Reference 14

Table A-3. Summary of aggregate tests - basalt (continued).

Pit Name and Number	Type of Rock	Sand Equiv.	Sp. GR.	California D_c	California D_f	LAA	DMSO	E.G.	CAD	Other
Berry Creek	Basalt	38(A.R.)		36	33	22				
(Ray Wells)		43(A.R.)		36	22	22				
		50(A.R.)		50	30	25				
		55		44	31					
		40		50	31					
		39(A.R.)		33	25	27				
		47		49	42					PI = 7
										LL = 16
Ocean Lake	Basalt		Bulk=2.85			12.14			16.78%/	
			SSD =2.87						0.6 in.	
			Bulk=2.85			11.70			13.17/	
			SSD =2.87						0.3	
			Bulk=2.85			12.32			14.69/	
			SSD =2.88						0.6	
			Bulk=2.85			13.30			14.01/	
			SSD =2.87						0.4	
			Bulk=2.85			13.74			16.04/	
			SSD =2.87						0.6	
			Bulk=2.86			11.96			16.90/	
			SSD =2.88						0.3	
			Bulk=2.87							
			SSD =2.87							
Ansley Ranch	Columnar over	50mfg	2.98F	66	40	26	4	0		
Quarry	marine basalt	65mfg	2.86F	56	40	21	6	1		
Boekelman Quarry		64mfg	2.93F	58	47	22	5	0		
35-06-0021		65mfg	2.96F	70	58	26	2	0		
		69mfg	2.98F	78	80	19	4	0		
		55mfg	2.99F	61	42	25	4	0		
		49mfg	2.86F	35	30	21	4	0		PI = 4
										LL = 28
				27	20		8	7		PI = 13
										LL = 38
				63			6	0		
				54		18	2	0		
Kenstone Quarry	Basalt	41mfg	2.88F	4	22	37	7	2		Strip < 95%
35-06-0041		49(A.R.)		34	34		7	5		PI = 7
										LL = 29
"County" Pit	Basalt			51	26	24				W.D. = 13
35-06-0052										
Woodward #2	Altered marine	38mfg	2.75F	46	32	24				Strip < 95%
35-06-0060	basalt	44mfg		27	25	29				
		43mfg	2.83F	25	26	32				
		44mfg		30	26	30				
Waterman Quarry	Metamorphic		2.77F	58	33	21		0		Strip < 95%
35-06-0064	(basalt?)			43	28	29				
Norway Rock Products	Sub-basalt (submarine)			24	26	19	10	10		
35-06-0079										
Highway 42 Quarry	Submarine basalt	53mfg	2.97F	62	48	22	10	0		
35-06-0095				54		20	9	5		

Table A-4. Summary of aggregate tests - sandstone.

Pit Name and Number	Type of Rock	Sand Equiv.	Sp. GR.	California		LAA	DMSO	E.G.	OAD	Other
				D_c	D_f					
Little Wolf Creek Quarry 35-10-0044	Sandstone	29	2.64F	65	40	32				S.S. = 30
		35	2.63F	70	40	40				S.S. = 21
		21	2.66F	54	30	36				S.S. = 83
Old Wolley Quarry 35-10-0127	Sandstone	27(Man)	2.64F	38	26	62	0	0		
		34(Man)	2.77F	52	28	56	0	0		
Manasha (Owner) 35-10-0151	Sandstone	58(Man)	2.59F	70	42	43				
		49mfg	2.68F	74	37	44				
		50mfg	2.67F	74	42	39				
		37(A.R.)		67	39	41				
N. Fork Coquille 35-06-0049	Sandstone	21	2.67F			96				
			2.66F			77				
		17				95				
				28	29	85		0		
BLM Pit 35-06-0054	Sandstone	38mfg	2.63F	65	31	49				S.S. = 73%
		46mfg	2.63F	51	34	48				S.S. = 92%
										Strip < 95
		49mfg	2.63F	54	31	49				S.S. = 63
		50mfg	2.63F	45	33	59				S.S. = 92%
		51mfg	2.61F	59	33	58				S.S. = 90
Buck Peak	Sandstone			48	35	15		0		PI = 4
										LL = 22
		31mfg	2.61F	46	28	47	0	0		
		30mfg	2.62F	50	29	49	0	0		
		28mfg	2.64F	36	27	52	0	0		
		33mfg	2.60F	54	28	47	0	0		
Moon Creek 35-06-0079	Sandstone	27mfg	2.67F	27	29	71	1	1		
		27mfg	2.70F	38	29	58				
		32mfg	2.62F	47	30	71				

Table A-5. Summary of aggregate tests - gabbro

Pit Name and Number	Type of Rock	Sand Equiv.	Sp. GR.	California D_c	California D_f	LAA	DMSO	E.G.	OAD	Other
Will. Ind. 35-21-0030	Gabbro		2.71F	82	60	22		0		Strip < 95%
Greenleaf Creek 35-20-0063	Gabbro	65	2.76F	67	46	30		9		Strip < 95%
		73	2.74F	76	58	24		1		Strip < 95%
		71	2.67F	78	58	23		0		Strip < 95%
		74	2.75F	74	54	25		3 of 8 (4)		Strip < 95%
		70	2.67F	80	67	24		3		
		58	2.72	80	50	29	6	2		
Deadwood Quarry 35-20-0048	Gabbro ledge rock	74	2.86F	85	64	17		0		Thin Section S.S. = 2% Strip < 95
		70	2.74F	82	65	16	0	0		
		73	2.77F	85	68	15	0	0		
		41	2.67F	67	39	33	2	0		
East Roman Nose 35-10-0055	Gabbro	80(Man) 49(A.R.)	2.78F	74	65	18		0		
		88(Man) 41(A.R.)	2.71F	78	74	18		0		
		40(A.R.) 80(Man)	2.79F	76	73	18		0		S.S. = 1%
Bridge Creek Quarry 35-10-0187	Sandstone and conglomerate	50(A.R.)		26	30	66		1		
		63mfg		19	27	82		0		
		72mfg		19	29	85		0		
Wooley (Owner) 35-10-0208	Gabbro			80	60	19		0		
		63mfg	2.79F	87	68	17	0	0		

Table A-6. Summary of aggregate tests - sand and gravel

Pit Name and Number	Type of Rock	Sand Equiv.	Sp. GR.	California D_c	California D_f	LAA	DMSO	E.G.	OAD	Other
Timmons Quarry 35-36-0044	Gravel	37		74	48	13				
		52		76	68	13				
		59		76	57	12				
				78	91	14	2	0		Wt. Ave.: DMSO 3.3 E.G. 0.1
Gooseneck R.Q. 35-27-0004	Gravel		2.94	78	73	15				Sodium Sulfate 6
		82(Man)	2.94	76	77	16				Sodium Sulfate 8 S.E. = 12 as received
		42(A.R.)			54	18		0		
Morse Bros. 35-02-0028	Gravel	68(Man)	2.75	78	82	17	1	0		Wt. Ave.: DMSO 9.03 E.G. 0.5
Umpqua River 35-10-0024	River gravel	78(A.R.) 80(Man)	2.70F	71	78	14				
Govt. Owned 35-29-0027	Quarry rock	65	2.82	70	46	28	10	3		
Sand Dune 35-29-0051	Dune sand	R @ 300 psi = 78--2.67--Density = 100 PCF--% w.c. 17--AASHO A-3(0)								
Slide Creek Quarry 35-02-0025	Diabase dike or sill	69	2.90	76	68	20	0	0		Strip < 95
		81	2.97	76	72	13	0	0		
		61	2.81	63	55	35	3	0		
		69	2.85	85	67	24	0	0		
Flat Mtn. Quarry 35-02-0029	Igneous intrusion	58(Man)	2.78	66	43	26	0	0		
		56(Man)	2.75	78	53	18	0	0		
			2.77F							Report given
			2.71C							
Dovre Peak West 35-29-0047	Intrusive; diorite?	58	2.72	68	41	21	2	2		

Table A-7. Summary of aggregate tests - miscellaneous

Pit Name and Number	Type of Rock	Sand Equiv.	Sp. GR.	California		LAA	DMSO	E.G.	OAD	Other
				D_c	D_f					
BLM 35-21-0025	Andesite			70	40	22		3		PI = 4 LL = 36
BLM 35-21-0026	Quartz diorite			63	47	28		1		
Beckley Thomas Quarry (Ten-mile Quarry) 35-10-0036	Metamorphased volcanic	58		71	52	22		0		
		64		70	51	20		0		
		70		78	74	19		0		
		53		73	47	20		1		
		90		71	50			0		PI = 4 LL = 21
		86		70	53			0		
		77			66	20		1		
Esmond Creek Quarry 35-10-0164	Gabbro sill	71mfg	2.72F	82	69	18				S.S. = 7%
Nelson Ridge Quarry 35-20-0019	Gabbro (diabase)	59	2.78F	76	49	25		4		Strip < 95%
		71	2.80F	85	66	22		0		Strip < 95
		63	2.79F	78	59	25		0		Strip < 95
		71	2.81F	76	63	23	0	3		Strip < 95
Langlois Quarry Sullivan Ranch Quarry 35-08-0058	Metamorphic	73mfg	2.91F	73	61	10	0	0		
		57(A.R.)	2.99F	74	66	14	0	0		
			2.93App							
					98	15	0	0		
McDowell Quarry 35-36-0047		27		56	40	14				PI = 2 LL = 28
		20		36	26	25				PI = 8 LL = 38
Gleneden Beach	Beach sand	98	Bulk=2.63 SSD =2.65							FF = 2.75

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