(2) Coal hopper wagon :

At present, between Sawahlunto and Bukitputus there are provided 119 Model-KKBR 4-axled hopper wagons for use in coal transportation, about 80% of which are operative.

Hopper volume and maximum load of those wagons are 31.6 m^3 and 25.2 t, respectively. However, the loading capacity, which is restricted by specific gravity of coal, is 23 t as maximum.

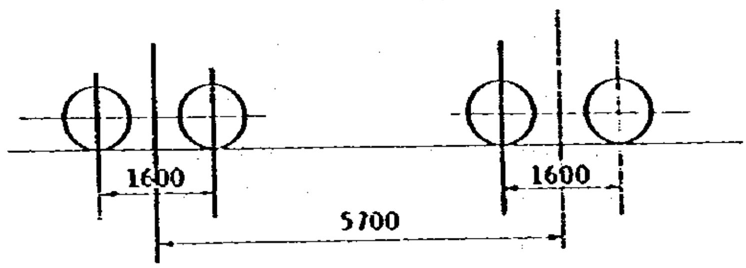
Indonesia National Railway (PJKA) has a plan to increase number of coal hopper wagons to thus answer possibly increased needs for transportation in future.

Specifications for the existing coal hopper wagon are listed below.

Coal Hopper Wagon

Model No.	KKBR
Year of manufacture	1967
Manufacture	TALBOT, West Germany
Overall length	10,650 mm
Overall width	2,320 mm
Overall height	3,200 mm
Hopper volume	31.6 m^3
Max. load	25.2 t
Wagon weight	14 t

Fig. 3-4 Wheel arrangement



Gross weight of the coal hopper wagon is 23 tons + 14 tons = 37 tons, this shall be considered to be 40 tons.

2.3.2 Current mode of service

For rail line between Teluk Bayur and Sawahlunto, Table 3-2 shows: station name, station spacing, and location of the stations having interchange facilities; average speed and travel time between stations as calculated from 1979's train diagram; and number of trains as planned in the train diagram.

(1) Sawahlunto - Solok:

In the train diagram,. there are planned 14 freight trains and 8 mixed trains, including 11 regualr trains which comprises 8 mixed trains and 3 freight trains.

At Muarakalaban and Sungeilasi, there are planned interchanges of opposed trains.

(2) Solok - Batutabal:

There are planned 12 freight trains and 4 mixed trains, including as regular train 4 mixed trains and 4 freight trains. No interchanges are planned in this train diagram.

No interchange is made at present, but interchange is possible at siding truck provided at Singkarak and Kacang.

(3) Batutabal - Padang panjang:

There are planned 24 freight trains, including 9 regular trains, and a interchange at Kubukerambil.

(4) Padang panjung - Kayutanam:

There are planned 6 freight trains to travel between Padang panjang and Kandangampat and 11 freight trains between Pandan panjang and Kayutanam, including now travelling 10 trains.

At present, no interchange between opposed trains is performed at Kandangampat, while interchange is possible with a siding track.

(5) Kayutanam - Lubukalung:

There are planned 14 trains in total: 4 regular mixed trains and 8 facultative freight trains between Kayutanam and Padang, and 2 facultative freight trains which travel only between Kayutanam and Lubukalung.

Therefore, only 4 mixed trains are now travelling.
At present, no interchange is made, while a siding track is provided at Sicincin and Paritmalintang.

(6) Lubukalung - Padang:

There are planned 20 trains in total: besides 4 regular mixed trains and 8 facultative freight trains at described in (5), 4 regular fast trains, 2 facultative fast trains, one facultative mixed train, and one facultative business train.

Therefore, serving regularly is only the above respective 4 mixed trains and fast trains.

In this railway section, there are planned interchanges at Pasarusang, Duku and Tabing.

(7) Padang - Bukitputus:

There are planned 13 trains in total: 6 regular freight trains and 7 facultative freight trains.

(8) Bukituputus - Telukbayur:

There are planned 14 trains in total: 5 regular freight trains and 9 facultative freight trains. Of those trains, one regular freight train and two facultative freight trains are planned to travel between Padang and Telukbayur.

2.3.3 Track capacity

As described in Section 2.3.2. at present, the number of trains in service is small. Hence, desired number of trains can travel without interchange operation of opposing trains even at the stations having siding tracks. However, when the needs for transportation is increased in future, it will become necessary to increase track capacity per line by increasing number of interchanges to shorten the length of block section or raising travel speed of train to shorten travel time between stations.

Track capacities between interchange stations are estimated for the case in which the number of interchange is increased by use of the existing siding tracks to shorten the length of block section, as shown in Table 3-2.

In the estimation, the following relationship was used:

$$\text{Track capacity} = \frac{24 \times 60}{\text{Travel time (min.)} + \text{Waiting time for interchange(min.)}} \times \text{availability factor}$$

The travel time as planned in the current train diagram is used without change. The waiting time for interchange is assumed to be 5 min.

And an availability factor of 0.6 - 0.75 is assumed according to the track capacity between stations.

Table 3 - 2

Gradient ‰	Location km	Station interchangeable	Station spacing km	Running time min.	Average speed km/h	No. of train scheduled	Track capacity No. of train
	0.000	Telukbayur					
			1.851	10	11.1	14	57
	1.851	Bukitputus					
			5.242	19	16.6	13	36
	7.093	Padang					
			9.247	16	34.7		41
	16.340	Tabing					
			9.692	17	34.2		39
4 6	26.032	Duku				20	
			5.789	12	28.9		50
	31.821	Pasarusang					
			7.878	15	31.5		43
	39.699	Lubukalung					
			6.814	12	34.1		50
	46.513	Paritmalintang					
6 12			6.623	10	39.7	14	57
	53.136	Sicincin					
			6.902	12	34.5		50
	60.038	Kayutanam					
51			5.373	24	13.4	11	34
	65.411	Kandangampat					
70			9.95	43	13.9	17	21
	75.361	Padangpanjang					
50			9.025	30	18.1		30
5	84.386	Kubukerambil				24	
			9.487	31	18.4		30
	93.873	Batutabal					
			10.736	23	28		30
6	104.609	Kacang					
10			9.586	19	30.3	16	36
	114.195	Singkarak					
			13.761	29	28.5		30
	127.956	Solok					
15			12.422	26	28.7		30
20	140.378	Sungeilasi					
-			11.064	25	26.6	22	30
	151.442	Muarakalaban					
13 30			4.078	11	22.2		54
	155.520	Sawahlunto					

2.4 Investigation of Bridge

2.4.1 General

Between Bukit Putus and Sawalunto at a 155 km distance therefrom along railroad, there are 155 steel bridges having 191 clear spans and an about 3 km length in total, which bridges are all of simple span steel and have been constructed in 1890's. They fall in seven types as listed below:

Table 3-3 Investigated Bridges by Types

Types	Indonesian symbol	Clear span (m)	Number of spans	Remarks
Deck bridge of I-beam	ras dl	2 ~ 11	48	
Deck bridge of double web I-beam	ras kemb	5	19	
Deck bridge of plate girder	ras pel	6 ~ 15	53	Photo 3-4
Through bridge of plate girder	dind pel 1-1-b	8 ~ 15	17	
Curved-chord truss bridge	dind parab	20 ~ 60	39	Photo 3-3
Parallel-chord truss deck bridge	ras rangka	20	14	Photo 3-6
Braced arch bridge	lengk	56	1	Photo 3-5

In any case, the substructure, i.e. abutment and pier, is a spread foundation of concrete. (See Photo. 3-7)

2.4.2 Outline of investigation

It was impossible to investigate all the bridges concerned.
The investigation mainly consisted of on-site visual inspections, excluding dynamical examinations such as deflection test and vibration test.

With a view to

1) span to be long,
2) environment to be corrosive with neighboring seashore, and
3) rack section in mountain,

a number of bridges were chosen for the investigation wherein we had a best luck that Mr. Supiyanto, Director of the West Sumatra Bureau of Indonesia National Railways and Mr. Gumasir, Engineering Manager of the same showed a kind to travel together with us.

The bridges investigated and rough results thereof are listed below:

Investigated Bridges and Inspection Results T_2

Table 3-4

Bridge number	Distance (km) (m)	Type	Clear span (m)	Inspection results
11	3 + 343	Curved-chord truss bridge	25	Rust in early stage
15	4 + 633	"	20+60+20	"
16	5 + 105	"	20+20	"
51a	8 + 600	Deck bridge of I-beam	78+11+11+78	Painting necessary
52	8 + 773	Curved-chord truss bridge	20	Re-erected in 1980
68	15 + 986	"	20	Corrosion at lower chord and diagonal members
77	19 + 958	"	40	Corrosion at lower chord member, esp. inner side
82	30 + 860	"	50+50+40	Painting necessary
161	67 + 254	"	50+30	Rust at early stage
163	67 + 524	Deck bridge of plate girder	15	Painting necessary (Near fall overside of Lembah Anai)
174	69 + 920	Curved-chord truss bridge	50	Painting necessary
176	70 + 302	"	30	"
177	70 + 420	"	30	"
178	70 + 504	Deck bridge of plate girder	15	"
186	71 + 555	Deck bridge of plate girder & Bracket arch bridge	15+15+56+15	"
252	80 + 591	Deck bridge of plate girder	8	"
271	83 + 662	Deck bridge of plate girder & Truss deck bridge	15+20+20+20 +15	Painting necessary (at high pier)

Bridge number	Distance (km) (m)	Type	Clear span (m)	Inspection results
310	93 + 125	Through bridge of plate girder & Deck bridge of plate girder	8+15	Painting necessary
329	97 + 788	Truss deck bridge	20+20+20	Painting necessary Corrosion at lower chord member, partial.
377a	107 + 280	Through bridge of plate girder	15	Corrosion at bearing member (Erosion partial)
590	151 + 126	Curved-chord truss bridge	40	Painting necessary

In general, the bridges which were constructed about 80 to 90 years ago still have their members and rivet joints maintained in a satisfactory state, excepting some which are suffering from corrosion and delay in painting as a whole. Detail results of the investigation will be described later.

2.4.3 Materials for judging soundness and improvement plan

The following materials have been obtained for use in judging soundness with respect to the final capacity of railway transportation under plan, i.e. 96.0 x 10^4 tons/year (1989), and for preparing improvement and repairing plan.

1) Design drawings

After on-site inspection, we have obtained design drawings of four bridges at the head office of Indonesia National Railways at Bandon: three typical bridges and one truss arch bridge of a 56 m clear span transversing a valley in a rack section. These drawings are listed in the table below, the drawings having been drawn 90 years ago.

Table 3-5 List of Design Drawings Obtaines

Bridge type	Model No.	Bridge No.	Effective span (m)	Remarks
Curved-chord truss* bridge	HNO-9	77	41.5	Photo [illegible]
Deck bridge of plate girder	HNO-11	163	16.2	Photo 3-[illegible]
Braced arch bridge	HNO-15	186	56.0	Photo [illegible]
Parallel-chord Truss Deck	HNO-14	329	21.15	Photo [illegible]

* As corrosion was found at inner flange plates of lower chorde member, the lower chorde member was examined by calculation far stress in its section as reduced by 40%.

2) Test piece

The material in use is said to be ST-37. To examine actual strength and chemical components, a test piece taken from steel members were sent to Japan for material test, the steel members having been used in the old No. 52 bridge which was reconstructed recently. Partial corrosion was found in the test pieces.

3) Paint coat

The painting have been applied with such four coats as following:

I. Lood menie

II. "

III. Aluminium

IV. "

Some pieces of paint coat was brought into Japan. No special analysis has been performed.

Photo 3-3
Curved-chord truss bridge (HNO-9)
Bridge number 77

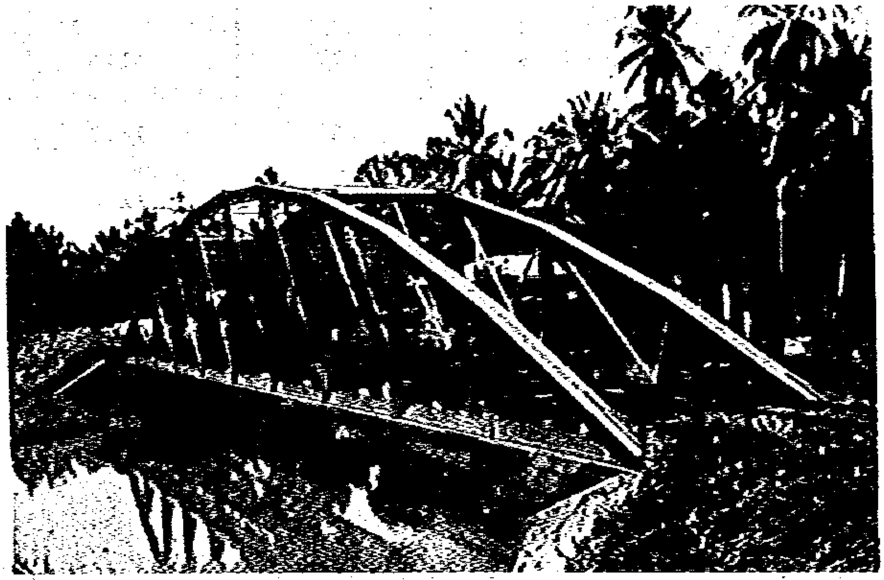


Photo 3-4
Plate girder bridge (HNO-11)
Bridge number 163

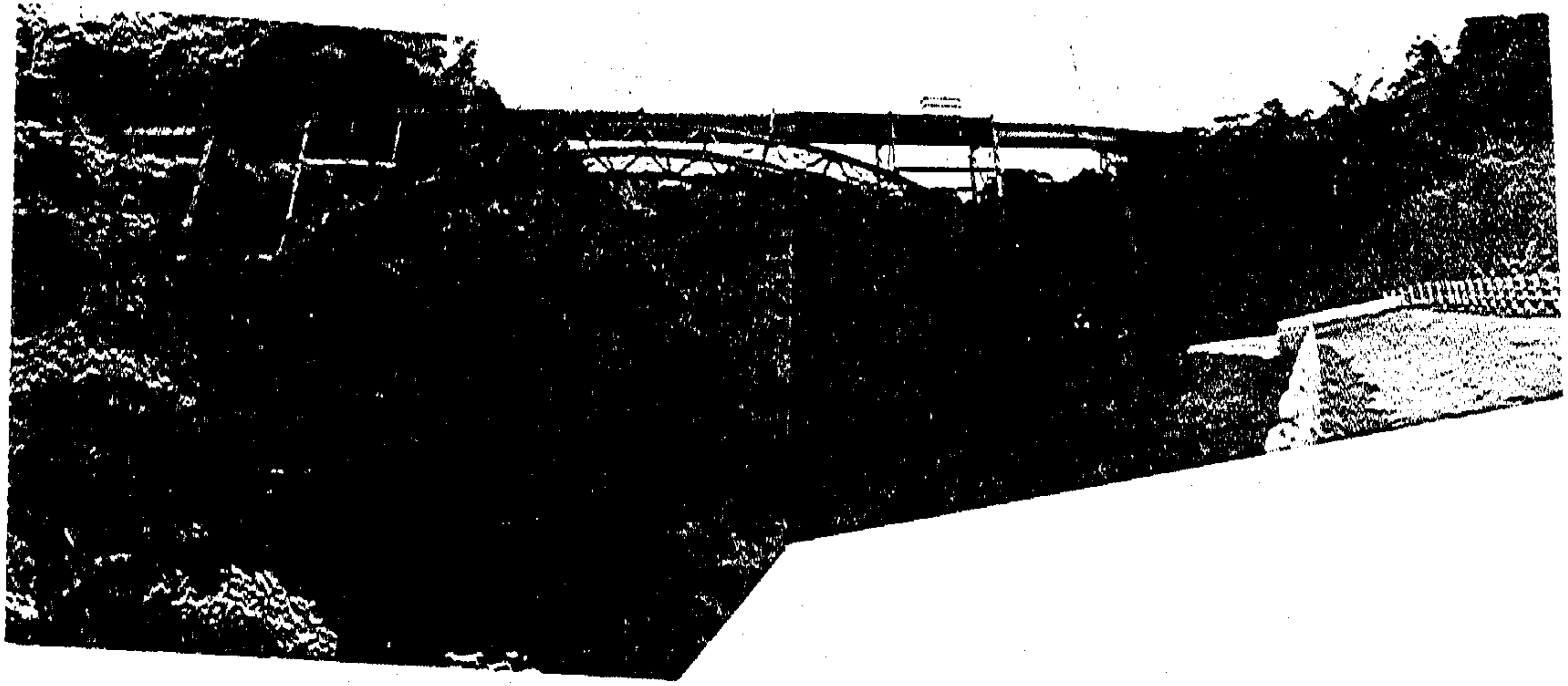


Photo 3-5
Braced arch bridge (HNO-15)
Bridge number 186

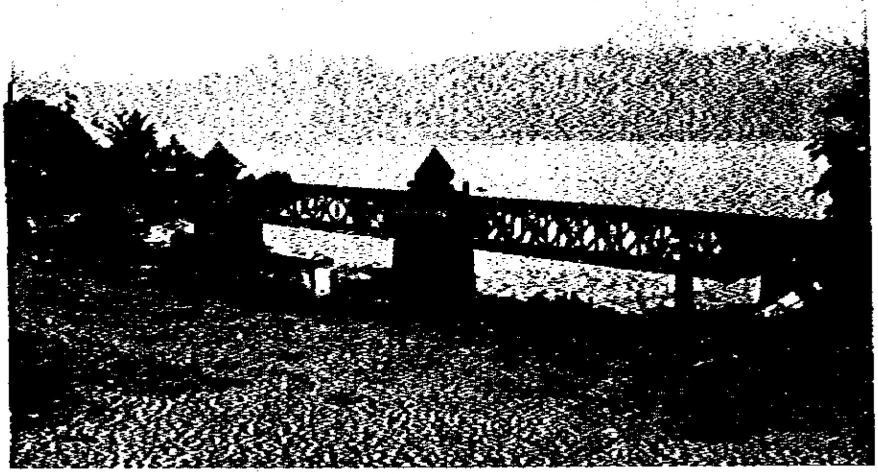


Photo 3-6
Truss deck bridge (HNÔ-14)
Bridge number 329

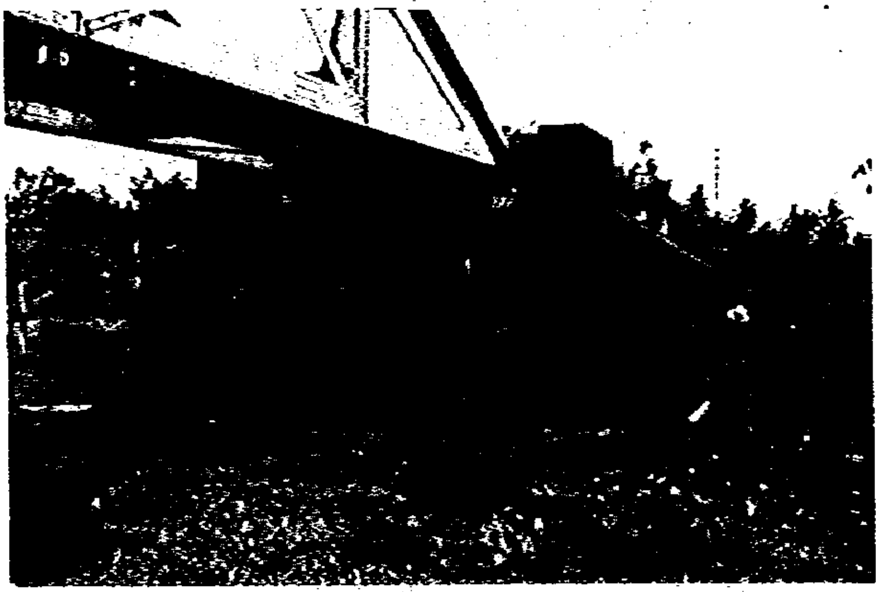


Photo 3-7
Substructure

2.4.4 Results of on-site inspection

1) Superstructure

a) Rust and corrosion on structural member

In an about 15 km railway section from Padang to a northwest point of Tabin, the railway lies near the seashore. In this section there was found corrosion in bridges, particularly at the inner side of lower chord member. See Photo 3-9.

Moreover, corrosion also found in No. 68 bridge at the inner side of diagonal member, in No. 329 bridge at a part of lower chord member, and in No. 377a bridge at corners of support member.

It had been required as a rule to apply painting every five years for bridges near the seashore or every ten years for other bridges. The West Sumatra Railway Bureau (PJKA) has been making great efforts to abide by the rule, while having failed due to restriction of budget. Because rust was found at most bridges, a suitable countermeasure is required to be taken urgently.

b) Crack at spliced portion, erosion and slackness of rivet

In any bridge, no crack was found at the spliced portion, in addition that there could be seen no problem with respect to the slackness of rivet. Moreover, there was found no rivet suffering from complete erosion, while a slightly adverse tendency was found at the base metal and lower chord member with respect to corrosion of rivet. As a whole, the inherent function of rivet was considered to be sufficiently maintained.

c) Deficit of elements

In No. 377a plate girder bridge, there was found an eroded portion at the lower flange plate of bearing member. See Photo 3-10. Any other bridge was not eroded.

d) Deformation of structural member

Collision, fire, plastic buckling due to overstress and the like are generally considered to be the cause of deformation. However, there was found no deformation in this inspection.

e) Vibration and displacement of girder due to passing train

The vibration of girder and lateral displacement thereof may well be responsible for derailment. Although there was made no quantitative measurement of girder vibration due to passing train, any such vibration appeared not to reach a critical point. Deviation of the distance between girders due to lateral displacement thereof was found to be very small.

f) Other checkpoints

It is serious in the problem of lateral turning that the spacing of girders in narrow relative to that of bearings. The bridges investigated had their girders sufficiently spaced apart. When considering they has been stable over 80 years or more, it should be reasonable to judge them to be safe also in future.

As for load bearing capacity of the material in use, detail description will be given later together with the results of strength test and stress calculation.

On the bearing-shoe, there was found no failure but slight cozing of rust.

2) Sub-structure

In the sub-structure, partial decay and stripping were found on the concrete surface. Particularly, both crack and stripping were found in the concrete of shoe portion. However, the cracks were not judged to be structural, but to be caused mainly by drying shrinkage due to construction joint.

There was found no settlement nor inclination of abutment or pier. As a whole, the sub-structure may well be considered to be sound enough. See Photo 3.7.

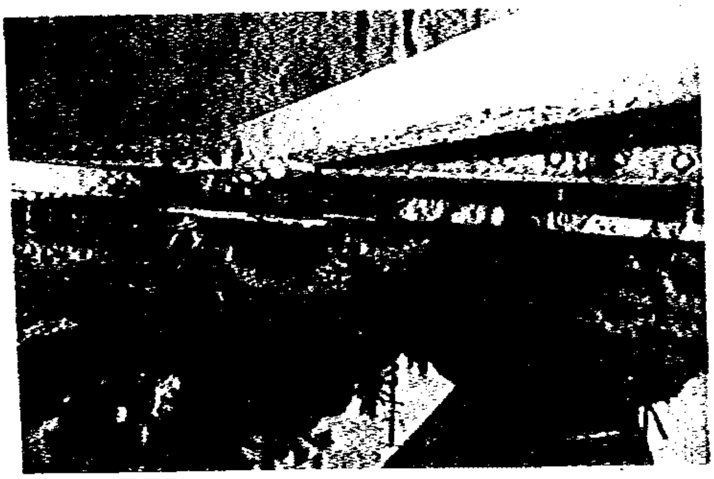


Photo 3-8
Rust and, corrosion at lower lateral bracing

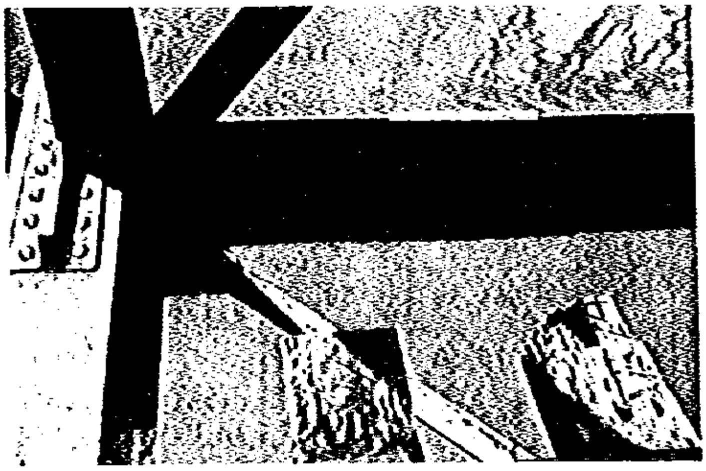


Photo 3-9
Corrosion at the inner side of lower lateral bracing

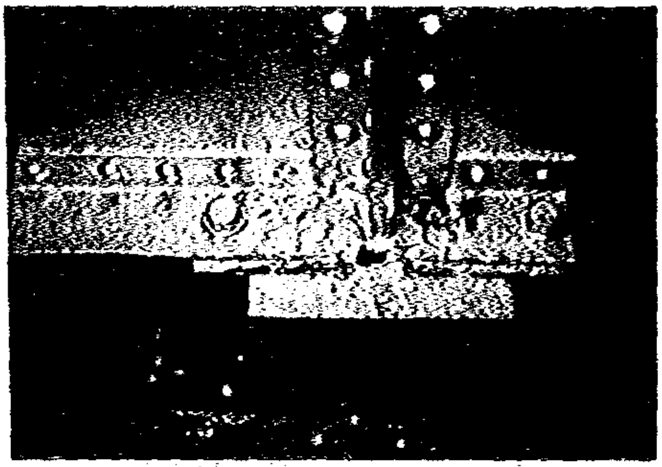


Photo 3-10
Erosion at lower flange plate of bearing

2.5 Inspection of Tunnel and Cut-and-Fill Work

2.5.1 Tunnel

There are three tunnels concerned, as listed below:

Table 3 - 6

Tunnel No.	Location	Length (m)	Type of rock
1	70 km + 565.50	38	Andesite, Diluvium to Pliocene
2	70 km + 670.50	65.5	- ditto -
3	153 km + 866.50	827	Granite, Permian period in Mesozoic era

No defect was found at No. 1 and No. 2 tunnels. In the No. 3 tunnel locating near Sawalunto, there was found madwater dropping at a central portion of the tunnel, which sedimental soil is periodically removed. This portion should be repaired.

2.5.2 Cut and fill

Throughout the railway inspected, cuts and fills were found to be maintained in a good state. Therefore, no repairing or improvement will be necessary. But, in a cut about a 113 km + 500 point near Singkarak, there is provided a protective fence against the falling of stone. On the natural slope and cut at the Batutabal side of that cut, there were found loose boulders and rock. Then, the above-said fence should be extended by about 150 m. (See Photo 3-11)

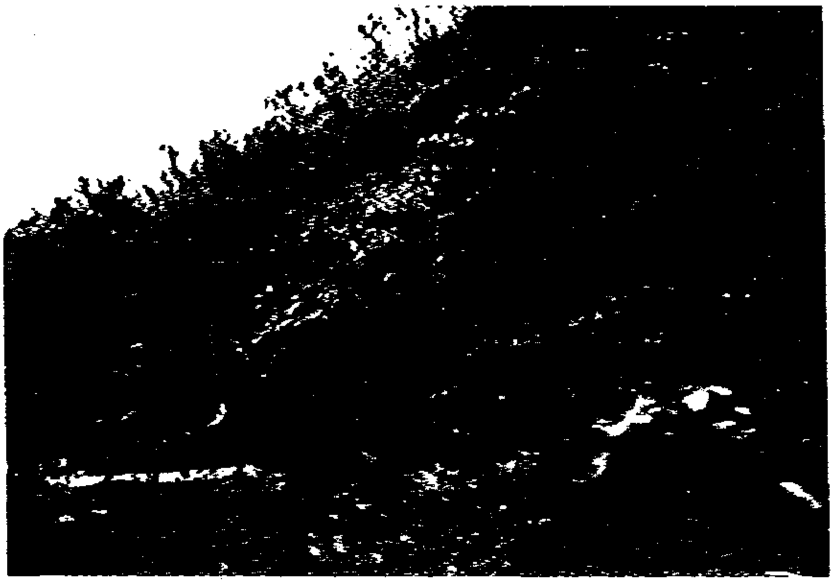


Photo 3-11
Protective fence region against falling of stone

3. DETERMINATION OF QUANTITY TO BE TRANSPORTED

On the basis of data stated above, below is mentioned the annual production plan, quantity to be used at the colliery and the quantity to be transported by railway of coal, as well as the quantity to be carried to Silo thereof from which the quantity to be assigned from Bukitputus to the cement plant is deducted.

Table 3 - 7

Year	Production Plan	Used at the Colliery	Transported by Railway			
			Sawahlunto-Bukitputus		Bukitputus-Silo	
	1000 ton/year	1000 ton/year	1000 ton/year	ton/day	1000 ton/year	ton/day
1980	150	15	135	380	10	30
1981	200	15	185	520	45	130
1982	300	15	285	800	50	140
1983	300	20	280	780	45	130
1984	400	20	380	1,060	50	140
1985	400	20	380	1,060	50	140
1986	550	40	510	1,420	180	500
1987	700	40	660	1,840	330	920
1988	850	60	790	2,200	460	1,280
1989	1,000	60	940	2,620	610	1,700

The above-mentioned quantity to be transported is divided into two stages from the standpoint of railway facilities, rolling stock and railway operation plan. That is to say, as regards the main line transport as far as Bukitputus, transport of 380,000 tons until 1985 and 94,000 which is the ultimate target. Study will be made on the basis of transport plan for each stages.

4. RAILWAY TRANSPORT AND ROLLING STOCK PLANS

4.1 Railway Transport Demand of Coal

The quantity of coal transport by railway from Sawahlunto to Bukitputus is divided herein into two stages, the first up to the year 1985 and the second for the period from 1986 till the ultimate target year 1989.

By 1985 at the first stage, the daily coal transport by railway is estimated at 1,060 tons per day equivalent to full load in about 46 hopper cars, since each car is capable of carrying 23 tons if the coal hopper car as is used at present is put into service.

By 1989 at the second stage, the transport is estimated at 2,620 tons a day, equivalent to about 114 hopper cars.

Estimate for coal transport from Bukitputus to the silo is divided into two terms, the first up to the year 1985 and the second up to the ultimate target year 1989.

By 1985 at the first stage, the daily transport is estimated at 140 tons of about 6 hopper cars equivalence.

By 1989 at the second stage, it is estimated at 1,700 tons a day, that is, equivalent to about 74 hopper cars.

4.2 Locomotive Performance Characteristic, Train Make up and Number of Trains

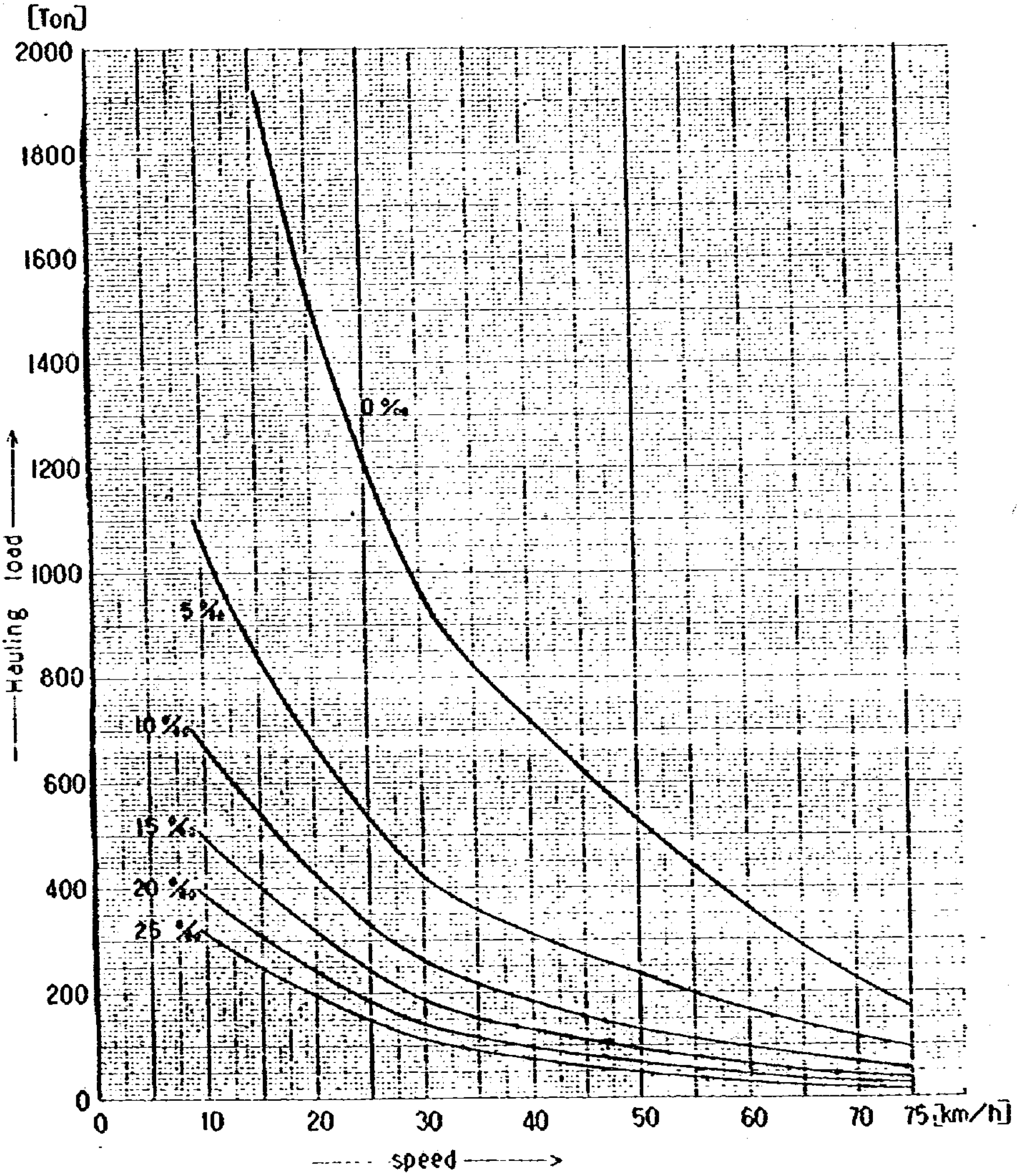
Study has been made on such conditions that the rack type diesel electric locomotive as is being proposed for purchase, should be operated for the rack rail section between Kayutanam and Batutabal while the BB 303 type diesel locomotive will be operated for all the rest sections of relative flatness.

Besides that, the BB 300 type diesel locomotive will be used for shunting of cars at Bukitputus and carriage to the silo.

The following are the results of study for determination of the optimum train make up and number of trains in daily operation for each section with due consideration to relevant factors such as track grade, hauling load-speed characteristics, track capacity and required coal transport.

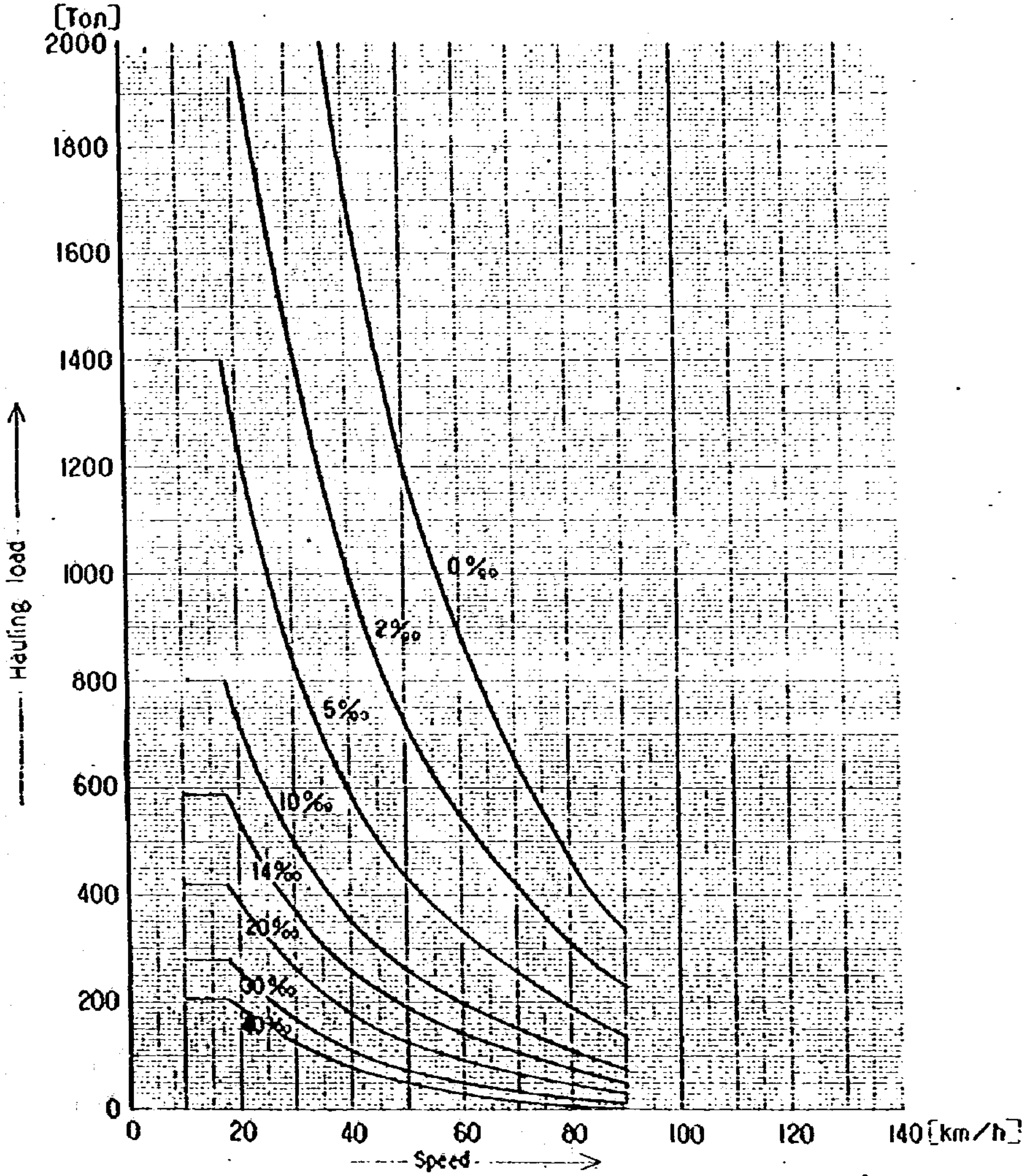
Hauling load-speed diagram

Disel-hydraulic locomotive Type BB 300 Fig 3-5



Hauling load-speed diagram

Diesel-hydraulic locomotive Type BB 303 Fig 3-6

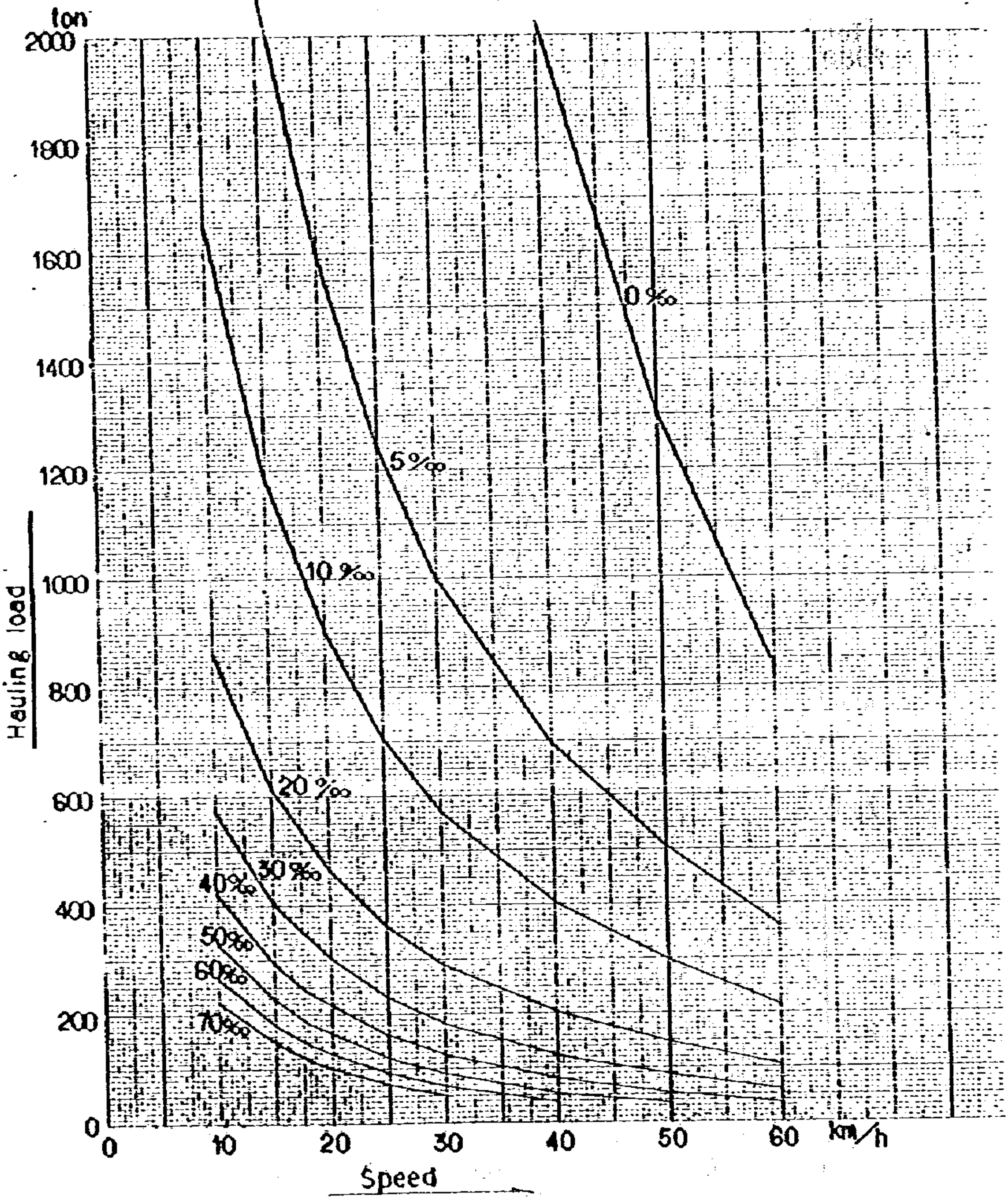


Running resistance of locomotive $0.585+1.075+0.009v+\frac{0.00454v^2}{44}$ kg/t

Running resistance of waggons $0.65+1.315+0.014v+\frac{0.0075v^2}{43}$ kg/t

Hauling load-speed diagram

Diesel rack-adhesion locomotive   Fig 3-7



Running resistance of locomotive $1.72 + 0.0084V + \frac{0.0369V^2}{5.5}$ kg/t

Running resistance of waggons $1.60 + 0.00077V^2$ kg/t

4.2.1 Sawahlunto to Batutabal section

1) Track grade conditions

The steepest up-grade in the Sawahlunto to Batutabal section is sloped at 20‰ just in between Silungkang and Guguksarai, which may be followed by the second steepest grade at 13‰ between Sawahlunto and Muarakalaban.

The existing up-grade at 30‰ from Muarakalaban toward Sawahlunto may not impede operation of carriage trains because all hopper trains are empty all the way in this section.

2) Track capacity

As shown in Table 3-2, the minimum track capacity between stations in this section is optimum for 30 trains per day.

3) Locomotive type and hauling capactiy

The locomotive will be of BB 303 type.
Hauling capacity of BB 303 type diesel locomotive at the 20 ‰ up-grade is estimated as follows:

About 240 tons at a speed of 32 km per hour
About 320 tons at a speed of 25 km per hour

Those estimated weights are equivalent to 6 hopper cars and 8 hopper cars respectively of full-load coal carriage.

4) Train make-up and number of trains in daily operation

a) First stage (1985)

Now, let it be assumed that 12 trains, each of 4 hopper-car make-up at full load (160 tons in gross weight) would be operated a day from Sawahlunto to Batutabal and on the way back to Sawahlunto same number of trains, each equally of 4 car make-up at empty load (56 tons in net weight) would be likewise operated. Then, the daily total of trains in operation would be 24 trains with total coal carriage of about 1,100 tons by 48 hopper cars.

b) Second stage (up to 1989)

The plan for the second stage envisages 30 trains in daily operation with total coal carriage of about 2,760 tons by 120 hopper cars, on assumption that 15 trains, each of 8 full load hopper-car make-up (320 tons in gross weight), would be operated from Sawahlunto to Batutabal and same number of trains, each of same make-up but at empty load (112 tons in net weight), would be operated on the way back to Sawahlunto.

5) Freight and Passenger transport other than coal carriage

For the second stage planning as aforestated, balanced speed for each train running at the 20‰ up-grade is estimated at a rate of about 25 km per hour with its hauling load of 320 tons. However, since the 20‰ up-grade section is limited to a relatively short length, it is conceivable that average running speed between stations throughout the whole section could be well maintained at the present average speed rate, even if a freight or a passenger car is connected to 8 hopper-car make-up.

For the reason above, the passenger traffic capacity can be increased more than now by operation of the daytime mixed make-up train of passenger cars coupled to coal hopper cars, same as set up by the present operation diagram.

4.2.2 Batutabal to Padangpanjang section

1) Track grade conditions

The steepest up-grade in the section from Batutabal toward Padang-panjang is sloped at 50 ‰, existing between Batutabal and Kubukerambil.

Next to that, the steep grade of 40 to 47 ‰ lies between Kubukerambil and Padangpanjang. Those graded sections are provided with rack rail.

2) Track capacity

As shown in Table 3-2, the track capacity in this section is optimum for 30 trains per day.

3) Locomotive type and hauling capacity

The locomotive will be of diesel rack adhesion type which is proposed for purchase.

The hauling weight of this locomotive at the 50 ‰ up-grade is estimated at about 160 tons during running at a restricted speed of 20 km per hour in the rack rail section, that is, equivalent to 4 hopper cars with full load of coal.

4) Train make-up and number of trains in daily operation

The train operation scheduled for this section at both first and second stages will be same as the operation schedule referred to in the foregoing item 4.2.1-4), except that only the locomotive will be replaced from BB 303 type to diesel rack adhesion type at Batutabal.

To further explain this, it is planned that 24 trains, each of 4-car make-up, will be operated at the first stage and 30 trains, each of 8-car make-up, to be operated at the second stage.

It should be noted, however, that the train must be double-headed by two locomotives so as to be able to haul up 8 full-load cars (320 tons) at the second stage.

In this case, if the train runs at a speed of 18 km per hour at the 50 ‰ up-grade, the hauling capacity can be increased up to 360 tons with an extra freight wagon in addition to coal hopper car.

4.2.3 Padangpanjang to Kayutanam section

1) Track grade conditions

The steepest grade in the Padangpanjang to Kayutanam section is sloped at 70 ‰ between Padangpanjang and Kandangampat, followed by the 51 ‰ grade in between Kandangampat and Kayutanam.

Those steep grade sections are provided with rack rail.

2) Track capacity

As shown in Table 3-2, since there is no interchange station between Padangpanjang and Kandangampat, the track capacity is limited to 21 trains per day, the smallest throughout the whole section between Sawahlunto and Bukitputus.

3) Locomotive type and hauling capacity

The locomotive is of diesel rack adhesion type, same as used for the preceding section.

The locomotive is capable of hauling a weight of about 180 tons at the 50 ‰ up-grade and about 115 tons at the 70 ‰ up-grade respectively at a running speed of 18 km per hour.

In this section, the train ascending on the grade is made up with empty coal hopper cars returning the way back, whose total weight of 180 tons covers 12 cars and 115 tons covers 8 cars.

4) Train make-up and number of trains in daily operation

a) First stage (1985)

With continuity from the preceding section it is planned that 12 trains, each of 4 hopper-car make-up (160 tons in gross weight) will be operated a day toward Kayutanam.

6 trains, each consisting of two locomotives in double heading and 8 cars (112 tons in gross weight), will be operated for returning after service to Padangpanjang. Therefore, 18 trains will be operated a day together with 12 trains to the opposite as aforestated.

b) Second stage (1989)

For operation in the dawngrade section toward Kayutanam, the number of trains will be reduced from 15 to 10 by increase of each train make-up from 8 to 12 (480 tons) upon arrival at Padangpanjang from Batutabal.

In the up-grade section toward Padangpanjang 10 trains each consisting of 12 empty cars (168 tons), returning from Bukitputus will be operated after replacement of the locomotives with diesel rack adhesion locomotives.

Therefore, 20 trains will be operated daily in this section. All such trains will be double-headed by two diesel rack adhesion locomotives.

4.2.4 Kayutanam to Bukitputus section

1) Track grade conditions

The steepest up-grade in the section from Kayutanam toward Bukitputus is sloped at 6 ‰ as is existing in between Paritmalintang and Lubukalung. The steepest up-grade toward Kayutanam is 12 ‰ between

Kayutanam and Lubukalung.

This 12 ‰ up-grade would not affect daily operation of trains in the least, since these trains return after their service with empty coal hopper cars.

2) Track capacity

This section is featured by its relatively flat track condition and many of the stations are provided with siding track so as to enable one train to crossover the other. Average speed of trains running between stations is maintained at high rate. Because of those favorable track conditions the track is capable of operating 36 trains a day between Padang and Bukitputus.

3) Locomotive type and hauling capacity

The locomotive will be of BB 303 type.

The hauling capacity at the 6 ‰ up-grade exceeds 500 tons at a speed of 40 km per hour while the capacity at the 12 ‰ up-grade is estimated at about 300 tons at a speed of 40 km per hour.

4) Train make-up and number of trains in daily operation

a) First stage (1985)

The trains proceeding to Bukitputus will be reduced from 12 to 6 upon arrival at Kayutanam from Padangpanjang by reformation of train make-up from 4 cars to 8.

Empty trains returning to Kayutanam will also be six (6), each of 8-car make-up.

Then, the total number of trains to be operated daily for coal carriage will be 12 in this section.

b) Second stage (1989)

20 trains will be operated daily for coal carriage if 10 trains, each of 12-car make-up, can be operated to both Bukitputus and Kayutanam. Even taking into account other trains (12 trains in both regular and facultative services under the present diagram) proceeding from Lubukalung to Naras, it is estimated that the track capacity can still afford to work well for all of those trains.

4.2.5 Bukitputus to Silo

1) Track condition

As shown in the Figure, the silo is situated on the hill side to Telukbayul about 800 m apart from Bukitputus. The line is of single track including the up-grade of about 20 ‰ to the silo.

2) Locomotive type and hauling capacity

The locomotive will be of BB 300 type as is used at present.

The hauling capacity of the locomotive at a speed of 30 km per hour is as follows:

About 130 tons at up-grade of 20 ‰
About 100 tons at up-grade of 25 ‰

It can be said, therefore, that the locomotive is capable sufficiently of hauling two (2) full load hopper cars (about 80 tons) for coal carriage.

3) Train make-up and number of trains in daily operation

a) First stage (1987)

Bukitputus will receive arrival of hopper cars with loading of about 1,060 ton coal per day, which will be equivalent to some 46 hopper cars. Out of the daily total delivery, coal of about 140 tons (equivalent to 6 hopper cars) will be carried to the silo, aside from delivery to the cement factory. Therefore, the train repeats 3 trips to and from the silo in a day, hauling two (2) hopper cars (of about 80 ton weight).

b) Second stage (1989)

Out of daily delivery of 2,620 ton coal (of 114 hopper car equivalence) to Bukitputus, about 1,700 ton coal (covering 74 hopper cars) will be transferred to the silo.

Therefore, the train will travel 37 times to and from the silo in a day, hauling two (2) hopper cars each time.

4) Review on track capacity

On the assumption that two (2) hopper cars would be hauled by the BB 300 type diesel locomotive per each trip to and from the silo for coal carriage, in order to try to refrain the future structural scale of the silo, such carriage cars of each train unit will have to make return trips 40 times a day from Bukitputus to the silo and its vice versa.

The silo conveyor will work for 16 hours a day on a 2-shift basis. While the conveyor will be out of service, train operation for coal carriage to the silo will also be suspended. Therefore, the carriage trains of late arrival will be stabled on the siding track at Bukitputus until next morning. Upon starting-up of the conveyor operation, coal will be carried to the silo. Therefore, return trips over 40 times by carriage trains will be made for a time interval of 16 hours (actual working hours: 14) during operation of the silo conveyor.

On this basis as aforestated, review has been made as here-under for determination of the optimum track capacity.

a) Required time for running of train

On the assumed condition that the normal operating speed of each train would be rated at 30 km per hour and acceleration and deceleration would be 0.75 km per hour per second, required time length for the train to reach its normal running speed and to stop its operation from the normal running speed would be estimated at 40 seconds respectively, during the time of which the train could travel over a distance of about 170 m.

Where the running distance from Bukitputus station to the silo would extend over 900 m, the net running distance of a train at its normal speed would be:

900 m - 170 m x 2 = 560 m

This would require a time length of about 70 seconds. From the calculated result as above, it is estimated that the running time of each train should require about 150 seconds for a one-way trip and about 300 seconds for a return trip. Therefore, it requires a total time length of 5 minutes.

b) Time to be required for unloading at silo

Let it be assumed that time to be required from opening to closing of side door of each hopper car, including downfall of coal, would be one (1) minute per each car, two (2) minutes would be required for unloading of coal.

It is then estimated that about five (5) minutes would be required for unloading work on the silo, allowing for extra time to be required for setting of the train at its exact position.

c) Time to be required for shunting at Bukitputus station yard

Time length to be required for separation, connection and shunting of hopper cars is estimated at about 5 minutes per each return trip to and from the silo.

d) Total time requirement for each train on return trip to and from silo

Time to be required for return trip of each train to and from the silo is estimated at about 15 minutes assumed up from the results estimated in the foregoing a) through c).

e) Track capacity

On the foregoing operating conditions, the optimum track capacity in this section within 14 hours may be calculated as follows:

$$\frac{14 \times 60}{15} \times 0.75 = 42 > 40$$

From this result, it is sure that the train can be operated on 40 return trips within the time limit of 14 hours.

4.2.6 Operating control for locomotive and hopper car

1) Brake

For safe descending of the train in the steep grade section, including the portions inclined at 70 ‰ and 50 ‰, between Batutabal, Padangpanjang and Kayutanam, the manual brake operator is on board the hopper car so as to operate the train at a restricted descending speed by handling the hand brake on the hopper car in addition to the main brake of the locomotive.

As for the braking effort of the rack rail diesel locomotive proposed for immediate future purchase, it is certain that only two (2) full-load coal carriage cars will be the maximum controllable limit by the locomotive brake alone, since the car weight assured of running at its regular speed on the downgrade by the locomotive brake is limited to 100 tons roughly when it runs on the descending grade of 70 ‰ at a speed of 15 km per hour.

The idea of getting a brake operator on board the car may be acceptable as the practicable method if the number of cars per each train is limited only to 2 to 4. However, as the number of cars increases up to 8 to 12 in the future, it would jeopardize safety of train operation to rely solely upon control by human power alone.

For this reason, it is recommended that the automatic air brake should be installed for both locomotive and hopper car so as to enable the whole train to be controlled simultaneously to stop by handling of the brake valve at the locomotive while the hand brake should be used as the auxiliary control unit or for stabling of the train on the siding track.

2) Locomotive control system

The diesel rack adhesion type locomotive must be put into operation by use of two units coupled together to haul the train on the steep grade.

To do so, the overall control device must be provided for each locomotive, so that the heading one of two locomotives coupled together can take control at its driver's seat simultaneously over the following one to help display of full operating performance by double-headed locomotives.

It is recommended that the diesel locomotive proposed for purchase in the near future should be provided with such functional advantage from the initial time of purchasing.

3) Coupler strength

The tractive effort for a single diesel locomotive is estimated at about 11.3 tons at a running speed of 20 km per hour. It is assured, from this estimation, that the coupler as is used now for the hopper car will work well with its allowable tensile force of 20 tons. However, at the second stage where eight full-load hopper cars will be hauled, the two double-headed locomotives will be required as aforestated and its tractive effort will reach about 22.6 tons, double as much as at the first stage, at a 20 km per hour speed, which will eventually exceed the present coupler strength. For this reason, those hopper cars proposed for additional purchase should be provided with the automatic coupler of sufficient strength for each. For future coal carriage in the said steep grade section, it is planned that hopper cars now being used will be added to the latter half of the train formation. If this project is to move into its implementation in the future, it should be considered that those couplers being in use with the existing hopper cars will be replaced with new automatic couplers provided that the underframe of the hopper car should be of sufficient strength to accept it. The couplers now being used for diesel locomotives of BB 303 and BB 300 type will remain unchanged without any operational problems, since those are designed to be either the automatic coupler or the coupler being used for the existing hopper car.

4.3 Type and Required Number of Rolling Stock

4.3.1 Locomotive

In order to seek the required number of locomotives for train operations, the following conditions have been assumed to envisage the train diagram for each section from the number of trains in operation as referred to in the foregoing item. Necessary number of locomotives has been counted back from the diagram as assumed above.

(1) Required time for operation between stations shall be same as required running time scheduled in the current train diagram, as shown in Table 3-2.

(2) The diagram shall cover only coal carriage trains available in the limited section between Sawahlunto and Bukitputus in defiance of train operations to Indarung, Puluaer and Naras.

(3) All trains in daily operation shall be operated at an equal distribution of time for 24 hours.

(4) Time of stoppage at each interchange shall be limited to 5 minutes as a normal standard. Only in the event that a time length of 5 minutes would be insufficient to cover stoppage

at such interchange, time could be prolonged a little over the standard limit.

(5) Retention time for each locomotive for shuttling at one end station of a certain section shall allow for more than two hours as may be required for routine inspection and repair.

(6) Finally, necessary number of locomotives for train operations should be the total number of locomotives in operation and during retention to await shuttling at any time scheduled in the train diagram.

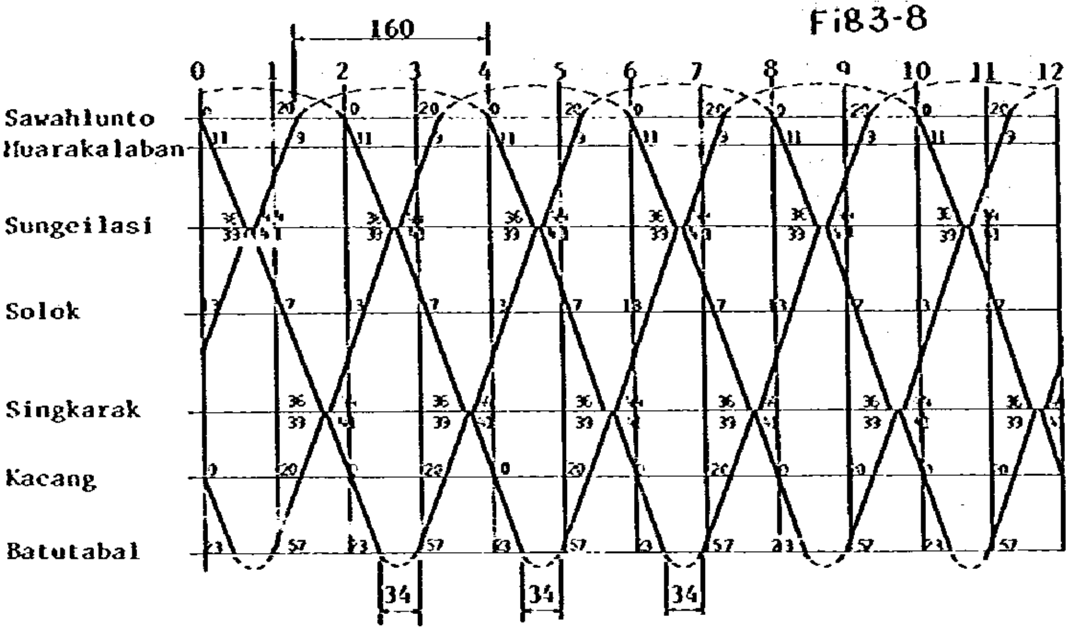
1) Savahlunto to Batutabal

The type of locomotive ... BB 303 Diesel hydraulic locomotive

a) First stage

- Daily frequency of return trip by train 12
- Average head way ...... 2 hours.

Fig3-8

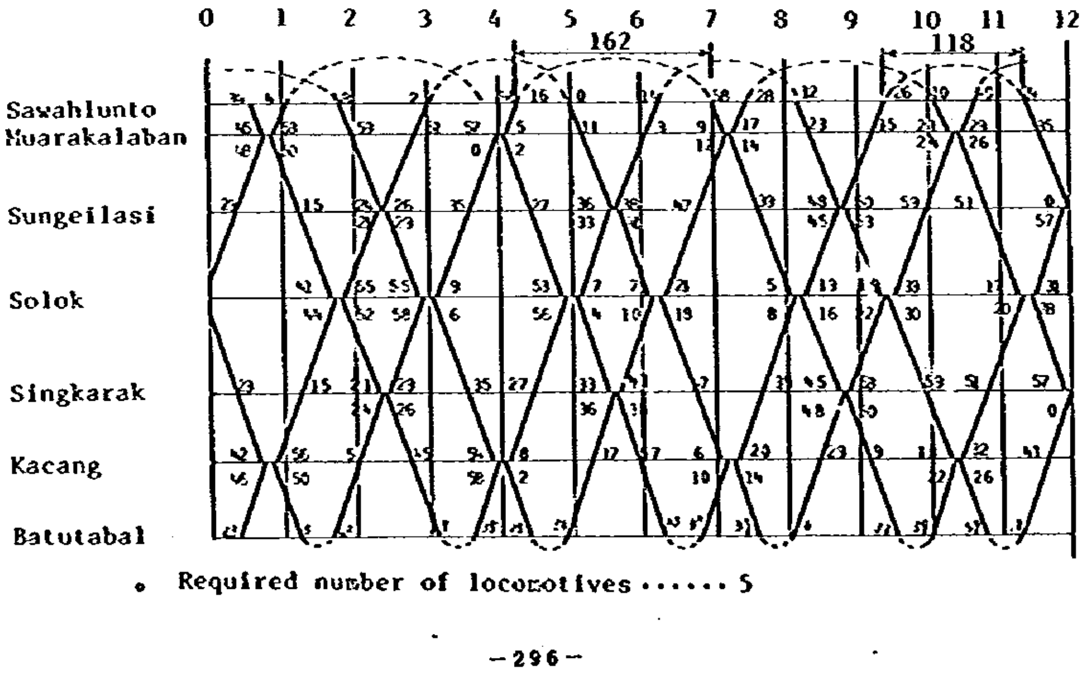


- Required number of locomotives 4

b) Second stage

- Daily frequency of return trip by train 15
- Average head way ..... 1.6 hours (96 min.)

Fig3-9



- Required number of locomotives 5

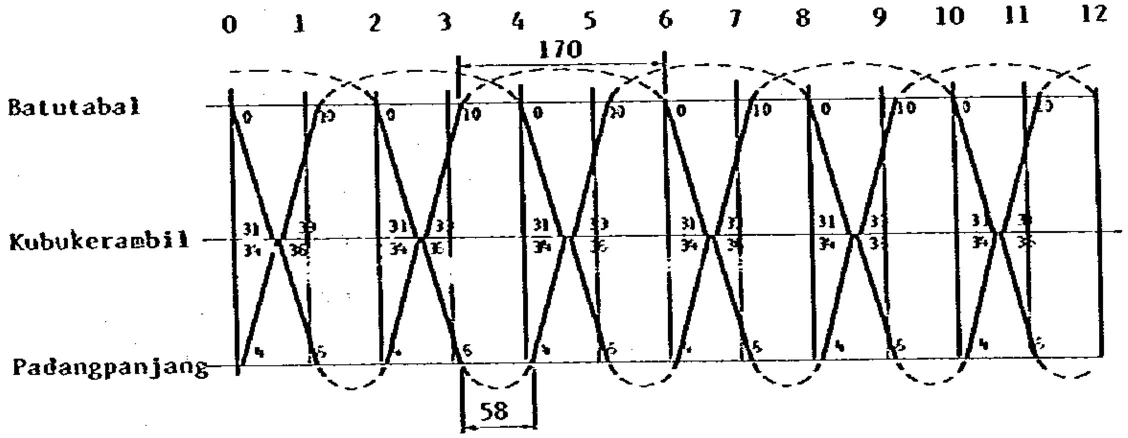
2) Batutabal to Padangpanjang

The type of locomotive ... Diesel electric locomotive for rack rail section

a) First stage

- Daily frequency of return trip by train 12
- Average head way .... 2 hours

Fig 3-10

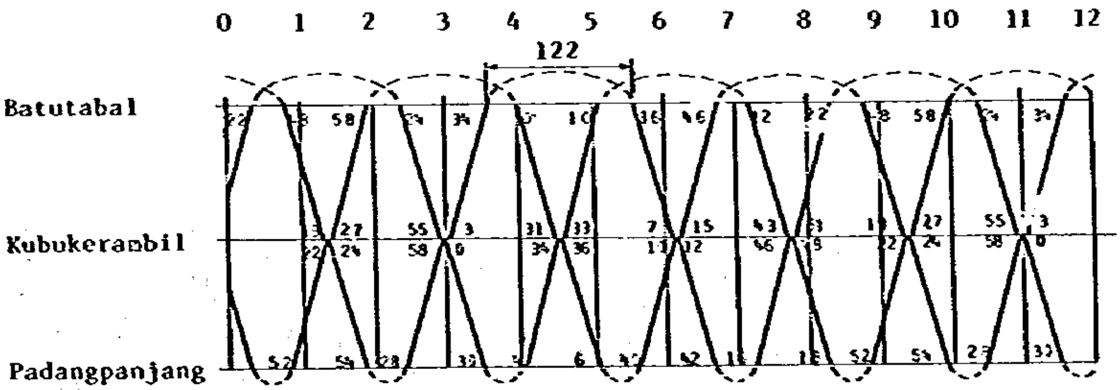


- Required number of locomotives 3

b) Second stage

- Daily frequency of return trip by train ..... 15 (Double heading).
- Average head way .... 1.6 hours (96 min.)

Fig3-11



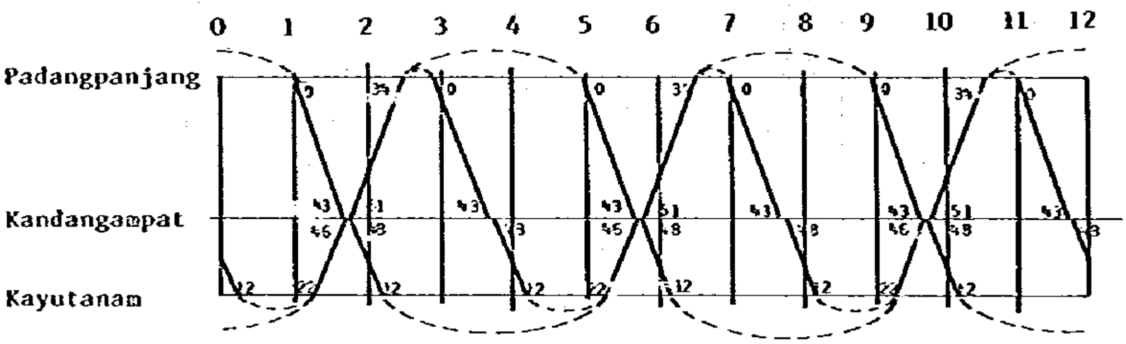
At the second stage, all trains will be hauled by double-headed two locomotives. Therefore, required number of locomotives will be 3 × 2 = 6 units.

3) Padangpanjang to Kayutanam

The type of locomotive ... Diesel electric locomotive for rack rail section

a) First stage

- Daily frequency of return trip by train 12
  Actually, 6 trains will be operated from Kayutanam to Padangpanjang. However, since each train will be hauled by double-headed locomotives, total number of trains are assumed herein as 12 trains.
- Average head way ... Padangpanjang→Kayutanam (2 hours)
  Kayutanam→Padangpanjang (4 hours)

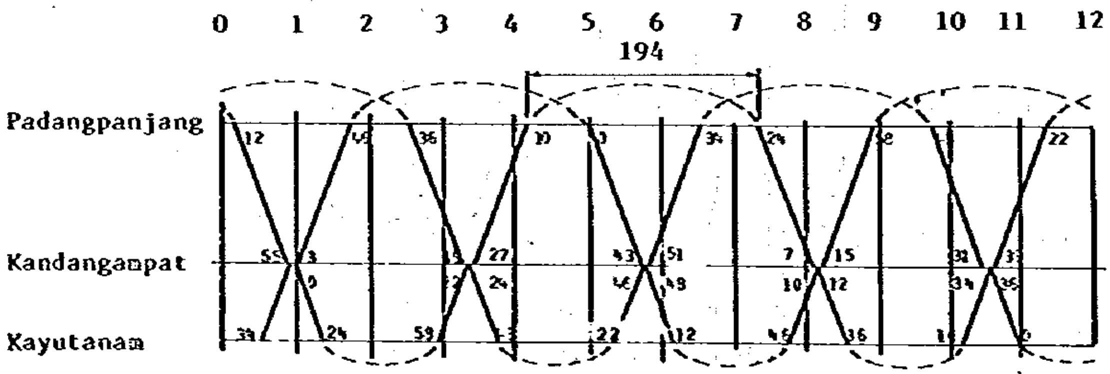


- Required number of locomotives 3

Fig 3-12

b) Second stage

- Daily frequency of return trip by train 10
  (Double-headed)
- Average head way ...... 2.4 hours (144 min.)



At the second stage, all trains will be hauled by double-headed two locomotives. Therefore, required number of locomotives will be 3 × 2 = 6 units.

Fig 3-13

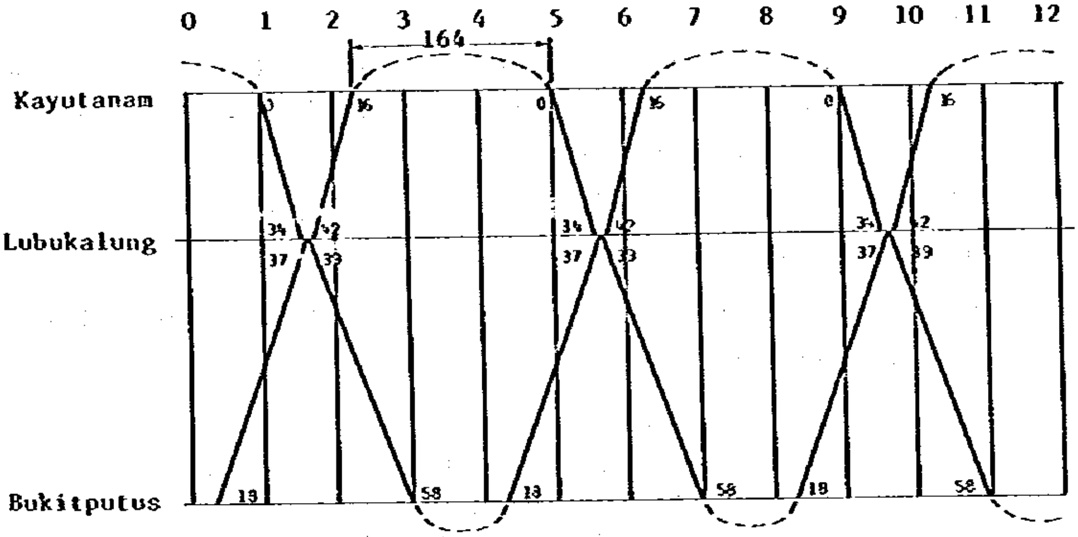
4) Kayutanam to Bukitputus

The type of locomotive ... BB 303 Diesel hydraulic locomotive

a) First stage

- Daily frequency of return trip by train 6.
- Average head way .... 4 hours

Fig 3-14

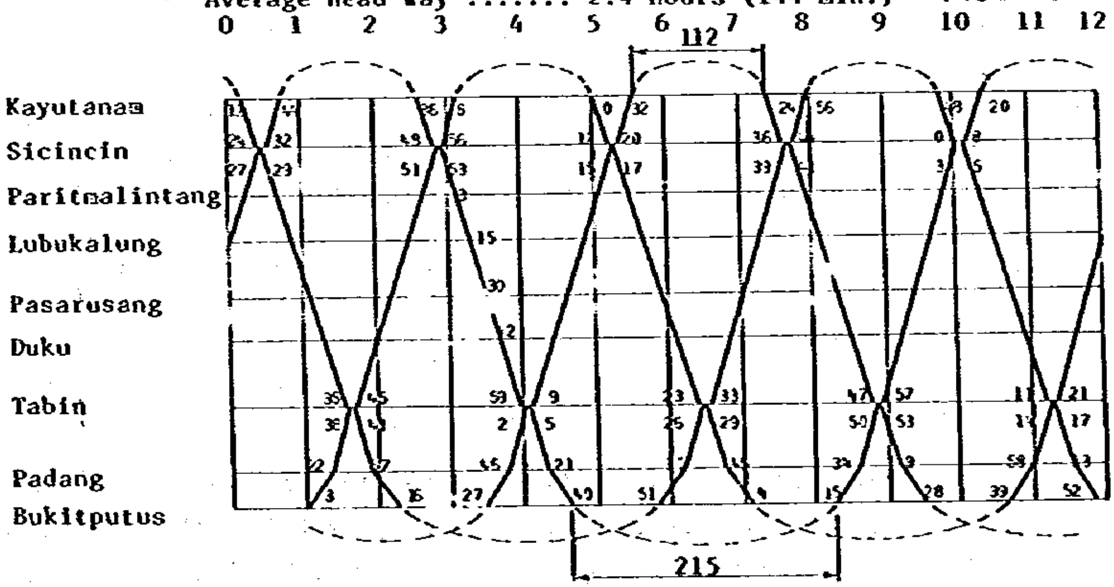


- Required number of locomoti es 2

b) Second stage

- Daily frequency of return trip by train 10
- Average head way .... 2.4 hours (144 min.)

Fig 3-15



- Required number of locomotives 4

5) Locomotive for shunting operation

Shunting locomotives being operated at present are as stated in the preceding item 2.3.1. In the future, it may be necessary that the locomotive of BB 300 type equivalence should be purchased for shunting of hopper cars, as demand for coal carriage increases, at Sawahlunto and Bukitputus.

With this view in mind, it is planned that one (1) locomotive should be purchased for shunting at Sawahlunto at the first stage and one (1) additional locomotive each for shunting at Sawahlunto and Bukitputus respectively at the second stage.

6) Additional procurement plan of locomotives

The results of calculation in the foregoing items 1) through 4) are summarized as shown in the following Table:

Table 3 - 8

Section	Sawahlunto to Batutabal		Batutabal to Padangpanjang		Padangpanjang to Kayutanam		Kayutanam to Bukitputus		Shunting	
Locomotive type	BB 303		Diesel Rack Locomotive		Diesel Rack Locomotive		BB 303		BB 300	
No. of locomotive in service	3		0 (Steam Rack Loco. 10)				2			
Stage of planning	1	2	1	2	1	2	1	2	1	2
Required number	4	5	3	6	3	6	2	4	1	3
Reserved service	1	1	1	1	-	1	-	1	-	-
Total	5	6	4	7	3	7	2	5	1	3
Comparison with present number	+2	+3	+4	+7	+3	+7	0	+3	+1	+3

In the Table, out of 5 BB 303 type diesel locomotives the present number of locomotives is counted as two (2) excluding the other two (2) being operated to Indarung and to Naras via Lubukalung and one reserve locomotive.

As the result, it is concluded that the BB 303 type diesel locomotive should be increased by two more than the present number of holdings by 1985 at the first stage of this planning.

At present, six (6) diesel rack adhesion type locomotives are proposed for purchase. In order to abolish use of steam locomotives now being operated by 1985, one (1) more unit of this type will have to be purchased additionally as the stand-by to be replaceable for any other unit receiving inspection and repair under the maintenance schedule.

At the second stage, the BB 303 diesel type locomotive will be required in further increased number to four (4) more and the diesel rack adhesion type locomotive to seven (7), in addition to the preceding increases at the first stage.

4.3.2 Hopper car

Required number of hopper cars for train operation in a certain section may be sought from the following formula:

Where,

N = Required number of cars for operation

t_1 = Required operation time on one way

t_2 = Required time for shuttling at terminal station

t_3 = Time interval of train operation = 24 hours/No. of trains in oneway operation at per day.

n = No. of cars in one train make-up

Then, $$N = \frac{(t_1 + t_2) \times 2}{t_3} \times n$$

Required running time between stations would exactly as set up in the present operation diagram, as indicated in Table 3-2. Besides, on assumption that the extra allowance of time to be required for shunting of locomotives and reshuffling of train make-up at Batutabal, Padangpanjang and Kayutanam would be averaged at 60 minutes and total length to be required for train interchange in the intermediate stations would be estimated at 40 minutes, then

t_1 = 374 + 60 x 3 + 40 = 594 min. ≑ 10 hours

Retention time for shuttling at terminal station:

t_2 = 8.5 hours

The following results are attained from calculation to seek required number of hopper cars on the basis of all the foregoing conditions.

1) First stage

At the first stage, there would be two patterns of daily train operation by different number; the one would be 12 trains in operation each of four (4) car make-up and the other would be 6 trains each of eight (8) car make-up. However, in either case the total number of hopper cars in daily operation would amount to 48.

Therefore, the value N would remain unchanged even though either case of 12 trains or 6 trains a day would be adopted for the value t_3.

Assuming that the number of trains in one-way operation a day would be 12, then

t_3 = 2 and n = 4

Therefore, $N = \frac{(10 + 8.5) \times 2}{2} \times 4 = 74$

Then, totally required number of hopper cars at the first stage, allowing for the reserve rate as 20 % for inspection and repair, would be sought as follows:

$$\frac{74}{0.8} ≑ 93$$

2) Second stage

At the second stage, there would also be two patterns of daily train operation by different number; the one would be 15 trains of 8-car make-up and the other would be 10 trains of 12-car make-up. However, in either case the total number of hopper cars in daily operation would be counted as 120.

Assuming that the number of trains in one-way operation a day would be 10, then, t_3 = 2.4 n = 12

$$N = \frac{(10 + 8.5) \times 2}{2.4} \times 12 = 185$$

Allowing for the reserve rate as 20 % for inspection and repair, the totally required number of hopper cars would be:

$$\frac{185}{0.8} \fallingdotseq 240$$

3) Plan for addition of hopper car

The total number of coal carriage hopper cars in the holdings amounts to 119 as of 1980, out of which 97 are availabe for daily operation.

Therefore, there is no need of increase from the present number of cars until 1985, at the end of the first stage, if the current operation diagram is revised and necessary number of locomotives can be provided.

However, by 1989 as the ultimate target year of the second stage the number of cars availabel effectively for operation will have to be increased up to 240.

At present, the PJKA authority plans additional purchase of 150 hopper cars and this plan is deemed to be able to fully meet any future increasing demand for coal transportation by railway.

5. IMPROVEMENT OF STATION FACILITIES

5.1 Siding Track for Train Interchange

As shown in Table 3-2, there exist 17 stations provided with siding track for train interchange, except Sumpur and Silungkang, between Sawahlunto and Batutabal.

As noted from the result of study in the foregoing item 4.2, there will be no need of additional siding track construction for this purpose beyond the present scale, in view of the current track capacity.

Of all siding tracks for interchange of trains, the shortest one in effective length is that installed at Kayutanam station of 181 m length.

On the other hand, the longest train coming into the said station will be of 12 hopper-car make-up to be hauled by two double-headed locomotives of rack adhesion diesel type for future operation at the second stage. The total length will be:

$$13.5 \text{ m} \times 2 + 10.65 \text{ m} \times 12 = 154.8 \text{ m}$$

This means that the existing siding track at that station can still afford to serve for the purpose of train interchange.

5.2 Terminal Station Facilities

All hopper cars of arrival at Bukitputus station will be divided into 2 cars per each unit of delivery to the silo. However, those cars of late arrival at night during shutdown of the silo will have to be stabled as they are on the siding track of that station until morning on the following day.

In anticipation that the number of late arrival trains would be estimated at nearly one-third of the total trains of daily arrival, it would be 2 trains each of 8 hopper-car make-up at the first stage and 3 trains each of 12 hopper-car make-up.

As shown in the Figure, Bukitputus has two turn-out tracks, one in the direction of Padang, the other of Indarung, as well as the six track lines

Out of those lines indicated as 1 thru 6, two tracks of 1 and 2 will be used for interchange of trains between Padang and Telukbayur, coal trans-

Increase Plan of Siding Tracks at Bukitputus Station

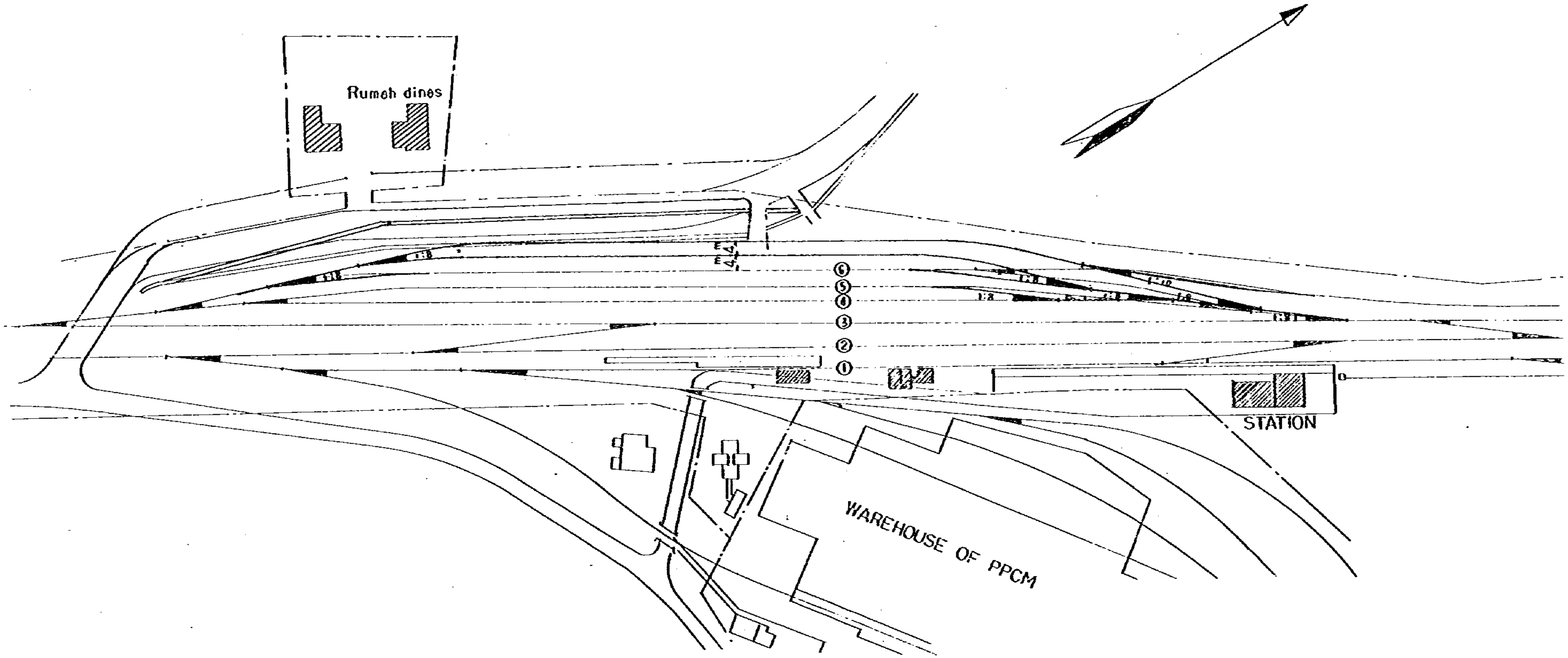
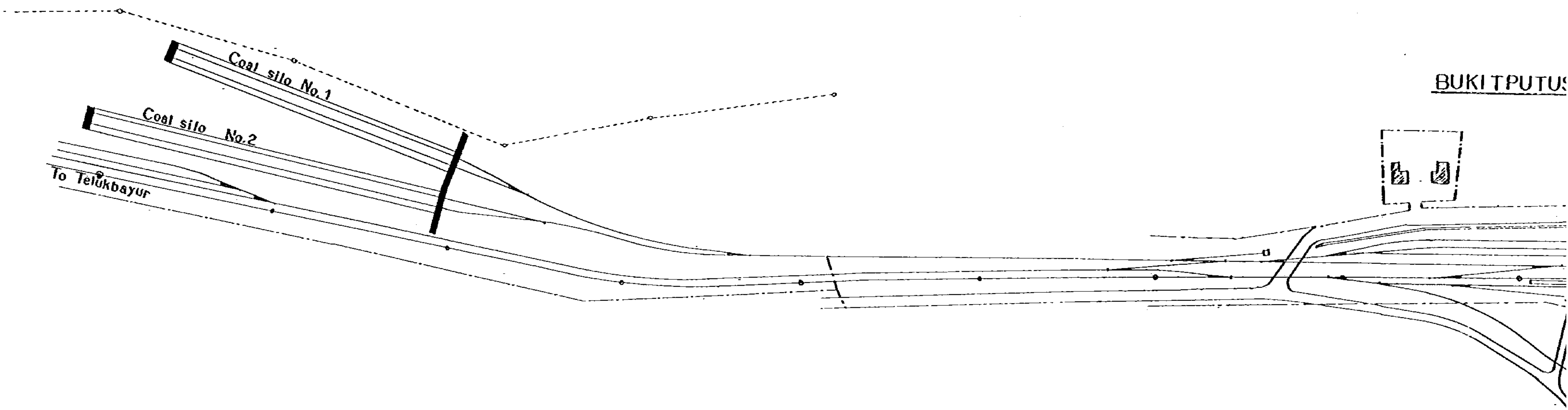


Fig 3-16

Scale 1:1000

Location of Bukitputus Station and Coal Silo



nd Coal Silo

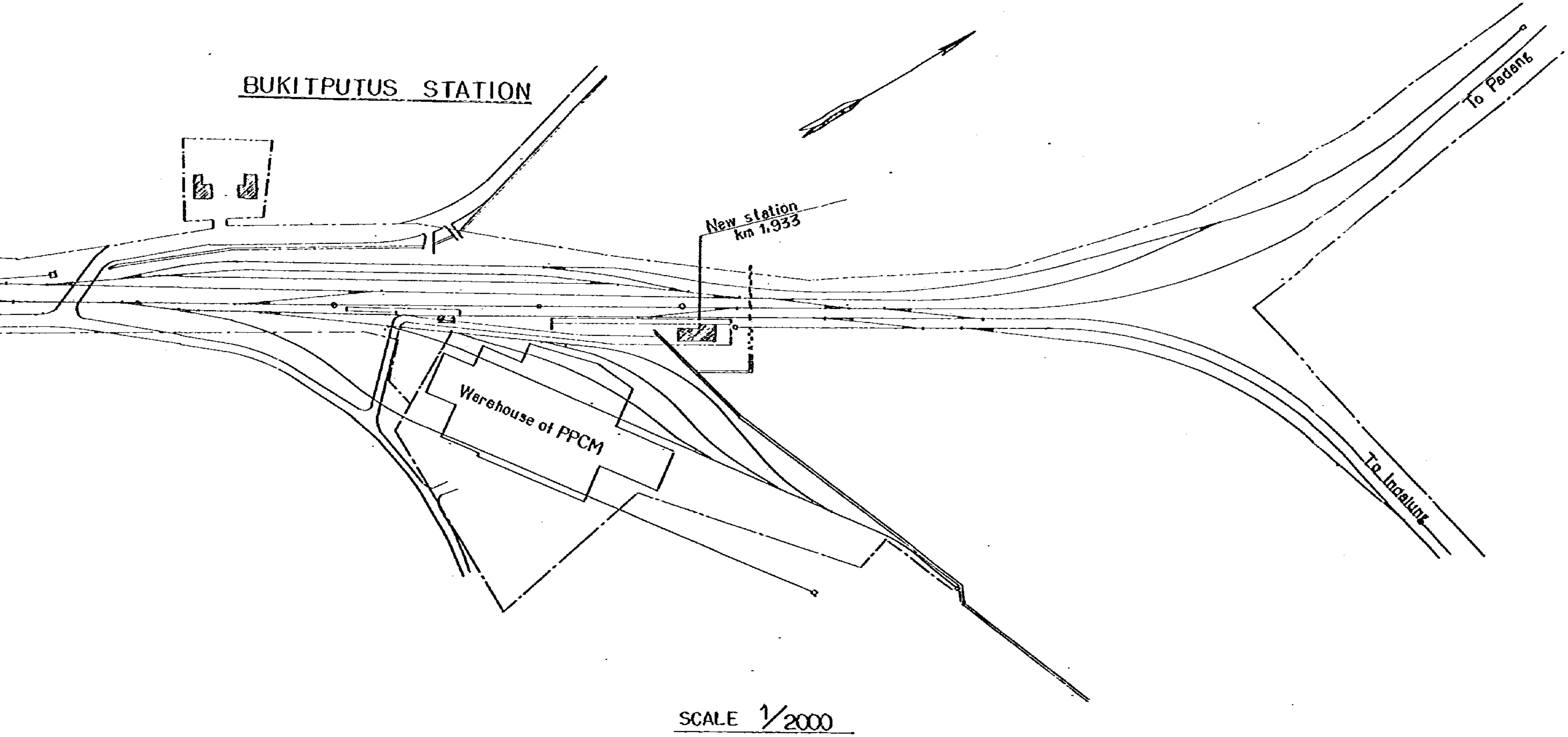


Fig 3 - 17

port to Indarung and cement transport from Indarung. The rest lines from 3 thru 6 will be used as arrival track for coal carriage trains, stabling track for empty hopper cars, passage track for locomotives and stabling track for freight wagons at night.

At the first stage, no track additions will be required as the track 3 can still afford to provide sufficient space for each train of complete make-up on both sides of its crossover, because each make-up length is relatively short (85.2 m with 8 cars).

However, at the second stage two additional siding tracks will have to be increased as shown in the Figure, since the track must accommodate 3 trains of complete make-up, each of train make-ups being increased to a considerable length (127.8 m with 12 cars).

As the result of such track additions, the road will have to be re-routed as shown in the Figure.

Required work volume for track addition will be as follows:

1)	Track addition	350 m
2)	Track re-routing	250 m
3)	Turnout addition and renewal	7 sets
4)	Turnout removal	1 set
5)	Road re-routing	Approx. 1,640 m^2

It seems to be a worthwhile problem for a futur to investigate the construction of the highway grade separation with railtrack in the yard of Bukitputus, depend on the increased return of the train to the Silo and also the traffic volume on the highway. This is the subject for a futur study.

6. TRACK IMPROVEMENT

6.1 Planned Transport Quantity and Track Structure

The planned transport quantity of coal was divided into two stages for planning train operation plan, but it is impossible to alter track structure for each stage. It is proper, therefore, to study for track structure, whether the present structure is suitable or not, on the basis of ultimate planned transport quantity, and if improvement is required, the extent thereof.

The passing tonnage running over the track is equal to transport quantity plus vehicle weight, and in the case of the railway under study, when summarily estimated, the vehicle weight is approximately equal to the load weight. Moreover, in the present railway, almost all of traffic is one-way traffic. When the forwarding of empty vehicle is added thereto, the passing tonnage may be roughly estimated as the triple of transport quantity. Namely, the fact that the planned transport quantity is one million ton a year amounts to three million ton a year of passing tons, which also means transport of 8,000 - 9,000 tons a day.

As for line classification and track structure they are as stated in 2.2, and the above-stated passing tonnage corresponds to the sixth grade of the new line classification. In PJKA, no regulation is yet stipulated as to track structure for line classification, but our study will be carried out in track structure without being restricted thereto.

It is needless to state that the track has to withstand the axle weight of the vehicle (10.7 ton) and train velocity (estimated to be 60 km/h), but it has also to be reasonable in point of maintenance economy against the increasing track deterioration which is caused due to above-mentioned passing tonnage. Therefore, as for the undermentioned track structure, stress at each part has been confirmed by calculation, and besides, the track structure which is well-balanced considered from maintenance experience will be important.

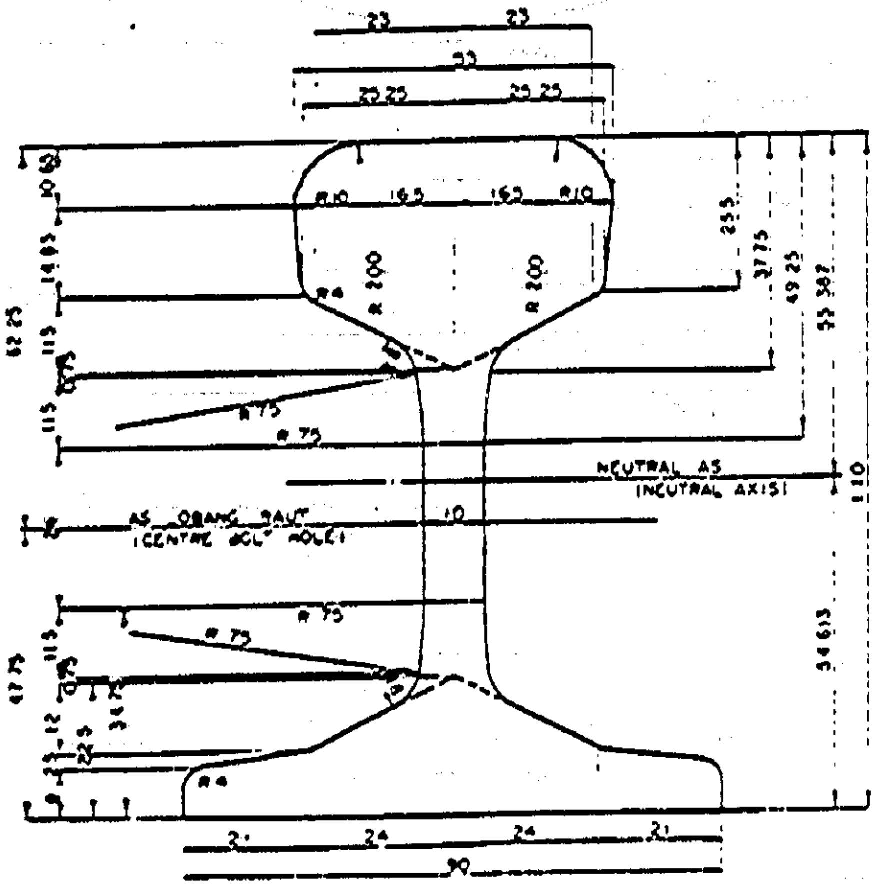
6.2 Rails and Rack-Rail (See Fig. 3-18 ∿ 20)

The use of heavy rails not only strengthen rail itself and reduces stress, but also reduces sleeper stress and roadbed pressure, making track itself firmer, and at the same time, is effective in the reduced application of

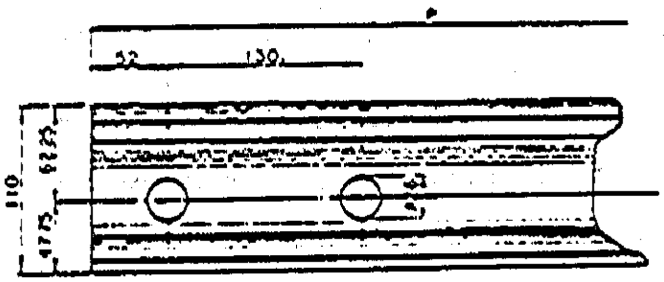
P. J K. A

F. 1441 S/D F. 1444

D43 REL PROPIL NO.2 BERAT 25.75 KG/M'
(RAIL PROFIL NO.2 WEIGHT 25.75 KG/M')



PANDANGAN SISI



F 1441
F 1442
F 1443
F 1444

PENDJELASAN

PANDJANG REL NO.2	(LENGTH) 6.75, 6.80, 10.25 DAN 10.20 M		
BERAT PER METER	(WEIGHT)		= 25.75 KG
WEERSTANDSMOMENT	(MOMENT OF RESISTANCE)	Wx	= 97.4 CM³
— „ —	— „ —	Wy	= 19.8 CM³
TRAAGHEIDSMOMENT	(MOMENT OF INERSIA)	Ix	= 538.3 CM⁴
— „ —	— „ —	Iy	= 88.9 CM⁴
LUAS	(AREA)	F	= 33 CM²

BANDUNG TG. 12-7-1963
DIKETAHUI OLEH
OKEB

FIG 3-18

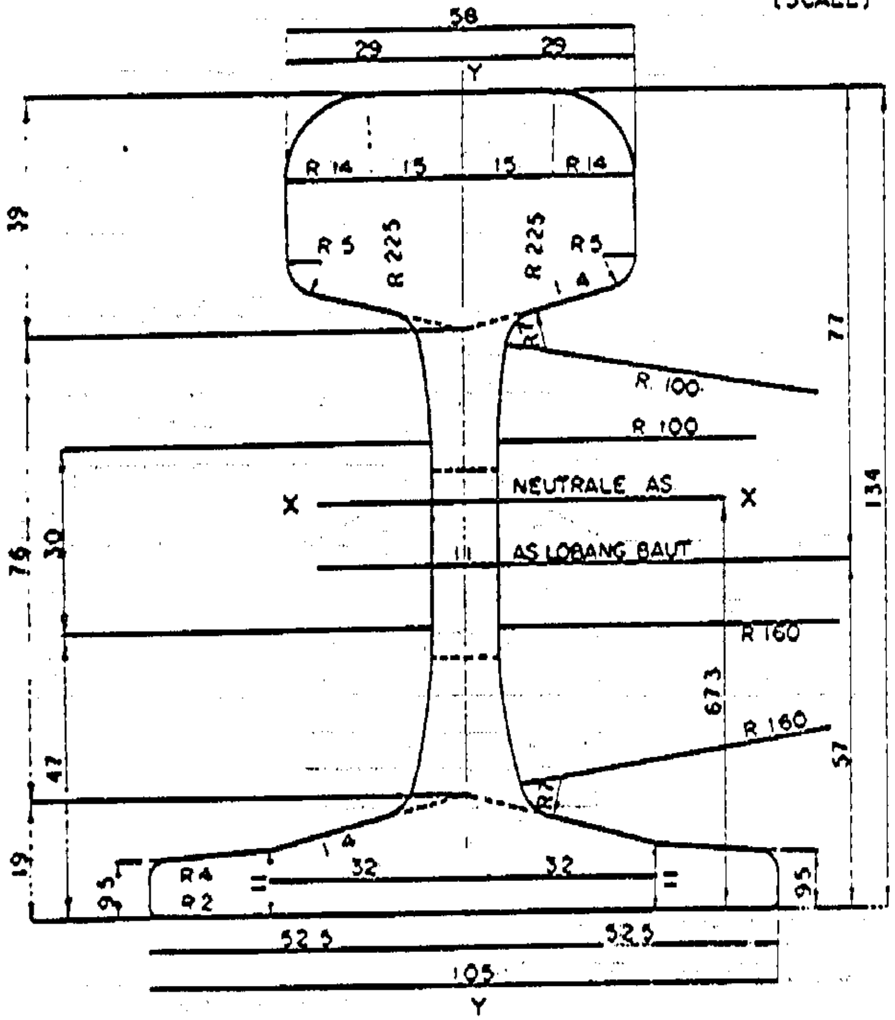
F.1446 S/D F.1448

D26 REL PROPIL NO.3 BERAT 33.40 KG/M'

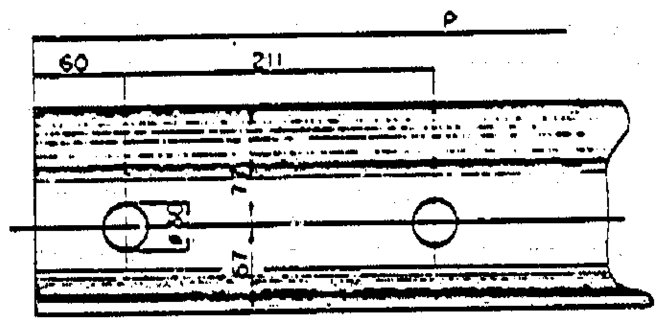
[RAIL PROFILE NO.3 WEIGHT 33.40 KG/M']

(SCALE) 1 : 4

P.J.K.A



PANDANGAN SISI



PENDJELASAN

F 1446
F 1447
F 1448

PANDJANG REL NO 3	(LENGTH)	= 11.90, 13.50, DAN 13.60 M
BERAT PER METER	(WEIGHT)	= 33.40 KG
WEERSTANDSMOMENT	(MOMENT OF RESISTANCE)	Wx = 154 CM³
— " —	— " —	Wy = 28.7 CM³
TRAAGHEIDSMOMENT	(MOMENT OF INERSIA)	Ix = 1036.6 CM⁴
— " —	— " —	Iy = 150.7 CM⁴
LUAS	(AREA)	F = 42.5 CM²

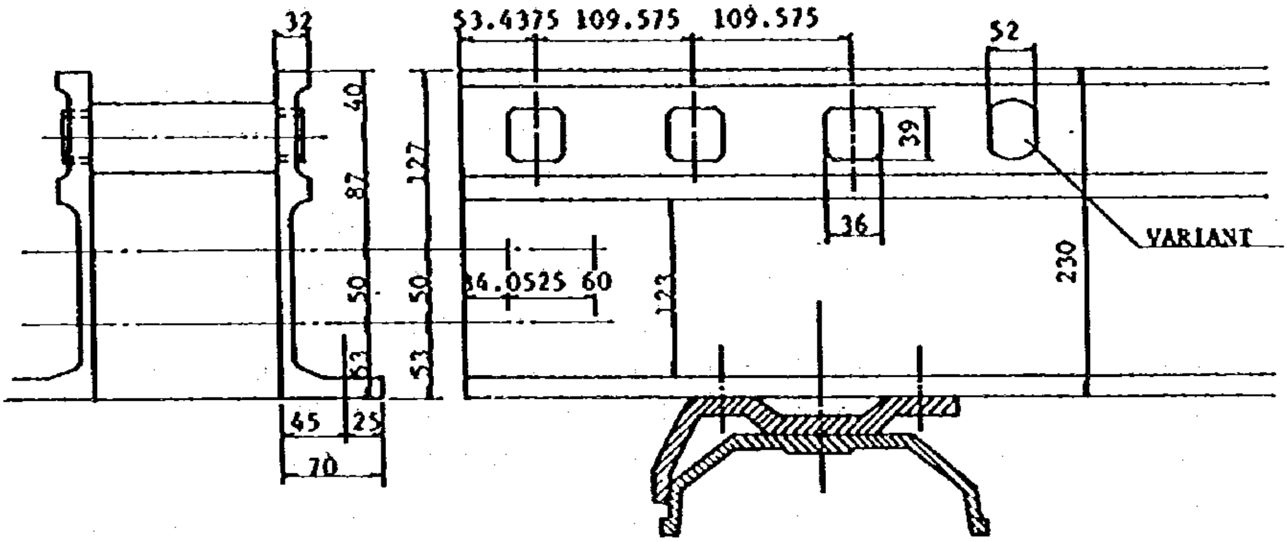
BANDUNG TG. 10-7-1963

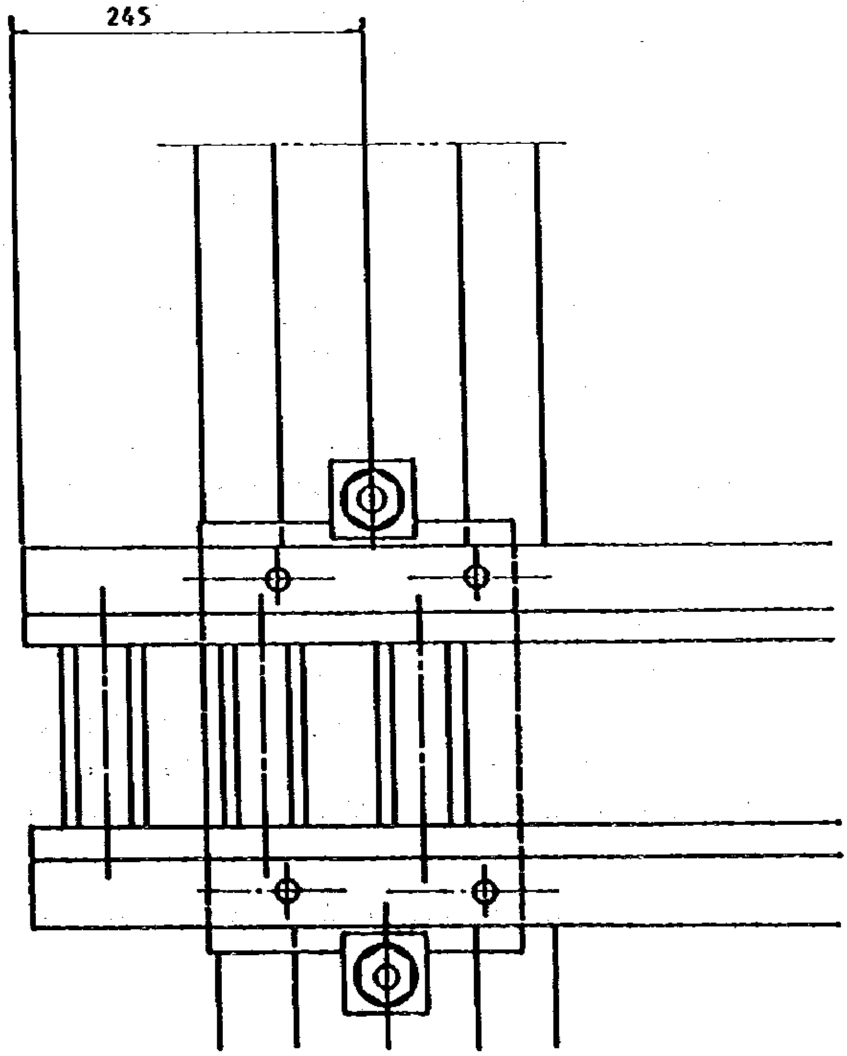
DIKETAHUI OLEH
DKEB

Fig 3-19

RACK RAIL

Fig 3-20





track maintenance. Accordingly, in recent times, the tendency is to use as larger rails as possible.

Taking rail stress alone, assuming that sleeper spacing is 680 mm, R2 rail (25.75 kg/m) may withstand the load, but is to be avoided due to insufficient marginal strength. Besides, the possibility of excess in stress in each part, especially excess pressure in roadbed, makes such use of rail less preferable from the maintenance point of view.

From such standpoint, the use of at least R3 (33.4 kg/m) rail becomes necessary. Moreover there are many problemes whether the use of R14 Rail (42 kg/m) is profitable or not, but, considering the fact that the R3 rail is available at no cost, which generates at present from other principal lines, it is thought advisable to use these R3 Rails.

In point of rail height alone, rack-rail is already replaced by R3 rails, and supposing that the replacing of these rails to R14 Rail is executed, the rail height will be only several mm higher, which causes the adjustment of fixing height of rack-rail unnecessary.

The rail of about 273 km (rail length) will be required to change R2 rail on whole (except rack-rail section) section into R3 rails. For this purpose, the entire rails will be supplied with the rails removed as the result of improvement work on trunk line track in Jawa.

As regards rack-rails, wearing is observed to a certain extent, but taken as a whole, they are comparatively in favourable condition, and is judged as usable for still longer period in future. Further, along with the increased transport amount in future, the tractive force of locomotives will gain, but it is considered that no especial hindrance will be caused as the result.

6.3 Sleepers.

The reducing of sleeper spacing is, as the use of heavy rail, is effective in lessening the stress on each portion of track. The existing 810 mm spacing is too long, and is not suitable for future planned transport. In the section west of Padangpanjang, sleeper is already improved to the spacing of 680 mm.

On the basis of the result of track strength calculation, the spacing of

680 mm is roughly adequate, also it is deemed that, for the object of avoiding excessive capital investment as well as from the point of track maintenance, sleeper spacing of this standard is rational. It may be said proper that the sleeper spacing for the section from Bukitputus to Padangpanjang has been improved to 680 mm. From now on, it is deemed necessary, on the section from Pandangpanjang on eastern half to Sawahlunto successively, to improve from present 810 mm to 680 mm, and in addition, to change about 30 % of sleepers thereon.

For this purpose, approximately 64,700 sleepers are required. For these sleepers, iron sleepers replaced in the improvement work of trunk line in Jawa may be used to considerable amount, but in this case, the use of new wooden sleepers is to be relied on.

At present, wooden sleepers are generally used while on rack-rail sections, iron sleepers are used. From the point of view of track structure as well as from track maintenance, the use of the same kind sleeper is desirable, but the mingled use of different kind of sleepers partially may not be avoidable.

6.4 Ballast

Assuming that ballast depth is 150 mm, on the basis of calculation conforming to the above-mentioned track structure, roadbed pressure is approximately 1.5 kg/cm^2 (15 ton/m^2). This value is deemed as the maximum allowable one, and therefore, it is desirable that the depth of roadbed is increased to 200 mm. However, in view of the extreme scarcely of ballast now prevailing, it is supposed that the increase of roadbed depth into 150 mm or more is exceedingly difficult. Accordingly, the roadbed depth will be limited to minimum necessity and so it is deemed practical to make it 150 mm.

It is necessary, for the sake of lateral stabilization of track, to secure the ballast shoulder outward from sleeper edge, to be 250 mm at the minimum, or 300 mm or so if possible. At present, not only ballast depth is insufficient, but ballast shoulder width is insufficient over the entire line. It is desirable that urgent partial supply be made where ballast shoulder width is exceedingly lacking on curved sections.

On the basis of above-mentioned statements, the ballast depth is taken as 150 mm, ballast shoulder width as 250 mm, and considering the present condition of insufficiency, the supply of Ballast anew of about 77,000 m^3 over the whole line will be necessary.

6.5 Turnouts

Simultaneously with rail replacement, the whole of R2 rail turnouts on the line, namely 85 sets, have to be replaced into R3 rail turnouts.

7. IMPROVEMENTS AND REPAIRS ON CIVIL WORKS

7.1 Bridges

7.1.1 Strength test of test piece

In the railway section between Sawalunto and Bukitputus, there had been an old bridge which was renewed by the existing No. 52 bridge in 1980. The old bridge had been a curved-chord truss bridge of type number II. No. 26 with a 20 m span and laid at an about 8 km distance from Padang into mountains.

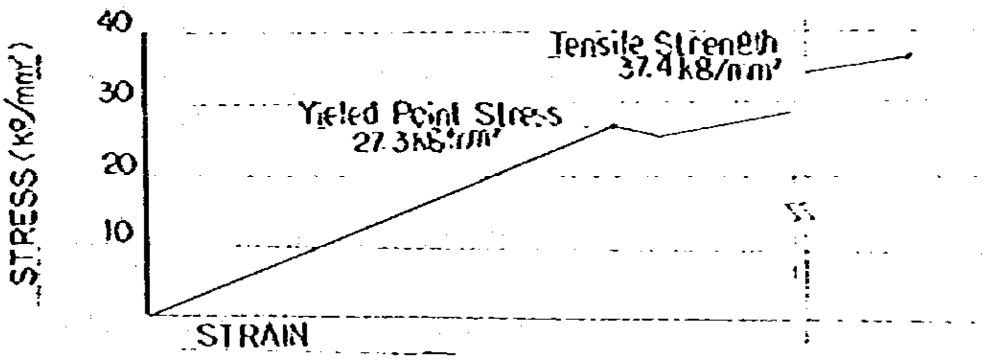
The test piece was taken from the above-said old bridge. On the test piece, the following tests were performed by methods according to the Japanese Industrial Standard (JIS).

1) Methods and results

(1) Tension test:

To know the yield point of the material which had served so long as about 90 years, its tensile strength and yield point stress were measured.

Table 3-9 Tension Test



(2) Charpy impact test:

A test to examine the effect of impact on material. To a test piece having its notch put on the center of a support bed, an impact is once given at the back of the notch with a hammer to thus fracture the test piece for obtaining its impact value.

Average Charpy impact value: 2.9 kg.m/cm^2

(3) Brinell hardness test:

Brinell hardness is defined as the from dividing the load, when giving a spherical indent on the test surface with a steel ball indenter, by the indented spherical area found from the diameter of permanent indent and calculated from the following formula:

$$H_B = \frac{2P}{\pi D(D - \sqrt{D^2 - d^2})} = 131$$

Where, H_B: Brinell hardness

P : Load

D : Diameter of steel ball

d : Diameter of inden

(4) Chemical analysis:

The test piece as a portion of the old bridge, which had been erected about 90 years ago, was subjected to a chemical analysis to examine whether its material is suitable for welding and which class of steel in current use be corresponded to.

Test results are as follows.

Table 3-10 Results of Chemical Analysis

C	Si	Mn	P	S
0.003	0.080	0.020	0.520	0.041

[unit: %]

2) Studies on test results

From the description ST37 of the test piece, the test piece was considered to the tensile strength criterion of 37 kg/mm^2 on more at 90 years ago. Since the tensile test showed a value 37.4 kg/mm^2, there should have been hitherto no extreme lowerment of strength. Moreover, as the value H_B was about three times of the tensile strength, those test results can be considered as reasonable. When judging from the test results including those of chemical analysis, the test piece seems to be similar to wrought iron.

To determine basic allowable stress intensity of the material of test piece, the yield point stress 2,730 kg/cm^2 was multiplied by a safety factor of $\frac{1}{1.7}$ judging from the test results and, in consideration of the fatigueness and sampling point of the test piece, which is only one in number, further multiplied by 70 %, thus obtaining:

$$\sigma_{sa} = 2{,}730 \text{ kg/cm}^2 \times \frac{1}{1.7} \times 0.7 \fallingdotseq 1{,}100 \text{ kg/cm}^2$$

As considered to be reasonable, this value 1,100 kg/cm^2 was employed as the basic allowable stress intensity of the material in problem.

From the results of chemical analysis showing a high content of P, such a judgement was made that weld reinforcement is unsuitable for the material.

7.1.2 Stress calculation for bridge

Stress calculation was made for the four bridges mentioned in Section 2.4. The bridges were actually inspected and their design drawings were obtained.

1) Method of calculation:

Linear static stress by influence line was calculated for two-dimensional frame structures of arbitrary shape using travelling load of the train planned to travel through the bridge considered.

(1) Train formation and location of bridge:

For train formation by the sections and location of each bridge, refer to Fig. 3-21.

(2) Structural type of bridge:

Structural type of each bridge is shown in Fig. 3-22 ∿ 25
Refer to Sec. 2.4.3 wherein bridge number, model number, etc. are detailed.

(3) Loads:

i) Dead load

a) Bridge weight $Wd_1 = A \times 7.85$ t/m

b) Track weight $Wd_2 = 0.2$ t/m, each side

ii) Live load

Live load was obtained by travelling the planned train through each bridge. See Fig. 3-22 ∿ 25.

iii) Impact load

The impact load is the stress of bridge due to train as multiplied by an impact fraction i as following.

$$\text{For } L \leqq 30 \text{ m}, \quad i = 0.7 - \frac{L^2}{4,000}$$

$$\text{For } L > 30 \text{ m}, \quad i = \frac{10}{L} + 0.14$$

Where, L: Basically, lengths (m) of base lines of those influence lines which are of the same symbol and cause maximum train loads in the structural members considered. However, for those web members of truss other than suspended member of through truss, median port of deck truss, diagonal member between panels, and the similar, the lengths L should be 75 % of their effective spans.

iv) Other loads

As other than preceeding loads, there are wind load, thermal load, etc. However, these loads were neglected because their values are very small. Still more, there is a provision that, when they are considered, the allowable stress intensity may be increased to some extent as a rule.

(4) Allowable stress intensity

The allowable stress intensity was assumed as following based on strength test results of the test piece of actual bridge.

i) Basic allowable stress intensity

TRAIN FORMATION OF EACH SECTION AND ELECTION PLACE OF EACH BRIDGE

TRAIN FORMATION

From		To
SAWAHLUNTO	→	BATUTABAL
BB 303 1	+	COAL WAGON 8
BATUTABAL	→ RACK SECTION	PADANG PANJANG
DIESEL RACK LOCOMOTIVE 2	+	COAL WAGON 8
PADANG PANJANG	→ RACK SECTION	KAYUTANAM
DIESEL RACK LOCOMOTIVE 2	+	COAL WAGON 12
KAYUTANAN	→	BUKIT PUTUS
BB 303 1	+	COAL WAGON 12
BUKIT PUTUS	→	SILO
BB 300 1	+	COAL WAGON 2

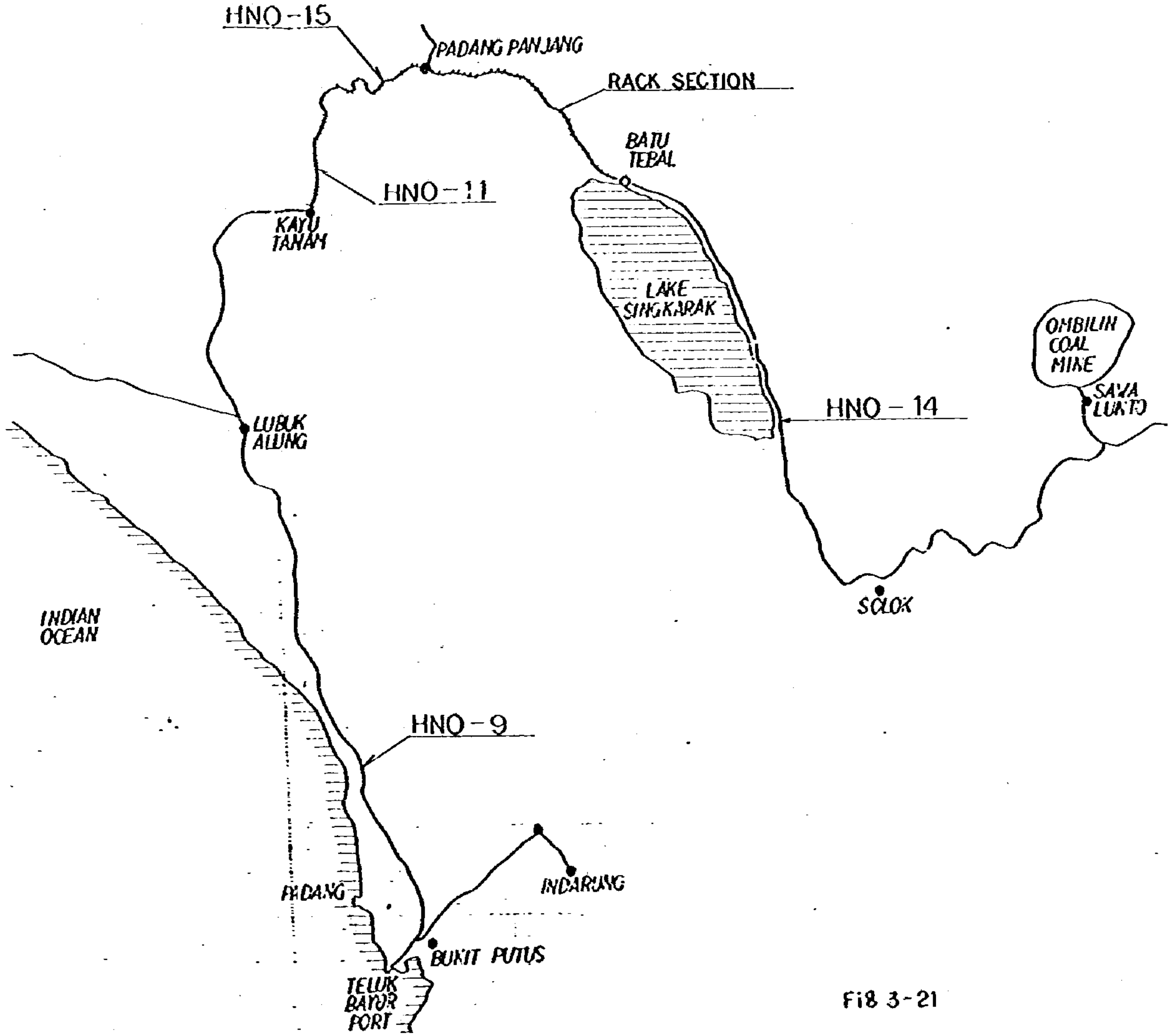
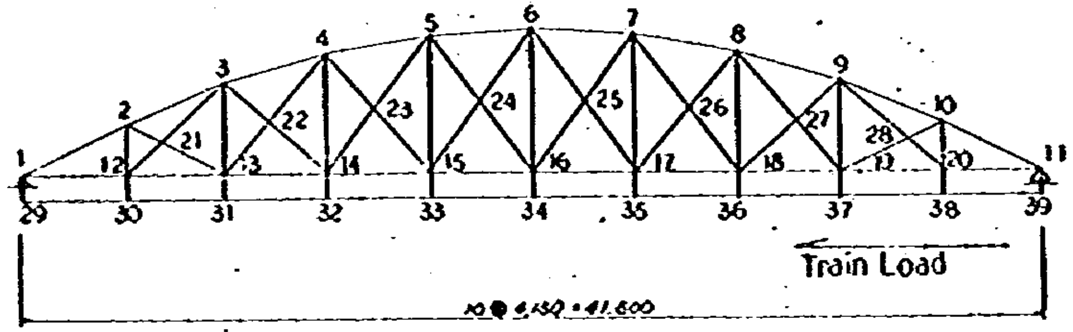


Fig 3-21

NO.77 BRIDGE (HNO-9 CURVED CHORD TRUSS BRIDGE)

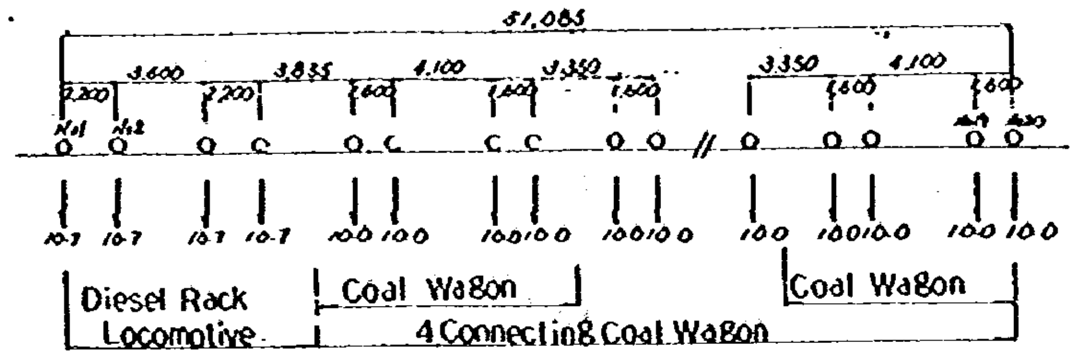


※ Standard Point is 16.

※ Joint 29~39 are rigid, and others are Pin support.

Train Load

Notice: Calculation use half of this load.



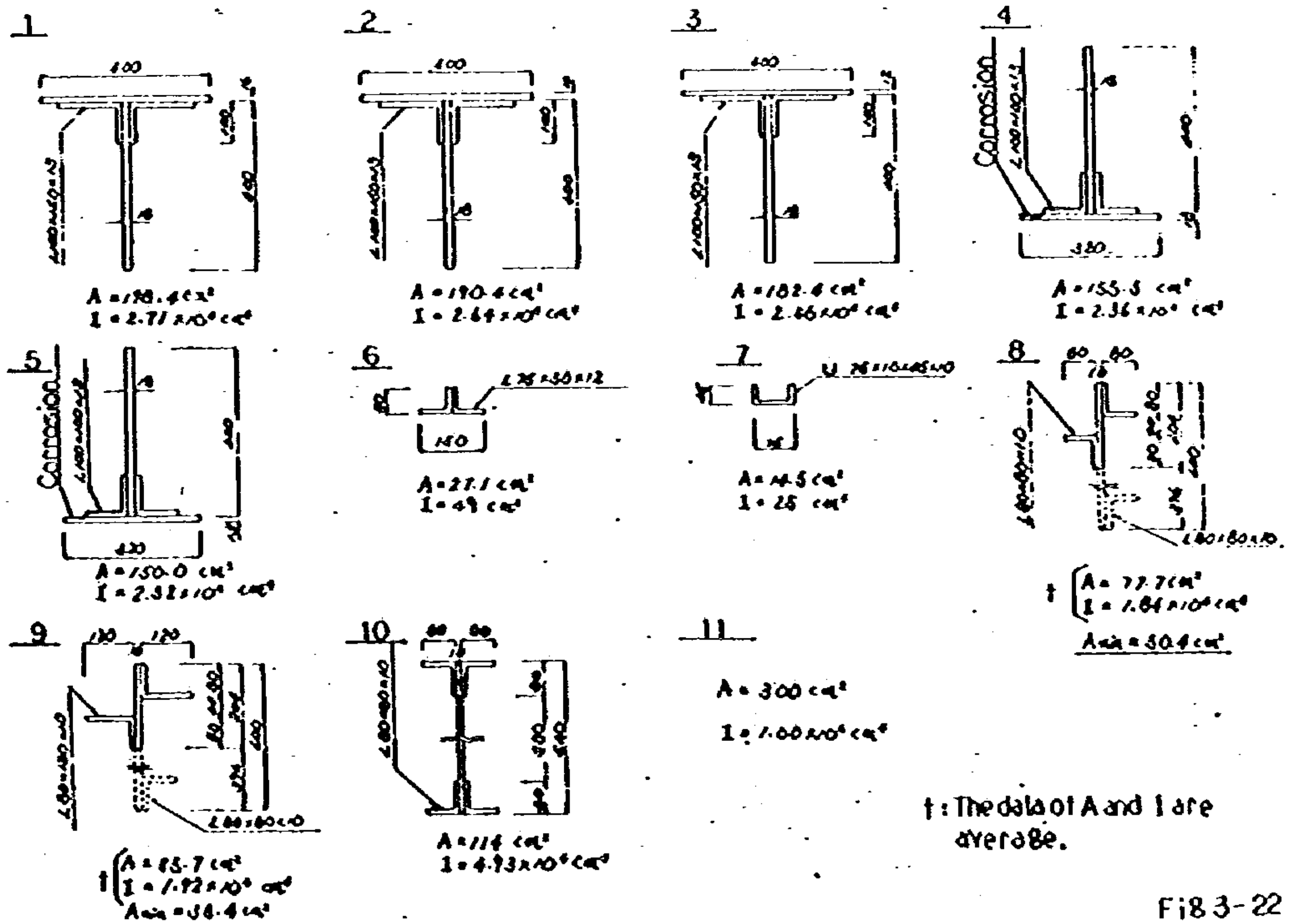
Jointed Coordinate

Number	Coordinate X	Coordinate Y	Number	Coordinate X	Coordinate Y
1	-20.750	0.000	29	-20.750	-0.300
2	-16.600	2.160	30	-16.600	〃
3	-12.450	3.840	31	-12.450	〃
4	-8.300	5.040	32	-8.300	〃
5	-4.150	5.760	33	-4.150	〃
6	0.000	6.000	34	0.000	〃
7	4.150	5.760	35	4.150	〃
8	8.300	5.040	36	8.300	〃
9	12.450	3.840	37	12.450	〃
10	16.600	2.160	38	16.600	〃
11	20.750	0.000	39	20.750	〃
12	-16.600	〃			
13	-12.450	〃			
14	-8.300	〃			
15	-4.150	〃			
16	0.000	〃			
17	4.150	〃			
18	8.300	〃			
19	12.450	〃			
20	16.600	〃			
21	-15.106	1.582			
22	-10.655	2.171			
23	-6.363	2.688			
24	-2.117	2.939			
25	2.117	2.939			
26	6.363	2.688			
27	10.655	2.171			
28	15.106	1.582			

Member List

Member	No	Member	No
1-2, 10-11	1	2-13, 10-19	7
2-4, 8-10	2		6
4-8	3	29-39	10
1-14, 18-11	4	1-29~11-39	11
14-18	5		
2-12, 3-13	8		
9-19, 10-20	8		
4-14, 5-15	9		
6-16, 7-17	9		
8-18	9		

Notice: The Number 6 means Other diagonal members. And 11 means Temporary members.



†: The data of A and I are average.

Fig 3-22

Table 3 - 11

Type of stress		Intensity [kg/cm^2]
Tensile stress	Axial	1,100
	Bending	
Compressive stress	Axial	
	Bending	
Shearing stress	Net section	640
Bearing stress	Between steel plates	1,700

ii) Allowable buckling stress (gross section)

a) Axial stress

For $0 < \ell/r \leq 28$, 1,000 kg/cm^2

For $28 < \ell/r \leq 130$, $1{,}000 - 8D(\ell/r - 28)$ kg/cm^2

For $130 < \ell/r$, $6{,}660{,}000(\ell/r)^2$ kg/cm^2

Where, ℓ/r is Slenderness ratio.

b) Bending stress 1,100 kg/cm^2

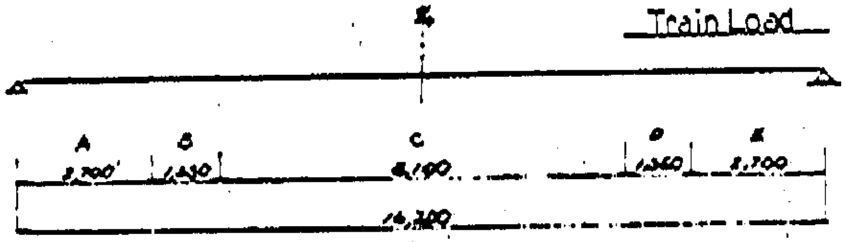
(5) Others

i) Young's modulus $E = 2.1 \times 10^6$ kg/cm^2

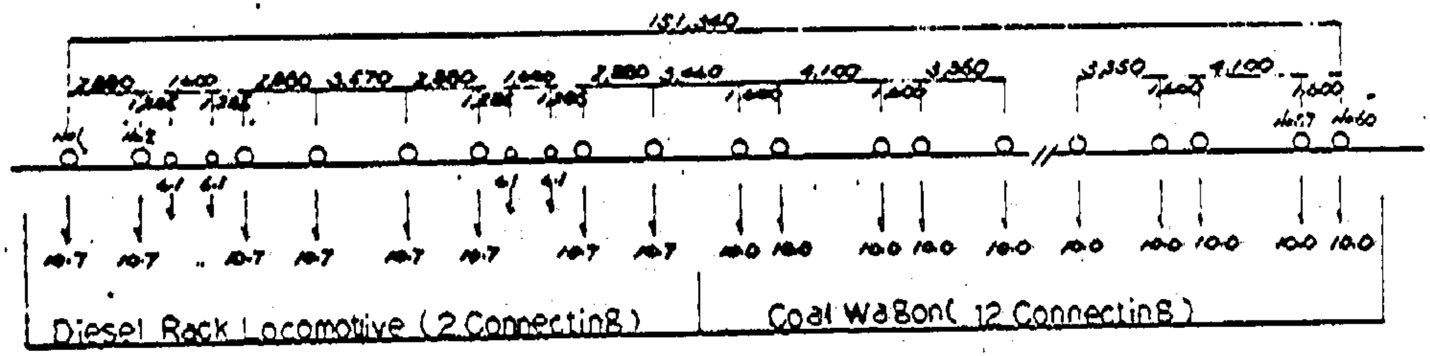
ii) Deflection was also determined by calculation.

The inside of lower chord member of No. 77 bridge, which the portion was considerably corroded, was examined after reducing the section by a 40 % deficit.

NO.163 BRIDGE (HNO 11 PLATE GIRDER)



TRAIN LOAD



Notice : Calculation of intensity strees use maximam bending moment. And calculation use halt of this load. Axle load number start left side from 1 to 60.

MEMBER A.E MEMBER B.D MEMBER C

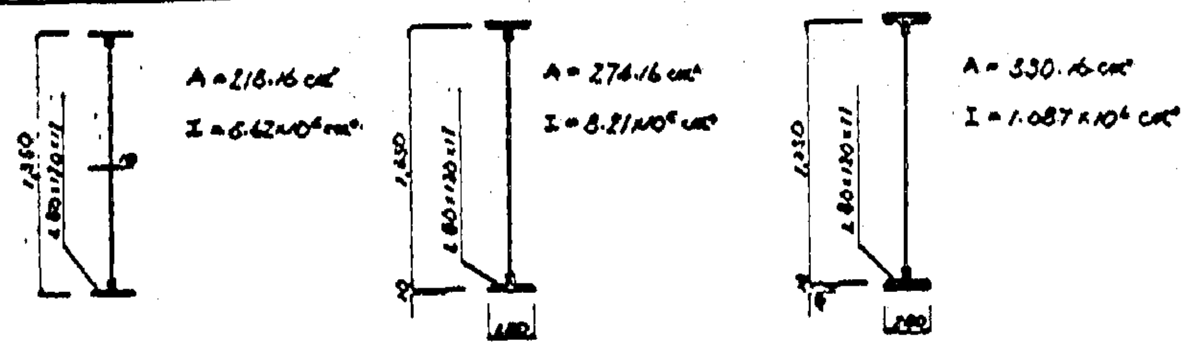
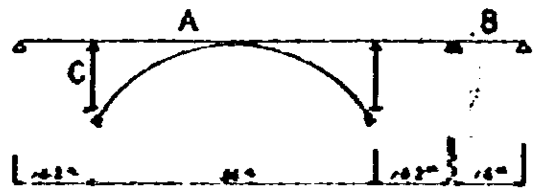


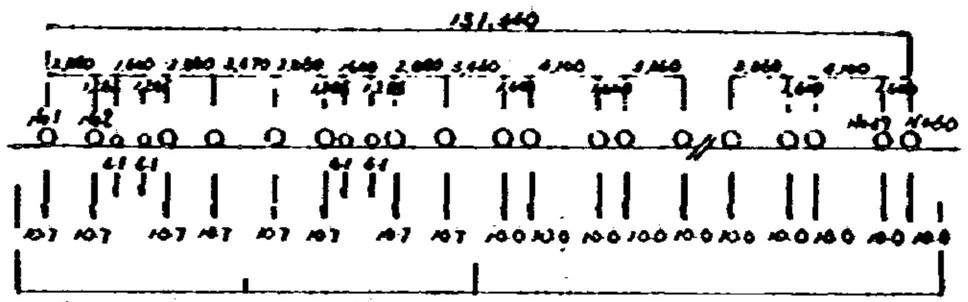
Fig 3-23

NO186 (HNO.15 ARCH TYPE BRIDGE)

STRUCTUAL TYPE

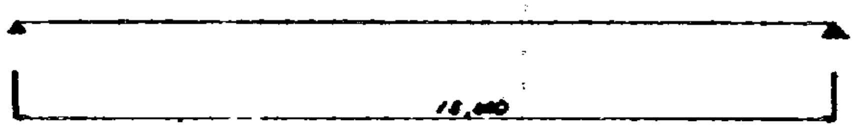


TRAIN LOAD



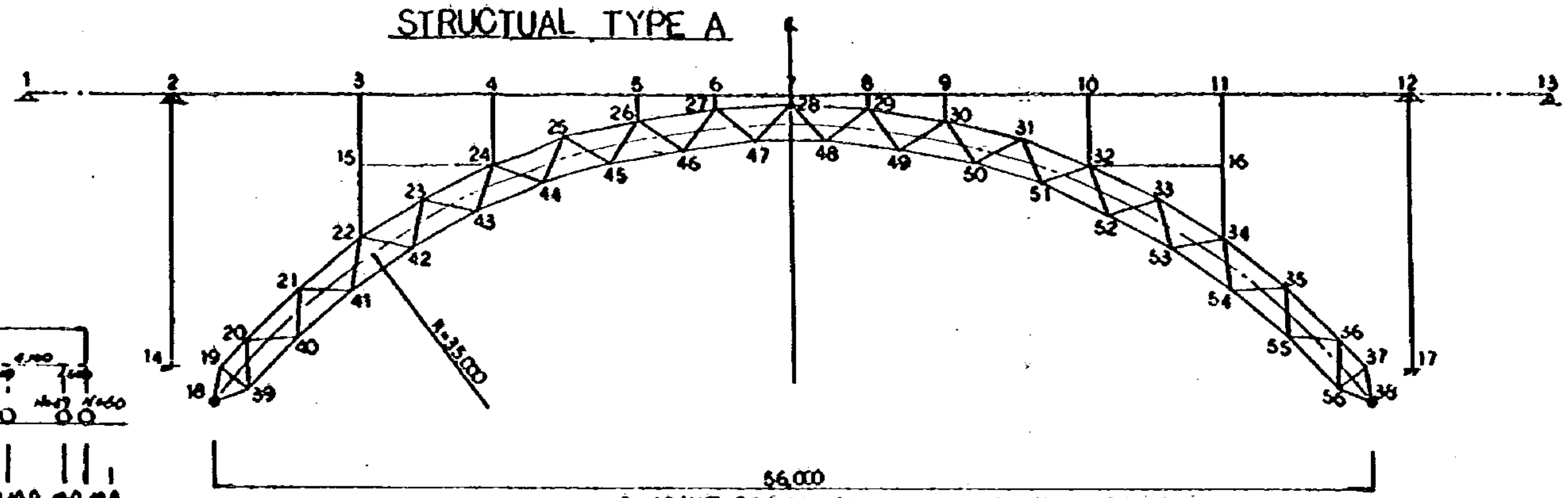
Diesel Rack Locomotive (2 Connecting) — Coal Wagon (12 Connecting)

STRUCTUAL TYPE B



Notice: Joint 2~12 are rijid Joint 14, 17 are fixed and otheres are Pin Joint.
Calculation use half of this train load.

STRUCTUAL TYPE A

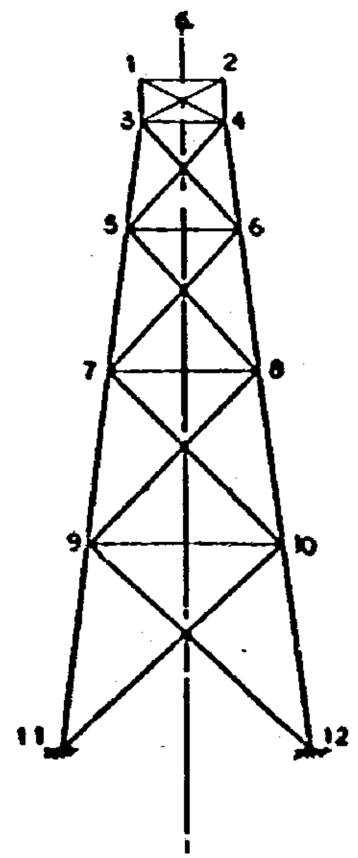


C JOINT COORDINATE

NO	Coordinate X	Coordinate Y
1	-0.350	0.000
2	0.050	0.000
3	-0.850	-0.875
4	0.850	-0.875
5	-1.134	-3.115
6	1.134	-3.115
7	-1.402	-6.015
8	1.502	-6.015
9	-1.958	-9.445
10	1.958	-9.445
11	-2.500	-13.860
12	2.500	-13.860

A JOINT COORDINATE

NO	Coordinate X	Coordinate Y	NO	Coordinate X	Coordinate Y
1	-46.176	0.000	29	3.727	-0.731
2	-27.976	〃	30	7.413	-1.307
3	-20.183	〃	31	11.021	-2.264
4	-14.509	〃	32	14.609	-3.687
5	-7.413	〃	33	17.841	-5.240
6	-3.701	〃	34	20.983	-7.283
7	0.000	〃	35	23.077	-9.611
8	3.701	〃	36	24.867	-12.250
9	7.413	〃	37	27.181	-13.698
10	14.509	〃	38	28.000	-14.437
11	20.183	〃	39	-26.302	-14.732
12	27.976	〃	40	-23.770	-12.117
13	46.176	〃	41	-21.340	-9.764
14	-27.976	-13.836	42	-18.960	-7.698
15	-20.976	-3.502	43	-15.381	-5.744
16	20.976	〃	44	-12.139	-4.316
17	27.976	-13.836	45	-8.766	-3.432
18	-28.000	-14.437	46	-4.277	-2.702
19	-27.781	-13.408	47	-1.772	-2.437
20	-26.337	-12.240	48	1.772	-2.337
21	-24.077	-9.611	49	5.277	-2.702
22	-20.983	-7.283	50	8.744	-3.432
23	-17.841	-5.248	51	12.139	-4.416
24	-14.409	-3.509	52	15.381	-5.744
25	-11.021	-2.264	53	18.960	-7.698
26	-7.413	-1.307	54	21.340	-9.764
27	-3.727	-0.731	55	23.770	-12.117
28	0.000	-0.431	56	26.302	-14.732



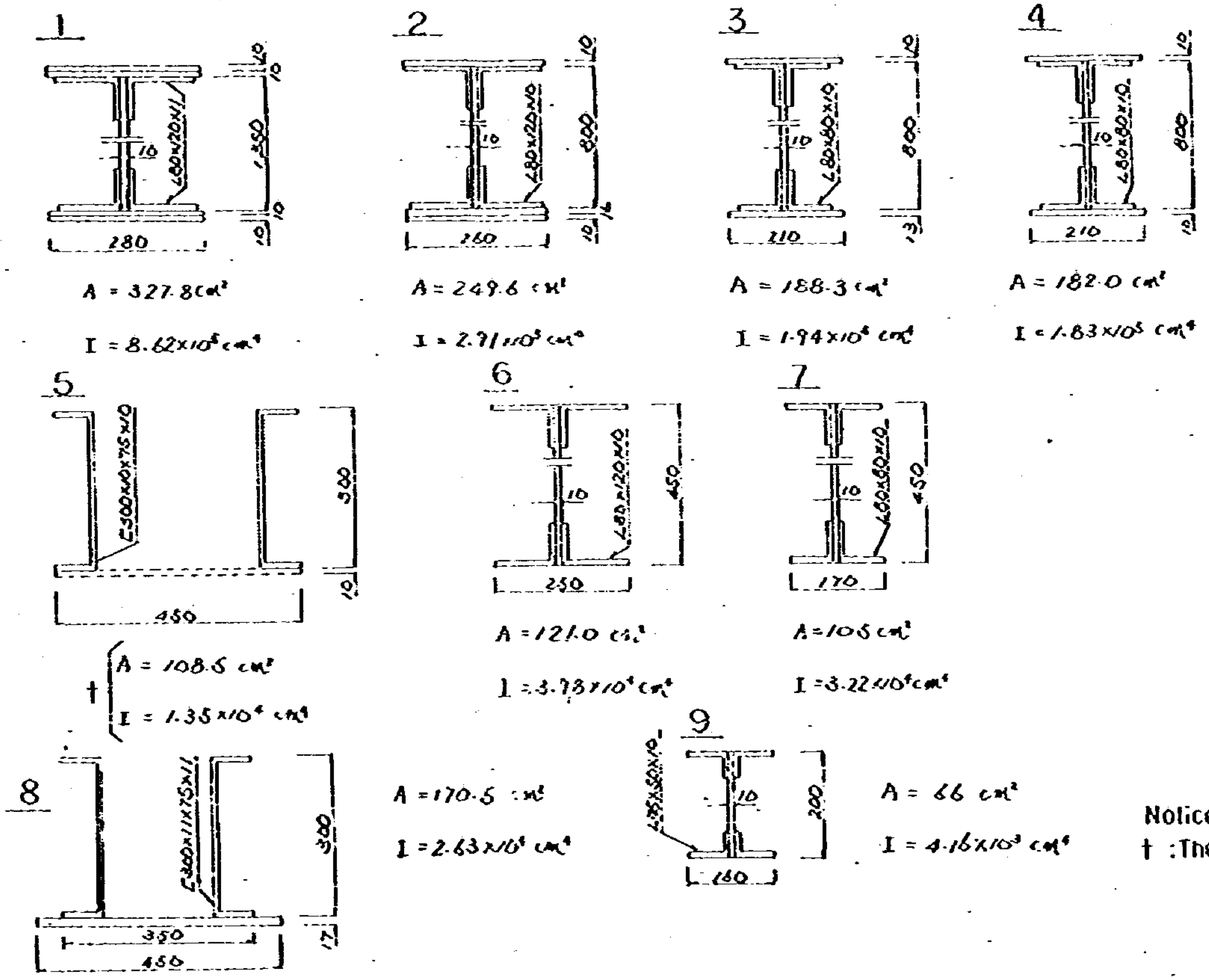
STRUCTUAL TYPE C

Fig 3-24

NO 186 BRIDGE(HNO -15 ARCH TYPE)

MEMBER LIST

NO.	MEMBER		
	Horizonal		
1		1	2
2		2	3
3		3	5
4		5	9
3		9	11
2		11	12
1		12	13
5		2	14
6		3	22
7	Vertical	4 ~ 10	24 ~ 32
6		11	34
5		12	17
8	Upper arch rib	18 ~ 37	19 ~ 38
8	Lower arch rib	18 ~ 56	39 ~ 38
9	Diagonal	19 ~ 37	39 ~ 56

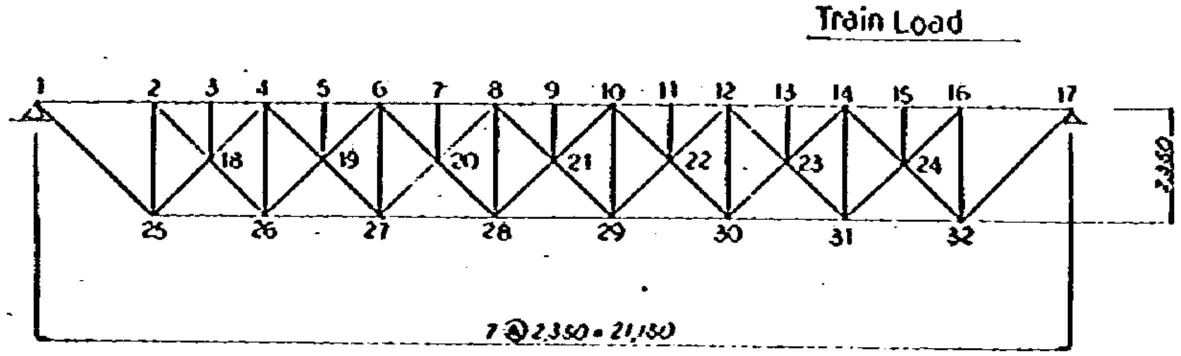


Notice
† :The data of A and I are average.

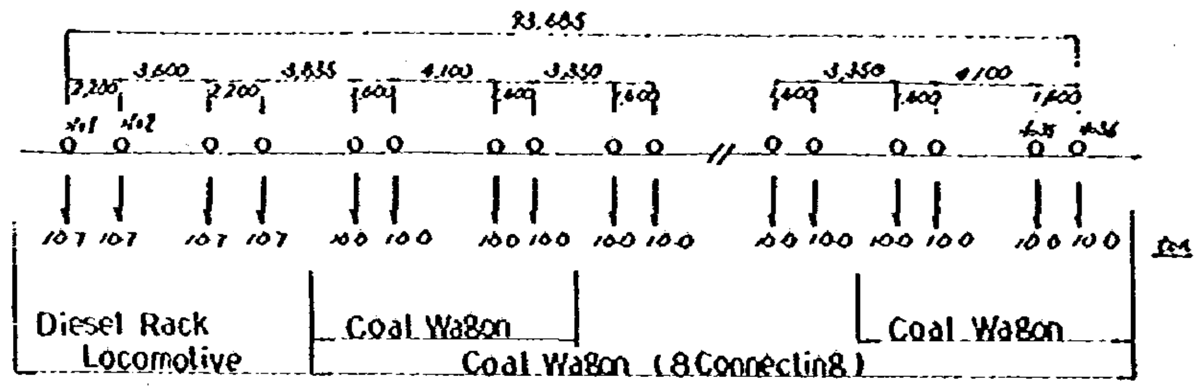
Fig 3-26

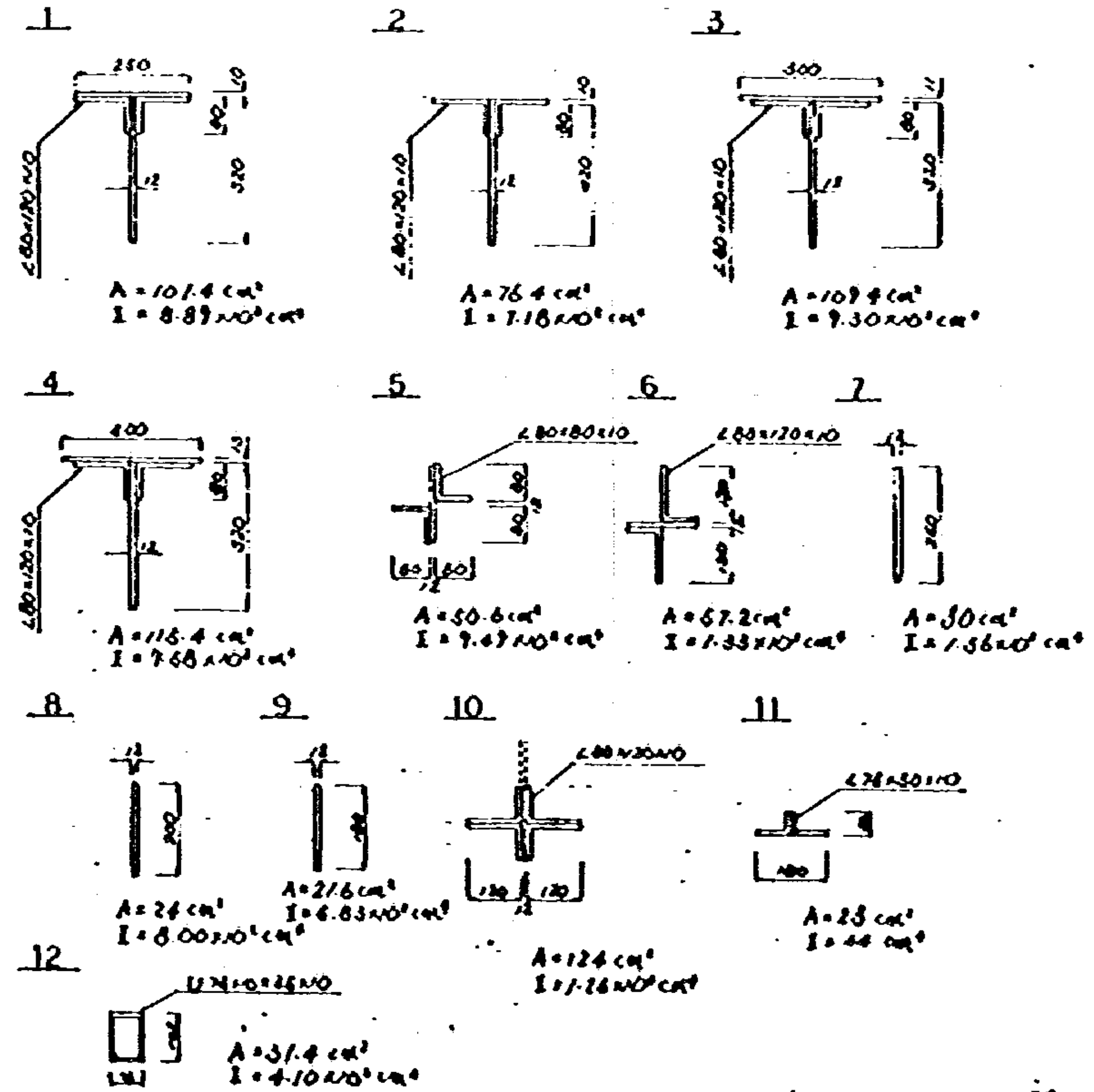
NO 329 BRIDGE (HNO 14 PARALLEL CHORD TRUSS)

STRUCTURE



TRAIN LOAD





JOINT COODINATE

NO.	Coordinate X	Coordinate Y
1	-10.575	0.000
2	-8.225	•
3	-7.050	•
4	-5.875	•
5	-4.700	•
6	-3.525	•
7	-2.350	•
8	-1.175	•
9	0.000	•
10	1.175	•
11	2.350	•
12	3.525	•
13	4.700	•
14	5.875	•
15	7.050	•
16	8.225	•
17	10.575	•
18	-7.050	-1.175
19	-4.700	•
20	-2.350	•
21	0.000	•
22	2.350	•
23	4.700	•
24	7.050	•
25	-8.225	-2.350
26	-5.875	•
27	-3.525	•
28	-1.175	•
29	1.175	•
30	3.525	•
31	5.875	•
32	8.225	•

MEMBER LIST

Member	Number
1-6	1
6-12	3
12-17	1
1-25	10
25-27	1
27-30	4
30-32	1
32-17	10
2-25 ~ 16-32	5
2-26, 16-31	7
4-25, 14-32	6
4-27, 14-30	8
6-26, 12-31	5
6-28, 12-29	9
8-27, 10-30	5
8-29, 10-28	11
3-18 ~ 15-24	12

Notice : Member 2-25 ~ 16-32 are vertical.
And 3-18 ~ 15-24 are sub vertical.
Joint 9 is standard point.
All of the Joint is pin.
Calculation use half of this train load.

Fig 3-26

(2) Result of Calculation

(1) No. 77 Bridge (HNO-9)

1) Result of stress calculation

Table 3-12

Number of member	Evaluated member	Max. member force				Structural stress	Allowable stress	Remark
		Dead load	Live load	Impact load	Total member force			
1	1 - 2	-37.120 (ton)	-75.149 (ton)	-28.557 (ton)	-140.826 (ton)	710 kg/cm^2	< 904 kg/cm^2	Upper chord member
2	2 - 3	-35.803	-72.686	-27.621	-136.110	715	< 920	"
3	4 - 5	-34.246	-69.255	-26.317	-129.818	712	< 936	"
4	13 - 14	32.867	66.746	25.363	124.976	803	< 1,100	Lower chord member
5	14 - 15	33.037	66.518	25.277	124.832	832	< 1,100	"
6	16 - 24	0.508	6.292	2.391	9.191	339	< 1,100	Diagonal member
7	2 - 21	0.337	4.148	1.576	6.061	418	< 1,100	"
8	2 - 12	2.649	7.049	3.243	12.941	257	< 1,100	"
9	4 - 14	2.213	6.386	2.938	11.537	198	< 1,100	"
10	34 point	0.167 (t.m)	0.848 (t.m)	0.322 (t.m)	1.337 (t.m)	73	< 1,100	Stringer

+: Tensile member

-: Compressive member

ii) Other studies

a) Deflection:

Deflection due to train load reached 20.4 mm as maximum. In consideration of various factors such as safety in running, confortableness, and stress in rails, the truss bridge is recommended to meet the relationship below, in general.

$$\delta < L/1,000$$

Where, δ : Deflection

L: Effective span length, mm

In the bridge considered, as the effective span length was 41.5 m, then 41.5 x 10^3 mm/ 1,000 = 41.5 mm. Hence, the bridge No. 77 is no problem on deflection. Likewise, in other bridges considered, there is found no problem concerning the deflection.

b) Width of bridge:

The width of bridge is responsible for the falling down of bridge, running quality, and lateral backling. Therefore, the width of bridge must be maintained at its predetermined value. Necessary width of bridge due to such reason is 1/20 of effective span length.

In this case, the effective span length is b m, and

$$b > 41.5/20 = 2.075 \text{ (m)}$$

Then, the bridge No. 77 has a sufficient width. Likewise, all other bridges considered are proved to have their sufficient widths.

(2) No. 163 bridge (HNO-11)

i) Dead load

Total member force has its acting point located at the acting point of maximum member force due to train load. The member force due to dead load at such point follows.

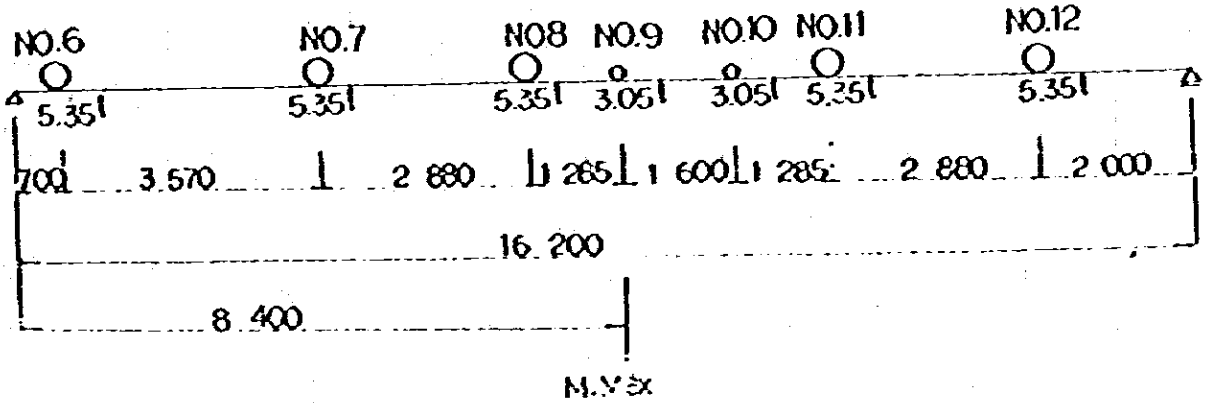
$$Md = 14.69 \text{ t.m}$$

ii) Train load

Maximum member force due to train load causes a loading mode as shown below.

$Mt = 72.36$ t.m

Fig. 3 - 27



iii) Impact load

$i = 0.7 - 16.2^2/4{,}000 = 0.634$ (i: impact fraction)

$Mi = 72.36 \times 0.634 = 45.88$ t.m

iv) Total member force

$\Sigma M = Md + Mt + Mi = 132.93$ t.m

v) Stress

$$\sigma = \pm \frac{M}{I} y = \frac{\pm 132.93 \times 10^5}{1{,}088 \times 10^6} \times \frac{135}{2} = \pm 825 \text{ kg/cm}^2 < 1{,}100 \text{ kg/cm}^2$$

$$\tau = \frac{Smax}{Aw} = \frac{36.924 \times 10^3}{1.0 \times 135} = 274 \text{ kg/cm}^2 < 640 \text{ kg/cm}^2$$

Smax is to be produced with a loading mode having its axial load No. 11 located at a 8 cm distance from the Point B.

(3) No. 186 Bridge (HNO-15)

Table 3-13

Number of member	Evaluated member		Maximum member force: Dead load	Live load	Impact	Total	Stress	Allowable stress	Remark
			Bending (t.m) / Shearing (t) / Axial force(t)	Bending (t.m) / Shearing (t) / Axial force(t)	Bending (t.m) / Shearing (t) / Axial force(t)	Bending (t.m) / Shearing (t) / Axial force(t)	Bending / Shearing / Axial force	Bending / Shearing / Axial force	
1	1-2	Bending	13.013	72.360	45.876	131.249	1,028kg/cm²	<1,100kg/cm²	Bending member
		Shearing	2.223	26.187	17.283	45.693	571 "	<640 "	
		Axial force							
2	2-3	Bending	4.256	23.784	16.173	44.213	714 "	<1,100 "	"
		Shearing	-0.592	-7.047	-4.897	-12.536	157 "	<640 "	
		Axial force							
3	4-5	Bending	2.199	18.061	12.408	32.668	697 "	<1,100 "	"
		Shearing	2.273	5.029	3.460	10.762	134 "	<640 "	
		Axial force							
6	3-22	Bending							Vertical member
		Shearing							
		Axial force	-6.698	-18.107	-6.881	-31.686	262 "	<1,000 "	
8	23-24	Bending							Upper chord member
		Shearing							
		Axial force	-17.786	-61.485	-23.364	-102.635	602 "	<984 "	
8	43-44	Bending							Lower chord member
		Shearing							
		Axial force	-19.937	-68.973	-26.210	-115.120	675 "	<1,000 "	
9	24-43	Bending							Diagonal member
		Shearing							
		Axial force	-4.514	-17.141	-6.514	-28.169	427 "	<968 "	

(4) No. 329 Bridge (HNO-14)

Table3-14

Number of member	Evaluated member	Max. member force (ton)				Structural stress (kg/cm^2)	Allowable stress (kg/cm^2)	Remark
		Dead load	Live load	Impact load	Total member force			
1	26 - 27	12.194	42.057	24.730	78.981	779	< 1,100	Lower chord member
2	4 - 5	-11.566	-39.560	-23.261	-74.387	974	< 1,000	Upper chord member
3	8 - 9	-14.484	-47.243	-27.779	-89.506	818	< 1,000	"
4	28 - 29	14.801	47.589	27.982	90.372	783	< 1,100	Lower chord member
5	19 - 26	-2.701	-11.295	-6.641	-20.637	408	< 916	Diagonal member
6	4 - 18	-3.955	-15.867	-9.330	-29.152	510	< 952	"
7	18 - 26	1.885	7.970	4.686	14.541	485	< 1,100	"
8	4 - 19	1.847	6.856	4.031	12.734	531	< 1,100	"
9	20 - 28	0.467	4.577	2.687	7.731	358	< 1,100	"
10	1 - 25	8.364	29.493	17.330	55.187	445	< 1,100	"
11	21 - 29	-0.229	4.314	2.537	7.080	334	< 1,100	"
12	3 - 18	-0.436	-3.853	-2.454	-6.743	215	< 960	Vertical member of intermediary

+: Tensile member

-: Compressive member

7.1.3 Judgement of soundness and guide of counterplan

Stress calculation in consideration of dead load, train load and impact load showed that there was produced no stress exceeding the allowable value, as described before. Moreover, deflection, width of bridge and the like were proved to be within their allowable values. When considering the bridges considered are of typical type, whereas they are four in number, it may well be said that all the bridges in concern have been kept within each allowable value, providing that the bridges have all cleared the same criterion.

With respect to corrosion, though some differences having been found among bridges, it was generally observed that those bridges located nearer to the sea shore or between Padang and Duku have the higher possibility of corrosion in advanced state. In fact, the No. 52 bridge was reconstructed recently. Still more, in the No. 68 and No. 77 bridges, there were found corroded portions in an advanced state at their lower chord members.

Stress calculation has resulted that structural members are still kept within their allowable values with the train load as of the final plan of coal transportation, even in consideration of corrosion. However, if the members are left intact, reconstruction of bridge will become necessary due to advanced corrosion. Therefore, as a countermeasure, the existing members should be securely maintained for strength. Namely, as a best way, coating should be applied to prevent the growth of corrosion. Such countermeasures will be detailed in the next Section

7.1.4 Countermeasure

1) Selection of countermeasure

As described in Section 7.1.3 "Judgement of soundness and guide of counterplan", certain countermeasure is requied over the whole length of rail line in accordance with the degree of corrosion and rust. Recommendable countermeasures are as follows.

a) Scaling and painting of corroded portion

b) Welding of reinforcing member

c) Replacement of member

The measure a) comprises the steps of completely removing corroded portions and those portions which are susceptible to corrosion by using a sander or such, and applying thereon painting for the prevention of corrosion. The bridges will thus be supported by their current effective section.

The measure b) is a method of securing by welding reinforcing members at or near those members which need maintenance to thus increase the sectional rigidity. However, as the results of chemical analysis are teaching the existing members are unsuitable for welding, a preliminary strength test of welded portion will become necessary to ensure the security. Therefore, this method is impractical for the time being. Moreover, the measure b) if employed will need qualified welding worker, since the welding greatly depends on the quality of person employed.

The measure c) is composed of the steps of providing temporary bearing members such as temporary supports and temporary beams under the girder of bridge by using piles or the like so as to suitably support the girder of bridge, removing rivets, and replacing members such as lower chord members. This method also carried problems. First, temporary work itself costs high in addition to that the execution should be difficult at some points for their topographical features. Secondly, lowerment of bearing capacity is inherently caused by lowered rigidity during the replacement period wherein rivets are removed. Therefore, extreme care to working procedure and stress check in temporary work will become necessary. In particular cases, total cost may exceed the cost for reconstruction of bridge.

From comparison of these three methods, the measure a) is judged to be the best in the light of economical and executional viewpoints. Hereafter, the measure a) will be detailed.

2) Working procedure:

At first, along the whole length of the bridge to be repaired, suspended scaffolds or built-up scaffold should be installed for temporary use, while the type of scaffold depends on whether their repairing portion is ranging wide extent or limited to underside members such as lower lateral bracings or lower chord members.

Then, corroded portion should be ground off using a disc sander or power brush or the like in accordance with the degree of corrosion. Finally, primer and surface coating should be applied on the base metal, the primer and surface coating being of two coats. This procedure is designated the first grade painting.

3) Portions to be repaired:

Since the on-site inspection did not cover all bridges and as no detail investigation was performed, it is difficult to exactly point out the portions to be repaired. However, as afore-mentioned, there is the possibility of repairing underside members (lower chord member, lower lateral bracing, lower flange plate, etc.) of the bridges between Padang and Duku. Further, besides Nos. 67, 68, 71 and 77 bridges of long span, it is assumed that 50 % of those bridges which were not inspected is to undergo the execution for repairing.

4) Quantity

Required quantity of materials was first estimated for the No. 77 bridge as standard, before multiplication by the length to be extended.

Lower chord member	$A = 0.32 \times 41.5 \times 2 = 26.56\ m^2$
Stringer	$A = 0.17 \times 41.5 \times 2 = 14.11\ m^2$
Lower lateral bracing	$A = 0.15 \times 5.63 \times 20 = 16.89\ m^2$
Floor beam	$A = 0.24 \times 3.8 \times 11 = 10.03\ m^2$
	$67.59\ m^2$

Thereafter, a consideration of 10 % was taken for other members such as gusset plate and sub-members.

$$A = 67.59 \times 1.1 = 74.35\ m^2/41.5\ m$$

Hence, the quantity per unit length is obtainable as $A = 1.79\ m^2$.

The extension length is 220 m in total of Nos. 67, 68, 71 and 77 bridges. Therefore, the total extension length as including the bridges not inspected is estimated as follows.

$$\ell = 220 \times 1.5 = 330\ m$$

Thus, the quantity to be applied the first grade painting is estimable.

$$A = 1.79\ m^2/m \times 330\ m \doteqdot 600\ m^2$$

5) Period of execution

As the quantity of materials is so small as 600 m^2, the necessary period for execution will be three months when started from 1983.

7.1.5 Painting

Basically, the painting is considered necessary for all bridges. However, in actual, 70 % of total area of painting is to undergo the execution for painting, in consideration that some of the bridges has not passed three years from the former execution or does not need painting.

$\Sigma A = 43{,}082 \times 0.7 \doteqdot 30{,}200\ m^2$

1) Painting method:

There is no significant difference from the measure described in Sec. 7.1.4. 2), while the scaling is scaled down and the method is somewhat different. As griding device, the disc sander will be sufficient. Moreover, the existing may be allowable to leave on the base metal slightly. The painting should comprise two coats of primer and surface coat. Paint should be the same as or similar to the existing painting. This procedure is designated the second grade painting.

2) Period of execution:

The total painting area is so wide as $3 \times 10^4\ m^2$. Moreover, the painting is desirable to be executed as quickly as possible.

Therefore, the execution will start from 1983 and end in 1984, thus having a period ranging over two years.

3) Service life of the painting:

Re-painting should be applied at intervals of five years.

7.1.6 Conclusion

In the foregoing examination on bridges, the bearing capacity is principally treated based on site inspection and stress calculation, in consideration of various factors even in the future. Particularly in the matter concerning stress, there can be seen such a case which deficit of section is considered in the calculation of a bridge, however, those calculations are operated on the assumption that the structural members are complete in quality and connection, whereas the members have passed about 90 years from the first erection. Therefore, it is considered that re-examination is necessary for those members whose the ratio of stress intensity to allowable stress exceed 80 %. Likewise, site inspection should be again performed. Especially, load test and materials test must be performed to ensure the security.

As a result of the investigation of this time, the existing bridges are judged to be able to bear the planned coal transportation by applying painting to the bridges according to the degree of corrosion and rust, and without reconstruction of bridge or the splicing of support members or such, whereas a detail inspection is essentially necessary for all bridges

7.2 Tunnel and Cut-and-fill Work

1) Tunnel

Tunnels are to be repaired at portions of cracked concrete and loosened ground by using cement milk so as to stop water. Cement milk should be filled in the ground by using a grout pump to repair the backfill. The cracks in concrete should be repaired with an epoxy resin so as to complete the cut-off of the seepage.

a) Quantity of materials

Filling range of cement milk should be 2 m in the sectional direction and 4 m in the direction of route. The section is to form the outside of a concrete semi-circle of 1.8 m radius. The filling ratio is supposed to be 40 %.

For cement paste,

$$V_1 = \frac{1}{2} \times \pi \times (3.8^2 - 1.8^2) \times 4 \times 0.4 = 28 \text{ m}^3$$

For epoxy resin,

$$V_2 = \frac{1}{2} \times 2 \times 1.8\pi \times 0.003 = 0.017 \text{ m}^3 \text{ (20 kg)}$$

b) Period of execution

At present, the defects are already affecting adversely. Then, prompt repairing is required to be started from the first year of the planned construction work.

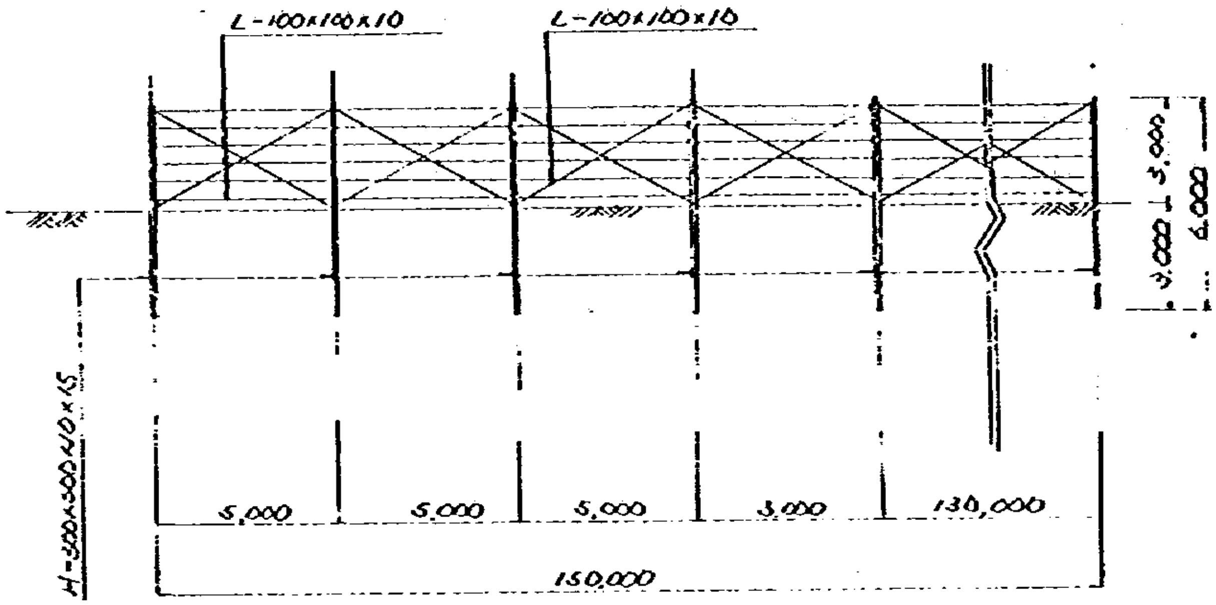
2) Slope

Prevention fences against the falling of stone will be provided in the manner and quantity shown in Fig. 3-28. These fences comprise H-shaped and L-shaped steels to thereby prevent stones over 30 cm from falling down to rail bed.

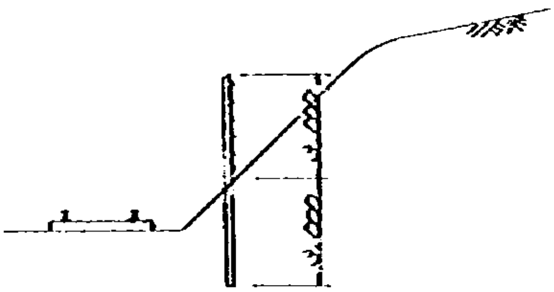
The execution will be completed within the first year of the planned construction work.

PREVENTION FENCE S=1:200 Fig 3-28

FRONT ELEVATION



CROSS SECTION



ITEM	MEMBER	UNIT MEMBER LENGTH	UNIT MEMBER WEIGHT	NOS.	TOTAL WEIGHT
		mm	t		t
H-Section Steel Pile	H-300x300x10x15	6 000	0.564	31	17.484
Prevention Fence	L-100x100x10	10 000	0.149	90	13.410
Diagonal Members	L-100x100x10	6 000	0.089	60	5.[illegible]
TOTAL					36.23[illegible] t

8. IMPROVEMENT ON SIGNAL AND SAFETY FACILITIES

8.1 Present System and Trend of Improvement

Present single line train operation system is communication system by telephone and telegraph. Under this system, between two neighbouring stations, one station allows, by arrangement through telephone, etc., a train to depart, depending solely upon human memory and judgement. This system has the possibility of causing accident to a large extent, and there are many records of such accidents of this sort in the past. It is deemed by all means necessary to improve signal system not only for security of rail way operation, but also for increasing the efficiency of train working.

There are several system to elevate the efficiency of train operation security on single line sections. Automatic signal on single line is effective in the case when trains are often operated in the same direction successively. But the fact that great expense is needed makes the system on this line ineffective. On this line, the tokenless system mentioned below is deemed adequate.

8.2 Tokenless System

There is the tablet system in which, one station or the section covering several stations, is made a block section, and to secure the principle of one train in one block system, and ordinarily a tablet (token) is carried by a train. Under this tokenless system, this troublesome tablet carrying is omitted, and detection of the presence or not of train is performed by means of electric track circuit or axle detector, thereby controlling the dispatch of the next train.
This tokenless system has three kinds when classified roughly.

8.2.1 Train direction indicator system

When a train is running in a block section, the fact that a train is running as well as its direction is indicated on the indicator panel at stations on both ends. The station master, not relying upon his memory, may know the status of train operation by this indication panel, and will not err in the handling of next trains. Under this system no order is emitted mechanically to the next train, but the train is checked by the judgement of man. Accordingly, though the error by the memory of station master is removed, but as the judgement of allowing or not of the departure of next train depends upon the station master's judgement, the possibility of error may not be said to be entirely removed.

8.2.2 Signal interlocking system

This is the system which is the improved type still one more step of the above-mentioned Train Direction Indication System, in which, instead of the indication on the panel, the indication is interlocked with departure signal, thus enabling a train to stop. The system completely removes the error in human memory and judgement, and is perfect functionally.

When this system is employed, it becomes necessary to change existing home signal to colour light one, and at the same time to newly erect departure signal. However, the whole expense is approximately the same as the expense of above-mentioned train direction indicator system.

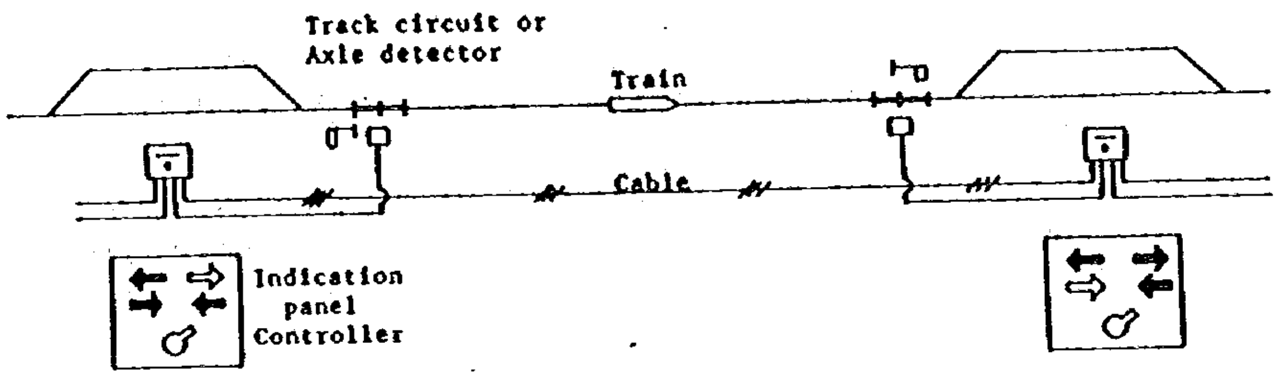
In view of the above points, this system is deemed most recommendable, and plan has been made assuming that this system is to be employed.

8.2.3 Automatic train stop system

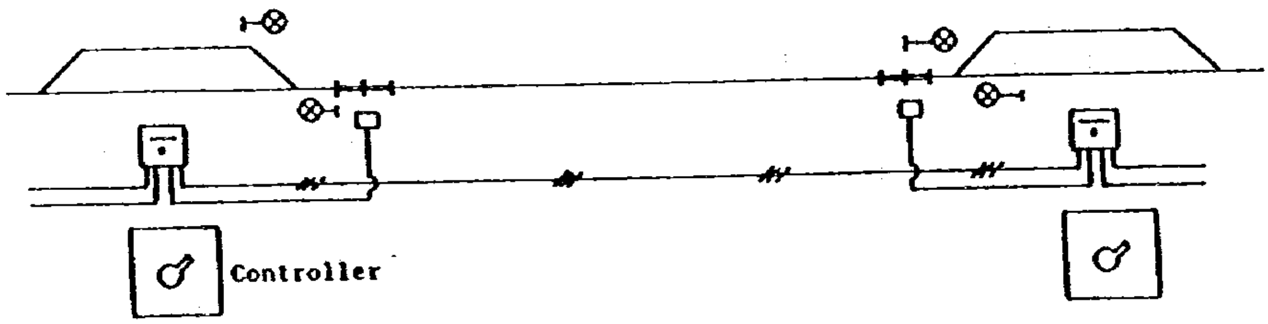
This is a system in which, automatic train stop system is added to the above-mentioned signal interlocking system, thus making the departure of train mechanically impossible.

This system is the best one among practically used systems. It is necessary, however, to provide certain devices with the locomotive making the expense extremely expensive. In addition, since the necessity of this system is rare from practical point of view, mention is made for reference's sake only, without considering the actual adoption.

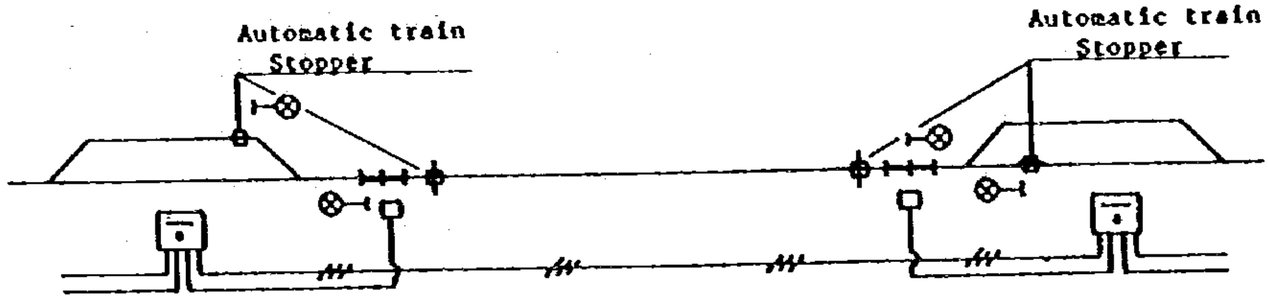
Train Direction Indicator System Fig 3-29



Signal Interlocking System



Automatic Train Stop System



9. IMPROVEMENT OF MAINTENANCE SYSTEM AND FACILITIES

9.1 Locomotive Depots and Work Shop

With increase in total travel distance or progress of time, rolling stocks have the performance gradually reduced, thus suffering from increased troubles at components.

In general, to prevent beforehand such troubles and to maintain inherent performance ability, periodical inspection and maintenance of principal portions as well as daily checks are required for due recovery of performance.

Meanwhile, diesel locomotives are periodically inspected at each depot according to the travel time and overhauled at work shop at intervals of about two years. This preferable maintenance system should be kept also in future.

9.1.1 Locomotive depots

At present, steam locomotives at each depot are to be gradually replaced by diesel locomotives.

(1) Solok and Padang locomotive depots:

These depots already have Model-BB303 diesel locomotives of 1978 make and are serving for maintenance thereof, moreover, Padang locomotive depot has Model-BB300 diesel locomotives of 1958 make.

Therefore, these depots already have necessary maintenance facilities for diesel hydraulic locomotive and are not considered in this time.

(2) Padang Panjang locomotive depot:

At present, this locomotive depot has rack type steam locomotives only. No service is available for the maintenance of diesel locomotive.

Therefore, it is necessary to provide here facilities for the maintenance of diesel locomotive before the above steam locomotives are replaced by diesel electric locomotives. Necessary facilities for adjustment, inspection and repairing of diesel electric locomotive are listed below as for locomotive depot.

Table 3 - 15

Items	Q'ty
Lifting jack	1 set
Insulation resistance tester	1 "
Dielectric strength tester	1 "
Fuel oil injection pump tester	1 "
Lubricating oil tester	1 "
Battery charger	1 "
Air filter washing machine	1 "
Parts cleaning equipment	1 "
Lathe	1 "
Refuelling equipment	1 "

Besides the above listed equipments, various instruments and tools will become necessary. However, considerable number of those for steam locomotive may permit common use. Therefore, no description is given in the matter.

9.1.2 Workshop

In Pandang, there is located a work shop for general inspection and repairing service of steam and diesel locomotives.

Therefore, necessary equipments for inspection and repairing service of diesel hydraulic locomotive are considered to be complete as well as the locomotive depots at Solok and Padang, and only those necessary for diesel electric locomotive under plan are to be introduced.

Principal machinery for special use in the inspection and repairing service of diesel electric locomotive is such as follows.

Table 3 - 16

Items	Q'ty
Insulation resistance tester	2 sets
Dielectric strength tester	1 set
Traction motor tester	1 "
Generator tester	1 "
Armature lathe	1 "
Vacuum impregnation device	1 "
Drying oven	1 "
Dynamic balancing machine	1 "
Layer short-circuiting tester	1 "
Wiring tester	1 "
Air brake valve tester	1 "

9.1.3 Personnel

At present, three locomotive depots are responsible for operation and usual maintenance of locomotives.

In the meanwhile, West Sumatra Bureau has 231 persons related to operational service and 115 persons, about a half thereof, are train crews such as locomotive engineer and sub-engineer. Of the 231 persons, it is estimated that 85 persons as crew and 99 persons as related to other services, 184 persons in total, are serving between Bukitputus and Sawahlunto.

To the contrary, the number of crews has been already in short and normally filled by helpers from other branch of the Bureau.

Moreover, it appears necessary to employ a 3-shift system for each locomotive in future, whereas, at present, a 2-shift system is employed for each locomotive for operational service in principal lines excepting the line between Bukitputus and Indarung. Accordingly, suitable increase in the number of personnel will be needed.

In other words, in the first stage of the plan, 173 persons are required as crew including 20 % thereof as reserve member and, in the second stage, 300 persons. This means an increase in number of personnel will become necessary by 88 persons for the first stage and 215 persons for the second stage.

Still more, at present, of the remaining 99 persons excluding crews, 66 persons are estimated to be working for adjustment and maintenance of locomotive in this line section. The number of such members also should be increased under plan by 16 persons for the first stage and 26 persons for the second stage.

In this line section, therefore, it will become necessary to increase number of operational service members from the present 184 persons by 104 persons to 288 persons as for the first stage and by 241 persons to 425 persons as for the second stage.

9.1.4 Necessary personnel of workshop

Steam locomotives arrenged in West Sumatra Region are to be gradually replaced by diesel locomotive and also the latter one has been tendency of increasing gradually at present. This study recommend that the 10 steam rack locomotives Model E-10 which is arrenged in Padang Panjang depot at present shall be replaced by 14 diesel rack-adhesion locomotive in near future an orderly manner, and further more 9 diesel locomotives Model BB-300 and BB-303 shall be increased and coal wagon to 240 in future from 119. The locomotives and wagons are inspected, repaired and overhauled at the workshop in Padang.

Therefore, the increase of necessary personnel shall be considered for the workshop. The increase in the working personnel will be 49 persons, out of these number of persons, 30 persons are relative to locomotive and 19 persons to wagon respectively. These number of persons are estimated based on the enlargement of work which are derived from the increase of rolling stock.

In addition to the increase of the working personnel mentioned above, the technicians relative to electricity and machinery, together with foremen, clerks, etc. will be necessary. Supposing that these personnel is 20 percent of working personnel, the following figure is derived:

49 x 0.2 ≒ 10 pers

Consequently, the increase of necessary personnel at the workshop will be total 59 persons, the total number will have to be trought up to 237 persons, by the way existing number of persons at the workshop is 178 persons.

9.2 Maintenance of Track and Structures

The function of track and structure gradually deteriorates through the destructive force by train operation as well as by the natural force of delapidation. Therefore, it becomes necessary to maintain and repair them so that they may be serviceable at all times. At present, for line length of about 182 km including Narasu Line of branch line section, three maintenance branch and one bridge maintenance branch are set up. The bridge maintenance branch consists chiefly of inspection member, the field work being ordered with outside contractor. As for the section between Bukitputus and Sawahlunto, the track length is 154 km, track worker being 208, which corresponds to 1.31 person/km.

9.2.1 Maintenance staff

The number of track maintenance worker in principal countries amounts to 0.6 - 2.3 person/km, the average figure being 1.4 person/km. The fundamental factor of these personnel-calculation is the magnitude of track destruction, namely the amount of train load; generally, personnel number according to cumulative passing tonnage per year is taken as measure for calculation.

The basic formula of maintenance personnel calculation adopted on Japanese National Railways is as follows:

$$Y = 0.6596 + 0.08972W$$

In this case Y: Number of maintenance workers per 1 km of converted track length

(Converted track length = Main line track length + 1/3 x length of side track)

W: Annual passing tonnage in million ton unit

When annual passing tonnage is taken as three million tons, and from amended formula, $Y = 1.19 + 0.16W$, which is deduced taking into consideration of the present situation of West Sumatra Bureau.

Maintenance staff number is calculated from above formula, it will be 1.67 person/km. On this basis, the number of workers on the whole line between Bukitputus and Sawahlunto will be 266, requiring the recruiting of 58 additional workers, and in addition, the additional employing of about five superior staff is considered necessary.

INSPEKSI	Length of Main Line (km)	Sideline Length x 1/3 (km)	Converted Track Length (km)	Superior Staff(prsn) 16(12 for Section ⓐ)	Workers (prsn)
ⓐ Bukitputus -Sawahlunto	153.7	5.4	159.1	3	245 { 208
ⓑ Lubukalung - Naras	27.9	0.3	28.2	1	37
ⓒ Padangpanjang -Payakumbuh	52.0	0.9	52.9	1	27
Total	233.6	6.6	240.2	21	272
					293 prsns

Number of Workers of ⓐ and ⓑ :

ⓐ + ⓑ $\frac{245 \text{ prsns}}{187.3 \text{ km}} = 1.308$ prsn/km

ⓐ 159.1 km x 1.308 prsn/km = 208 prsns

ⓑ 28.22 km x 1.308 prsn/km = 37 prsns

Correction of formula for calculation of full member of staffs:

$Y = 0.6596k + 0.08972k \times W$

$1.308 = 0.6596k + 0.08972k \times 0.6$

$k \fallingdotseq 1.8$

On the basis of above:

$Y = 1.19 + 0.16W$

9.2.2 Track maintenance work

Present working system consists basically of periodical regular repair work at two-three months interval, and besides spot maintenance as necessity therefore arises. It is considered that track improvement will be carried out in future and train operation frequency increases as the result, this system may not be altered. It is strongly desired, however, to arrange the equipment of tie tamper so that the efficiency of tamping operation of track, which occupies the primary portion of maintenance work, be raised. It is deemed necessary to arrange about 20 sets of tie tamper for this purpose.

9.2.3 Facilities maintenance expense

It is estimated that, the converted track length of the entire line being 159 km, the track maintenance workers for the track is 266 in number. The personnel number in the management section related this line being 17 including those engaged in bridge maintenance section the total number of personnel is 283. The annual average allowance for the entire personnel amounts to 445,000 Rp., and therefore, the annual personnel expense for facilities maintenance is deemed to be 125,935,000 Rp.

On the other hand, on the basis of Five Year Plan in PJKA, the annual facilities maintenance expense for 7th grade line amounts to 973,000 Rp./km. From this figure, the total facilities maintenance expense as to the converted total track length for the entire line is counted as 154,804,000 Rp., which is considered a rational figure.

The balance of above-mentioned maintenance personnel expense and total facilities maintenance expense may be deemed as articles expense and commission work expense.

9.3 Maintenance of Signal and Communication Facilities

The number of signal and communication facilities personnel in West Sumatra Region is fixed as 19, and as for that of lines under study from Bukiputus to Sawahlunto, it is estimated as about 15 according to the proportion of traffic amount.

It is deemed necessary, in case the tokenless system is newly adopted, to recruit additionally 7 personnel who is educated in electrical technics, besides the re-education of existing personnel.

As for maintenance expenses, the personnel expense for these 22 persons amounts to 9,790,000 Rp., and it is considered that other expenses is of insignificant amount.

10. CAPITAL INVESTMENTS

10.1 Rolling Stock Improvement Costs

10.1.1 Diesel locomotive

The investment cost for additional purchases of the locomotive may be broken down as follows:

Table 3 - 17

Investment year	Type	Number	Unit price (Thousand dollar)	Amount (Thousand dollar)
1982	Diesel Rack-adhesion Locomotive	6	760	4,560
1985	Diesel Rack-adhesion Locomotive	1	760	760
	BB303	2	550	1,100
	BB300	1	420	420
1986	Diesel Rack-adhesion Locomotive	7	760	5,320
	BB303	4	550	2,200
	BB300	2	420	840
			Total	15,200

The diesel rack-adhesion locomotive will be operated on the rack-rail track, and also the locomotive has the overall control system and automatic air brake system.

10.1.2 Coal hopper car

The coal hopper car with automatic air brake and automatic coupler will be increased gradually in number for the period of 1984 to 1988.

All the existing hopper cars in service will be provided with automatic air brake for the period of 1983 to 1985.

The investment for addition or improvement of coal hopper cars will be as follows.

Table 3 - 18

Investment year	Increased number	No. of cars equipped with air brake	Unit price (Thousand dollar)		Amount (Thousand dollar)		Total
			Foreign currency	Local currency	Foreign currency	Local currency	
1983		35	5	2	175	70	245
1984	20		40	-	800	-	800
		35	5	2	175	70	245
1985	20		40	-	800	-	800
		27	5	2	135	54	189
1986	40		40	-	1,600	-	1,600
1987	40		40	-	1,600	-	1,600
1988	30		40	-	1,200	-	1,200
Total	150	97	Total		6,485	194	6,679

10.1.3 Rolling stock improvement cost

Total investment cost for rolling stock improvement will amount to the following sum:

Table 3 - 19

	Foreign currency (Thousand dollar)	Local currency (Thousand dollar)	Total
Locomotives	15,200	-	15,200
Hopper cars	6,485	194	6,679
Total	21,685	194	21,879

10.2 Track Improvement Cost

10.2.1 Quantity of materials

The quantity by each item for track improvement is as enumerated below:

Renewal of Rail, Rail accessories and Fastening Devices;

Track Length	:	136.5 km
Additional Laying of Sleepers	:	80.0 km
Addition of Ballast	:	154.0 km
Turnout	:	85 sets

The quantity of these track materials will be as stated hereunder, including certain margin:

No. of track panel	136.500 m x 105% ÷ 13.6 m	(Rail length) : 10,550
Rails	10,550 x 2 x 13.6 m	: 286,960 m
Fishplate LIH	10,550 x 2	: 21,100 pieces
Fishplate LUH	10,550 x 2	: 21,100 "
Fishbolt BL		: 126,600 "
Tie plate OF	10,550 x 4	: 42,200 "
Tie plate OD	10,550 x 38	: 400,900 "
Clip KE	10,550 x 84	: 886,200 "
Clip KF	10,550 x 46	: 485,300 "
Screw TN	10,550 x 130	: 1,371,500 "
Rail Anchor	17.5 km x 1,000 pieces/km	: 17,500 "
Sleepers	wood(80,000^{m}/13.6^{m}) x 10 pieces x 110 %	: 64,700 "
Ballast crushed stone	154,000 m x 0.5 m^3/m	: 77,000 m^3
Turnouts #9		: 85 sets

10.2.2 Improvement work cost

For rails and other steel materials, recoverable materials from renewal work in Java is to be appropriated. In this case, though the material is free of cost, the expense of 80 dollars per ton is required as transport expenses.

The above-mentioned weight of steel material will be approximately as follows:

Rails	286,960 m x 30.4 kg/m	8,723.6 ton
Fish plate LIH	21,100 x 26.35 kg	556.0 "
Fish plate LUH	21,100 x 26.35 kg	556.0 "
Fishbolt BL	126,600 x 0.84 kg	106.3 "
Tie plate OF	42,200 x 9.66 kg	407.7 "
Tie plate OD	400,900 x 5.18 kg	2,076.7 "
Clip KE	886,200 x 0.44 kg	389.9 "
Clip KF	485,300 x 0.56 kg	253.8 "
Screw TN	1,371,500 x 0.45 kg	617.2 "
Rail anchor	17.500 x 1.0 kg.	17.5 "
Turnout	85 x 6.3 ton	535.5 "
TOTAL		14,240.2 ton

Therefore, the transport cost will be 14,240 x 80 = 1,139,216

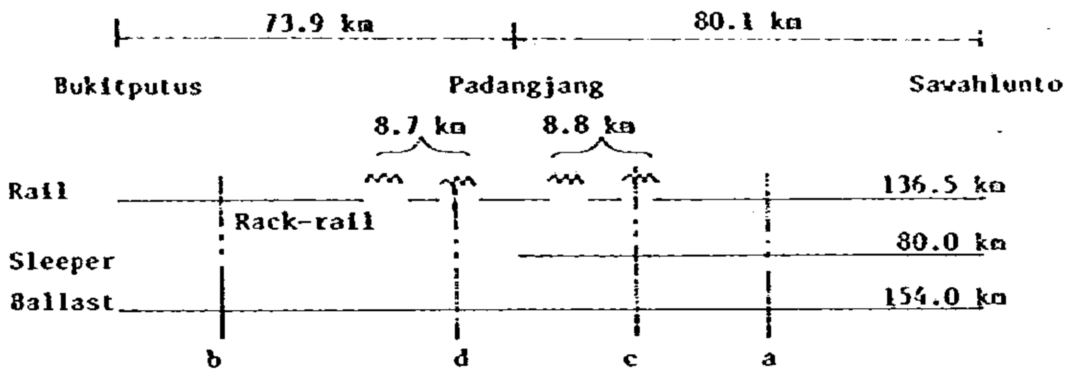
14,240 x 80 = 1,139,216 dollars.

The material cost of sleeper and ballast will be as follows:

Sleeper	25,900 x $12.8 =	$331,520
Ballast	77,000 x $ 8.0 =	$616,000
TOTAL		$947,520

As for working expenses, the category of work will be considered as divided into five kinds:

Fig. 3 - 30



When the unit work cost is estimated on the basis of actual result, the work cost will be as follows:

a)	Rail, Sleeper, Ballast	71.3 km x $51,200 =	$3,650,560
b)	Rail, Ballast	65.2 km x $25,600 =	$1,669,120
c)	Sleeper, Ballast	8.8 km x $30,720 =	$ 270,336
d)	Ballast	8.7 km x $10,240 =	$ 89,088
e)	Turnout	85 sets x $2,560 =	$ 217,600
	TOTAL		$5,896,704

Accordingly, the total amount of track improvement work cost will be as mentioned hereunder.

Transport expenses	(LC)	$1,139,216
Material expenses	(LC)	$ 947,520
Work expenses	(LC)	$5,896,704
TOTAL		$7,983,440

10.3 Improvement Cost on Signal Facilities

Assuming that signal interlocking tokenless system is to be adopted, and counting the number of object station as 21, the works will require the following cost.

Table 3 - 20

	Material Cost($)	Work Cost($)	
	F.C.	F.C.	L.C.
Main Cable 2 mm^2 6 core 154 km x 6,690 $/km	1,030,260	38,675	348,075
Local Cable 2 mm^2 6 core 0.5 km x 21 sta.x6,690$/km	70,245	2,185	19,655
Axle detector 2 x 21 sta. x $4,910	206,220	35,640	3,960
Controller 1 x 21 sta. x $8,860	186,060	31,940	3,550
Signal 4 x 21 sta. x $1,180	99,120	4,730	4,730
Total	1,591,905	113,170	379,970
F.C. Total	1,705,075		
L.C. Total			379,970
GRAND TOTAL	$2,085,045		

10.4 Improvement Costs of Station Facilities

10.4.1 Work volume

The work volume to be required for siding track additions to retain hopper cars at Bukitputus station is broken down below.

Track addition	Approx. 350 m
Track re-routing	Approx. 250 m
Turnout addition and renewal	7 sets
Turnout removal	1 set
Road re-routing	Approx. 1,640 m^2

10.4.2 Track addition cost

1) Quantity of materials

Required quantity of materials for siding track additions may be specified as follows:

Track panel	350 m x 105 % ÷ 13.6 m (rail length)	27
Rail	27 x 2 x 13.6 m	735 m
Fish bolt LHH	27 x 2	54 sheets
Fish bolt LUH	27 x 2	54 sheets
Fish bolt BL		324 pcs.
Tie plate OF	27 x 4	108 sheets
Tie plate OD	27 x 38	1,026 sheets
Clip KE	27 x 84	2,268 pcs.
Clip KF	27 x 46	1,242 pcs.
Screw TN	27 x 130	3,510 pcs.
Rail anchor	0.6 km x 1000 pcs./km	600 pcs.
Sleeper	Wood (whole replacement) 600 m/0.68 m x 110 %	970
Ballast	Crushed stone	600 m^3
Turnout		7 sets

2) Material transport cost

Rail and other steel materials will be reused from those replaced for renewal in Java.

In this case, the transport cost will require 80 dollars per tonnage, though materials may be available at no extra cost.

Steel materials may be weighed as follows:

Rail	735 m	x	30.4 kg/m	22.3 tons
Fish bar LIM	54	x	26.35 kg	1.4 tons
Fish bar LUM	54	x	26.35 kg	1.4 tons
Fish bolt BL	324	x	0.84 kg	0.3 tons
Tie plate OF	108	x	9.66 kg	1.0 tons
Tie plate OD	1,026	x	5.18 kg	5.3 tons
Clip KE	2,268	x	0.44 kg	1.0 tons
Clip KF	1,242	x	0.56 kg	0.7 tons
Screw TN	3,510	x	0.45 kg	1.6 tons
Rail anchor TN	600	x	1.00 kg	0.6 tons
Turnout	7	x	6.30 tons	44.1 tons
TOTAL				79.7 tons

Therefore, the transport cost may be estimated at:

79.7 tons x 80 dollars = 6,376 dollars

3) Material cost

Material costs for ballast and ties other than steel materials may be estimated as follows:

Sleepers	970 x 12.8 dollars =	12,416 dollars
Ballast	600 x 8.0 dollars =	4,800 dollars
TOTAL		17,216 dollars

4) Work cost

The work cost may be estimated as follows as determined from unit costs on previous work of similar nature.

Track	0.6 km x 51,200 dollars =	30,720 dollars
Turnout	8 units x 2,560 dollars =	20,480 dollars
TOTAL		51,200 dollars

5) Track addition work costs

The work cost for track addition may be estimated as follows:

Material transport (L.C.)	6,376 dollars
Material purchase (L.C.)	17,216 dollars
Work cost (L.C.)	51,200 dollars
TOTAL (L.C.)	74,792 dollars

10.4.3 Road re-routing cost

The road of about 1,640 m will have to be relocated for siding track additions.

The cost to be required for re-routing of the road may be estimated as follows, on the basis that the road construction cost including side ditches and simplified retaining walls would require 50 dollars per square m.

$1,640\ m^2 \times 50\ dollars/m^2 = 82,000$ dollars (L.C.)

10.4.4 Siding track addition work cost at Bukitputus station

After summing up the total costs as above, it is estimated as follows for addition of siding tracks.

Track addition	74,792 dollars
Road re-routing	82,000 dollars
TOTAL	156,792 dollars (L.C.)

10.5 Cost for Improvement of Rolling Stock Maintenance Equipment

10.5.1 Locomotive depot

The Solok and Padang locomotive depots are excluded from consideration since they are already complete for inspection and minor repairing of diesel locomotive. The Padang Panjang locomotive depot should be equipped with the machinery listed in Section 9.1.1 for inspection and maintenance of diesel locomotive.

When assuming the inspection and maintenance equipments to be purchased with foreign capitals and the installation work to be executed with domestic capitals, rough cost for construction can be estimated as following:

Table 3 - 21

	Foreign currency	Local currency	Total
Equipment cost	264		264
Installation cost	23	70	93
Total construction cost	287	70	357

10.5.2 Workshop

Like the locomotive depots, services for inspection and maintenance of diesel hydraulic locomotive are completed. As new installment of capital, therefore, the machinery listed in Section 9.1.2 should be equipped, which machinery is necessary for inspection and maintenance of diesel electric locomotive.

When assuming the inspection and maintenance equipments to be purchased with foreign capitals and the installation work to be executed with domestic capitals, rough cost for the construction can be estimated as following:

Table 3 - 22

	Foreign currency	Local currency	Total
Equipment	533	-	533
Installation cost	43	136	179
Total construction cost	576	136	712

10.6 Cost for Painting

10.6.1 Unit price

	Local	Foreign	Remarks
Paint	-	$ 5.9	Carbonastic 15
First Grade Grinding	$ 1.0	-	High build, modified
Second Grade Grinding	($ 0.5)	-	Aluminum epoxy mastic
Skilled Labor	$ 0.48	-	(This painting material has given good results
Unskilled Labor	$ 0.15	-	at ASAHAN Project.)
Stage	$ 1.28	-	
Accommodation	$ 0.01	-	
Local Supervisor	$ 0.3	-	
Transportation (Truck)	$ 1.9	-	
Tools & Others	$ 1.6	-	
Total			
First Grade	$ 6.72	$ 5.9	(First Grade Painting)
Second Grade	$ 6.22	$ 5.9	(Second Grade Painting)

10.6.2 First grade painting

Direct Cost

Local $ 6.72 x 600 m^2 = $ 4,032

Foreign $ 5.9 x 600 m^2 = $ 3,540

	Local	Foreign
Direct Cost	$ 4,032	$ 3,540
Indirect Cost	$ 403	$ 354
Overhead on Site	$ 403	$ 354
Others	$ 202	$ 177
Japanese Engineer	-	$ 5,974
	$ 5,040 ≒ 5,000	$10,399 ≒ 11,000

10.6.3 Second grade painting

Direct Cost

Local $ 6.22 x 30,200 = $ 187,844

Foreign $ 5.9 x 30,200 = $ 178,180

	Local	Foreign
Direct Cost	$ 187,844	$ 178,180
Indirect Cost	$ 18,784	$ 17,818
Overhead on Site	$ 18,784	$ 17,818
Others	$ 9,394	$ 8,909
Japanese Engineer	-	$ 11,949
	$ 234,804 ≒ $ 235,000	$ 234,674 ≒ $ 235,000

10.6.4 Maintenance

Repainting will be needed every Five(5) years, and it will be spend for two(2) years.

Quality and Area the maintenance

Area 43,000 m^2, Second Grade Painting.

Second Grade

Direct Cost

Local	\$ 6.22 x 43,000 = \$ 267,460
Foreign	\$ 5.9 x 43,000 = \$ 253,700

	Local	Foreign
Direct Cost	\$ 267,460	\$ 253,700
Indirect Cost	\$ 26,746	\$ 25,370
Overhead on Site	\$ 26,746	\$ 25,746
Others	\$ 13,373	\$ 12,685
	\$ 334,325	\$ 317,125
	≒ \$334,000/2years	≒ \$317,000/2years

Japanese Engineer

One Japanese Engineer will stay the first three(3) months as a trainer.

Salary	3,000,000 Rp/month x 3 = 9,000,000 Rp
Dwelling Expense	15,000 Rp/day x 30 x 3 = 1,350,000 Rp
Travel Fares	Air Fright Tickets including returns = 852,000 Rp
Total	11,202,000 Rp ≒ \$ 17,923

First Grade	\$ 17,923 x 1/3 = \$ 5,974
Second Grade	\$ 17,923 x 2/3 = \$ 11,949

10.7 Cost Tunneling and Fence

10.7.1 Cost of tunnel repairing

Grouting Cost	\$ 230/m^3
Quantity	28 m^3

\$ 230/m^3 x 28 m^3 = \$ 6,440

	Local	Foreign
Direct Cost	\$ 6,000	-
Indirect Cost	\$ 600	\$ 1,200
Overhead on Site	\$ 600	\$ 1,200
Others	\$ 600	\$ 1,200
	\$ 7,800	\$ 3,600
	≒ \$ 8,000	≒ \$ 4,000

10.7.2 Cost of fence

Piling Cost	30 x 3 m x \$ 9.0	= \$ 810
Materials and Others	36.2 t x \$ 1,000/t	= \$ 36,200
		\$ 37,010 ≒ \$ 37,000

	Local	Foreign
Direct Cost	\$ 37,000	-
Indirect Cost	\$ 3,700	\$ 7,400
Overhead on Site	\$ 3,700	\$ 7,400
Others	\$ 3,700	\$ 7,400
	\$ 48,100	\$22,200
	≒ \$ 48,000	≒ \$ 22,000

Total Cost

	Local	Foreign
Tunneling	\$ 8,000	\$ 4,000
Fence	\$ 48,000	\$ 22,000
	\$ 56,000	\$ 26,000

11. OPERATING REVENUES AND EXPENSES

11.1 Operating Revenues

The actual records of freight traffic and revenue earnings by the West Sumatra Region are focussed on coal transportation, as is shown in Table 11-1. The traffic volume of coal at present is 78 thousand tons (10.6 million ton-kms). It is estimated that the coal transportation would increase in volume to 940 thousand tons (144.5 million ton-kilos) in 1989.

Table 3 - 23 Breakdown of Operating Revenues 1979-1980

Description	Ton	TKM	Freightage Rp.	Average	
				AD	Tariff
	a	b	c	b/a	c/b
Rice	1,560	150,080	1,301,550	96.2	8.67
Firewood	120	18,120	244,500	151.0	13.49
Gasoline	3,318	314,471	4,492,430	94.8	14.29
Cement	35,058	546,756	23,701,450	15.6	43.35
Fertilizer	3,250	327,229	4,678,250	100.7	14.30
Sand	12	552	40,400	46.0	18.84
Coal	78,412	10,582,331	152,435,600	134.9	14.40
Brick	2,064	126,913	2,347,950	61.5	18.50
Bean Cake	3,950	220,360	3,970,150	55.8	18.03
Miscellaneous	3,115	152,343	4,186,750	48.9	27.48
Total	130,859	12,439,152	197,369,030	95.1	15.87

AD = Average distance in kilometers.

On the supposition that the volume of freight traffic other than coal transportation and the passenger traffic remain unchanged in future, the trend of revenue earnings for the current one year period would come out as follows:

	1980 year			1989 year		
	thousand	nillion	million	thousand	million	million
Coal	78 tons	(14.4 TKM)	Rp.152	940 tons	(144.5 TKM)	Rp.2,080
Others			45			45
Passengers			16			16
Total			213			2,141

Note: TKM = Ton-kilometer

11.2 Operating Expenses

11.2.1 Personnel expense

(1) The annual personnel expense per person

The current number of the personnel in the Region totals 1,233, with the annual personnel expenses amounting to Rp. 526 million.

Based on these figures, the following figure is obtained.

Rp. 526 nillion/1,233 persons = Rp. 0.427 million

(2) The number of necessary personnel

The personnel of the Region at present total 1,233. As those in the workshop are 178, all the personnel would be 1,411 in the aggregate, when both are combined.

Furthermore, the increase in the necessary personnel as devided by each sector in the year 1989 is assumed to be as follows:

	Sector	Increase in Personnel
Region :	Administration	6
	Health & Welfare	1
	Fixed installation	63
	Signal & Communication	7
	Operation	241
	Transportation	42
Workshop:		59
Total		419

The necessary personnel in 1989 would, therefore, total 1,411 + 419 = 1,830 persons.

(3) The auunal personnel expense

The annual personnel expense when both of those in the Region and workshop are put together would be as follows:

- At present

  1,411 prsns x 0.427 million/prsn = Rp. 602 million

- In the year 1989

  1,830 prsns x 0.427 million/prsn = Rp. 781 million

11.2.2 Cost of supplies

Of all the cost of supplies, the expenses for fuel, grease and lubricants are assumed to be in proportion to the train kilometers. While as to the other materials, the consumption amount would be in proportion to the number of locomotives in service.

(1) Train kilometers

The current train kilometers amount to 318 thousand train kilometers.

As to the year 1989, the following figures are obtained:

Bukitputus } Padangpanjang	20 trains x 73.5 km = 1,470 thsnd km	} 3,876 thsnd train km
Padangpanjang } Sawahlunto	30 trains x 80.2 km = 2,406 thsnd km	

Ratio 3,876/318 = 12.2

(2) Number of locomotives

At present	21
1989	31

Ratio = 1.5

(3) Cost of supplies

	At present	1989
Fuel, grease and lubricants	Rp.89 million	Rp.1,086 million
Others	468	702
Total	557	1,788

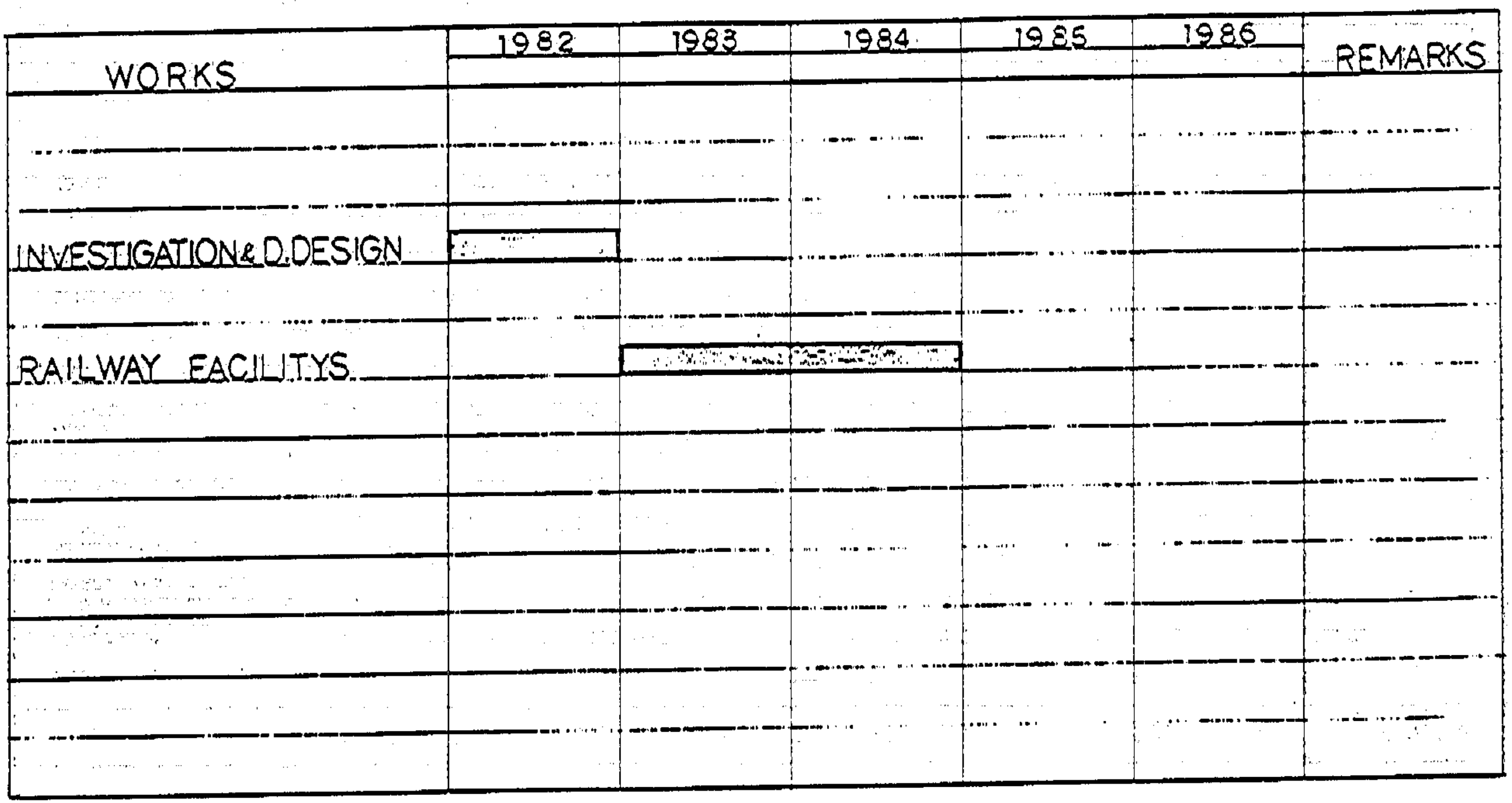
11.2.3 Total operating expenses

Based on the above figures, the annual operating expenses would be as follows:

	At present	1989
Personnel expense	Rp. 602 million	Rp. 781 million
Cost of supplies	557	1,788
Total	1,159	2,569
	($ 1,869 thsnd)	($ 4,144 thsnd)

Year	Transport Tonnage of Coal	Operating Expense
	thsnd tons/year	$
1980	135	1,869,000
1981	185	2,004,000
1982	280	2,275,000
1983	280	2,275,000
1984	380	2,546,000
1985	380	2,546,000
1986	510	2,925,000
1987	660	3,331,000
1988	790	3,738,000
1989	940	4,144,000

CONSTRUCTION SCHEDULE Fig 3-32



CONSTRUCTION COST

Fig 3-33

Item	Quantity	Local Cost	Foreign Cost	Total Cost	1982	1983	1984	1985	1986	1987	1988	REMARKS
DIESEL LOCOMOTIVE	23		15 200 000	15 200 000	4 560 000			2 280 000	8 360 000			
COAL WAGON	247	194 000	6 485 000	6 679 000		245 000	1 045 000	989 000	1 600 000	1 600 000	1 200 000	
IMPROVEMENT OF THE STATION FACILITIES	LUMP SUM	157 000		157 000			157 000					
IMPROVEMENT OF THE RAIL ROAD	〃	7 983 000		7 983 000		5 035 000	2 948 000					
IMPROVEMENT OF THE SIGNAL	〃	380 000	1 705 000	2 086 000		1 048 000	1 042 000					
LOCOMOTIVE DEPOT	〃	70 000	287 000	357 000	357 000							
WORK SHOP	〃	136 000	576 000	712 000		712 000						
PAINTING (FIRST GRADE)	600 m²	5 000	11 000	16 000		12 000	4 000					
(SECOND GRADE)	30 200 m²	236 000	235 000	470 000		287 000	188 000					
TUNNEL & FENCE	LUMP SUM	56 000	26 000	82 000		82 000						
CONTINGENCY	〃	1 073 000	113 000	1 186 000	36 000	717 000	433 000					
ENGINEERING	〃		841 000	841 000	535 000	181 000	125 000					
TOTAL		10 289 000	25 479 000	35 768 000	5 488 000	8 314 000	5 937 000	3 269 000	9 960 000	1 600 000	1 200 000	

OPERATION COST

Fig.3-

Item	Quantity	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990 ~2010
REPAINTING †	43,000 m^2									325,000	325,000	
OPERATING EXPENSES	LUMP SUM	1,869,000	2,004,000	2,275,000	2,275,000	2,546,000	2,546,000	2,925,000	3,331,000	3,738,000	4,144,000	4,144,000 every year

†: NOTICE Repainting cost will be needed every five years. And it will be spent two years.

CHAPTER IV

ECONOMIC EVALUATION

INTRODUCTION

A study for "Development of coal mine", "Coal storage and ship-loading" and "Railway transportation" has been carried out in the former chapters based upon the annual coal production of 1 million tons from the Ombilin Coal Mine.

In this chapter an economic evaluation on the whole project will be made in connection with coal sales, production costs, head office expenses and selling expenses.

However, since the railway and the facilities concerned do not belong to the mine but to P.J.K.A., a present railway freight is taken in the project evaluation with the exception of an investment for the railway transportation facilities which is to be assessed independently.

A rate of return obtained by the Discounted Cash Flow Method is taken as the basic index of the examination.

CHAPTER IV ECONOMIC EVALUATION

1. PROFIT AND LOSS, AND CASH FLOW

For an evaluation of the economics the profit and loss as well as its cash flow shall be estimated as its basis. It is considered as a basic condition that all the necessary equipment fund is raised from the Government. Accordingly no situation of loan occurs and the interest is not taken into consideration. The shortage of funds expected in the early stage of the project shall be covered by raising also from the Government. A corporation tax is not taken into account in this study, since it shall be examined by the profit and loss account in connection with the terms and conditions of the fund procurement.

And the estimation period amounts to 26 years from 1980 to 2005 and the prices in every fiscal year are estimated on the basis of those in 1980.

1.1 Sale of Coal

1.1.1 Amount of coal sale

In this study the whole amount of coal produced at Ombilin Coal Mine is considered to be sold except for coal for own consumption. And then it is deemed that all this sales potential is sold out within the fiscal year concerned and at its end no coal stock remains.

Table 4-1 Coal sales potential by year

(10^3t)

			1980	1981	1982	1983	1984	1985	1986	1987	1988	1989~2005
Clean coal production	Current operating area	Open cut	66	87	132	132	175	175	175	175	175	175
		Underground	84	113	168	168	225	225	225	225	225	225
		Sub total	150	200	300	300	400	400	400	400	400	400
	Planning area								150	300	450	600
	Total		150	200	300	300	400	400	550	700	850	1,000
Own-consumption			15	15	15	20	20	20	40	40	60	60
Sales potential			135	185	285	280	380	380	510	660	790	940

1.1.2 Sales plan

Since the sales plan presented by P.N. Tambang Batubara is inconsistent with the schedule of mine development and infrastructure improvement, a partially modified sales plan is prepared here.

Table 4-2 Sales plan by market

(10³t)

			1980	1981	1982	1983	1984	1985	1986	1987	1988	1989~2005
Batubara Plan	Indalung (I)		45	45	45	45	45	45	45	45	45	45
	Indalung (II)		80	95	95	95	95	95	95	95	95	95
	Indalung (III)				95	95	95	95	95	95	95	95
	Indalung (IV)						95	95	95	95	95	95
	Andalas					150	150	150	150	150	150	150
	Malaysia			180	240	240	240	240	240	240	240	240
	Total		125	320	475	625	720	720	720	720	720	720
Modified Plan	Domestic	Indalung (I-IV)	125	140	235	235	330	330	330	330	330	330
		Andalas							150	150	150	150
		Sub total	125	140	235	235	330	330	480	480	480	480
	Export	Malaysia							30	180	240	240
		Others	10	45	50	45	50	50			70	220
		Sub total	10	45	50	45	50	50	30	180	310	460
	Total		135	185	285	280	380	380	510	660	790	940
	(Shipping amount)		(10)	(45)	(50)	(45)	(50)	(50)	(180)	(330)	(460)	(610)

Note: The shipping amount includes coal for Andalas Cement (Ache) among it for domestic consumption and it for export.

1.1.3 Selling prices and sales amounts

1) Selling prices

(1) Selling price for domestic consumption
(for Indarung Cement and Andalas Cement)

The coal selling price (on rail at the coal mine) amounts to 13,500 RP/ton (22 US$/ton) in 1980. The selling price in this study is planned on the basis of 22 US$/ton.

For your reference the price comparison with petroleum will be investigated in relation with the power generation cost in APPENDIX 1.

(2) Selling price of coal for export

Since at present no world-wide market is formed for steaming coal and its supply and demand is unbalanced, no uniform price is established for it. Accordingly it is necessary to investigate which price is adequate for coal to be exported.

The following three opinions are predominant for the future prospect concerning the selling price of steaming coal from the world-wide viewpoint.

a) The coal price is equivalent to that of petroleum on the basis of calorific value, taking the relative demerits of coal into consideration.

b) The coal price is determined on the cost basis which consists of the production cost, transportation cost and adequate profit.

c) The coal price rises with the demand increase, losing the correlation with its cost, and a peculiar price is formed for it according to its inherent conditions independently on the petroleum price.

Conclusively we consider that the opinion stated in the item (b) is most probable. The reason for it will be explained below.

At first the opinion stated in the item (a) is considered. Citing an example of coal for power generation, since coal is competitive with atomic energy as a substituting energy for petroleum and its reserve is ample, it seems that the rise of its price causes its supplying capacity to increase and acts as a factor for dropping its price in the result.

Furthermore, the opinion stated in the item (c) is considered. The coal reserves are ample and distributed in many countries. Since coal producers require enormous investments for developing new collieries and improving infrastructure, a mutually advantageous relation in terms of long-term contracts is created between producers and consumers. Nowadays the international market for steaming coal is on the way of its formation and coal producing countries make an effort competitively for expanding their share in it. Under these circumstances it seems to be difficult that such a cartel as it in the case of petroleum is formed. Accordingly it is not probable that the coal price rises independently on its cost.

Now the opinion stated in the item (b) which we think most probable is considered. In the case where a new colliery is developed, a price securing the reproduction (cost + return) will be set up. Consumers will be obliged to accept this return. In the concrete it is Australia, Canada and U.S.A. where colliery developments as large scale supplying sources having influence on the international coal price formation are expected. (Except for communist countries) Underground coal in the eastern U.S.A. seems to be of the highest cost among them. And also consumers come to be in a position in which they cannot help accepting the cost return for such coal, since they intend to multiply their supplying sources. Consequently according to the economical principle that one article has its single price, the price of the underground coal in the eastern U.S.A. has a large possibility to predominate the international price of coal.

According to "Coal Export Study" of Department of Energy, U.S.A., the price of steaming coal from the collieries in the eastern U.S.A. was set up in the range of 30 - 45 US$/ton in 1979 on the basis of F.O.B. From the viewpoint of the above consideration, coal export price shall be decided in connection with the price of coal produced in underground at the eastern mines of U.S.A.

However, since worldwide steaming coal market has not yet formed firmly, present Ombilin coal export price of US$ 30 per ton is tentatively taken as a basis of this study in consideration also of the harbour capacity of Teluk Bayur.

(For a reference) Coal Export Study (1979)-Department of Energy U.S.A.

Table 4-3 Indicative steam coal costs and prices

(US$/t)

	Price FOB mine	Mine to port	Price FOB port	Port loading	Ocean freight	Port unloading	Delivered price range	Avg.	S/MBTU
To:NW Europe From:United States									
East-Underground	20-35	10-15	30-45	1-2	6-10	2	39-59	49	1.85
West-Surface	8-18	10-20	20-35	1-2	8-11	2	31-50	41	2.19
Canada West-Surface	15-20	10-20	25-35	1	8-12	2	36-50	42	1.92
Australia									
Underground	15-25	5-10	20-25	2	10-14	2	34-43	39	1.63
Surface	12-20	5-10	18-25	2	10-14	2	32-43	38	1.52
South Africa Underground	10-15	5-7	15-22	1	8-10	2	26-35	31	1.41
Poland Underground			23-31	1	5	2	31-39	35	1.46
To:Japan From:United States									
East-Underground	20-35	10-15	30-45	1-2	11-15	2	44-64	54	2.05
West-Surface	8-18	10-20	20-35	1-2	9-12	1	31-50	40	2.00
Canada West-Surface	15-20	10-20	25-35	1	8	1	35-45	40	2.00
Australia									
Underground	15-25	5-10	20-25	2	6-8	1	29-36	33	1.38
Surface	12-20	5-10	18-25	2	6-8	1	27-36	32	1.33
South Africa Underground	10-15	5-7	15-22	1	9	1	26-33	30	1.36
Poland Underground			23-31	1	11-13	1	36-44	40	1.67

2) Sales amount

The sales amount is obtained from the sales quantity in the sales plan by market and the coal prices. The sales amount here includes only that of coal and the other incomes are regarded as included as minus factors in the general expenses in the production cost at mine, since they are only a small amount.

Table 4-4 Sales amount by year

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989∿2005
Saleable amount (10^3 t)	Domestic	125	140	235	235	330	330	480	480	480	480
	Export	10	45	50	45	50	50	30	180	310	460
	Total	135	185	285	280	380	380	510	660	790	940
Sales (10^3US$)	Domestic	2,750	3,080	5,170	5,170	7,260	7,260	10,560	10,560	10,560	10,560
	Export	300	1,350	1,500	1,350	1,500	1,500	900	5,400	9,300	13,800
	Total	3,050	4,430	6,670	6,520	8,760	8,760	11,460	15,960	19,860	24,360

1.2 Production Cost at Mine

The production cost at mine is stated in the Section 9, Chapter I, in detail. Accordingly only the cost table by fiscal year is shown here. (Refer to Table 1-56).

Table 4-5 Production cost at mine

(10³US$)

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Labor cost	Current operating area	731	731	731	682	592	563	563	563	563	563
	Planning area							443	582	607	650
	Surface and others	818	818	818	769	716	716	716	716	716	716
	Sub total	1,549	1,549	1,549	1,451	1,308	1,279	1,722	1,861	1,886	1,929
Maintenance cost	Current operating area	2,194	2,302	2,514	3,381	3,558	3,558	3,558	3,558	3,558	3,558
	Planning area							3,731	3,835	3,779	3,807
	General expenses	681	695	709	723	737	752	767	782	798	814
	Sub total	2,875	2,997	3,223	4,104	4,295	4,310	8,056	8,175	8,135	8,179
Depreciation		968	968	1,006	2,013	2,013	2,013	4,568	4,920	5,699	5,733
Total		5,392	5,514	5,778	7,568	7,616	7,602	14,346	14,956	15,720	15,841

1.3 Head Office Expenses

At present the head office of P.N. Tambang Batubara in Jakarta manages in principle not only Ombilin Coal Mine. Therefore, all expenses derived now from it should not be charged only to Ombilin Coal Mine. However, even if Ombilin Coal Mine becomes independent, the existing facilities and personnel of the head office would be necessary, and still more in the case where the present production scale is extended to 1,000,000 ton per year.

According to the record of P.N. Tambang Batubara, the head office expenses were as follows in 1979:

Table 4-6 Head office expenses

	1979 (RP)	(10^3US$)
Personal expenditure	143,361,740	231
Other expenses	331,603,922	535
Total	474,965,662	766

1US$=620RP

The amount corresponding to 10% up of the above is considered here as the head office expenses in 1980. After that it is considered to be the same amount every year irrespectively of the coal production scale at that time.

1.4 Selling Expense

For selling coal it should be transported to its consuming places, which requires the railway and ships as transport means. Therefore, railway freight, port handling charge and shipping freight are incurred. Since these expenses are of the different character from the production cost, they are classified separately into the item of the selling expense.

At present the railway freight for coal consumed in Indonesia are borne by consumers, which is taken into consideration the price of coal. Accordingly the railway freight stated in this study means that of coal for export which should be burdened by P.N. Tambang Batubara. Also in the case where the marine transportation is required (for both overseas and inland), port handling charge and shipping freight are incurred.

For the domestic consumption these expenses shall be burdened by consumers likewise in the case of railway freight. Accordingly the price of coal for the domestic consumption shall be invoiced in the conditions of F.O.R. at the mine. On the other hand, in the case of overseas trade the coal price is generally in the condition of F.O.B. and its shipping freight is only burdened by consumers. For this reason the port handling charge stated in this study is applied only for export coal and no shipping freight is taken into consideration in its price.

1.4.1. Railway freight

For the railway freight the present freight system is applied as it is. Accordingly the equipment and installation investment which will be executed by P.J.K.A. for the transportation capacity increase and the change on income and expenses at P.J.K.A. are not taken into consideration in this economic evaluation. A railway freight for coal transportation in the section between Sawahlunto and Bukit Putus amounts to 2,538 RP/t (4.09 US$/t) at present (in 1980). Accordingly it is estimated here that the railway freight in the section between Sawahlunto and Teluk Bayur Port is also 4.09 US$/t since the distance between above both cases makes little difference.

Table 4-7 Railway freight expenditure by year

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989~2005
Coal amount to be transported (only for export) (10^3t)	10	45	50	45	50	50	30	180	310	460
Railway freight (10^3US$)	41	184	205	184	205	205	123	736	1268	1881

1.4.2 Port handling charge

Coal wharf, coal storage yard, and coal shipment facilities will be constructed correspondingly to the production increase at the Ombilin Coal Mine. Various expenses are derived from management of these facilities. (Refer to Table 2-14.)

A small amount of coal is to be shipped even for a period until the above-mentioned facilities are constructed and put in operation.
The charge for using the existing general cargo wharf and port handling charge will be incurred for this period, which are estimated here as 3 US$ per ton.

Table 4-8 Port handling charge by year

(10^3US$)

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991~2005
Maintenance cost	Charge for general cargo wharf	30	135	150	135	150	150						
	Others							Δ891	Δ380	Δ214	Δ100	Δ100	Δ9
	Sub total	30	135	150	135	150	150	Δ891	Δ380	Δ214	Δ100	Δ100	Δ9
Depreciation								1,118	1,118	1,118	1,118	1,117	752
Total		30	135	150	135	150	150	227	738	904	1,018	1,017	743

(Note) The mark Δ means the value of minus.

The every expenditure stated in the above is summarized in Table 4-9. Since all these profits and losses are computed on the basis of the prices in 1980, they are seemed to be unreal. Accordingly, based on the profits and losses shown in Table 4-9, the economic evaluations on the assumptions of the various cases are investigated in the Section 2.

Table 4-9 Ombilin Coal Mine profit and loss, and cash flow

No.	Item	Unit	Formula	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
(1)	Capital investment (loan)	US$ 10³														
(2)	" (cash)	"		717	1,639	9,133	4,758	24,523	20,124	5,272	8,090	874	3,616	7,639	4,117	3,779
(3)	Dep. asset	"		717	1,839	9,133	4,764	24,523	20,124	5,277	8,090	874	3,616	7,639	4,117	3,779
(4)	Clean coal production	t 10³		150	200	300	300	400	400	560	700	840	1,000	1,000	1,000	1,000
(5)	Salable amount (inland use)	"		125	140	235	235	330	330	480	480	480	480	480	480	480
(6)	" (export)	"		10	45	50	45	50	50	30	160	310	460	460	460	460
(7)	" (total)	"		135	185	285	280	380	380	510	660	790	940	940	940	940
(8)	Sales	US$ 10³		3,050	4,430	6,670	6,520	8,760	8,760	11,460	15,960	19,860	24,360	24,360	24,360	24,360
(9)	Operating cost (current operating area)	"		2,925	3,033	3,245	4,063	4,150	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121
(10)	" (planning area)	"								4,173	4,617	4,366	4,457	4,457	4,457	4,457
(11)	Common expense	"		1,499	1,513	1,527	1,492	1,453	1,468	1,483	1,498	1,514	1,530	1,530	1,530	1,530
(12)	Selling expense (railroad fare)	"		41	184	205	184	205	205	123	736	1,268	1,881	1,881	1,881	1,881
(13)	" (port charge)	"		30	135	150	135	150	150	△401	△380	△214	△100	△100	△9	△9
(14)	Overhead of head office	"		843	843	843	843	843	843	843	843	843	843	843	843	843
(15)	Operating profit	"	8 − 9 − 10 − 11 − 12 − 13 − 14	△2,748	△1,278	700	△197	1,959	1,973	1,607	4,775	7,942	11,678	11,628	11,537	11,537
(16)	Interest on loan	"														
(17)	Depreciation	"		968	968	1,006	2,013	2,013	2,013	5,686	6,038	6,817	6,851	6,890	6,834	5,858
(18)	Fixed cost	"														
(19)	Profit B.F. tax	"	15 − 16 − 17 − 18	△3,716	△2,246	△306	△2,210	△54	△40	△4,079	△1,313	1,125	4,777	4,738	4,703	5,679
(20)	Income tax	"														
(21)	Net profit	"	19 − 20	△3,716	△2,246	△306	△2,210	△54	△40	△4,079	△1,313	1,125	4,777	4,738	4,703	5,679
(22)	Cash flow	"	21 + 17	0	0	0	0	1,959	1,973	1,607	4,775	7,942	11,678	11,678	11,537	11,537
(23)	Repayment	"														
(24)	Net cash flow	"	22 − 23	0	0	0	0	1,959	1,973	1,607	4,775	7,942	11,628	11,628	11,537	11,537
(25)	Cumulative N.C.F.	"		0	0	0	0	1,959	3,932	5,539	10,294	18,204	29,834	41,462	52,999	64,536
(26)	Balance of debt	"														

No.	Item	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
(1)	Capital investment (loan)													
(2)	" (cash)	3,097	4,875	8,793	4,040	7,404	8,161	3,887	4,071	2,793	2,796	3,117	3,314	2,886
(3)	Dep. asset	3,097	4,875	8,793	4,040	2,604	8,161	3,887	4,071	2,793	2,796	3,117	3,314	2,886
(4)	Clean coal production	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
(5)	Salable amount (inland use)	480	480	480	480	480	480	480	480	480	480	480	480	480
(6)	" (export)	460	460	460	460	460	460	460	460	460	460	460	460	460
(7)	" (total)	940	940	940	940	940	940	940	940	940	940	940	940	940
(8)	Sales	24,360	24,360	24,360	24,360	24,360	24,360	24,360	24,360	24,360	24,360	24,360	24,360	24,360
(9)	Operating cost (current operating area)	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121	4,121
(10)	" (planning area)	4,457	4,457	4,457	4,447	4,447	4,447	4,447	4,447	4,447	4,447	4,447	4,447	4,447
(11)	Common expense	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530
(12)	Selling expense (railroad fare)	1,881	1,881	1,881	1,881	1,881	1,881	1,881	1,881	1,881	1,881	1,881	1,881	1,881
(13)	" (port charge)	△9	△9	△9	△9	△9	△9	△9	△9	△9	△9	△9	△9	△9
(14)	Overhead of head office	843	843	843	843	843	843	843	843	843	843	843	843	843
(15)	Operating profit	11,537	11,537	11,537	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547
(16)	Interest on loan													
(17)	Depreciation	6,417	5,737	5,771	5,674	5,738	5,833	5,861	5,868	5,928	5,949	5,967	5,335	5,364
(18)	Fixed cost													
(19)	Profit B.F. tax	5,720	5,800	5,766	5,873	5,809	5,714	5,686	5,679	5,619	5,598	5,580	6,212	6,183
(20)	Income tax													
(21)	Net profit	5,720	5,800	5,766	5,873	5,809	5,714	5,686	5,679	5,619	5,598	5,580	6,212	6,183
(22)	Cash flow	11,537	11,537	11,537	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547
(23)	Repayment													
(24)	Net cash flow	11,537	11,537	11,537	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547	11,547
(25)	Cumulative N.C.F.	76,073	87,610	99,147	110,694	122,241	133,788	145,335	156,882	168,429	179,976	101,523	203,070	214,617
(26)	Balance of debt													

2. ECONOMIC EVALUATION BY MEANS OF D.C.F. METHOD

An economic effect on the investment is evaluated by the rate of return obtained in the computation by means of the D.C.F. method in various cases described below.

ACOS-300 "Computer" with the individual programs for the study is used for the examination.

Following formula is applied for the basis of program in the computation.

$$\sum_{i=0}^{25} \frac{I_i}{(1 + r)^i} = \sum_{i=0}^{25} \frac{C_i}{(1 + r)^i}$$

I : Investment
C : Cash flow
i : Year (0 - 25)
r : Rate of return

2.1 A Case Considering No Escalation

The rate of return is obtained as 6.02% in the case considering no escalations for all of the coal price and cost factors on the 1980 basis shown in Table 4-9. However, it seems to have little means, since the coal prices and the costs will increase undoubtedly in the tendency of worldwide inflations. Therefore, following examinations considering the certain escalation are carried out.

2.2 A Case Considering An Appropriate Escalation

An escalation rate of 10 % a year would be regarded as the most appropriate for coal prices, investments, various costs and the like in consideration of its worldwide level and the current economic conditions in Indonesia.

In that case, the rate of return of 16.62 % is obtained as the result.

For a reference, although the domestic coal sales price of US$ 22 per ton is basically applied in this study, the rate of return of 21.94 % is estimated if the price of US$ 28 per ton is allowable which was obtained from the comparison with heavy oil.*

* Refer to Appendix 1.

2.3 Sensitivity Analysis

As all the factors in price and cost as well as escalation were estimated based on some assumption, a fluctuation of the rate of return is inevitably anticipated in accordance with the variation of such factors in practice. Sensitivity analyses are carried out to recognize the influences of the variations giving to the rate of return.

Variable factors are classified to following two categories.

A. Basic amount of each factor in the price and cost.

B. Escalation rate for the above amounts.

Following ranges are estimated for the changes of each factor in the examination.

. Coal price (Export only)	-5% ∿ US$ 38.0
. Investment	-10% ∿ +10%
. All expenses	-5% ∿ +5%
. Escalation rate for the aboves	5% ∿ 15%

Results of the sensitivity analyses are summarized in Fig. 4-1 and Fig. 4-2.

Followings are briefly concluded from the results.

(1) An influence of the amount of coal export price giving to the rate of return is high in comparison with those of the other factors. That is, such difference is obtained as follows;

Coal price (FOB, US$/ton)	Rate of return (%)
30 (Most likely case)	16.62
28.5 (-5%)	15.55
38	21.47

(2) An influence of the amount of investment is relatively low. That is,

Investment (%)	Rate of return
100	16.62
90	18.50
110	14.93

(3) All of the other expenses such as operation cost, head office overhead, selling expenses etc. give little affection to the rate of return as follows.

All expenses (other than Investment)	Rate of return
100	16.62
95	17.78
105	15.42

(4) An escalation gives extremely high affection to the rate of return.

If an escalation rate of 15% a year is expected for the coal prices with that of 10% a year for all of the other expenses, the rate of return is obtained as 34.75 %. And the return of Zero "0" is resulted at an escallation of 8.5 % in the same conditions of the other expenses.

Meanwhile, an escalation is secured as the rate of 5 % a year with that of 10 % for the coal prices, the rate of return is obtained as 29.30 %.

2.4 Risk Analysis

Risk analysis is carried out in order to recognize the probability of the project materialization.

For the above examination, a probability of the occurrence frequency is each factor is regarded as the normal distribution. The result is shown in Fig. 4-3.

Although the decision of the project materialization depends upon the judgement by the Authorities in consideration of various conditions, the probability of the project feasibility would be expected to be rather high.

For an instance, the probability of 65 % will be estimated when the required rate of return is settled as 15 %.

Fig. 4-1 SENSITIVITY ANALYSIS .... (1)

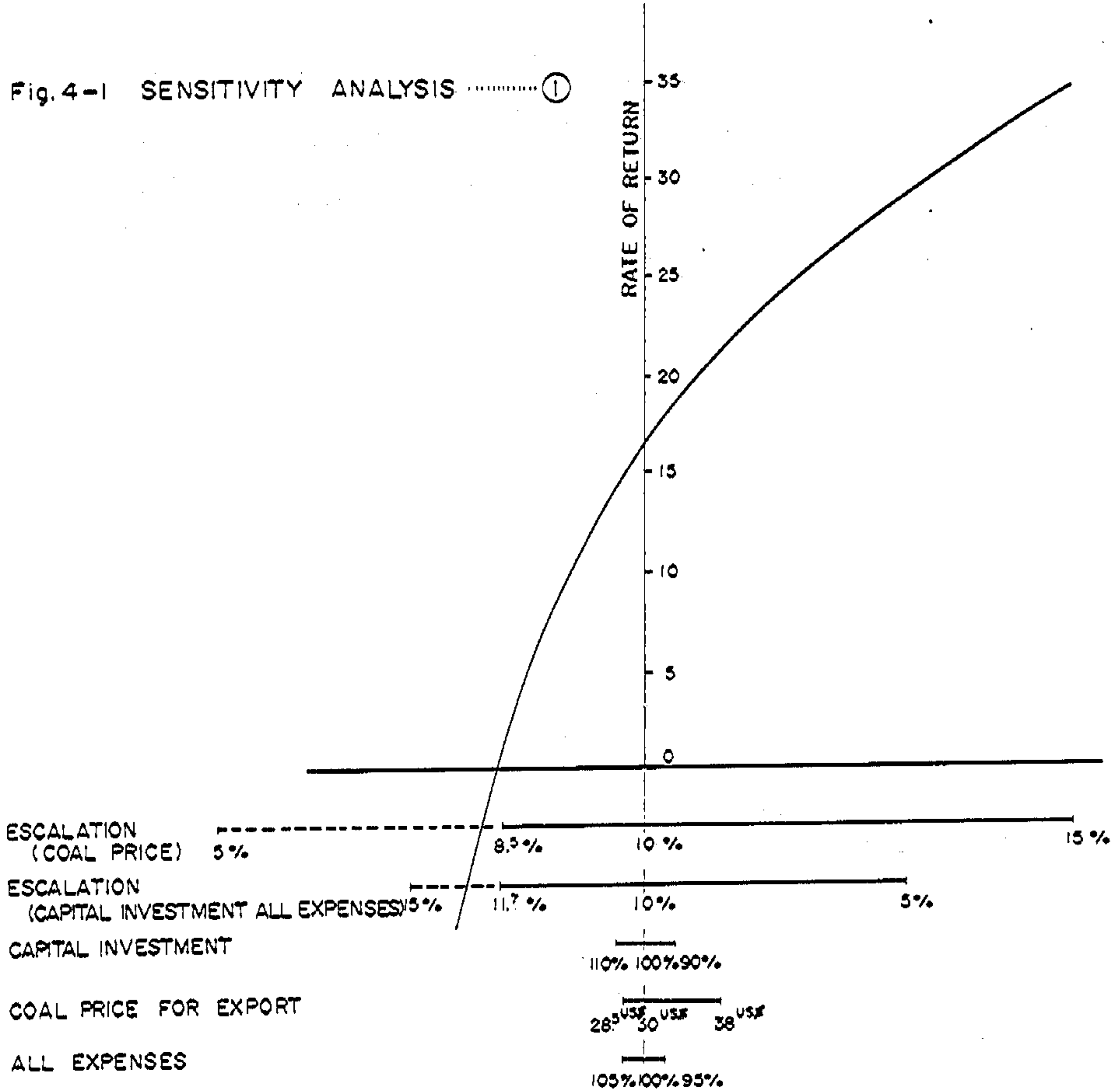


Fig 4-2 SENSITIVITY ANALYSIS ………… ②

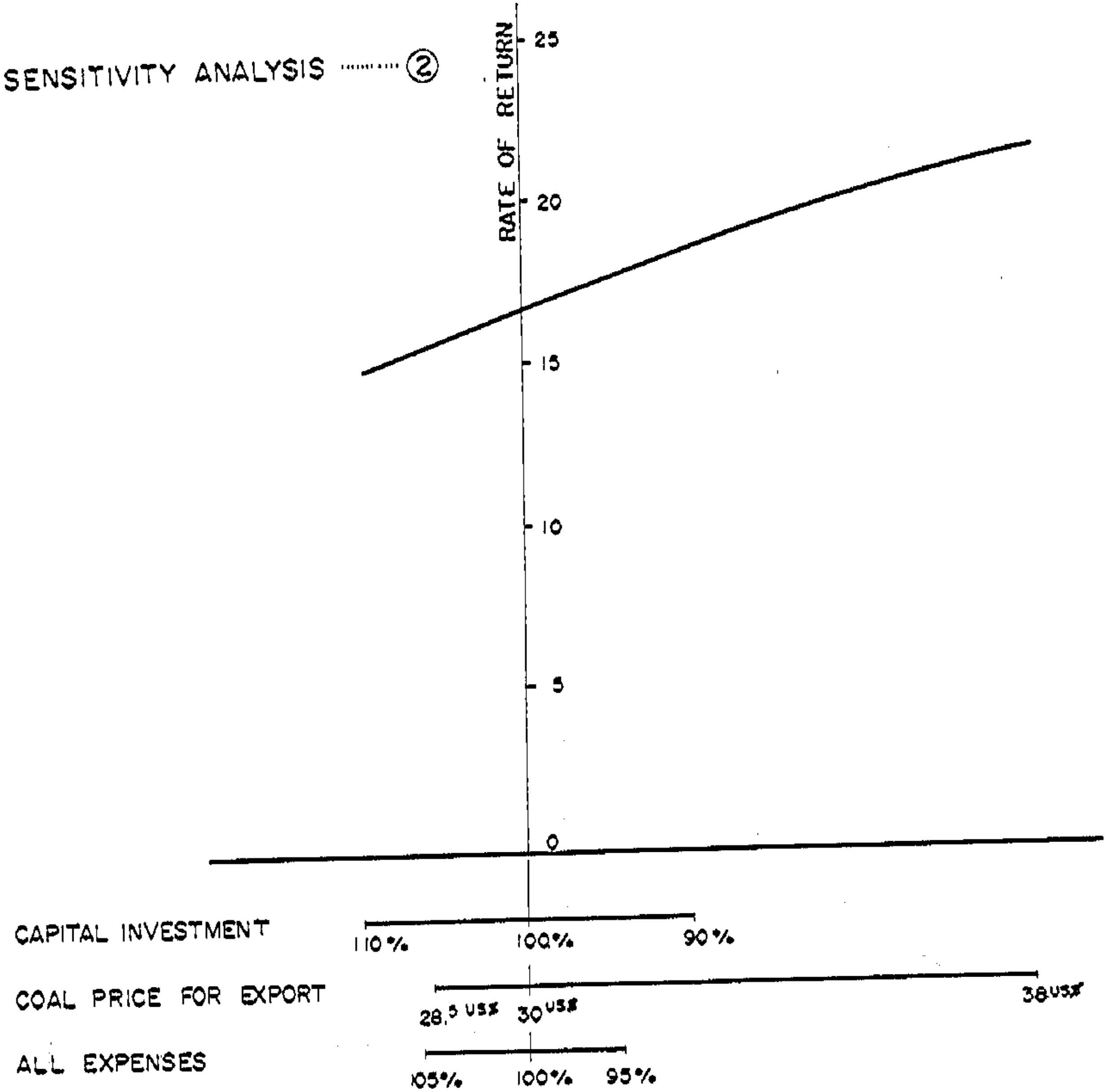


Fig. 4 - 3 RISK ANALYSIS

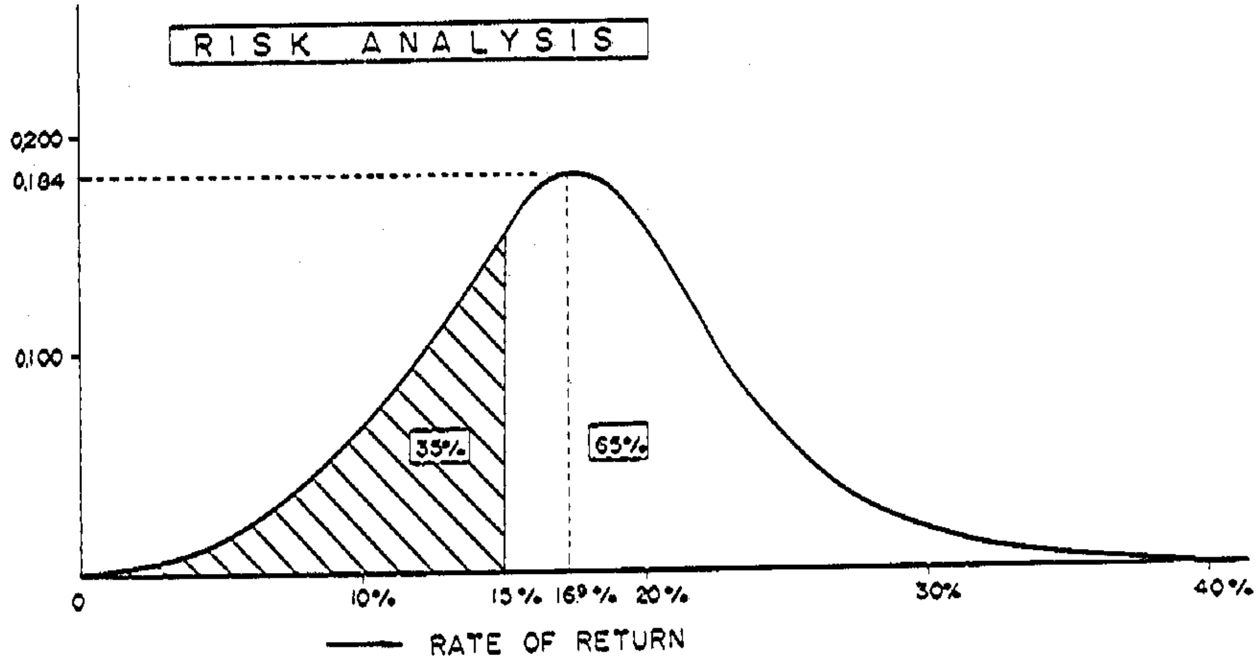


Table 4-10 Computation Data

APPENDIX 1 ECONOMIC COMPARISON OF PETROLEUM AND COAL IN INDONESIA

For a reference to the consideration of an appropriate coal price (steaming coal) for the domestic consumption in Indonesia the economics on heavey oil and coal are compared on an example of power generation cost. It is natural that the coal price depends not only upon the petroleum price. However, as far as it is considered that coal is competitive against petroleum or regarded as a substituting energy of petroleum, this comparison is expected to be available for a standard for the coal price determination.

(a) Construction costs for coal and heavy oil power stations

The site and operating conditions of the power station assumed here are as follows:

* The power station site is located along a bay in an underpopulated area apart from a city. Therefore, no environmental regulations are applied and installation of a fluegas treatment plant is not required.
* Maximum output: 1,000,000 KW (2 units of 500,000 KW)
* Annual availability rate: 70 %
* Annual power generation: 6,132 million KWH
* Power transmission: 5,924 million KWH in the case of heavy oil (Self-consumption ratio of 3.4 %), 5,813 million KWH in the case of coal (Self-consumption ratio of 5.2 %)
* Thermal efficiency: 38 %
* Calorific value of fuel: 9,900 kcal/kg for heavy oil, 7,000 kcal/kg for coal
* Fuel consumption: 1,400,000 kl of heavy oil (The specific weight is regarded as 0.95.), 2,130,000 ton of coal

Table A1-1 Construction costs for coal and heavy oil power stations

(10^6US$)

		Coal power station (A)	Heavy oil power station (B)	Dif-ference (A)-(B)
Land		43	29	14
Buildings		40	30	10
Other structures	Port facilities	63	13	50
	Enbankment for ash dumping ground	1	—	1
	Others	48	48	—
	Sub-total	112	61	51
Machinery and equipment	Major machinery	272	252	20
	Fuel storage facilities	1	10	Δ9
	Auxiliary equipments	81	34	47
	Foundation	28	19	9
	Sub-total	382	315	67
Furnishings		4	4	—
Expenditures		97	82	15
Total		678	521	157

According to Table A1-1 the construction cost of a coal power station is higher by 30 % than that of heavy oil power station in total, which is mostly attributed to the construction cost difference for the ash dumping yard and port facilities.

(b) Economics of coal power station

According to the above conditions, the coal price with which the power generation cost at a coal power station is equal to that at heavy oil one is as shown in Table A1-2. For the estimation the heavy oil price is regarded as 45 RP/l (0.07 US$). But this price includes no transportation cost and others, which is considered as equivalent to the F.O.R. price of coal.

Table A1-2 Coal price with which power generation cost at coal power station is equal to that at petroleum one

			Coal power station	Heavy oil power station	Note
Construction cost (10^6US$)			521	678	
Power generation (10^6KWH)			6,132	6,132	
Power transmission (10^6KWH)			5,924	5,813	
Fuel consumption			$1,400 \times 10^3$ kl	$2,130 \times 10^3$ ton	
Power generation cost (10^3US$)	Capital expenditure	Interest and depreciation	83,360	108,480	Construction Cost × 16%
		Fixed property tax	7,294	9,492	Construction Cost × 1.4%
		Sub-total	90,654	117,972	Construction Cost × 17.4%
	Direct expenditure	Personal expenditure	2,188	2,848	Construction Cost × 0.42%
		Repairing expenses	7,815	10,170	Construction Cost × 1.50%
		Others	7,450	9,695	Construction Cost × 1.43%
		Sub-total	17,453	22,713	Construction Cost × 3.35%
	Related expenditure		4,637	6,034	Construction Cost × 0.89%
	Total		112,744	146,719	Construction Cost × 21.64%
	Coal unloading and ash dumping costs		—	2,459	
	Fuel cost		98,000	60,090	
	Grand total		210,744	209,268	
Power cost (US$/KWH)			0.036	0.036	

Table A1-2 shows that coal price of 28 US$ is economically equivalent to heavy oil.

$$60,090 \times 10^3 \text{ US\$} \div 2,130 \times 10^3 \text{ ton} \approx 28 \text{ US\$}$$

As far as the above result, the present coal price of 22 US$ for the domestic consumption is seemed to be somewhat lower. For a reference, the economic evaluation in the case where the coal price for the domestic consumption is regarded as 28 US$ is also trially computed.

APPENDIX 2 PROSPECTIVE INCOME AND EXPENDITURE AT P.J.K.A. THROUGH INCREASE OF COAL TRANSPORTATION CAPACITY

The present railway freight system is applied for the study as it is. That is to say, economic evaluations are computed considering that P.N. Tambang Batubara pays P.J.K.A. the railway freight corresponding to the transportation amount. Meanwhile P.J.K.A. is required to invest for increasing the transportation capacity as the coal mine production increases, and the income and expenditure at P.J.K.A. should change correspondingly. Therefore, the effect of the production increase at Ombilin Coal Mine on the income and expenditure relations at P.J.K.A. are investigated under the present freight system on the basis of the results in 1979 and prospect in 1989 (the prices are on the basis of those in 1980) where the coal transportation amount reaches its maximum (940,000 ton/year). However, as it was hard to understand the current costing systems in P.J.K.A., this trial examination is worried its well relevancy.

The calculation method and applied values are based on Chapter III.

1. Income of P.J.K.A.

It is assumed that the other incomes than coal are unchanged.
(Refer to p. , Chapter III)

Table A2-1 Income of P.J.K.A. (10^3US$)

	1979	1989	Difference
Coal	69,000 ton 245	940,000 ton 3,355	871,000 ton 3,110
Others	98	98	0
Total	343	3,453	3,110

Note: the exchange rate is regarded as 1 US$=620 RP.

2. Plan for the Investment (Refer to Fig. 3-33.)

A plan for the investment contains also the items which are seemed to have no direct connection with the increase of coal transportation capacity. The repainting expenses for bridges are also included in this investment plan.

3. Expenditure (Refer to the item 11.2, Chapter III.)

1) Labor cost

Table A2-2 Labor cost in the railway transportation

(10^3US$)

	1979	1989	Difference
P.J.K.A. West Sumatra	1,233 persons 849	1,593 persons 1,097	360 persons 248
Work shop	178 persons 122	237 persons 163	59 persons 41
Total	1,411 persons 971	1,830 persons 1,260	419 persons 289

2) Material expenses

Table A2-3 Material expenses for the railway transportation

(10^3US$)

	1979	1989	Difference
Fuel & oil	143	1,752	1,609
Others	755	1,132	377
Total	898	2,884	1,986

4. Depreciation

The depreciation method is the same as that of the Coal Mine and the port. However, the contingency is excluded from depreciation.

1) Durable period

Taking the durable period accepted in Japan into consideration, they are determined as follows:

* 30 years for locomotives coal wagons, loco. depot, work shop, etc.
* 40 years for station facilities, rail tracks, signal systems

* 60 years for tunnels and fences

* 5 years for painting and engineering

2) Depreciations

Table A2-4 Depreciation amount

(10^3US$)

	1979	1989
Locomotives	Depreciations are included in Table 4A-5.	507
Coal wagons		222
Station facilities		4
Railway track		200
Signal system		52
Locomotive depot		12
Work shop		24
Painting		97
Repainting		—
Tunnels and fences		1
Engineering		168
Total	0	1,287

Note: The facilities stated here mean the additional ones related to increase of the coal transportation capacity. However, the depreciation for the investment for maintenance is included in Table A2-3.

5. Income and Expenditure

Above mentioned income and expenditure are summarized as the Table A2-5.

Table A2-5 Summary of income and expenditure

(10^3US$)

		1979	1989	Difference
Coal transportation amount		69,000 ton	940,000 ton	871,000 ton
Income		343	3,453	3,110
Expenditure	Labor cost	971	1,260	289
	Material expenses and others	898	2,884	1,986
	Sub-total	1,869	4,144	2,275
Depreciation		—	1,287	1,287
Balance		Δ1,526	Δ1,978	Δ452

Note: The mark Δ means minus.

As shown in the above trial computation, the income and expenditure relation becomes worse by 452,000 US$ in spite of increasing the coal transportation amount. In the case where this worsened amount is burdened by Ombilin Coal Mine the coal railway freight is required to raise by about 0.5 US$ according to the following equation.

452,000 US$ ÷ 940,000 ton ≒ 0.5 US$

APPENDIX 3 COMMENT ON THE INDONESIAN PROPOSAL FOR THE INCREASE OF RAILWAY TRANSPORTATION CAPACITY

The Steering Committee of Indonesia presented the new idea to the JICA team at the meeting on the Feasibility Study of the Sawah Lunto Coal Exploration on March 3rd 1981 at Jakarta. Indonesia's new proposal is as follows;

1. The capacity of railway transportation needs to be increased in consideration to the future regional development such as in agriculture and in mining, besides the transportation of the coal product from the Ombilin Coal Mine.
2. Based on the above idea, the following measures are under consideration.

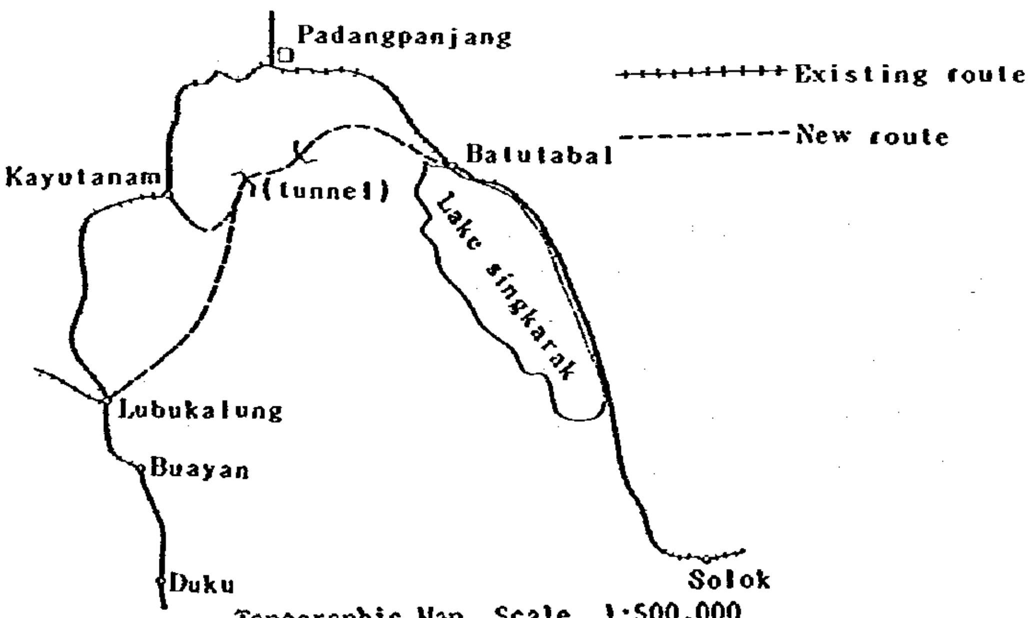
   a) Necessity of new route avoiding the rack section

   b) Adoption of large sized locomotive and coal hopper wagon

Discussion on the above proposal, however, is beyond the content of this feasibility study. In addition, it is difficult to consider the viability of the proposal without any pricise data on it. Thus, the following statements are only our private comments on this matter.

A. A view of new route

The rack section between Kayutanam and Batutabal via Padangpanjang is the control section of the transport capacity at present. (Ref. Chapter 3, Table 3-2, 4.2.2 and 4.2.3) The possible new route, which avoids the rack section, is as follows;



Topographic Map, Scale 1:500,000

The construction of the new route above will require some long tunnels, some high piered bridges and a large quantity of hard rock excavation. Furthermore 3 or 4 stations provided with siding track (grade ≑ 0 %) for train interchange are needed. In conclusion, it is worth studying the new route in view on regional development, and also from the technical and economical point of view.

B. A view of adoption of large sized rolling stock

The following three points with regarding to the adoption of large sized rolling stock was raised by the Steering Committee of Indonesia at the meeting.

1. Large sized locomotive with the axle load of 14 tons. (the one applied in this F/S is 10.7 tons)

2. Large sized coal hopper wagon of 30 tons capacity. (in this F/S, 23 tons)

3. Revision of impact coefficient affected by rolling stock to bridge. ($\varphi = 1.2 + \frac{25}{L + 50}$, L in m)

Our letter of March 2nd, 1981, required the Committee to give the necessary data on specification of the large sized rolling stock. However, there was no reply for it from the Committee. Thus, the discussion here was based on the data obtained at the meeting.

B-1. Bridge

The results of the stress calculation on the four bridges studied in Chapter 3 are approximately as follows;

1. Curved-chord truss bridge (Bridge No. 77)

   The structural stress induced to upper and lower chord members, which are of the main menbers in nearly same level and/or excess of few percent to the allowable stress.

2. Plate girder bridge (Bridge No. 163)

   The structural stress induced is nearly same level to the allowable stress.

3. Truss deck bridge (Bridge No. 329)

   The structural stress of some portion of the upper chord members is in excess of 20 % to the allowable stress, and the stress of some portion of upper and lower chord members is nearly to the allowable stress.

4. Braced arch bridge (Bridge No. 186)

The stress induced of all members of arch portion is proved to be within the allowable stress, but the stress induced to the simple bean bridges (plute girder type), which are connected to the arch portion, is in excess of 10 - 15 % to the allowable stress.

Taking all these factors into consideration, it is needed to take carefull study on the existing conditions, strength of used material, stress calculation, necessity of the rainforcement and renewal of all the bridges.

B-2. Track structure

In is necessary that the accumulated deterioration of track due to the repeating train load is not excessive and also the stresses of track structure due to the axle load of train is not exeed the allowable range of stress. This is important for securing the maintenance period long enough and reducing the maintenance cost.

It is expected that the importance of the maintenance economy will become greater than that of the initial construction cost, thus the adoption of the hevier rails seems to be more effective.

As to the study so far, the use of 30.8 kg/m rail has been recommended, since the axle load was comparatively small, 10.7 t, and the procurement of used rail of 30.8 kg/m was free of charge and this kept the initial cost cheap.

If the axle load is increased to about 14 tons, the rails to be used are necessary to be at least 40 kg.m from both track stress and maintenance economy. Thus, the use of R14A rail (42.59 kg/m) is considered to be suitable.

The other parts of track structures should be also well ballanced, such that sleeper spacing is 600 - 650 mm and ballast depth is 200 mm.

APPENDIX 4 ECONOMIC EVALUATION ON THE CONDITIONS PROPOSED BY THE STEERING COMMITTEE OF INDONESIA

In Chapter IV of this study, an economic evaluation on an expansion project of the Ombilin Coal Mine has been made by means of D.C.F. method. In this appendix, further calculation will be made on the following financial conditions by the request of the Steering Committee. Only a rate of return is to be obtained in this appendix.

1. Additional Conditions

1) Funding for equipments

The half of fund for equipments in each year is paid at own expence of the Ombilin Coal Mine. The remainder is paid by the loan of the money.

2) Loan conditions

An interest of the loan is 9 % per annum. The term of deferment is five years. After that, it will be repaid by installments per annum levy for fifteen years. The loan is obtained at the beginning of the year, and repayment is made at the end of the year. Therefore, an interest is allowed on the remainder at the beginning of the year.

3) Income tax

A tax rate is 45 % of annual profit every year. Where a loss is incurred before the taxation, it is allowed to be carried forward to the following four years.

4) The coal selling prices utilized in Chapter IV is on the 1980 price basis, which amounts to 22 US$ (FOR) for domestic consumption and 30 US$ (FOB) for export. In this appendix, however, the 1981 prices are adopted, that is 28 US$ (FOR) for the former and 42 US$ (FOB) for the latter.

5) An escalation rate in this appendix is 10 % per year. This rate will be applied for all costs factors including coal prices and various other investment.

6) Evaluation period

The evaluation covers a period of 25 years from 1981 to 2005 since the coal price in 1981 is adopted as a basis in this appendix. Thus, the investment amount shown in Table 4-9 on the 1980 price basis is increased by 10 % following the above escalation rate.

7) Borrowing for operation cost

In 1981, the deficit of the operating cost is covered by borrowing 650,000 US$ at 9 % per year. The repayment will be made from the cashflow in 1982.

2. Calculation Result

Profit and loss, and cashflow under the above mentioned conditions is shown in Table A4-1. Thus the rate of return is calculated as 14.6 %.

Table A4-1

Overall Project Cash Flow	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1 Capital Invest (Loan)	1011	5525	3167	17951	16205	6669	7882	938	4264	9906	5872	5929	5345	9256	18365	9282	6580	22684	11887	13696	10333	9347	13952	16315	15632
2 " (Cash)	1012	5525	3167	17953	16205	6670	7883	937	4264	9908	5875	5932	5348	9259	18365	9282	6580	22690	11887	13696	10333	9347	13961	16324	15632
3 Op Asset	2023	11051	6333	35904	32409	9339	15765	1875	8527	19814	11747	11660	10693	18515	36729	18564	13160	45374	23774	27387	20667	18693	27913	32638	31263
4 Clean Coal Product	200	300	300	400	400	550	700	850	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5 Saleable Amt (Inlan)	140	235	235	330	330	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480
6 " (Export)	45	50	45	50	50	30	180	310	460	460	460	460	460	460	460	460	460	460	460	460	460	460	460	460	460
7 " (Total)	185	285	280	380	380	510	660	790	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940	940
8 Sales	5810	9548	10249	15074	14605	23674	37202	51562	70224	77246	86971	93448	102913	115094	124406	134867	150851	165384	182143	200357	222029	242452	266475	297334	333226
9 Ope. Cost (Current)	3356	3927	5407	6074	6637	7300	8030	8836	9717	10689	11757	12933	14226	15649	17214	18935	20829	22912	25203	27723	30496	33545	36900	40590	44649
10 " (Plan)	0	0	0	0	0	7394	8608	9405	10510	11561	12717	13989	15388	16926	18619	20473	22479	24726	27199	29917	32911	36202	39822	43804	48185
11 Common Expense	1464	1848	1966	2127	2365	2627	2920	3245	3609	3966	4565	4802	5282	5810	6391	7030	7733	8507	9357	10293	11322	12455	13700	15070	16577
12 Selling Expense (Rail)	202	249	244	301	331	217	1475	2710	4435	4879	5366	5903	6493	7143	7857	8643	9507	10458	11503	12654	13919	15311	16842	18526	20379
13 " (Port)	149	182	180	270	242	-1578	-741	-458	-236	-259	-26	-29	-31	-35	-38	-42	-46	-51	-56	-61	-67	-74	-81	-90	-98
14 Overhead Of H.O.	927	1020	1122	1234	1357	1493	1642	1806	1987	2186	2404	2645	2909	3200	3520	3872	4260	4685	5154	5669	6236	6860	7546	8301	9131
15 Operating Profit	-466	2323	1309	5136	5672	6221	15308	26015	40203	44223	48386	53225	58547	64402	70842	77972	85770	94347	103781	114160	125575	138133	151946	167141	183855
16 Int. (Capital Inve	91	580	873	2489	3947	4367	5071	5116	5461	6167	6432	6675	6817	7306	8589	8996	9125	10665	11203	11848	12080	12179	12676	13274	13046
17 " (Deficit Cover)	58	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18 " (Total)	149	667	873	2489	3947	4367	5071	5116	5461	6147	6432	6675	6917	7306	8589	8996	9125	10665	11203	11848	12080	12178	12676	13274	13044
19 Depreciation	1045	1218	2677	2967	3242	10074	11767	14412	14134	17871	16666	10585	20065	21787	24107	26070	29002	32429	35895	37478	42870	46427	53653	52555	58112
20 Profit B.F Tax	-1682	459	-2743	-299	-1517	-8220	-1529	6286	18408	20194	25310	28165	31467	35509	38147	42907	47643	51252	54734	62033	69625	77532	85837	101314	111893
21 Deficit	-1274	0	-2743	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 Taxable Income	0	0	0	0	0	0	0	0	13328	20194	25310	28165	31467	35509	38147	42907	47643	51252	54734	62033	69625	77532	85837	101314	111893
23 Income Tax	0	0	0	0	0	0	0	0	5998	9084	11390	12674	14241	15889	17166	19308	21439	23063	25530	28275	31331	34889	38627	45591	50353
24 Net Profit	-1682	459	-2243	-299	-1517	-8220	-1529	6286	12410	11102	13921	15491	17406	19420	20981	23599	26204	28189	31203	34358	38294	42642	47211	55723	61542
25 Cash Flow	33	1676	434	2667	1725	1854	10237	20900	26766	28973	30565	33876	37489	41207	45087	49669	55207	60618	67048	74037	82166	91970	100663	108276	119656
26 Ope. Bal. Of Debt (Ca	1011	6536	9703	27654	43859	48528	56342	56842	60458	69520	71669	76162	75766	81179	95436	99951	101372	110502	124478	131644	134225	135269	140867	147687	153868
27 " (Def)	650	650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28 " (Tot)	1661	7186	9703	27654	43859	48528	56342	56842	60458	69520	71669	76162	75766	81179	95436	99951	101372	110502	124478	131644	134225	135269	140867	147687	153868
29 Repayment (Capital)	0	0	0	0	0	67	434	667	1044	2924	3235	3761	3823	4107	4768	5159	5554	5911	6528	7752	8303	8374	9675	9271	13475
30 " (Deficit)	0	650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31 " (Total)	0	650	0	0	0	67	434	667	1044	2924	3235	3761	3823	4107	4768	5159	5554	5911	6528	7752	8303	8374	9675	9271	13475
32 Net Cash Flow	33	1026	434	2667	1725	1787	9802	20233	26720	26049	27329	30116	33666	37100	40320	44510	49653	54707	60521	66285	73860	82696	90988	99005	106181
33 Cumulative N.C.F	33	1059	1493	4160	5867	7654	17456	37709	64429	90477	118007	148122	181788	218888	259207	303717	353370	408077	468598	534883	608743	691439	782427	881432	987613
34 End. Bal. Of Debt (Ca	1011	6536	9703	27654	43859	48460	55906	56195	59815	65596	68234	70402	71923	77072	90669	94792	95817	112591	117981	123692	125922	126693	131117	138217	140373
35 " (Def)	650	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36 " (Tot)	1661	6536	9703	27654	43859	48460	55906	56195	59815	65596	68234	70402	71923	77072	90669	94792	95817	112591	117981	123692	125922	126693	131117	138217	140373

DISCOUNTED CASH FLOW		
Capital	693015	113119
Return	987373	113121
Rate Of Return	0.14663	