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Page

ANNEX - 1 Economic Indices of Ethiopia in Comparison with African Countries

1 - 1 Amount and Growth Rate of Gross Domestic Product at Constant 1970 Market Prices in Developing Africa - 1969-1972

Countires	Amount in million US$				Annual growth rate %		
	1969	1970	1971	1972 a/	1969-70	1970-71	1971-72 a/
NORTH AFRICA							
Algeria	4,109.6	4,343.9	4,281.4	4,795.2	5.7	-1.4	12.0 a/
Egypt	7,094.8	7,295.3	7,504.1	7,804.3	2.8	2.9	4.0 a/
Libyan Arab Rep.	3,565.0	3,722.5	3,420.6	3,359.0	4.4	-8.1	-1.8
Morocco	3,187.7	3,351.8	3,516.5	3,720.4	5.1	4.9	5.8
Sudan	1,794.3	1,831.1	1,936.6	1,994.7	2.1	5.8	3.0 a/
Tunisia	1,227.4	1,387.0	1,508.7	1,787.8	13.0	8.8	18.5
Total	20,978.8	21,931.6	22,167.9	23,461.4	4.5	1.1	5.8
WEST AFRICA							
Dahomey	226.0	249.0	259.0	264.2	10.2	4.0	2.0 a/
Gambia	40.9	46.1	49.1	50.6	12.7	6.6	3.0 a/
Ghana	2,371.6	2,519.6	2,530.8	2,589.0	6.2	0.4	2.3
Guinea	292.9	320.0	283.1	297.3	9.3	-11.5	5.0 a/
Ivory Coast	1,312.0	1,490.8	1,526.5	1,648.6	13.6	2.5	8.0 a/
Liberia	399.7	417.5	449.1	468.0	4.5	7.6	4.2
Mali	251.4	267.4	277.2	278.6	6.4	3.7	0.5 a/
Mauritania	180.8	191.6	200.4	208.4	6.0	4.6	4.0 a/
Niger	355.8	363.3	345.3	367.4	2.1	-5.0	3.5 a/
Nigeria	6,765.9	7,438.8	8,329.8	8,946.2	9.9	12.0	7.4
Senegal	767.7	796.7	736.8	766.3	3.8	-7.5	4.0 a/
Sierra Leone	447.5	444.1	476.3	504.9	-0.8	7.2	6.0 a/
Togo	252.3	269.5	270.2	281.0	6.8	0.3	4.0 a/
Upper Volta	304.8	309.7	314.7	321.0	1.6	1.6	2.0 a/
Total	13,969.3	15,124.1	16,048.3	16,981.5	8.3	6.1	5.8
CENTRAL AFRICA							
Burundi	193.7	211.1	212.9	212.9	9.0	0.9	0.0 a/
Cameroon	977.3	1,011.9	1,017.5	1,058.2	4.6	-0.4	4.0 a/
C.A.R.	193.5	194.1	192.1	201.7	0.3	-1.0	5.0 a/
Chad	284.3	288.1	294.2	303.0	1.3	2.1	3.0 a/
Congo	240.0	235.5	237.2	249.1	-1.9	0.7	5.0 a/
Equatorial Guinea	75.8	76.0	75.3	79.1	0.3	-0.9	5.0 a/
Gabon	330.7	335.2	355.8	391.4	1.4	6.1	10.0 a/
Rwanda	194.4	215.7	221.2	221.2	11.0	2.5	0.0 a/
Zaire	1,869.6	2,050.8	2,161.7	2,265.5	9.7	5.4	4.8
Total	4,359.3	4,628.4	4,767.9	4,982.1	6.2	3.0	4.5
EAST AFRICA							
Botswana	78.5	83.0	97.7	109.8	5.7	17.7	12.4
Ethiopia	1,711.2	1,836.0	1,874.1	1,949.0	7.3	2.1	4.0
Kenya	1,472.1	1,617.8	1,733.0	1,852.6	9.9	7.1	6.9
Lesotho	78.5	78.1	79.5	81.9	-0.5	1.8	3.0 a/
Madagascar	823.4	891.8	918.1	875.9	8.3	3.0	-4.6
Malawi	318.5	325.1	354.4	381.7	2.1	9.0	7.7
Mauritius	189.3	188.6	205.6	226.2	-0.4	9.0	10.0
Somalia	231.7	245.0	252.6	265.2	5.7	3.1	5.0 a/
Swaziland	95.3	96.2	104.9	115.4	0.9	9.0	10.0 a/
Tanzania	1,201.2	1,281.0	1,339.6	1,428.0	6.6	4.6	6.6
Uganda	1,267.1	1,304.2	1,326.3	1,340.9	2.9	1.7	1.1
Zambia	1,790.0	1,604.5	1,686.4	1,770.7	-10.4	5.1	5.0 a/
Total	9,256.8	9,551.3	9,972.2	10,397.3	3.2	4.4	4.3
Total 41 countries	48,564.2	51,235.4	52,956.3	55,822.3	5.5	3.4	5.4

Source: ECA Secretariat.
a/: Preliminary estimates.

1 - 2 Growth of Nation and per capita GDP in Developing Africa, 1969 - 1972

	Population in million				Annual increase of population, per cent			Per capita GDP at constant 1970 market prices (US $)				Growth rate in per capita GDP, per cent		
	1969	1970	1971	1972[a]	1969-70	1970-71	1971-72[a]	1969	1970	1971	1972[a]	1969-70	1970-71	1971-72[a]
NORTH AFRICA														
Algeria	13.91	14.33	14.77	15.27	3.0	3.1	3.4	295.4	303.1	389.0	314.0	2.6	-4.4	8.3
Egypt	32.50	33.33	34.08	34.84	2.6	2.4	2.2	218.3	218.9	219.9	224.0	0.3	0.5	1.7
Libyan Arab Rep.	1.87	1.94	2.01	2.08	3.7	3.6	3.6	1,906.4	1,918.8	1,701.8	1,614.9	0.7	-11.3	-5.1
Morocco	15.28	15.78	16.25	16.80	3.2	3.0	3.4	208.6	212.4	216.4	221.5	1.8	1.9	2.4
Sudan	15.31	15.70	16.09	16.49	2.5	2.5	2.4	113.8	116.3	120.4	121.0	2.0	3.5	0.5
Tunisia	5.03	5.14	5.25	5.35	2.2	2.2	2.2	244.0	269.8	287.4	334.2	10.6	6.5	16.3
Total	83.90	86.22	88.45	90.83	2.8	2.6	2.7	250.0	254.4	250.6	258.3	1.7	-1.5	3.1
WEST AFRICA														
Dahomey	2.62	2.69	2.76	2.83	2.7	2.6	2.6	86.2	92.6	93.8	93.4	7.4	1.3	-0.4
Gambia	0.35	0.36	0.37	0.38	2.8	2.8	2.8	116.9	128.1	132.7	133.2	9.6	-3.6	0.4
Ghana	8.43	8.64	8.86	9.09	2.5	2.5	2.6	281.3	291.6	285.6	284.8	3.7	-2.1	-0.3
Guinea	3.83	3.92	4.01	4.10	2.3	2.3	2.3	76.5	81.6	70.6	72.5	6.7	-13.5	2.7
Ivory Coast	4.21	4.31	4.42	4.53	2.4	2.6	2.6	311.6	345.9	345.4	363.9	11.0	-0.1	5.4
Liberia	1.15	1.17	1.19	1.21	1.7	1.7	1.7	347.6	356.8	377.4	386.8	2.6	5.8	2.5
Mali	4.93	5.05	5.14	5.26	2.4	1.8	2.4	51.5	53.3	53.9	53.0	3.5	1.1	-1.7
Mauritania	1.14	1.17	1.20	1.23	2.6	2.6	2.6	158.6	163.4	167.0	169.4	3.0	2.2	1.4
Niger	3.91	4.02	4.13	4.24	2.8	2.7	2.7	91.0	90.4	83.6	86.7	-0.7	-7.5	3.7
Nigeria	53.70	55.07	56.51	57.98	2.6	2.6	2.6	126.0	135.1	147.4	154.3	7.2	9.1	4.7
Senegal	3.78	3.93	4.02	4.11	4.0	2.3	2.3	203.1	202.7	183.3	186.4	-0.2	-9.6	1.7
Sierra Leone	2.58	2.64	2.70	2.77	2.3	2.4	2.6	173.4	168.2	176.4	182.3	-3.0	4.8	3.3
Togo	1.92	1.97	2.02	2.07	2.6	2.5	2.6	131.4	136.8	133.8	135.7	4.2	-2.2	1.4
Upper Volta	5.28	5.38	5.49	5.60	1.9	2.0	2.0	57.7	57.6	57.3	57.3	-0.2	-0.5	0.0
Total	97.83	100.32	102.82	105.40	2.6	2.5	2.5	142.8	150.8	156.1	161.1	5.6	3.5	3.2
CENTRAL AFRICA														
Burundi	3.47	3.54	3.62	3.70	2.0	2.2	2.3	55.8	59.6	58.8	57.5	6.8	-1.3	-2.2
Cameroon	5.74	5.84	5.97	6.11	1.7	2.2	2.3	170.3	174.4	170.2	173.2	2.7	-2.6	1.6
Central African Rep.	1.58	1.61	1.64	1.67	1.9	1.9	1.9	122.5	120.6	117.1	120.8	-1.6	-2.9	3.2
Chad	3.62	3.71	3.80	3.89	2.5	2.4	2.4	78.5	77.4	77.4	77.9	-1.1	-0.3	0.6
Congo	0.92	0.94	0.96	0.98	2.2	2.2	2.1	260.9	250.5	247.1	254.2	-4.0	-1.4	2.9
Equatorial Guinea	0.29	0.29	0.30	0.30	2.0	3.0	2.0	261.4	262.1	251.0	263.7	2.7	-4.0	3.0
Gabon	0.49	0.50	0.51	0.52	2.0	2.0	2.0	674.9	670.4	697.6	752.7	-0.7	4.0	6.9
Rwanda	3.49	3.59	3.69	3.80	2.9	3.0	3.0	55.7	60.1	59.9	58.2	7.9	-0.4	-2.8
Zaire	20.70	21.57	22.48	23.43	4.2	4.2	4.2	90.3	95.1	96.2	96.7	5.3	1.2	0.5
Total	40.30	41.59	42.97	44.40	3.2	3.3	3.3	108.2	111.3	110.9	112.2	2.9	-0.3	1.2
EAST AFRICA														
Botswana	0.63	0.65	0.67	0.69	3.2	3.1	3.1	124.6	127.7	145.8	159.1	2.5	14.2	9.2
Ethiopia	24.02	24.63	25.25	25.89	2.5	2.5	2.5	71.2	74.5	74.2	75.3	4.6	-0.4	1.5
Kenya	10.88	11.22	11.67	12.07	3.1	3.9	3.4	135.3	144.2	148.5	152.5	6.6	3.0	2.7
Lesotho	0.90	0.92	0.94	0.96	2.2	2.1	2.1	87.2	84.9	84.6	85.3	-2.6	-0.3	0.8
Madagascar	6.60	6.75	6.94	7.33	2.2	2.8	2.8	124.8	132.1	132.3	122.8	5.8	0.2	-7.2
Malawi	4.33	4.44	4.55	4.67	2.5	2.5	2.6	73.6	73.2	77.9	81.9	-0.5	6.4	5.1
Mauritius	0.80	0.81	0.82	0.83	1.2	1.2	1.2	236.6	232.8	250.7	269.3	-1.6	7.7	7.4
Somalia	2.73	2.79	2.86	2.94	2.2	2.5	2.8	84.9	87.8	88.3	90.5	3.4	0.5	2.5
Swaziland	0.40	0.41	0.42	0.43	2.5	2.4	2.4	238.3	234.6	249.8	268.4	-1.6	6.5	7.8
Tanzania	12.93	13.27	13.63	14.00	2.6	2.7	2.7	92.9	96.5	98.3	102.0	3.9	1.9	3.8
Uganda	9.55	9.81	10.13	10.46	2.7	3.3	3.3	132.7	132.9	130.9	128.2	0.2	-1.5	-2.1
Zambia	4.17	4.28	4.40	4.52	2.7	2.7	2.7	429.3	374.9	383.3	401.5	-12.7	2.2	4.7
Total	77.94	79.98	82.28	84.79	2.6	2.9	3.1	118.8	119.4	121.2	122.6	0.5	1.5	1.2
Total 41 countries	299.97	308.11	316.52	325.42	2.7	2.7	2.8	161.9	166.3	167.3	171.5	2.7	0.6	2.5

Sources: United Nations Monthly Bulletin of Statistics, January 1973 and ECA Secretariat.
a/: Provisional estimates.

1 - 3 External Trade in Developing Africa, 1970 - 1972

Value in Million US$ and % Changes

	Total Exports f. o. b.					Total Imports c. i. f.				
				% Change					% Change	
	1970	1971	1972	1970-1971	1972-1972	1970	1971	1972	1970-1971	1971-1972
NORTH AFRICA										
Algeria	1,008.9	852.5	1,429.4	-15.5	67.7	1,257.1	1,221.3	1,759.2	-2.8	44.0
Egypt	761.7	789.3	825.2	3.6	4.5	786.6	919.7	873.8	16.9	-5.0
Libyan Arab Rep.	2,365.6	2,695.0	2,310.4	13.9	-14.3	554.4	701.0	1,094.4	26.4	56.1
Morocco	488.3	500.5	639.1	2.5	27.7	684.3	697.9	771.5	2.0	10.5
Sudan	293.5	330.8	360.3	12.7	8.9	311.1	355.1	353.4	14.1	-0.5
Tunisia	182.5	215.8	310.5	18.2	43.9	304.6	341.9	458.5	12.2	34.1
Total	5,100.5	5,383.9	5,874.9	5.6	9.1	3,898.1	4,236.9	5,310.8	8.7	25.3
WEST AFRICA										
Dahomey	32.6	41.9	39.1	28.5	-6.7	63.6	76.3	86.3	20.0	13.1
Gambia	16.9	13.3	19.5	-21.3	46.6	18.0	26.1	25.8	45.0	-1.1
Chana	438.8	322.4	442.0	-25.5	37.1	410.7	434.3	309.0	5.7	-28.9
Guinea	54.0	50.0	59.4	-7.4	18.8	70.0	80.0	06.8	14.3	21.0
Ivory Coast	468.8	455.7	545.5	-2.8	19.7	387.8	399.2	442.1	2.9	10.7
Liberia	212.6	221.1	245.0	4.0	10.8	149.6	157.4	180.0	5.2	14.4
Mali	32.8	35.3	26.2	7.6	-25.8	47.2	54.9	55.0	16.3	0.2
Mauritania	88.9	93.9	117.3	5.6	24.9	55.9	63.0	78.2	12.7	24.1
Niger	31.7	38.4	52.8	21.1	37.5	58.4	53.9	66.5	-7.7	23.4
Nigeria	1,239.6	1,810.6	2,143.8	46.1	18.4	1,059.0	1,510.5	1,505.9	42.6	-0.3
Senegal	151.9	125.0	213.0	-17.7	70.4	192.8	217.9	275.0	13.0	26.2
Sierra Leone	101.5	100.1	119.3	-1.4	19.2	116.3	113.2	124.3	-2.7	9.8
Togo	54.6	49.1	49.0	-10.1	-0.2	64.6	70.1	83.6	8.5	19.3
Upper Volta	18.2	15.9	20.1	-12.6	26.4	46.7	50.6	58.7	8.4	16.0
Total	2,936.9	3,372.7	4,092.0	14.8	21.3	2,740.6	3,307.4	3,387.2	20.7	2.4
CENTRAL AFRICA										
Burundi	23.6	18.5	26.3	-21.6	42.2	22.4	29.9	31.3	33.5	4.7
Cameroon	226.1	206.3	218.0	-8.8	5.7	242.1	249.7	299.0	3.1	19.7
C. A. R.	30.6	34.3	35.2	12.1	2.6	34.2	35.1	37.1	2.6	5.7
Chad	29.5	28.0	33.2	-5.1	18.8	61.4	61.6	60.6	0.3	-1.6
Congo P. R.	30.8	42.3	50.8	37.3	20.1	57.3	78.9	86.0	37.7	9.0
Gabon	121.0	186.5	196.5	54.1	5.4	79.7	96.5	136.8	21.1	41.8
Rwanda	24.6	22.3	19.1	-9.3	-14.4	29.1	33.0	35.0	13.4	6.1
Zaire	788.2	680.0	700.0	-13.7	2.9	616.9	726.9	600.0	17.8	-17.5
Total	1,274.4	1,218.2	1,279.1	-4.4	5.0	1,143.1	1,311.6	1,285.8	14.7	-2.0
EAST AFRICA										
Botswana	28.0	46.2	41.3	65.0	-10.6	62.7	84.0	90.3	34.0	7.5
Ethiopia	122.3	123.8	168.4	1.2	36.0	171.6	187.8	189.4	9.4	0.9
Kenya	305.0	314.3	359.1	3.0	14.3	442.2	560.2	534.6	26.7	-4.6
Lesotho	5.2	3.1	3.9	-40.4	25.8	32.1	39.2	38.7	22.1	-1.3
Madagascar	144.8	146.9	163.6	1.5	11.4	170.5	213.3	202.3	25.1	-5.2
Malawi	59.6	71.2	84.1	19.5	18.1	99.0	107.8	133.6	8.9	23.9
Mauritius	69.2	64.9	107.0	-6.2	64.9	75.6	114.1	120.0	50.9	5.2
Somalia	31.4	34.5	43.3	9.9	25.5	45.1	62.7	75.5	39.0	20.4
Swaziland	70.5	78.4	94.4	11.2	20.4	59.8	67.0	74.6	12.0	11.3
Tanzania	259.0	278.4	318.8	7.5	14.5	318.4	381.6	410.0	19.8	7.4
Uganda	279.1	260.0	282.5	-6.8	8.7	171.9	249.6	162.2	45.2	-35.0
Zambia	1,000.9	678.8	758.5	-32.2	11.7	544.0	630.0	645.0	15.8	2.4
Total	2,375.0	2,100.5	2,424.9	-11.6	15.4	2,192.9	2,697.3	2,676.2	23.0	-0.8
Total 40 countries	11,686.8	12,075.3	13,670.9	3.3	13.2	9,974.7	11,553.2	12,660.0	15.8	9.6

Source: ECA Secretariat.

1 - 4 Total Value of Exports and Re-Exports, Imports, and Visible Balance of Trade

(in million Eth. $)

Gregorian Year	Exports and Re-Exports	Imports	Visible Balance of Trade	Ethiopian Year
1946	76.2	94.9	-18.7	1938/9
1947	98.7	121.2	-22.5	1939/40
1948	96.6	124.0	-27.4	1940/1
1949	94.0	119.1	-25.1	1941/2
1950	91.3	105.5	-14.2	1942/3
1951	151.9	147.4	- 4.5	1943/4
1952	131.4	161.9	-30.5	1944/5
1953	169.4	137.9	+31.5	1945/6
1954	160.3	160.1	+ 0.2	1946/7
1955	162.2	168.0	- 5.8	1947/8
1956	151.4	157.1	- 5.7	1948/9
1957	192.0	178.4	+13.6	1949/50
1958	156.8	193.6	-36.8	1950/1
1959	179.2	208.9	-29.7	1951/2
1960	192.6	219.3	-26.7	1952/3
1961	188.7	235.6	-46.9	1953/4
1962	199.5	257.3	-57.8	1954/5
1963	223.4	276.1	-52.7	1955/6
1964	262.5	307.6	-45.1	1956/7
1965	289.8	375.7	-85.9	1957/8
1966	277.0	404.3	-127.3	1958/9
1967	252.7	357.4	-104.7	1959/60
1968	266.0	432.5	-116.5	1960/1
1969	298.1	388.3	-90.1	1961/2
1970	305.9	429.1	-123.2	1962/3
1971	314.4	469.6	-155.2	1963/4
1972	384.1	435.6	-51.5	1964/5

ANNEX - 2 Port Statistics

2 - 1 Export and Import for Last 10 Years

(MASSAWA and ASSAB)

(unit: M/T)

Year	MASSAWA			ASSAB		
	Import	Export	Total	Import	Export	Total
E.C. (G.C.)						
1955 (62 - 63)	186,423	167,550	353,973	95,578	221,430	317,000
1956 (63 - 64)	190,175	171,765	361,940	132,305	209,668	341,973
1957 (64 - 65)	242,006	184,697	426,703	204,554	166,796	371,350
1958 (65 - 66)	295,571	190,148	485,719	250,854	213,958	464,812
1959 (66 - 67)	299,769	181,197	480,966	314,578	185,948	500,526
1960 (67 - 68)	207,882	210,144	418,026	433,321	407,301	840,622
1961 (68 - 69)	256,547	240,656	497,203	556,768	444,409	1,001,177
1962 (69 - 70)	283,116	181,870	464,986	628,383	511,656	1,140,039
1963 (70 - 71)	290,195	259,565	549,760	688,637	491,852	1,180,489
1964 (71 - 72)	264,374	210,277	474,651	714,856	517,427	1,232,283

(DJIBOUTI)

(unit: M/T)

Year	EXPORT				IMPORT		
	General Cargo	Refined Oil Supply	Water Supply	Total	General Cargo	Refined Oil Supply	Total
1963 G.C.							
1964	125,589	1,504,667	194,456	1,824,712	170,555	1,605,400	1,775,955
1965	139,173	1,850,251	274,697	2,264,121	224,395	1,915,193	2,139,588
1966	119,190	1,739,528	275,724	2,134,442	233,961	1,863,461	2,097,422
1967	99,048	1,155,065	242,339	1,496,452	190,746	1,280,695	1,471,441
1968	85,876	449,952	97,971	633,799	204,175	524,785	728,960
1969	112,820	543,817	103,827	760,464	194,938	636,806	831,844
1970	88,092	632,584	100,731	821,407	232,866	765,467	998,333
1971	90,937	493,707	113,270	697,914	256,461	638,364	894,825
1972	132,421	451,540	109,065	693,026	195,448	586,938	782,386

2 - 2 Export and Import for Selected 3 Years

(MASSAWA)

(unit: 1,000 M/T)

	1962 E.C.	1963 E.C.	1964 E.C.
IMPORT			
Dry Cargo	127.5	130.4	107.2
Refinary Oil	60.4	89.8	32.5
Sub Total	187.9	220.2	139.7
Transshipment	-	-	1.3
Home Trade	95.2	70.0	123.1
Grand Total	283.1	290.2	264.4
EXPORT			
Dry Cargo	98.9	117.9	119.9
Cement	21.7	33.2	17.8
Salt	55.8	101.6	66.9
Sub Total	176.4	252.7	204.6
Transshipment	-	-	0.1
Home Trade	5.5	6.9	5.9
Grand Total	181.9	259.6	210.3

(ASSAB)

(unit: 1,000 M/T)

	1962 E.C.	1963 E.C.	1964 E.C.
IMPORT			
Dry Cargo	81.8	106.7	88.7
Refinary Oil	6.3	5.3	10.1
Sub Total	88.1	112.0	98.8
Crude Oil	540.3	575.7	612.3
Transshipment	-	-	1.3
Home Trade	-	0.9	2.5
Grand Total	628.4	688.6	714.9
EXPORT			
Dry Cargo	166.0	81.6	109.6
Coffee		46.2	49.3
Salt	91.1	58.0	59.6
Refinary Oil	154.6	244.3	179.0
Sub Total	411.7	430.1	397.5
Home Trade	100.9	61.8	120.1
Grand Total	511.7	491.9	517.4

2 - 3 Transshipment to and from Ethiopia via Djibouti

(unit: 1,000 M/T)

	1969 G.C.	1970 G.C.	1971 G.C.
IMPORT			
Dry Cargo		82.8	111.5
Urea		29.7	28.5
Salt		29.8	28.4
Sub Total		142.3	168.4
Refinary Oil		77.6	72.0
Grand Total		219.9	230.4
EXPORT			
Dry Cargo		7.4	11.7
Coffee		55.7	35.9
Fruits and Vegetables		6.9	12.2
Sugar		4.7	10.0
Grand Total		74.7	69.8

ANNEX - 3 Statistics of Inland Transport

3 - 1 Distances in Kilometres between Principal Towns

Addis Ababa	Asmera	Aseb	Debre Markos	Dese	Dire Dawa	Djibouti	Gonder	Jima	Kassala	Khartoum	Mitsiwa	Moyale	Nekemte	Yirga Alem
1074														
847	1177													
302	987	1149												
395	702	498	697											
531	1605	1378	903	926										
841	1915	1688	1213	1286	310									
760	529	1607	458	1132	1270	1601								
335	1409	1182	637	730	866	1176	1095							
1491	417	1594	1404	1119	2022	2322	946	1826						
1919	845	2022	1832	1547	2450	2760	1374	2254	428					
1164	115	1244	1102	769	1695	2005	844	1501	532	960				
786	1861	1634	1089	1459	1157	1488	1547	1424	2278	2706	1951			
330	1404	1177	632	725	861	1171	1090	665	1821	2249	1494	1117		
299	1373	1146	601	971	669	1000	1059	636	1790	2218	1463	488	629	

Source: Road Map of Ethiopia

3 - 2 All Weather Roads by Maintenance Districts

(unit: km)

1961 (E.C.)				
Alemgena	623	736	-	1,359
Combolcha	661	295	-	956
Shashamane	827	181	-	1,008
Dire Dawa	314	52	452	818
Gondar	525	15	-	540
Debre Markos	378	-	-	378
Jimma	468	-	-	468
Asmara	262	558	-	820
Adigrat	466	37	-	503
Total	4,524	1,874	452	6,850
1962				
Alemgena	673	736	-	1,409
Combolcha	661	295	-	956
Shashamane	827	180	-	1,007
Dire Dawa	314	52	452	818
Gondar	525	15	-	540
Debre Markos	378	-	-	378
Jimma	468	-	-	468
Asmara	261	558	-	819
Adigrat	466	37	-	503
Total	4,573	1,873	452	6,898
1963				
Alemgena	898	729	-	1,627
Combolcha	510	451	-	961
Shashemane	843	181	-	1,023
Dire Dawa	369	52	235	658
Gonder	576	15	-	591
Debre Markos	400	-	-	400
Jimma	470	45	-	515
Asmara	331	566	-	897
Adigrat	470	38	-	508
Total	4,867	2,077	235	7,179

Source: Imperial Highway Authority

3 - 3 Highway Transport Tariffs Per Metric Ton on Principal Roads

FROM ADDIS ABABA TO

(in Eth. $)

	Assab	Asmara	Dessie	Jimma	Dilla	Lekemt	Debre Markos	Nazareth
Length of Route (KMS)	875	1,080	397	335	370	331	300	100
1957	42.5	62.5	40	40	35	50	...	...
1959	35 - 50	45 - 75	25 - 35	25 - 28	25 - 28	25 - 28	25 - 35	8 - 11
1959	32 - 48	42 - 72	22 - 32	22 - 32	22 - 25	22 - 25	22 - 30	7.5 - 10.9
1960	30 - 45	40 - 70	20 - 30	20 - 22.5	20 - 22.5	20 - 22.5	20 - 30	7.5 - 10
1966	15 - 45	35 - 45	15 - 20	15 - 20	15 - 20	15 - 20	20 - 25	2 - 4
1967	15 - 40	35 - 45	15 - 20	15 - 25	15 - 22	15 - 20	15 - 20	2 - 5
1968	28	40	17.50	22.50	17.50	15	17.50	3.50
1969	15 - 40	35 - 45	15 - 20	15 - 25	15 - 22	15 - 20	15 - 20	2.5
1970	20 - 25	40 - 65	15 - 20	25 - 30	15 - 20	25 - 30	20 - 25	10
1971	20 - 30	40 - 70	15 - 20	25 - 30	15 - 30	25 - 30	25 - 30	10

Source: Imperial Highway Authority

3 - 4 Prevailing Tariffs for Goods on Assab/Addis Ababa Route as of Hider 1965 E. C.

(I. E. G. Road Transport Administration ADDIS ABABA)

No.	Type of Commodity	Rate per Quintal (Eth. $)
1	Alcoholic Drinks and Beverages	6.50
2	Advertising Materials	6.00
3	Aluminium	6.00
4	Asphalt	5.00
5	Acids	10.00
6	Any One Item Wt. Exceeding 2 tons	8.00
7	Acustic Boards	6.00
8	Astral Cream	5.75
9	Acrylic Yarn	6.00
10	Aluminium Profiles	6.00
11	Acetate	5.75
12	Ammunitions	8.00
13	Agricultural Equipment	8.00
14	Brass Handles	5.50
15	Bended Pipes	5.75
16	Beans	5.50
17	Butagas	6.00
18	Bath Tubs	5.50
19	Buldozer and Accessories	8.00
20	Balts	6.00
21	Barble in Various Size	5.50
22	Barley/Malt/	5.00
23	Bridge Components	3.75
24	Brushes	5.75
25	Buttons	5.75
26	Bricks	5.00
27	Batteries for Cars and Trucks	5.75
28	Baby Powder	5.75
29	Cable Drums	6.00 - 8.00
30	Cotton, Woolen, Rayon, and Nylon Goods	5.75
31	Carpets	5.00
32	Candles	5.75
33	Chemicals	6.00
34	Cars, Pickups and Light Delivery Vans	10.00
35	Cement Pipes	5.20
36	Cartons	5.00
37	Cement	5.00
38	Colours and Pencils	5.75

39	Curtain Fittings	5.75
40	Coffee Pulper Machines	5.30 - 8.00
41	Corks	5.75 - 6.00
42	Cardboard Sutcases	5.75
43	Cellophone and Cellulose	5.75
44	Chains	5.50 - 5.75
45	Construction Steel	6.00
46	Calculators and Typewriters	5.75 - 6.00
47	Chemical Sprays	6.00
48	Cigarettes, Cigars and Tobacco	7.00
49	Crane	8.00
50	Cotton Seeds	5.00
51	Chillies	6.00
52	Conductor	6.00
53	Castor Wheels	5.75
54	Cosmetics	6.00
55	Cement Additive	5.75
56	Compressors	6.00
57	Carbon	6.00
58	Cylinders	5.75 - 6.00
59	Chalk	5.00
60	D.D.T. in Drums	6.00
61	Door and Window Fittings	5.50 - 5.75
62	Duplicating Machines	7.00
63	Dyestuff	8.00
64	Engines Wt. Less Than 2 tons	6.00
65	Engines Wt. more than 2 tons	8.00
66	Electric Bulbs	6.00
67	Electric Cables	6.00
68	Empty Bags and Tins	5.75 - 6.00
69	Envelopes, Exercise Books	5.75
70	Electrical Materials and Appliances	5.75 - 6.00
71	Empty Bottles	5.75 - 8.00
72	Fire Extinguishers	5.75
73	Furniture	8.00
74	Flour	5.00
75	Flattened Bodies	5.75
76	Foodstuffs, Fruits	5.75
77	Flashlights	5.75
78	Filters	5.75
79	Fencing Wire	4.75
80	Fruit Nectar	6.00
81	Fertilizers	5.00
82	Glass Tumber	6.00
83	Glue	5.00
84	General Cargo	5.75

87	Granulators	6.00
88	Gate Valves	5.50
89	G. I. Sheets	4.75
90	Grinding Mills	6.00
91	Grease Oil	6.00
92	Buns	8.00
93	Glassware, Porcellain Ware	6.00
94	Green Peas	5.75
95	Ghee	5.75
96	Hard Soft Boards, Plywoods, Lamia, Plastics	5.75
97	Hoses	5.75
98	Honey Extractors	5.75
99	Hops	5.75
100	Hides	5.75
101	Hinges	5.75
102	Iron, Iron Channels	4.75
103	Industrial Adhesive	5.75
104	Industrial Belting	6.00
105	Iron Works	5.75
106	Irrigation Equipment	5.50 - 6.00
107	Iron Hardware	5.50
108	Iron Pipes of 13 metres, 12 metres	7.00
109	Iron Pipes of 9 metres	6.15
110	Iron Pipes of 7.40 metres	5.50
111	Iron Pipes of 6 metres	5.50
112	Iron Bolts	5.75
113	Insedticides	6.00
114	Insulation Boards	6.00
115	Iron Key Chains	5.75
116	Iron Bars and Angles	4.75
117	Iron Nails	5.75
118	Ink	5.00
119	Jam and Margarins	5.75
120	Kitchen Equipment	8.00
121	Kerosene	6.00
122	Linolium	7.50
123	Lub Oils in Drums	5.75
124	Laminated (Plastic) Sheets	5.50
125	Lead Tubes and Soldering Tin	5.50
126	Measurement Tape	5.50
127	Mahogany	5.75
128	Machine for Bars	8.00
129	Mineral Salts	6.00
130	Motor Boats	10.00
131	Matresses	7.00 - 8.00
132	Medical Cotton Gauges	6.00

133	Milk Powder	5.75
134	Machinery Spare Parts	6.00
135	Machinery	7.30 - 8.00
136	Mighty (large-sixe) Plates	5.50
137	Naphtaline	6.00
138	Plastic in Rolls	6.00
139	Pharmaceuticals	6.00
140	Photo Goods	6.50
141	Pad Locks	5.50
142	Perfumes and Toilet Preparations	6.50
143	Paints, Thinner, Turpentine	5.00
144	Plaster	6.00
145	Plastic Pipes	6.00
146	Personel Effects and Household Goods	8.00
147	Photo Paper	6.00
148	Pick Trails	8.00
149	Plant Protections	6.00
150	Polythene Buckets	5.75
151	Pipe Fittings	5.50
152	Pipes for Toilet Booms	6.00
153	Paint in Drums	5.75
154	Printing Ink	5.75
155	Painting Materials	6.00
156	Paper Reels	5.75
157	Processing Materials	5.75
158	Razor Blades	5.75
159	Radios, Record Players, Gramaphone Discs and Spares	8.00
160	Refrigerators and Spares	8.00
161	Raw Rubber for Factory	5.75
162	Radio Batteries	6.00
163	Raw Plastic for Factory	6.00
164	Raw Materials	5.75
165	Road Pavers	8.00
166	Rubber Pipes	6.50
167	Rollers	8.00
168	Soaps and Detergents	5.75
169	Sanitary Ware and Fittings	5.50 - 5.75
170	Steel Pipes, Round Steel Window	4.75
171	Salt	5.00
172	Spare Parts and Tools	5.75 - 6.50
173	Steel Structures	6.00
174	Synthetic Rubber	5.73
175	Steel Wire and Sheets	4.75
176	Sauce	5.75
177	Steel Angles	4.75
178	Soda Ash	6.00

179	Stationery	5.75
180	Sanitary and Other Toilet Paper	5.75 - 6.00
181	Steel Sinks	5.50 - 6.00
182	Sweets and Other Confectionaries	5.75
183	Skin Cream	5.75
184	Spring Leaves	6.00
185	Springs (Balestre)	6.00
186	Slaughterhouse Equipment	6.00
187	Soft Boards	6.00
188	Steel Panels	5.75
189	Shoes	5.57
190	Safe	8.00
191	Saw Blades	5.75
192	Stoves	8.00
193	Shutters	5.75
194	Toys	5.75
195	Tubes	5.75 - 6.50
196	Tiles	5.00
197	Toothpastes	5.75
198	Tea	5.75
199	Tin Plates (Lamera)	4.75
200	Tyres	6.50
201	Tractors and Trailers	8.00
202	Tinned Provisions	5.75
203	Tarapuline	5.75 - 6.50
204	Unlined Board, Paper Extra Strong Writing Paper	5.75
205	Umbrella	5.75
206	Unprotacted Timber	4.75
207	Welding Electrodes	5.50
208	Window Glass	6.00
209	Winches	5.75
210	Washing Machine	8.00
211	Whiting (omaya) for Factory	6.00
212	W.C. Seats and Covers	5.50
213	Welded Tubes and Profiles	4.75
214	Water Heaters	8.00
215	Wheel Axles	5.75
216	Xylol Solvent	6.00

3 - 5 Freight Rates on the Franco - Ethiopian Railway for Selected Import Goods

(Eth. $ per ton)

COMMODITY	1961 (E.C.)	1962(E.C.)	1963(E.C.)
DJIBOUTI - ADDIS ABABA:			
Building Materials and Supplies			
Building Materials	62.70	51.00	62.00
Cement	42.70	41.00	52.00
Corrugated Iron Sheets	41.00	41.00	41.00
Food			
Fresh Fruits and Vegetables	78.70	78.70	78.00
Rice	62.70	62.70	62.00
Salt	25.00	29.00	29.00
Sugar	52.70	51.00	52.00
Motor-Vehicles, Fuel and Equipment			
Motor-Vehicles	96.70	96.70	149.00
Benzine	51.00	51.00	51.00
Lubricating Oils	62.70	62.70	62.00
Tyres and Tubes	70.70	71.00	71.00
Textiles			
Cotton, Raw	41.70	41.70	56.00
Cotton Yarn	56.00	67.70	67.00
DJIBOUTI - DIRE DAWA:			
Building Materials and Supplies			
Building Materials	26.45	26.85	25.75
Cement	22.50	22.10	21.00
Corrugated Iron Sheets	22.45	28.40	25.75
Food			
Fresh Fruits and Vegetables	32.75	32.75	32.05
Rice	26.45	26.45	25.75
Salt	25.00	29.00	25.00
Sugar	32.00	32.00	31.30
Motor-Vehicles, Fuel and Equipment			
Motor Vehicles	59.85	59.85	60.15
Benzine	38.00	41.00	39.00
Lubricating Oils	26.45	26.45	25.75
Tyres and Tubes	42.25	41.25	41.55
Textiles			
Cotton, Raw	18.15	24.85	17.45
Cotton, Yarn	30.40	30.40	29.70

For full-wagon
Source: Franco-Ethiopian Railway

3 - 6 Freight Rates on the Franco - Ethiopian Railway for Selected Export Goods

(Eth. $ per ton)

Commodity	1961 (E. C.)		1962 (E. C.)		1963 (E. C.)	
	Season		Season		Season	
	ON-	OFF-	ON-	OFF-	ON-	OFF-
ADDIS ABABA - DJIBOUTI						
Beeswax	41.00	41.00	41.00	41.00	30.00	30.00
Cattle, Live (per m^2)	27.00*	27.00	27.00	27.00	27.70	27.70
Cereals	31.00	31.00	31.00	31.00	31.00	31.00
Chat	183.00	183.00	183.00	183.00	183.00	183.00
Coffee	28.00	28.00	28.00	28.00	41.00	41.00
Flour	46.00	46.00	46.00	46.00	46.00	46.00
Fresh Fruits and Vegetables	78.70	78.70	78.70	78.70	78.70	78.70
Hides and Skins	41.70	41.70	41.00	41.00	46.00	46.00
Oil Cake	15.00	15.00	15.00	15.00	31.00	31.00
Oil Seeds and Pulses	22.50	22.50	21.00	21.00	36.00	36.00
DIRE DAWA - DJIBOUTI						
Beeswax	26.45	26.45	26.45	26.45	26.45	26.45
Cattle, Live (per m^2)	12.00	12.00	12.00	12.00	12.00	12.00
Cattle Hides	34.00	34.00	34.00	34.00	33.95	33.95
Cereals	23.70	23.70	23.70	23.70	23.70	23.70
Chat	300.00	300.00	300.00	300.00	300.00	300.00
Coffee	39.10	39.10	39.10	39.10	39.10	39.10
Flour	31.70	21.70	21.70	21.70	21.70	21.70
Fresh Fruits and Vegetables	32.75	32.75	32.75	32.75	32.75	32.75
Goat and Sheep Skins	37.50	37.50	37.50	37.50	37.50	37.50
Oil Cake	18.15	18.13	18.15	18.15	18.15	18.15
Oil Seeds	21.30	21.30	21.30	21.30	21.30	21.30
Pulses	22.10	22.10	22.10	22.10	22.10	22.10

* For a monthly minimum of 100 m^2

Source: Franco-Ethiopian Railway

ANNEX - 4 Marine Container Transport

4 - 1 Containerlizable Cargoes

Of all the cargos now transported by liners, it is said, 70 to 80 % can be containerised. Cargos which can be put into containers, except grains, sugar, fertilizer and coal which are transported by specialized bulk cargo ships, can be containerized.

If we devide further cargos into two categories,

a) quite suitable for container transport and

b) fairly well suitable for container transport,

beverage tabacco, medicines, dyestuffs, ruber and plastic products, textilies small size electric appliances, sewing machines, motor cycles, stationary machines, etc. belong to a) --- if furnished with refrigirator, meat and dairy products as well --- while raw hide, pulp, vegitable oil in drum, tar, metal goods and non-ferrous metals to b).

Please refer to SITC

4 - 2 Container Cargo in Japan

IMPORT (unit: million ¥)

Commodities	Import Total (A)	ratio to the last survey (%)	Containerized (B)	ratio to the last survey (%)	(B/A) %	last survey (%)
Section 0						
Food and Live Animals	98,117	120.9	16,487	238.0	16.8	8.5
(01 Meat and Meat Products)	11,944	222.5	6,475	323.4	54.2	37.3
Section 1						
Beverages and Tobacco	3,137	390.2	1,565	1,176.7	49.9	16.5
Section 2						
Crude Materials, Inedible, except Fuels	196,409	103.0	20,387	195.6	10.4	5.5
(211 Hides and Skins undressed)	6,429	260.3	5,868	334.9	91.3	70.9
(262 Wool and other Animal hair)	13,879	140.0	7,938	148.9	57.2	53.7
Section 3						
Mineral Fuels, Lubricants	163,736	139.0	235	290.1	0.1	0.1
Section 4						
Animal and Vegetable Oil and Fats	2,384	80.0	68	6,800.0	2.9	0.0
Section 5						
Chemicals	24,332	92.5	10,506	344.0	43.2	11.6
(541 Medicinal and pharmaceutical products)	3,409	85.5	2,091	606.1	61.3	8.7
(581 Plastic Materials)	2,601	135.5	1,805	330.6	69.4	28.4
Section 6						
Manufactured Goods Classified Chiefly by Materials	43,120	104.5	8,562	309.5	19.9	6.7
Section 7						
Machinery and Transport Equipment	36,966	83.8	18,397	205.8	49.8	20.3
(732-1 - 7 Motor Vehicles)	3,519	139.1	759	251.3	21.6	11.9
Section 8						
Miscellaneous Manufactured Articles	21,411	135.6	12,911	189.5	60.3	43.2
Section 9						
Commodities and Transactions not Classified by Kind	2,804	144.8	618	195.6	22.0	16.3
Total	592,416	113.3	89.736	227.5	15.1	7.5

Note: Above figures are the result of the survey which had been done in Japan during the period of Oct. 21st to Nov. 20th in 1973 G.C.
Figures listed in the colum 8, ratio to the last survey' are shown as increases from the same period of 1971 G.C.

EXPORT (unit: million ¥)

Commodities	Export Total (A)	ratio to the last survey (%)	Containerized (B)	ratio to the last survey (%)	(B/A) %	last survey (%)
Section 0 Food and Live Animals	18,705	112.9	7,166	341.6	38.3	12.7
Section 1 Beverages and Tobacco	397	70.4	307	548.2	77.3	10.0
Section 2 Crude Materials, Inedible, except Fuels	12,411	137.7	1,670	497.0	13.5	3.7
Section 3 Mineral Fuels, Lubricants	1,872	141.2	35	437.5	1.9	0.6
Section 4 Animal and Vegetable Oil and Fats	437	37.9	78	312.0	17.8	2.2
Section 5 Chemicals	46,159	137.0	8,796	358.9	19.1	7.3
Section 6 Manufactured Goods Classified Chiefly by Materials	219,918	125.2	35,239	227.9	16.0	8.8
Section 7						
Machinery and Transport Equipment	353,552	161.9	95,307	217.3	27.0	20.1
(717-3 Machines)	4,746	131.5	2,192	182.8	46.2	33.2
(724-1 Televisions)	12,690	106.8	11,121	119.1	87.6	78.6
(724-2 Radios)	25,856	132.2	19,587	191.7	75.8	52.3
(732-9 Mtorcycles)	26,242	196.5	16,934	319.0	64.5	39.8
Section 8						
Miscellaneous Manufactured Articles	68,399	103.7	43,204	198.2	63.2	33.1
(891-1 Phonographs, taperacorders)	18,884	126.4	16,085	183.4	85.2	58.7
(894 Permbulators, toys, games)	5,725	124.2	3,484	176.1	60.9	42.9
Section 9 Commodities and Transactions not Classified According to Kind	5,548	265.2	1,053	1,238.8	19.0	4.1
Total	727,398	138.7	192,855	223.8	26.5	16.4

Note: Above figures are the result of the survey which had been done in Japan during the period of Oct. 21st to Nov. 20th in 1973 G.C.
Figures listed in the column 8, ratio to the last survey, show increases from the same period of 1971 G.C.

4 - 3 ISO Standard of Container

Series 1				Series 2			
Name	Height(ft)	Width(ft)	Length(ft) (Rated)	Name	Height(ft)	Width(ft)	Length(ft)
1 A	8	8	40	2 A	2100	2300	2920
1 B	8	8	30	2 B	2100	2100	2400
1 C	8	8	20	2 C	2100	2300	1450
1 D	8	8	10				
1 E	8	8	6 2/3				
1 F	8	8	5				

Dimension & Weight

(1ton = 2240 lbs = 1016 kg)

Name	Height				Width				Length				Weight
		allowable	error	alloable	error		allowable	error	alloable	error		allowable	error	alloable	error	
	St.	in.	in.	mm	mm	St.	in.	in.	mm	mm	St.	in.	in.	mm	mm	Tons
1 A	8	0	+0 -3/16	2435	+3 -2	8	0	+0 -3/16	2435	+3 -2	40	0	+0 -3/8	11900	+2 -8	30
1 B		"		"			"		"		29	11 1/4	+0 -3/8	9125	+0 -10	25
1 C		"		"			"		"		19	10 1/2	+0 -3/16	6055	+3 -3	20
1 D		"		"			"		"		9	9 3/4	+0 -3/16	2990	+1 -4	10
1 E		"		"			"		"		6		+0 -3/16	1965	+3 -2	7
1 F		"		"			"		"		4	9 1/2	+0 -1/8		+0 -3	5
2 A	6	10 1/2	+3/16 -0	2100	+0 -5	7	6 1/2	+3/16 -0	2300	+0 -5	9	7 -3/16	+0 -3/16	2920	+0 -5	7
2 B		"		"		6	10 1/2	+3/16 -0	2100	+0 -5	7	10 1/2	+0 -3/16	2400	+0 -5	7
2 C		"		"		7	6 1/2	+3/16 -0	2300	+0 -5	4	9	+1/16 -1/8	1450	+0 -5	7

4 - 4 Dimension of Typical Container Ships (may be sailing through Suez and Red Sea)

Ship Owner	Nationality	Name of Ship	Date of const-ruction	G/T	D/W	Loading capacity (number of container)	Length x Width x Draft	Speed (knot)	Route of Service
Overseas Containers Ltd.	U.K.	Encounter Bay	69 - 1	27,000	29,100	1,408/20'	745ft x 100ft x 29.8ft	22.5	Europe-Australia
		Flinders Bay	69	27,000	29,100	"	"	"	"
		Moreton Bay	69-6-29	26,876	29,100	"	"	"	"
		Botany Bay	69 - 6	26,876	29,100	"	"	"	"
		Discovery Bay	69 - 6	26,876	29,100	"	"	"	"
		Jervis Bay	70 - 5	26,750	29,100	"	"	"	"
		Tokyo Bay	72 - 4	57,000	49,700	2,050/20'	289.5m x 32.3m x 11m	26	Japan-Europe
		Liverpool Bay	72 - 5	"	"	"	"	26	"
		Kowloon Bay	72 - 6	58,889	47,800	2,250/20'	274.3m x 32.3m x 13.0m	26	Far East-Europe
		Cardigan Bay	72 - 9	57,000	47,800	2,250/20'	"	26	"
		Total 10		334,267	369,600	17,048/20'			
Associated Container Transportation	U.K.	ACT 1	69-3-6	24,821	26,420	1,223/20'	715ft x 95ft x 34.6ft	22.1	Europe-Australia
		ACT 2	69-5-9	24,821	26,420	1,223/20'	"		"
		Ben Alder	72 - 10	57,889	50,000	2,215/20'		26	Far East-Europe
		ACT 6	72 -	24,212	26,097	1,223/20'		22.5	Europe-Australia
		Total 4		206,143	203,043	9,004/20'			
Australian National Line	Australia	Australian Endeavour	69-7-30	25,144	29,500	1,223/20'	715ft x 95ft x 34.6ft	22.1	"
N.Y.K.	Japan	Kamakura Maru	71 - 11	51,139	35,406	1,840/20'	254m x 32.2m x 12m	26	Japan-Europe
		Hiei Maru	72 - 4	23,700	23,600	1,006/20'	203m x 30m x 10.5m	23	Japan-USW
		Kurama Maru	72 - 3	51,139	35,396	1,840/20'	245m x 32m x 12m	26	Japan-Europe
		Kitano Maru	72 - 5	51,300	35,250	"	"	26	"
Mitsui OSK	"	Rain Maru	72 - 1	51,300	28,950	1,836/20'	245m x 32.2m x 12.0m	26	Japan-Europe
		Erube Maru	72 - 2	53,500	27,950	1,842/20'	252m x 32.2m x 12.0m	26	"
Scan Dutch	Sweden	Nihon	72 - 6	50,804	35,000	2,208/20'	275m x 32.2m x 10.7m	26	Far East-Europe (SEACO)
	Denmark	Slandia	72 - 9	49,890	34,500	2,270/20'		26	" (EACO)
	Norway	Toyama	72 - 12	52,196	34,500	2,270/20'		26	" (SEACO)
		Total 3		152,890	104,000	6,748/20'			
Zim Container Ser Service	Israel	Zim New York	72 - 4	25,800	25,045	700/40'	683m x 100m x 34	23	Far East-Mediterrenian
		Zim Tokyo	72 - 6	"	"	"	"	23	"
		Zim Haifa	72-(6-12)	"	"	1,394/20'		23	"
		Zim Genoa	72 - 10	"	"	1,394/20' 1,400/40'		23	"
		Total 4		103,200	100,180	2,788/20'			

4 - 5 Container Terminal, Facilities and Defenition

Definition

Container Terminal is an area within a port on which containerized sea and land transport meets. It has all the facilities for loading and unloading, its preparation, storage of cargos, reception and delivery of containers and containerized cargos, and administration of all equipment and machinery. (Japanese Association of Marine Container Transport.)

Container Terminal is an area within a port specified by a shipping company on which the shipping company collects, has custody of, stores cargos and receives and delivers containers.

(Trans Pacific Freight Conference of Japan)

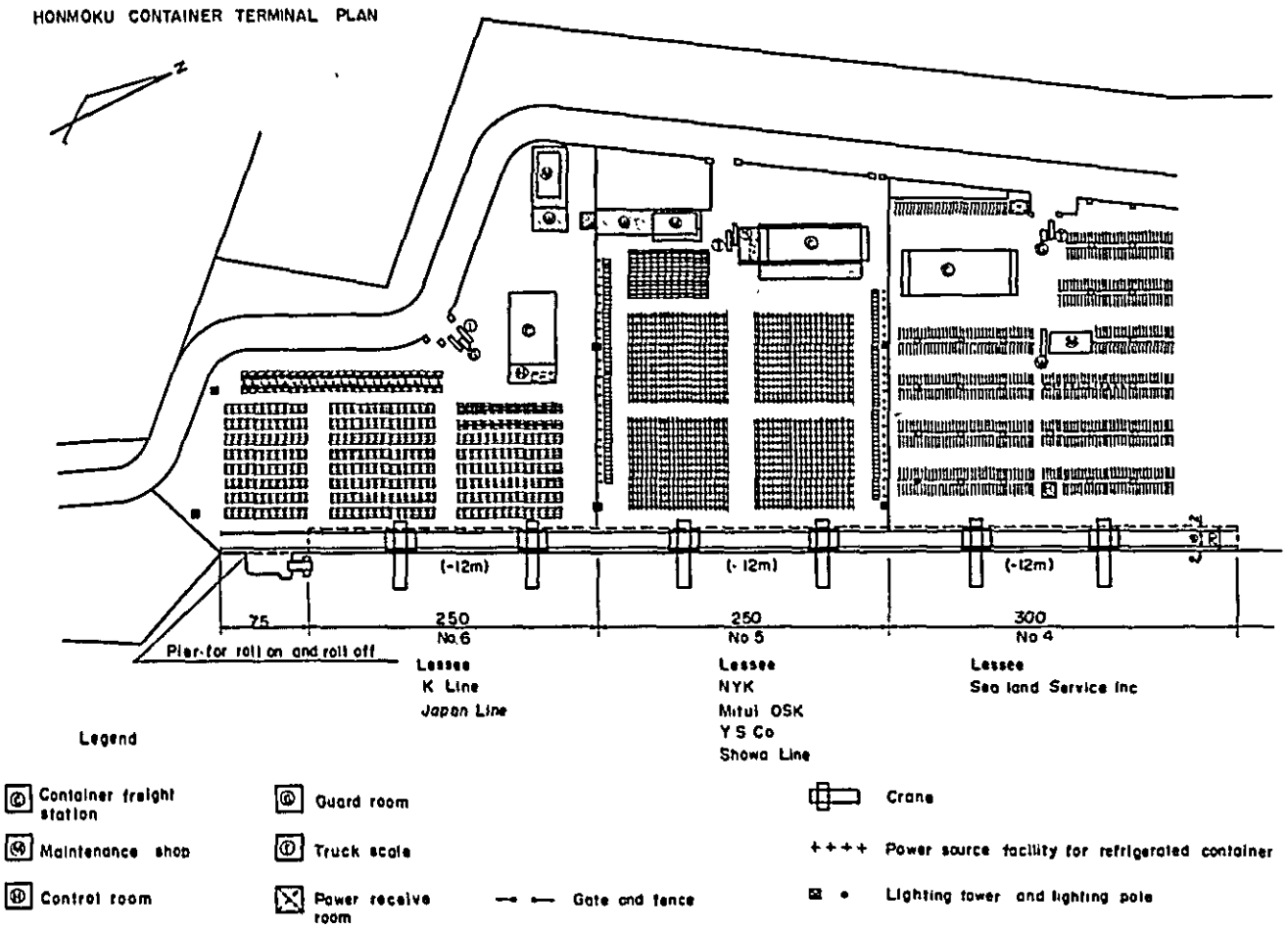
Facilities of Container Terminal

In usual case, following facilities are involved in container terminal.

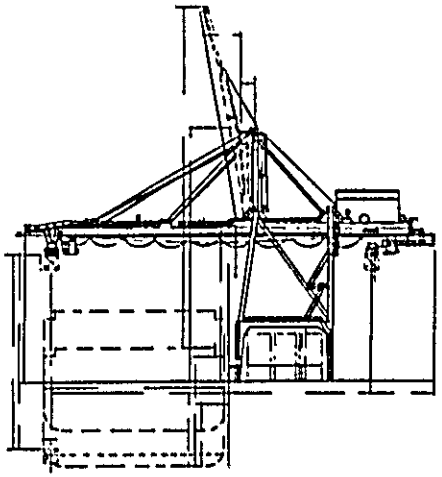
1.	Basic Facilities		
	i)	Basin	
	ii)	Berthing Facility	Quay Wall or Pier, Ramp-Way
	iii)	Cargohandling Facility(Fixed)	Apron, Marshalling Yard, Freight Station
			Container Crane, etc.
		(Movable)	Straddle Carrier, Yard Tructer, Fork Lift
	iv)	Storage Facility	Warehouse
	v)	Access Road and Railway Siding	
	vi)	Revetment	
2.	Attached Facilities		
	vii)	Bunkering and Water Supply	
	iix)	Maintenance Shop	
	ix)	Others	Storage Yard, Truck Scale, Lighting Facility
			Power Supply for Reefer, Parking Lot
3.	Administration Facilities		Office, Control Tower, Gate and Fence
4.	Other Facilities		
	i)	Domitory and Clinic	
	ii)	Power Supply and Communication Facilities	
	iii)	Water Supply, Drainage and Sewerage Facilities	

ANNEX 4-6 EXAMPLE OF CONTAINER TERMINALS

(Unit: M)



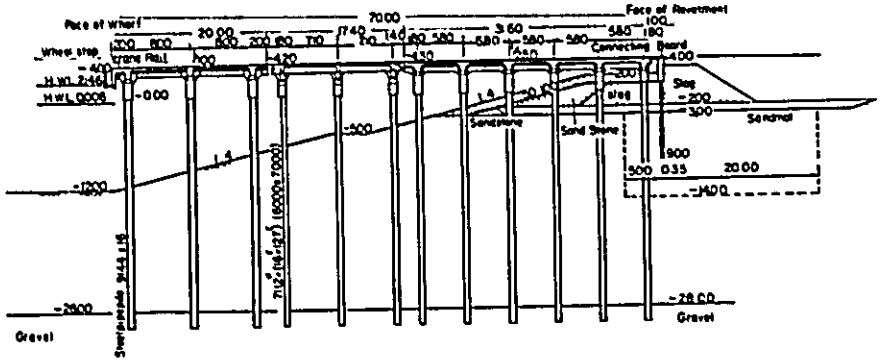
30.5 t Container Crane



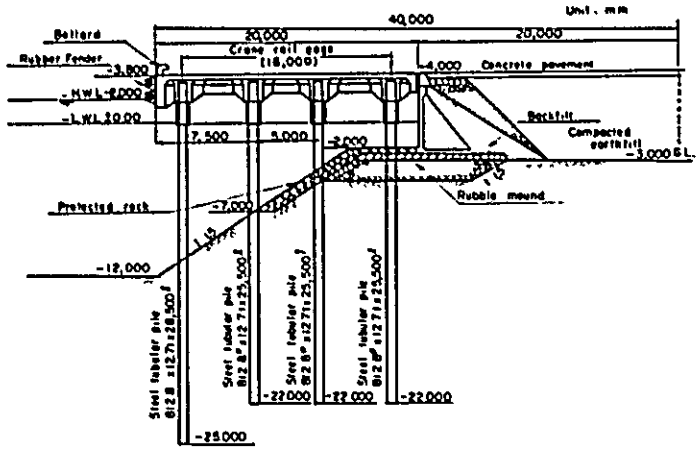
Principal Specifications of Crane

	(In No.5, No.6 terminal)	
Rated load	30.5 t	
Rail span	16 m	
Total width	25 m	
Effective width inside straddle	14.5 m	
Liftrange	Seaside running rail face	upper 21.7 m down 11.8 m
Out reach	From seaside rail centre	33.5 m
Back reach	From landside rail centre	7.5 m
Power receiving system	Cable coil carrier system	
Power source	Power receiving: AC 550 V	50 ∞
	Main circuit: DC 440 V	
	Operation circuit: DC 220 V	
	Illumination, heating, alarm purpose: AC 100 V	50 ∞

Cross Section of the Container Pier in Ohi Terminal, Tokoyo port



Cross section of Honmoku container Terminal, Yokohama port



Summarized Table of Facilities (Hommoku Container Terminals)

	o No. 6 Terminal	o No. 5 Terminal	o No. 4 Terminal
Lessee	'K' Line Japan Line	NYK Mitsui OSK Y - S Co. Showa Line	Sea - land Service, Inc.
Total Yard Area	82,600 m^2	80,800 m^2	78,400 m^2
Apron	11,100 m^2	10,000 m^2	10,000 m^2
Marshalling yard	31,500 m^2	40,000 m^2	40,000 m^2
Other areas	31,500 m^2	30,800 m^2	28,000 m^2
Berth	-12 m 250 m	-12 m 250 m	-12 m 300 m
Container freight station	(Length) (Width) 64.3 m x 40.8 m = 2,620 m^2	(Length) (Width) 88.0 m x 30.0 m = 2,620 m^2	(Length) (Width) 85.4 m x 18 m = 3,420 m^2
Maintenance shop	40 m x 20 m = 800 m^2	40 m x 20 m = 800 m^2	36 m x 18 m = 650 m^2
Crane	2 units	2 units	2 units
Power source facilities for refrigerated container	100 locations	120 locations	48 locations
Lighting facilities	4 units, 112 KW	4 units, 112 KW	43 units, 68 KW
Power receiving facilities	(P. R. Room 160 m^2) 2,760 KVA	(R. R. Room 160 m^2) 2,625 KVA	(P. R. Room 210 m^2) 2,340 KVA
Other facilities			
Cleansing facilities	720 m^2	1,100 m^2	110 m^2
Oiling facilities	10,000 ℓ	10,000 ℓ	-
Guand room	72 m^2	-	60 m^2
Truck scale	2 units	2 units	1 unit
Vessel water supply facilities	8 locations	8 locations	8 locations
Vessel telephone	3 locations	3 locations	3 locations
Communication facilities facilities	21 circuits	21 circuits	9 circuits
Control room	1,170 m^2	1,250 m^2	180 m^2
Number of Stored Containers			
(one stair stocking)	1,012	1,276	697
Dry	912	1,177	649
Reefer	100	39	48

4 - 7 Abbreviation of Container Terminalogy

A.

A. A. R.	Association of American Railroads
A. C. L.	Atlantic Container Lines
A. C. T.	Associated Container Transportation, Ltd.
A. E. I. L.	American Export Isbrandtsen Lines
A. I. C.	International Railway Congress Association
A. I. S. E.	Association of Iron and Steel Engineering
A. M. H. S.	American Material Handling Society
A. M. L.	American Mail Line
A. N. L.	Australian National Line
A. P. L.	American President Line
A. S. A.	American Standard Association
A. S. M. E.	American Society of Mechanical Engineer
A. T. A.	1) Air Transport Association of America
	2) American Trucking Association

B.

B. H. P.	Brake Horse Power
B/L	Bill of Landing
B. O. R.	Baltimore and Ohio Railroad

C.

C. A. B.	Civil Aeronautic Board
C. B. & Q	Chicago Burlington & Quincy
C. C. C.	1) California Cargo Containers
	2) Compass Containers Company
	3) Customs Cooperation Council
C. E. M. A. T.	Societa Costruzioni Esercizio Mezzi Ausiliari di Transporto
C. F. S.	Container Freight Station
cft.	cubic feet
C. I. F.	Cost, Insurance and Freight
C. I. M.	International Convention Concerning the Carriage of Goods by Rail
C. L.	1) Car Load
	2) Container Load
C. L. A. S. S.	Containerized Lighter Aboard Ship System
C. L. cargo	1) car load cargo
	2) container load cargo
C. L. rate	1) car load rate
	2) container load rate
C. L. service	car load service
C. L. shipment	container load shipment
C. M. I.	Comite Maritime International
C. M. L.	Container Marine Line

	C. M. S. P. & P.	Chicago Milwaukee St Paul and Pacific Railroad
	C. M. R.	Convention on the Contract fox International Carriage of Goods by Road
	C. N. A. W. F. C.	Continental North Atlantic Westbound Freight Conference
	C. & O.	Chesapake and Ohio Railway
	C. O. F. C.	Container on Flat Car
	Conex	Container Express
	C. T. I.	Container Transport International Inc.
	C. T. S.	Central Terminal Station
	C. Y.	Container Yard
D.		
	D. B.	Deutsche Bundesbahn
	DO/DO system	drive on/drive off system
	D. O. T.	Department of Transport
	D. R.	Deutsche Reichsbahn
	D. & R. G. W.	Denver and Rio Grande Western Railroad
	D/W	dead weight
	DWT	dead weight ton
E.	E. C. E.	Economic Commission for Europe
	E. C. E.	Economic Commission for Europe
	E. C. T.	Europe Container Terminal N. V.
	E. E. C.	European Economic Community
F.		
	F. A. K.	Freight All Kinds
	F. M. B.	Federal Maritime Board
	F. M. C.	Federal Maritime Commission
	F. O. B.	free on board
	FRP Container	fiberglass reinforced plastics container
	F. X.	Parrovie dello Stato Italia
G.		
	G. A. T.	General American Transportation Co.
	G. N.	Great Northern Railway
H.		
	H. K.	Hong Kong
	Hp	Horse power
	H. & M.	Hulland Machinery Insurance
I.		
	I. A. T. A.	International Air Transport Association
	I. C. Act	Interstate Commerce Act
	I. C. B.	International Container Bureau
	I. C. C.	Interstate Commerce Commission

I. C. H. C. A.	International Cargo Handling Coordination Association
I. C. S.	Integrated Container Service Inc.
I. H. I.	Ishikawajima-Harima Heavy Industries Co., Ltd.
I. L. A.	International Longshoremens' Association
I. L. W. U.	International Longshoremens' and Warehousemens' Union
I. M. H.	Institute of Material Handling
I. R. F.	International Road Federation
I. R. U.	International Roadtransport Union
I. S. A.	International Federation of National Standardization Association
I. S. O.	International Organization for Standardization
I. S. O. T. C.	International Organization for Standardization Technical Committee

J.

J. A. G.	Japan Atlantic and Gulf Freight Conference
J. A. R.	Japan Association of Rolling Stock Manufacturers
J. I. S.	Japanese Industrial Standard
J. N. R.	Japanese National Railways

K.

Kn	knot
Kt	kiloton

L.

L. A. S. H.	Lighter Aboard Ships
lbs/cuft	pounds per cubic foot
L. C. L.	Less than Container Load
L. C. L. cargo	1) less than car load cargo 2) less than container load cargo
L. C. L. service	less than car load service
LO/LO system	lift on/lift off system
L/T	long ton
L. T. L. cargo	1) less than trailer load cargo 2) less than truck load cargo

M.

M. A.	Maritime Administration
M. H.	Materials Handling
M. H. Committee	Materials Handling Committee
M. H. I.	Mitsubishi Heavy Industries, Ltd.
M. M.	Messageries Maritimes
M. & M. Agreement	Mechanization & Modernization Agreement
M. & M. Fund	Mechanization & Modernization Fund
M. S. C. C.	Mitsubishi Seairland Containerization Committee
M. S. T. S.	Military Sea Transportation Service
M/T	metric ton

N.

N. A. C. F. C.	North Atlantic Continental Freight Conference
N. A. I.	North American International
N. A. W. F. A.	North Atlantic Westbound Freight Association
N. B. C.	National Bulk Carriers, Inc.
N. C. T.	Nippon Container Terminal Co., Ltd.
N. C. Y.	Nippon Container Yuso Co., Ltd.
N. E. M. A.	National Electrical Manufacturers Association
N. H.	New York, New Haven and Hartford Railroad
N member	non participating member
N. P.	Northern Pacific Railway
N. S.	Nederlandsche Spoorwegen
N. V. O.	Non-Vessel Operating Common Carrier by Water
N. Y.	New York
N. Y. C.	New York Central System
N. Y. S. A.	New York Shipping Association, Inc.

O.

O. C. L.	Overseas Containers Ltd.
O. E. C. D.	Organization for Economic Co-operation and Development

P.

P. F. E. L.	Pacific Far East Line
P. W. G.	Pacific Westbound Freight Conference

Q.

R.

RO/RO	Roll on/Roll off
rpm	revolutions per minute

S.

S. C. O. F. C.	Stacked Container on Flat Car
S. H. P.	shaft horse power
S. N. C. F.	Societe National des Chemins de Fer Francaise

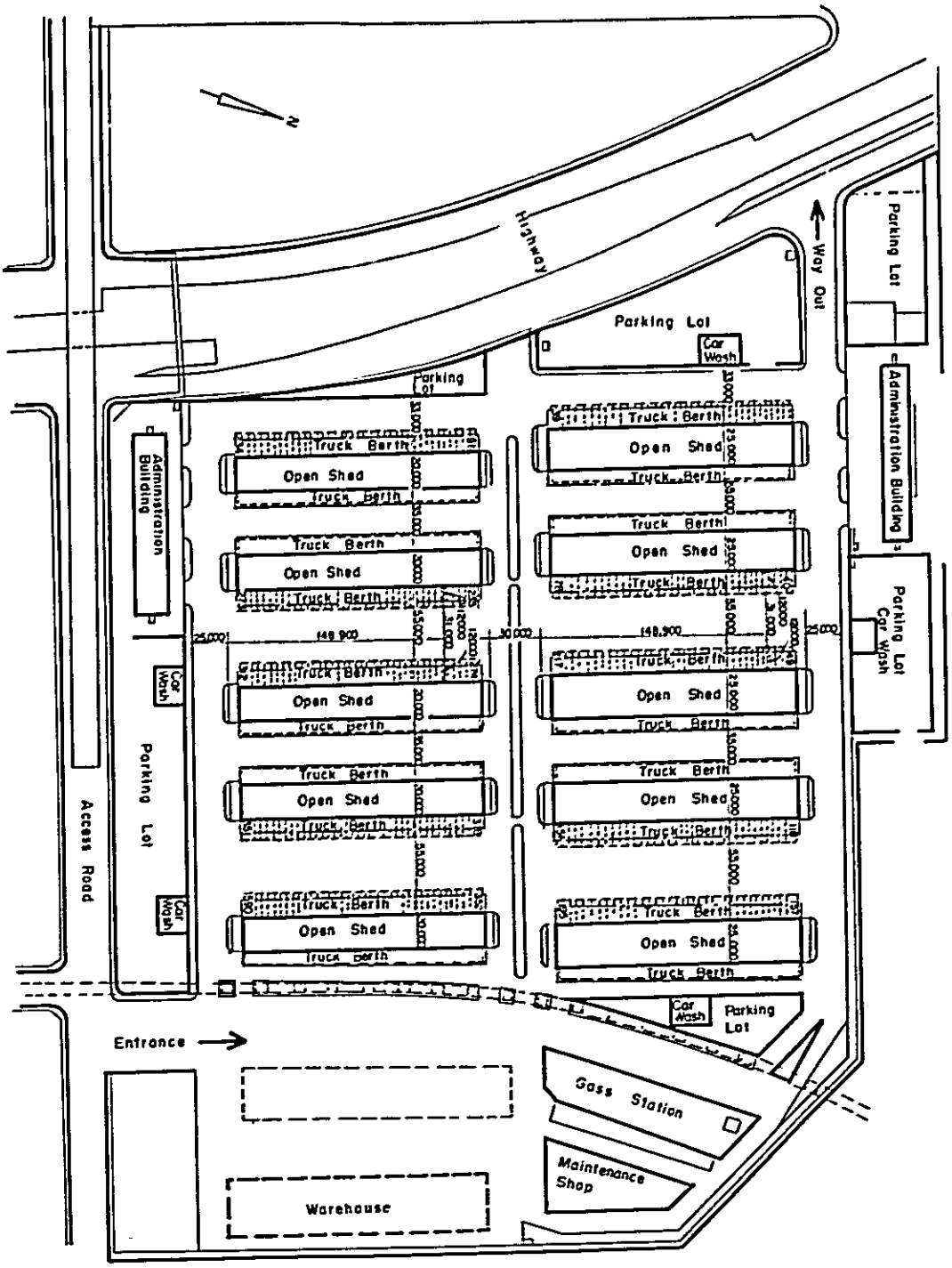
T.

T. E. R. R. E.	Trans Europe Road Rail Express
T. I. F.	Convention Internationale pour Faciliter le Franchissement des Frontieres aux Marchandises Transportees par Voie Terree Geneve 1952
T. O. F. C.	Trailer on Flat Car
T. O. T. T.	Trailer on Truck Train
T. P. F. C. J.	Trans Pacific Freight Conference of Japan
T. T. T. System	Tractor Trailer Train System

U.

U. C. C.	United Cargo Corporation
U. I. C.	1) International Union of Railway
	2) Union Internationale des Chemins de Fer
U. S. L.	United States Lines
U. S. S. A.	United States Standards Association

ANNEX 5 EXAMPLE OF TRUCK TERMINAL
Keihin Truck Terminal



Summarized Table of Facilities (Keihin Truck Terminal)

Total Area	222,890 m^2
Number of Truck Berth	390
Cost of Construction	66 million Eth. $[1)]
Cargo Handling Capacity	11,700 ton/day
Facilities	
1) Open Shed	20 m x 136.5 m x 5
	25 m x 136.5 m x 5 / Total 30,712 m^2
	Attached Office 4,652 m^2
ii) Administration Buildings	2 unit Total 15,092 m^2
Basement (1,422 m^2)	Bath Room, Laundry, Utility
Ground Floor (3,224 m^2)	Administration Office, Conference Room, Post Office, Cafeteria, Telephone Exchange
First Floor (3,352 m^2)	Bed Room (96 rooms, each for 10 beds), Looby
Cooling Tower & Water Tank	388 m^2
iii) Truck Berth	110,180 m^2
iv) Parking Lots	18,400 m^2
v) Maintenance Shop	1,275 m^2
vi) Gass Station	3,570 m^2 (10 berth)
vii) Car Wash	2,190 m^2 (28 berth)
iix) Warehouses	18,160 m^2

1): This figure includes cost of land aquisition. Weight of this item may be 30 to 40 % of total construction cost.

ANNEX - 6 An Example of Systems Analysis on Port Planning

.... *Estimation of* Optimum Number of Berths ....

(1) Introduction

One of the most powerfull tools for deciding optimum number of facilities, such as berths and cargohandling equipment, or estimating capacity of *facilities is so called queuing theory.* Papers concerned with applications of this technique to port planning apeared on ASCE or the Dock & Harbour Authority after 1966, but we have rather long experience in the use of this technique. The first trial in Japan was done in Port of KOBE by the group of young engineers quided by Dr. NAGAO at the end of 1950s.

As a concise expression of queuing models, Kendall's notations such as M/M/S (∞), M/M/S(N), M/D/S(N) and $M/E_k/S(N)$ are used. These expressions are corresponding to the following factors which govern queuing phenomenum.

i) distribution of customers' arrival
ii) distribution of service time for each customer
iii) number of channels servicing
iv) disciplin of service

The above mentioned Kendalls' notations mean i) queuing models with Poisson arrival, exponential service time and S channels, ii) Poisson arrival, Erlang distribution with phase k, with S channels, iii) Poisson arrival, constant service time, with S channels, respectively. These three models are frequently used for estimating the optimum number of berths, and the most of them are treated with "first come first served" servicing disciplin.

Mathematical models of queuing phenomenum are solved, in usual case, only for steady state and few are solved in time dependent from. This *is the reason why simulations by electronic* computer are extensively carried out for the time dependent characteristics of queuing phenomenum.

A simple inventory model of OR is also used for the estimation of optimum number of berths. In next section, we will find that approach from inventory model yields a special case of queuing model and contains self-contradiction in it.

(2) Inventory model and its' limitation

This method based on the estimation of number *of ships staying in port,* in general case demand distribution, is rather simple and aplicable to the some special cases. Papers concerned with this application are as follows:

i) Yoshimi Nagao: Report of Planning & *Designning of MAYA Pier in Port of* KOBE, 3rd Regional Construction Bureau, Ministry for Transport, 1958
ii) Fratar T. J. & Goodman A. S.: Prediction of Maximum Practical Berth Occupancy, Transaction, ASCE Part IV, Vol. 126, 1961
iii) *Plumee C. H.: Optimum Sise Seaport,* Journal of the Waterways and Harbors Division, ASCE, Vol. 92, No. WW3, Proc. Paper 4880, Aug. 1966

Suppose, we are going to estimate the optimum number of berths for given port and it is confirmed that number of ships staying the port in each day is expressed by probability distribution of P(n).

Let C_1 as loss of idling one berth per day anc C_2 as ships' denurrage per day, we can minimize total loss TC(S) by selecting adequate number of berths S.

$$TC(S) = C_1 \sum_{n=0}^{s} (S-n) P(n) + C_2 \sum_{n=s+1}^{\infty} (n-S) P(n) \quad \cdots\cdots (1.1)$$

If S is large enough, we can treat (1.1) as continuous one as approximation and replace P(n) by f(n)dn.

$$TC(S) = C_1 \int_0^s (S-n) f(n)\, dn + C_2 \int_{s+1}^{\infty} (n-S) f(n)\, dn \quad \cdots\cdots (1.2)$$

Here, TC(S) is minimized by such S as satisfying $\frac{d(TC(S))}{dS} = 0$

$$\frac{d(TC(S))}{dS} = C_1 \int_0^s f(n)\, dn - C_2 \int_{s+1}^{\infty} f(n)\, dn = C_1 F(S) - C_2 [1 - F(S)] = (C_1 + C_2) F(S) - C_2 = 0$$

Naturally,

$$F(S) = \int_0^s f(n)\, dn, \quad \int_0^{\infty} f(n)\, dn = 1 \qquad F(S_0) = \frac{C_2}{C_1 + C_2} \quad \cdots\cdots (1.3)$$

Direct derivation of (1.1) yields a similar result (1.4)

$$P(n \leqq S_0 - 1) < \frac{C_2}{C_1 + C_2} < P(n \leqq S_0) \quad \cdots\cdots (1.4)$$

We can decide S_0, if P(n) or f(n) are known, and this procedure is applicable to any distribution of P(n) or f(n). Fig. - 1 is a schematic expression of (1.3).

The most of the papers concerned stated that number of ships staying in port can be approximated by Poisson distribution. If it is so, P(n) satisfy (1.5)

$$P(n) = \frac{m^n}{n!} e^{-m} \quad \cdots\cdots (1.5)$$

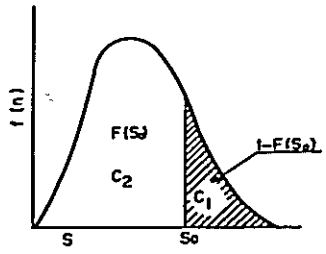
Here, m denote average number of ships staying in port. Partial sum of P(n) is expressed as (1.6) by incomplete function.

$$\sum_{n=s}^{\infty} P(n) = \sum_{n=s}^{\infty} \frac{m^n}{n!} e^{-m} = \frac{\Gamma_m(C)}{\Gamma(C)} \quad \cdots\cdots (1.6)$$

Here,

$$C \geq 1, \quad \Gamma = \int_0^{\infty} e^{-\theta} \theta^{C-1} d\theta, \quad \Gamma_m(C) = \int_0^{m} e^{-\theta} \theta^{C-1} d\theta$$

Fig. - 1



An example of Poisson approximation to number of ships staying in port is shown in Fig. - 2.
The source of this figure is Paper 2).

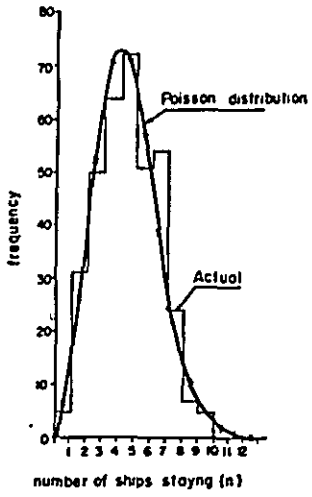
Fig. - 2 clearly shows that there is no port congestion in this port, because if congestion occurs, frequency distribution around full berth must be higher than smooth Poisson approximation.

By setting S_0, port forced to be in congested situation in certain extent. Therefore, frequency distribution is also changed. This is the self-contradiction of inventory model approach.

Next step is to find the reason why Poisson distribution fits well for distribution of number of ships staying in port in some cases.

Here, we introduce a type of queuing model which yields Poisson distribution as P(n), namely M/M/(∞). Let, Pn(t) as probability of n ships staying in port at the time t, and replace P(n) by Pn, M/M/(∞)type queuing model satisfys equation (1.7).

Fig. - 2 Number of Ships Staying in Port and Approximation of Poisson distribution



$$P_n(t+\Delta t) = P_{n-1}(t)(\lambda\cdot\Delta t + o(\Delta t)) + P_{n+1}(t)((n+1)\cdot\mu\cdot\Delta t + o(\Delta t)) + P_n(t)(1-\lambda\cdot\Delta t - n\cdot\mu\cdot\Delta t + o(\Delta t)) + o(\Delta t) \quad \cdots\cdots (1.7)$$

$$\lim_{\Delta t\to 0}\frac{P_n(t+\Delta t)-P_n(t)}{\Delta t} = P'_n(t) = \lambda\cdot P_{n-1}(t) + (n+1)\mu\cdot P_{n+1}(t) - (\lambda+n\mu)P_n(t) \quad \cdots\cdots (1.8)$$

Equation (1.8) has steady state solution, that means existence of Pn in equation (1.9) is proved.*1

$$\lim_{t\to\infty} P_n(t) = P_n \quad \cdots\cdots (1.9)$$

Therefore, if t is long enough, Pn(t) becomes 0. We can rewrite (1.8) as (1.10).

$$\left.\begin{aligned} &\lambda P_0 = \mu P_1 \\ &(\lambda+n\cdot\mu)P_n = \lambda\cdot P_{n-1} + (n+1)\mu\cdot P_{n+1} \quad (n\geqq 1)\end{aligned}\right\} \cdots\cdots (1.10)$$

We can derive (1.10) to (1.12)

$$P_n = (\lambda/n\cdot\mu)P_{n-1}$$
$$P_n = \left(\frac{\lambda}{\mu}\right)^n \frac{1}{n!}\cdot P_0 \quad \cdots\cdots (1.11)$$

Here, $\sum_{n=0}^{\infty} P_n = 1$ so we obtain

$$\sum_{n=0}^{\infty} P_n = \sum_{n=0}^{\infty}\left[\left(\frac{\lambda}{\mu}\right)^n \frac{1}{n!}\cdot P_0\right] = P_0\cdot\sum_{n=0}^{\infty}\left(\frac{\lambda}{\mu}\right)^n \frac{1}{n!} = P_0\cdot e^{\frac{\lambda}{\mu}} = 1$$

Putting Po into (1.11), we obtain

$$P_n = \frac{(\lambda/\mu)^n}{n!} \cdot e^{-\frac{\lambda}{\mu}} \quad \text{.....(1.12)}$$

Equation (1.12) is nothing but Poisson distribution with means of λ/μ. This means port where ships arrival occur random way, with exponential service time yields good fit of Poisson distribution for number of ships staying in port, if number of berth is large enough against the incomming vessels.

(3) Queuing model approach - I

... analytical solution ...

Queuing model approach to the estimation of optimum number of berths is usually done by applying analyticaly solved solution. Here, characteristics of queu such as average waitting time Wq, average queu length Lq, Pn and probability of full berth Pn($n \geq S$) agenst berth occupancy become important.

In acutual port problem, multi-channel solution is required. The most popular models which are applicable to the port are M/M/S(∞) and M/D/S(N).

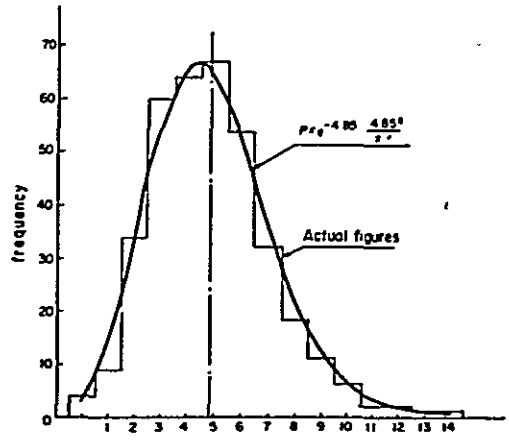
The first step of analysis is survey of distribution of ships arrival and ships service time in port. Though some case studies report that ships arrival to port can be approximated by Poisson distribution or ships stay in port by exponential distribution, we must carefully examine characteristics of given port. Fig. - 3 and Fig. - 4 are the result of case study at Keelung Harbour respectively ships arrival and ships stay in port. In this case, service desciplin was "first come first served".

Formulation of M/M/S(∞) type queuing model is equation (1.13). That is coresponding to equation (1.10) of M/M/(∞)type.

$$\left.\begin{aligned} &\lambda P_0 = \mu P_1 \\ &(\lambda + n\mu) P_n = \lambda P_{n-1} + (n+1)\mu P_{n+1} \qquad (1 \leqq n \leqq S-1) \\ &(\lambda + S\mu) P_n = \lambda P_{n-1} + S\mu P_{n+1} \qquad (n \geqq S) \end{aligned}\right\} \quad \text{.....(1.13)}$$

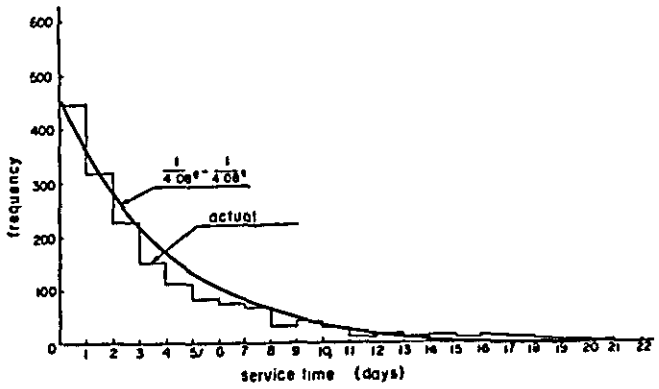
The difference of (1.10) and (1.13) is in the third line of (1.13).
If we rewrite n → S and (n+1) → S in the second line of equation (1.10), the third line of equation (1.13) is obtained.
Since there is no limitation on number of berth in equatior (1.10), probability that one of ships staying in port finish her service is expressed $n \cdot \mu \cdot \Delta t + o(\Delta t)$
or $(n+1) \cdot \mu \cdot \Delta t + o(\Delta t)$
But, this must be expressed as (1.14) under the limitation of berth number S.

Fig. - 3 Shipsarrival at Keelung (1966)



$$\left.\begin{aligned} &n \cdot \mu \cdot \Delta t + o(\Delta t) \qquad (n \leqq S) \\ &S \cdot \mu \cdot \Delta t + o(\Delta t) \qquad (S \leqq n) \end{aligned}\right\} \quad \text{.....(1.14)}$$

Fig. - 4 - (1) Service Time Distribution at Keelung (1966)



Solving equation (1.14), we obtain following characteristics.

Here, necessary condition for existence of solution is

$$\rho = \lambda/\mu \cdot S < 1 \qquad \text{otherwise equation diverges.}$$

i) Probability of n ships stay in port

$$\left.\begin{aligned} P_n &= \frac{a^n}{n!} P_0 \qquad (0 \leqq n \leqq S) \\ P_n &= \frac{S^S \rho^n}{S!} P_0 \qquad (S \leqq n) \end{aligned}\right\} \quad \cdots\cdots (1.15)$$

here,

$$P_0 = \left[\sum_{n=0}^{S-1} \frac{a^n}{n!} + \frac{aS}{(a-1)^2(S-a)}\right]^{-1} \quad \cdots\cdots (1.16)$$

ii) Probability of full berth

$$\pi = P(n \geqq S) = \sum_{n=S}^{\infty} P_n = \frac{a^S P_0}{S!(1-\rho)} \quad \cdots\cdots (1.17)$$

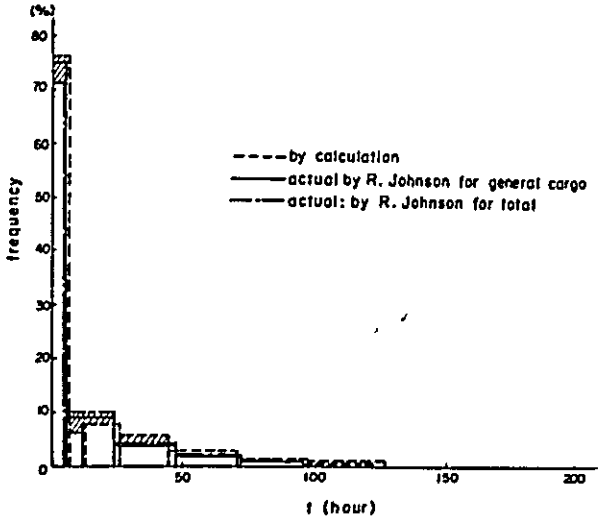
iii) Probability ship must wait longer than t

$$P(>t) = e^{-(S\mu-\lambda)t} \cdot \pi \quad \cdots\cdots (1.18)$$

iv) average length of queu

$$L_q = \frac{\lambda\mu a^S}{(S-1)!(S\mu-\lambda)^2} P_0 = \frac{\rho(S\rho)^S}{S!(1-\rho)^2} P_0 \quad \cdots\cdots (1.19)$$

Fig. - 5



v) average waiting time Wq

$$Wq = \frac{Lq}{\lambda} = \frac{\mu a^s}{(S-1)!(S\mu-\lambda)^2} P_0 = \frac{S^{s-1}\rho^s}{S!\mu(1-\rho)^2} P_0 \quad \cdots\cdots (1.20)$$

Fig. - 5 shows p(> t) of Keelung Harbour. Discrepancy between calculated value and actual figures is satisfactory small. Fig. - 6 shows an example of (1 - π) curve against various S. Average waiting time Wq is often examined in the relation to average service time 1/ μ. Wq curve is shown in Fig. - 7 where ordinate is expressed by μ Wq.

Fig. - 6 Probabilities of Zero Waiting (M/M/S(∞))

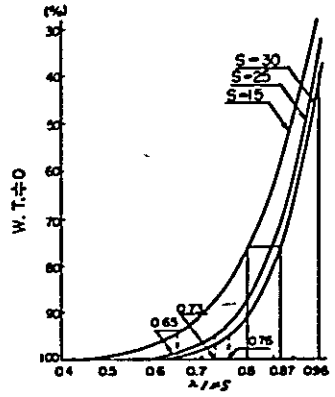
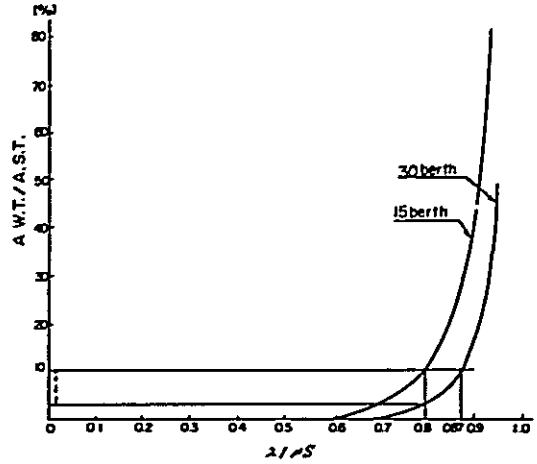


Fig. - 7 Number of Berths & AWT/AST



Equation (1. 21) is the formulation of M/D/S(N) type queuing model. This model is important not only yielding better fit to the analysis of bulk cargo berths where service time converges in very narrow range, but also providing one extream case of Poisson queu.

$$\left.\begin{aligned} P_0 &= a s e^{-\lambda} \\ P_1 &= a_1 \lambda e^{-\lambda} + P_{s+1} e^{-} \cdot \\ &\cdots\cdots\cdots\cdots \\ &\cdots\cdots\cdots\cdots \\ P_n &= a_s \frac{\lambda^n}{n!} e^{-\lambda} + P_{s+1} \frac{\lambda^{n-1}}{(n-1)!} e^{-\lambda} + \cdots\cdots\cdots\cdots + P_{n+s} e^{-\lambda} \end{aligned}\right\} \cdots\cdots (1.21)$$

Here, $1/\mu$ is taken as unity (or unit time). This formulation is easily understood, if following two characteristics are clearly recornized.

i) In unit time span, probability of n arrival occurs is $(\lambda^n/n!)e^{-\lambda}$, and of no arrival is $e^{-\lambda}$

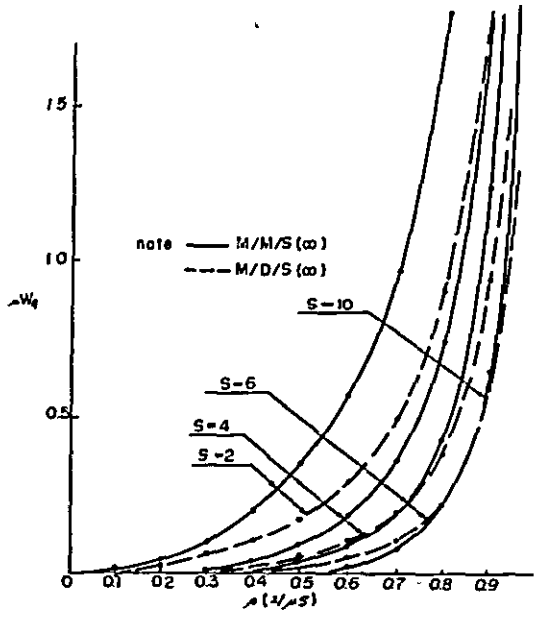
ii) Suppose i ships stay in port and no arrival occurs within unit time span, port will be vacant.

In this case Wq is given by (1.22). But, it should be noted that Wq calculated by (1.22) has the characteristics of μWq of M/M/S type model. Fig. - 8 shows difference of μWq of M/M/S model and M/D/S model.

$$Wq = \sum_{i=1}^{\infty} e^{-\lambda}\left[\sum_{j=\mu}^{i}\frac{(\lambda)^j}{j!} - \frac{S}{\lambda}\sum_{j=i+1}^{i}\frac{(\lambda)^j}{j!}\right] \quad \cdots\cdots (1.22)$$

The most important fact shown in Fig. - 8 is that μ Wq of M/D/S model is about the half of μWq of M/M/S model for the same values of ρ.

Fig. - 8 M/M/S(∞) & M/D/S(∞) μWq



(4) Queuing model approach - II

... by numerical solution ...

Distribution of ships service time in port fall in the range between exponential distribution and constant one. Erlang distribution has the characteristics covering this area (Erlang distribution becomes exponential distribution with phase 1, and approachs to constant with increasing its phase). This is the reason that M/Ek/S(N) type model is important in port problem. Unfortunately, this type of model could not solved by analytical way.

Balance equation of M/E2/S(N) is formulated in following manner:

i) Ships arrival occur following Poisson distribution with average arrival rate λ.

ii) Ships staying time in port is approximated to Erlang distribution with phase 2.

iii) Service desciplin is "first come first served".

iv) Maximum number of waiting ships, denoted by Nmax, exist and overflow (ship will give up entering the port) is taken place.

Any state of this model can be discribed by a set of three variables (N, M_1, M_2) where N, M_1, M_2 mean number of ship waitting for berth, number of ship staying in phase 1 and 2 respectively.

To this model, existence of steady state is proved under the condition of $\rho = \lambda/\mu \cdot S < 1$

If we take time interval t small enough, state of system changes only two ways;

i) new arrival of one ship, and

ii) one of the ships staying in either phase end her service.

Fig. - 9

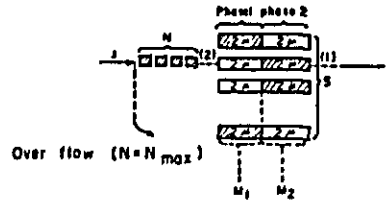


Fig. - 9 is the schematic expression of this model. Transition between states of system can be discribed in following manner.

i) notecing $(0, M_1, M_2)$ at $S > M_1 + M_2$

a) from this state to other state

$$\lambda \cdot P(O, M_1, M_2) + 2\mu (M_1 + M_2) \cdot P(O, M_1, M_2) \quad \cdots\cdots (1.23)$$

b) from other states to this state

$$\lambda \cdot P(O, M_1 - 1, M_2) + 2\mu (M_1 + 1) P(O, M_1 + 1, M_2 - 1) + 2\mu (M_2 + 1) P(O, M_1, M_2 + 1) \quad \cdots\cdots (1.24)$$

ii) notecing (N, M_1, M_2) at $M_1 + M_2 = S$, and $N \neq Nmax$

a) from this state to other state

$$\lambda \cdot P(N, M_1, M_2) + 2\mu \cdot SP(N, M_1, M_2) \quad \cdots\cdots (1.25)$$

b) from other state to this state

$$2\mu (M_2 + 1) P(N + 1, M_1 - 1, M_2 + 1) + 2\mu (M_1 + 1) P(N, M_1 + 1, M_2 - 1) + \lambda P(N - 1, M_1, M_2) \quad \cdots\cdots (1.26)$$

Since, each pair of equation must be balanced in steady state equation (1. 27), (1. 28) and (1. 29) are obtained.

$$\left.\begin{aligned} &\lambda P(O, M_1, M_2) + 2\mu (M_1 + M_2) P(O, M_1, M_2) \qquad M_1 + M_2 < S \\ &= \lambda P(O, M_1 - 1, M_2) + 2\mu (M_1 + 1) P(O, M_1 + 1, M_2 - 1) + 2\mu (M_2 + 1) P(O, M_1, M_2 + 1) \end{aligned}\right\} \quad \cdots\cdots (1.27)$$

$$\left.\begin{aligned} &\lambda \cdot P(N, M_1, M_2) + 2\mu \cdot S \cdot P(N, M_1, M_2) = 2\mu (M_2 + 1) \cdot P(N + 1, M_1 - 1, M_2 + 1) \\ &+ 2\mu (M_1 + 1) \cdot P(N, M_1 + 1, M_2 - 1) + \lambda \cdot P(N - 1, M_1, M_2) \qquad M_1 + M_2 = S, N \neq Nmax \end{aligned}\right\} \quad \cdots\cdots (1.28)$$

$$\left.\begin{aligned} &2\mu \cdot S \cdot P(N, M_1, M_2) = 2\mu (M_1 + 1) P(N, M_1 + 1, M_2 - 1) + \lambda \cdot P(N - 1, M_1, M_2) \\ &M_1 + M_2 = S, N = Nmax \end{aligned}\right\} \quad \cdots\cdots (1.29)$$

State probability $P(N, M_1, M_2)$ can be obtained solving simultaneous equation of (1. 27), (1. 28) and (1. 29) under the condition of

$$\sum_{N=0}^{N=N_{max}} P(N, M_1, M_2) = 1 \quad \cdots\cdots (1.30)$$

Using P(N, M_1, M_2), we can calculate following characteristics

i) probability of N ships waiting for berth

$$P_N = \sum_{M_1, M_2} P(N, M_1, M_2)$$

ii) average number of waiting ships

$$Lq = \sum_{N=1}^{N=N_{max}} N \cdot P_N \quad \cdots\cdots (1.31)$$

iii) average waiting time for berth

$$Wq = Lq/\lambda \quad \cdots\cdots (1.32)$$

If we are interested in average waiting time, Lee-Longton conventional formula can be utilized.

$$Wq = \frac{Es}{2}[1 + V(v/b)] \quad \cdots\cdots (1.34)$$

Here, Wq : average waiting time we are analysing

Es : average waiting time of M/M/S(∞) model which has the same value of λ , μ and S of we are analysing.

b : average service time

v : variation of service time

M/D/S model V(v/b)=0, and V(n/b)=0. 75 for $M/E_2/S$ model.

Note : in Erlang distribution

$$E(Ek) = 1/\mu$$
$$V(Ek) = 1/k\mu^2$$

Therefore

$$V(v/b) = V(v)/b^2 = \frac{1/k\mu^2}{(1/\mu)^2} = 1/k \quad \cdots\cdots (1.35)$$

and

$$Wq = \frac{Es}{2}[1 + V(v/b)] = \frac{Es}{2}(1 + 1/k) \quad \cdots\cdots (1.36)$$

These relationship is shown in Fig. - 10 for $M/E_2/5(25)$, M/M/5(∞) and M/D/5(∞).

Fig. - 10 Example of Wq Calculated by Lee-Longton Formula