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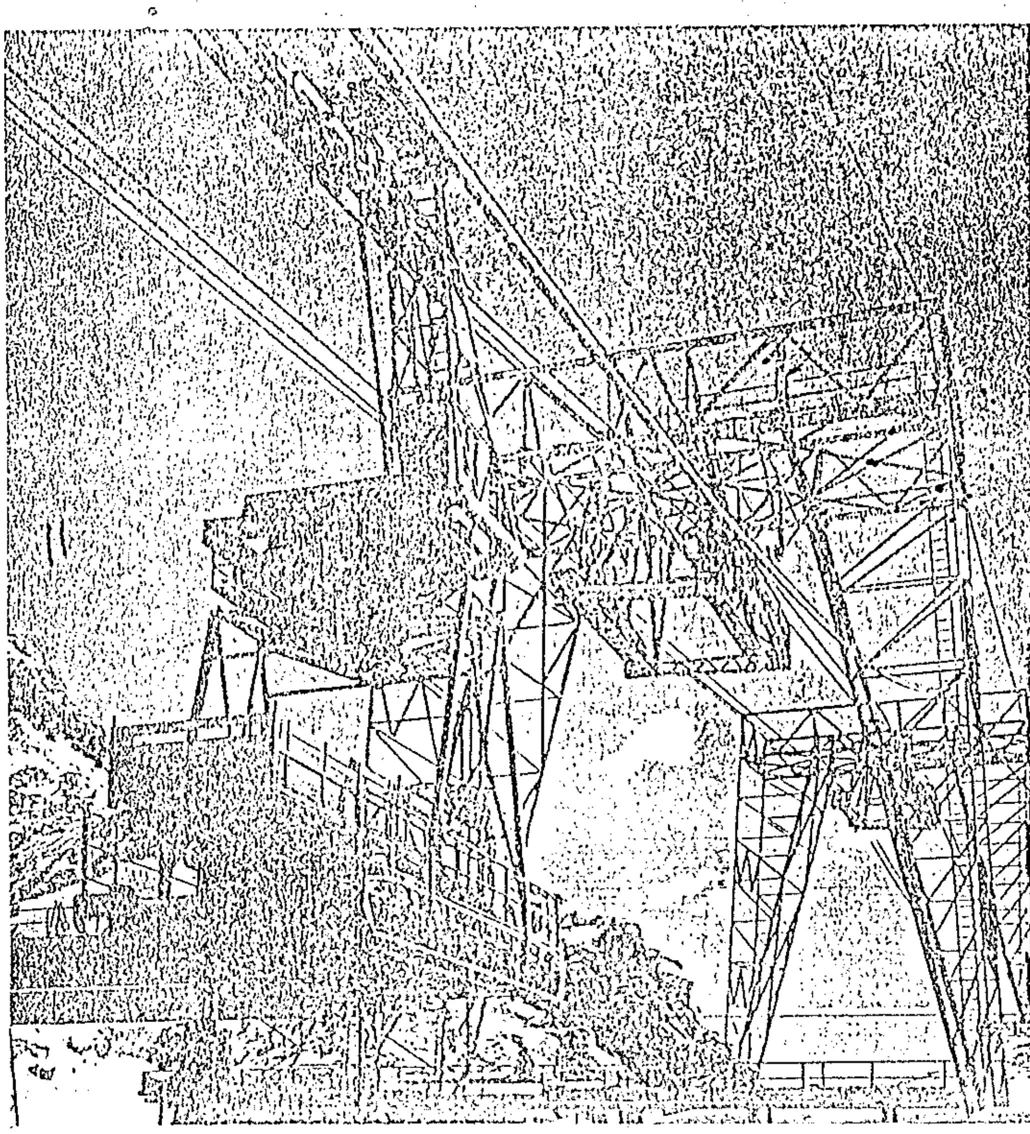
LOWARI-PASS

ROPEWAY PROJECT



NTRC 11

CH-3653 Oberhofen, January 1977

Mr. Malik Mohammed Saeed Khan
Deputy Chief
Transport and Communications
National Transport Research Centre
124-E, G/6-3, 90th Street
Embassy Road
Islamabad /Pakistan

C-3551

Dear Sir,

I am very pleased to submit to you the detail project and the respective cost evaluation for the Lowari-Pass Ropeway.

The longitudinal profiles surveyed by Survey of Pakistan have now given the basis for this study.

As already outlined in my report of July 24, 1974, the project is in any respect feasible and needs to be compared with other solutions for a year round link with the Chitral Valley.

Yours sincerely,

Bernhard H. Zurgi
Consulting Engineer

Table of contents

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LOWARI - PASS ROPEWAY PROJECT

I General

In summer 1974 a preliminary study for this ropeway was carried out, and the results were summarized in the report dated July 24, 1974. In this report the various possibilities were outlined to ensure a year round access to the Chitral Valley.

The Government of Pakistan has now decided to carry on the studies for this ropeway project to get accurate figures of the technical data as well as of the costs.

Two years ago the topographic maps, which were available did not allow to work out a more detailed project. Consequently Survey of Pakistan was charged with the survey of the longitudinal profiles of section I and II. In addition to this work a great number of contour maps for station buildings and tower locations had to be made. This big work was carried out with much care and serves now as basis for the present project engineering.

This study will treat all parts necessary and directly related to the ropeway over Lowari-Pass. According to the request of the Government of Pakistan two solutions will be discussed. One solutions will describe an installation over Lowari-Pass which has the capacity to handle the traffic of today's peak period in summer. We call this variant the <u>maximum solution.</u>

The other variant will treat an installation of <u>same</u> type, but with much less capacity. This smaller ropeway will secure a year round connection with the Chitral Valley, but - compared with the summer months - with a substantially reduced capacity. We call this variant the <u>minimum solution.</u>

All indicated capacities are based on the research, which was carried out in summer 1974 according to the previous mentioned report.

The operation of both ropeway sections needs the following personnel:

- 1 manager or ropeway superintendant,
- 1 graduated electrical engineer as his representative.

  These two men form the head of the ropeway operation.

- 4 - 6 mechanics and electricians for all maintenance work to be carried out. 1 - 2 should always be on duty when the installation is in operation. The mechanics and electricians must be skilled and very reliable.
- Approx 20 attendants to run the system from the load platforms. These men do not need to be skilled. They must have a good sense of duty and will be trained for all the technical problems.
- Approx 20 additional people as helps in the station areas. These men will have to help loading vehicles or goods onto the load platforms or just work around the stations, e.g. to remove snow etc.

All the staff has to be trained for emergencies such as power-failures, heavy wind, severe icing conditions, a blocked vehicle etc.

The mechanics and the electricians will not be needed for the actual operation of the ropeway. They will be busy with maintenance work according to the manager's and the manufacturer's specifications.

During winter time people will be needed to clear the parking areas and the station surroundings from snow and ice.

3. Vehicle traffic

As already outlined in the previous report, it will be possible to carry vehicles over the Pass. This may not be a very economic solution on the first look because the truck with its dead weight is transported too. But on the other hand unloading and reloading of the truck as well as of the ropeway can be eliminated.

The present study leaves it open, whether one or the other method will be chosen. In case loaded or empty trucks will go over the Pass with this ropeway the following procedure has to be observed:

3.1. Loading at Lowari Village on section I

When arriving in the lower station of section I the driver will place his vehicle backwards up onto the load platform. This can easily be done by using a removable ramp. If all the vehicles are on the platform, they are secured from rolling off by cables or brake shoes. Simultaneously the same procedure has been made with other vehicles being loaded in the upper station of section I on top of Lowari-Pass.

When loading has been finished in both stations the cabin attendants will start the ropeway as indicated in paragraph II/2.

3.2. Unloading on top of Lowari-Pass

When arriving on top of Lowari-Pass the vehicles will be driven off the platform while in the lower terminal at Lowari Village the same action takes place. As soon as the vehicles have left the platforms, reloading starts.

The vehicles having come up to the Pass will continue their trip onto section II. This section will take them down to Ziarat.

4. Cargo traffic

The transportation of cargo alone not carried by a truck needs in all terminals loading and unloading facilities. It may take more time, but no dead weight has to be transported. Especially if a container service is provided, loading and unloading times may be kept to a minimum.

In each station forklifters, cranes and the necessary personnel must be at hand. Furthermore each station must have ample storage and parking space.

5. Transport of passengers

All passengers arriving at a ropeway station by car, truck or bus will remain in their vehicles for the trip. No special equipment is necessary for passenger transport.

III Technical description

1. Terminals

Usually the terminals are built as combination of reinforced concrete and structural steel. For the lower part of the building, concrete is necessary, but for the upper part of the station, structural steel is in most cases less expensive and moreover faster erected.

The track cables are fixed in the upper terminals by wrapping them around a concrete bollard. These bollards are lined with non-agressive hard wood and covered with galvanized sheet iron to prevent corrosion.

In the lower terminals the track ropes are tensioned by large counterweights. These weights consist of a steel frame and are filled with concrete. The track rope is often deflected on to the counterweight by a chain saddle. The advantage of this construction lies in the fact, that no tension rope nor usually requested sockets have to be used.

Above the loading platforms special supporting rope saddles are installed in order to maintain, independent of load, the same level of the platform floor. Furthermore chain pulleys with a carrying capacity of 10 tons are provided to lift off the carriage in case of maintenance or inspection.

The drive stations are located as follows:

Section I: Lowari Village
Section II: Top of Lowari-Pass

The different locations for the drive stations have been chosen according to the availability of electric current.

The hauling rope which is driven by the drive is always tensioned in the opposite station. This means that the counterweights for the hauling ropes are located as follows:

Section I: Top of Lowari-Pass
Section II: Ziarat

The machinery for the drives is usually located in the lower part of the station, where the heavy parts can directly be fixed on the foundations. On level access from the outside to the machinery makes the erection and later on the maintenance easier.

The large volumes of ropeway stations - due to technical requirements - often allow to build in tranformer stations, workshops etc.

2. Cables

According to most countries' regulations, the track cables have to be of fully locked coil construction. These cables have a very smooth surface resulting in a low specific pressure of the running wheels with limited wear of the rubber lining and a noiseless operation. Furthermore this type of cable has a very tight closing of the cable surface, preventing the cable from entering moisture.

The 6 x 19 Seale Type rope will mostly be used as hauling rope. Best results are obtained with ropes with galvanized wires. The zinc coating prevents the wires from external and internal corrosion.

3. Intermediate towers

The towers supporting the track cables and the hauling rope on the line are made of steel in latticework construction. Four large concrete foundations, or if the tower is on rock, prestressed anchor cables, absorb the forces.

On each tower four track rope saddles are supporting track and hauling ropes at the predetermined elevations. These saddles can be passed by the vehicle with the same speed. All tower parts are hot dip galvanized and not subject to corrosion.

4. Vehicles

The vehicles consist of the following components:

- load platform
- hanger
- carriage

The load platform and the hanger are designed in such a way that the position of the platform is always horizontal. Swinging due to acceleration or braking of the system will be damped by a special system. The floor is covered with sawn timber and at various points hooks are provided to fix the cargo.

The running carriages have 32 rollers, all equipped with special resistant rubber linings. As bearings for the main bogies elastic rubber silent blocs are used instead of bearing bushes. Owing to the design, a lubrication is needed only three to four times a year at a few points.

To avoid any overloading of the vehicles a measuring cell will be installed at the suspending hanger. If the platform is overloaded, the system is blocked, and the attendant can see the amount of excess weight on a scale on its panel.

5. Drive machinery

The layout of each drive station is as follows:

Two DC-motors drive over large reduction gears two bull wheels which in turn move the hauling rope. The requested power is too big to have only one motor. However, this arrangement will have the advantage, that the ropeway can be operated with half power, e.g. in case of maintenance or when repairs on one driving unit have to be done. Also the transport of the electrical and mechanical parts to the site as well as the erection can be made easier with smaller single loads.

Each drive disposes of the following braking systems:

Service brake: This brake acts upon both bull wheels or on a
special brake disk and is released in the following cases:

- when the system comes to a stop after normal running
  conditions
- in the event of a power failure
- in the event of approx 10 % overspeed of the system
- when a safety-system component fails

Safety brake: This brake is acting upon both bull wheels
in the following cases:

- when the speed of the system exceeds 15 % of normal speed
- when the end-buffer in the station is overrun
- when the service brake is underrating a max lag

6. Electrical equipment

The main drive system consits of a DC-Motor, the corresponding
thyristor power supply, the ropeway control and surveillance
board, the control deck and the two copying units. As a
variant a Ward Leonard set can also be taken in consideration.

In the control and surveillance switch board are mounted all
relays, contactors and breakers necessary for the control of
the ropeway drive. In addition there are all the electronic
components, which are necessary for the speed control and
monitoring of the main drives. The latest developments assure

- smooth, but also fast start of drive,
- minimum time loss when passing towers (deceleration -
  acceleration),
- shortest possible time for cabin entrance in terminals due
  to the continuous speed monitoring system,
- indication on control deck of all malfunctions by lamps
  causing very short standstill periods.

On the control deck is furthermore the cabin position indicator.

7. Telephone, safety and remote control system

In the attendant's cabin on each vehicle a control panel is provided with all the necessary push buttons for remote control.

The following push buttons are used:

UP	=	to start the ropeway upwards
DOWN	=	to start the ropeway downwards
STOP	=	emergency stop
FASTER	=	ropeway accelerates to maximum speed as long as push button is pressed
SLOWER	=	ropeway decelerates as long as push button is pressed and comes to a full stop

The circuit is designed for absolute safety. All the commands are interlocked and safety has absolute priority, e.g. there is no possibility to start if the control in the other cabin is not switched on or if there is overweight etc.

Controls are made of highly reliable parts, mostly solid state. Relays are only used for rarely operated circuits, safety functions and where galvanic insulation is required.

All the signals are transmitted from the vehicle to the drive inductively via the hauling rope. The hauling rope is electrically insulated and a RF signal is coupled continuously to the rope. A test unit checks this signal and causes an emergency stop as soon as the signal is missing (e.g. short circuit between hauling rope and track rope).

All these circuits are completely electronic, no service or maintenance is required.

In all stations telephones are installed in the machinery room and on the vehicles. The telephones work similar to the safety system with contactless transmission. They can be used whether the ropeway is in use or not.

8. Auxiliary drive

In each station an auxiliary drive unit will be provided in case there is no power. However, this unit will not allow full speed and is not designed to maintain the operation for a longer period. Its purpose is to ensure that vehicles stranded on line can be safely moved on to their terminals.

Usually a large Diesel engine is used as auxiliary motor. This engine is driving with a hydraulic motor the main drive of the ropeway. The entire installation may be controlled from the control desk and all safety devices are fully effective.

9. Rescue equipment

In case the ropeway gets blocked on the line and cannot be repaired immediately, equipment must be provided to rescue the passengers. Such cases may occur if some mechanical parts fail and block the installation (e.g. a failure in the reduction gear).

On each vehicle rescue equipment such as ropes, roping down apparatus etc. will always be carried. In addition each attendant must have a radio equipment.

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IV Technical data

The ropeway has been calculated according to the Swiss Ropeway Specifications, which are similar to those of the International Ropeway Association (O.I.T.A.F.).

As already indicated in paragraph I the calculations have been made for the maximum and the minimum solution.
Both solutions are defined as follows:

- Maximum solution

  The carrying capacity will be 18 tons or two loaded trucks. This means that the load platform of the ropeway can carry at once a load of 18 tons. Of course both vehicles of the same section can simultaneously be loaded with this pay-load.

  Two trucks means that the platform is designed in such a way, that there is enough space to carry them at once. The dimensions of the platform are as follows:

length	approx	7,5 m
width	approx	5,5 m

  According to the weight limitations both trucks may be up to 9 tons each.

- Minimum solution

  The carrying capacity will be reduced to 5 tons or a loaded light vehicle. The dimensions of the load platform are as follows:

length	approx	5,5 m
width	approx	3,6 m

1. Technical data of the 18 ton ropeway

1.1. Section 1: Lowari Village - Lowari-Pass

1.1.1. Topographical data

Lower terminal	Lowari Village
Elevation	2591 m above sea level
Upper terminal	Lowari-Pass
Elevation	3142 m above sea level
Longitudinal profile	9/10.51118
Horizontal distance	3324 m
Difference in level	551 m
Inclined length	3401 m
Maximum slope of the track	65,5 %
Max distance between vehicle and ground	approx 90 m

1.1.2. Operational data

Number of load platforms	2
Carrying capacity each	18 tons
Speed: - max	6 m/sec
- over towers	6 m/sec
Time of travel	625 sec
Time for unloading / reloading	300 sec
Number of trips/hr	approx 3,9
Carrying capacity	70 tons/hr
Max wind pressure	
- in operation	30 kg/m2
- not in operation	125 kg/m2

1.1.3. Ropes

Number of track cables	2 x 2
Length of each track cable	3690 m
Diameter	65 mm
Type	fully locked coil
Weight	23,57 kg/m
Breaking strength	444000 kg
Tensile strength of the wires	180 kg/mm2
Safety factor	3,5

Length of the lower hauling rope	3485 m
Diameter	47 mm
Type	WS
Weight	8,17 kg/m
Breaking strength	150400 kg
Tensile strength of the wires	200 kg/mm2
Safety factor	5
Diameter ratio rope / bull wheel	1 : 85,1

Length of the upper hauling rope	3485 m
Diameter	47 mm
Type	WS
Weight	8,17 kg/m
Breaking strength	150400 kg
Tensile strength of the wires	200 kg/mm2
Safety factor	5
Diameter ratio rope / deflection sheave	1 : 85,1

1.1.4. Towers and line equipment

Number of towers	4
Type	Central tower
Height of towers	55 m
	24 m
	32 m
	62 m
Radius of rope saddle	32 m
Number of hauling rope rollers	132
Diameter of hauling rope rollers	500 mm
Number of intermediate supports	32
Distance between intermediate supports	approx 150 m
Track gauge: Lower terminal	9,0 m
Tower 1, 2, 4	10,0 m
Tower 3	11,0 m
Upper terminal	9,0 m

1.1.5. Vehicles

Number of vehicles	2
Carrying capacity	18 tons
Distance between track rope and load platform	10 m
Number of rollers per carriage	32
Roller diameter	315 mm

Weights

Empty weight	9500 kg
Payload	18000 kg
Total vehicle weight	27500 kg
Max roller pressure	860 kg
Length of platform	7,5 m
Width of platform	5,5 m

1.1.6. Mechanical equipment of the stations

Track cable anchoring in	Upper terminal
Total rope load on station	4 x 127 tons
Track gauge	9,0 m
Distance between track cables	700 mm
Track cable tensioning in	Lower terminal
Length of roller chain	4 x 18 m
Track gauge	9,0 m
Counterweight	4 x 103 tons
Lift of counterweight	approx 21 m
Hauling rope drive in	Lower terminal
Type of drive	2 x ø 4000 mm
Number of grooves	2 each
Arc of contact	3π
Requested coefficient of friction	0,164/0,206
Gear ratio	48,86 : 1
Service brake, diameter	2 x 4000 mm
Safety brake, diameter	2 x 4000 mm
Hauling rope tensioning device in	Upper terminal
Number and diameter of sheaves	2 x 4000 mm
Requested counterweight	98 tons
Lift of counterweight	8 m

1.1.7. Electrical equipment

Tension and cycles	to be determined
Type of drive motor	DC
R.P.M.	1400
Drive System	Thyristor or Ward Leonard
Peak output of DC-motor	2 x 710 KW
Continuous output	2 x 385 KW
Control	- hand, automatic, remote

1.1.8. Telephone and safety installation

System	contactless from vehicles, over telephone rope from station to station
Number of phones	6
Number of emergency switches	6
Telephone rope:	
Number and length	1 x 3420 m
Diameter	15 mm
Type	Spiral
Weight	1,09 kg/m
Tensile strength of wires	180 kg/mm2
Breaking strength	19700 kg

1.1.9. Sundries

Roping down apparatus	
Number	4
Requested length of rope	90 m

1.2. Section II: Lowari-Pass - Ziarat

1.2.1. Topographical data

Lower terminal	Ziarat
Elevation	2363 m
Upper terminal	Lowari-Pass
Elevation	3142 m
Longitudinal profile	9/10.51119
Horizontal distance	3429 m
Difference in level	779 m
Inclined length	3545 m
Maximum slope of the track	82 %
Max distance between vehicle and ground	approx 140 m

1.2.2. Operational data

Number of load platforms	2
Carrying capacity each	18 tons
Speed: - max	6 m/sec
- over towers	6 m/sec
Time of travel	636 sec
Time for unloading / reloading	300 sec
Number of trips/hr	3,85
Carrying capacity	70 tons/hr
Max wind pressure	
- in operation	30 kg/m2
- not in operation	125 kg/m2

1.2.3. Ropes

Number of track cables	2 x 2
Length of each track cable	3750 m
Diameter	65 mm
Type	fully locked coil
Weight	23,57 kg/m
Breaking strength	444000 kg
Tensile strength of the wires	180 kg/mm2
Safety factor	3,5
Length of the lower hauling rope	3630 m
Diameter	30 mm
Type	WS
Weight	3,31 kg/m
Breaking strength	48850 kg
Tensile strength of wires	160 kg/mm2
Safety factor	5
Diameter ratio rope / deflection sheave	1 : 80
Length of the upper hauling rope	3630 m
Diameter	47 mm
Type	WS
Weight	8,17 kg/m
Breaking strength	143100 kg
Tensile strength of wires	190 kg/mm2
Safety factor	5
Diameter ratio rope / bull wheel	1 : 85,1

1.2.4. Towers and line equipment

Number of towers	6
Type	Central tower
Height of towers	34 m
	32 m
	77 m
	39 m
	28 m
	47 m
Radius of rope saddle	32 m
Number of hauling rope rollers	196
Diameter of hauling rope rollers	500 mm
Number of intermediate supports	32
Distance between intermediate supports	approx 150 m
Track gauge: Lower terminal	7,4 m
Tower 1, 2, 5, 6	10,0 m
Tower 3, 4	11,0 m
Upper terminal	9,0 m

1.2.5. Vehicles

Number of vehicles	2
Carrying capacity	18 tons
Distance between track rope and load platform	10 m
Number of rollers per carriage	32
Roller diameter	315 mm

Weights

Empty weight	9500 kg
Payload	18000 kg
Total vehicle weight	27500 kg
Max roller pressure	860 kg
Length of platform	7,5 m
Width of platform	5,5 m

1.2.6. Mechanical equipment of the stations

Track cable anchoring in	Upper terminal
Total rope load on station	4 x 127 tons
Track gauge	9 m
Distance between track cables	700 mm
Track cable tensioning in	Lower terminal
Length of roller chain	4 x 18 m
Counterweight	4 x 95 tons
Lift of counterweight	approx 11,8 m
Hauling rope drive in	Upper terminal
Type of drive	2 x ø 4000 mm
Number of grooves	2 each
Arc of contact	3π
Requested coefficient of friction	0,144/0,179
Gear ratio	48,86 : 1
Service brake, diameter	2 x 4000 mm
Safety brake, diameter	2 x 4000 mm
Hauling rope tensioning device in	Lower terminal
Number and diameter of sheaves	2 x 2400 mm
Requested counterweight	26 tons
Lift of counterweight	approx 6,5 m

1.2.7. Electrical equipment

Tension and cycles	to be determined
Type of drive motor	DC
rpm	1400
Drive system	Thyristor or Ward Leonard
Peak output of DC-Motor	2 x 850 KW
Continuous output	2 x 450 KW
Control	hand, automatic, remote

1.2.8. Telephone and safety installation

System	contactless from vehicles, over telephone rope from station to station
Number of phones	6
Number of emergency switches	6
Telephone rope:	
Number and length	1 x 3560 m
Diameter	15 mm
Type	Spiral
Weight	1,09 kg/m
Tensile strength of wires	180 kg/mm2
Breaking strength	19700 kg

1.2.9. Sundries

Roping down apparatus	
Number	4
Requested length of rope	approx 150 m

2. Technical data of the 5 ton ropeway
(Minimum solution)

2.1. Section I: Lowari Village - Lowari-Pass

2.1.1. Topographical data

Lower terminal	Lowari Village
Elevation	2591 m above sea level
Upper terminal	Lowari-Pass
Elevation	3142 m above sea level
Longitudinal profile	9/10.51118
Horizontal distance	3324 m
Difference in level	551 m
Inclined length	3401 m
Maximum slope of the track	61,6 %
Max distance between vehicle and ground	approx 90 m

2.1.2. Operational data

Number of load platforms	2
Carrying capacity each	5 tons
Speed: - max	6 m/sec
- over towers	6 m/sec
Time of travel	625 sec
Time for unloading / reloading	100 sec
Number of trips/hr	approx 4,96
Carrying capacity	24,82 t/hr
Max wind pressure	
- in operation	30 kg/m2
- not in operation	125 kg/m2

2.1.3. Ropes

Number of track cables	2 x 2
Length of each track cable	3690 m
Diameter	47 mm
Type	fully locked coil
Weight	12,35 kg/m
Breaking strength	232500 kg
Tensile strength of the wires	180 kg/mm2
Safety factor	3,5
Length of the lower hauling rope	3485 m
Diameter	35 mm
Type	WS
Weight	4,38 kg/m
Breaking strength	78500 kg
Tensile strength of the wires	190 kg/mm2
Safety factor	5
Diameter ratio rope / bull wheel	1 : 80
Length of the upper hauling rope	3485 m
Diameter	35 mm
Type	WS
Weight	4,38 kg/m
Breaking strength	78500 kg
Tensile strength of the wires	190 kg/mm2
Safety factor	5
Diameter ratio rope / deflection sheave	1 : 80

C-3551

2.1.4. Towers and line equipment

Number of towers	4
Type	Central tower
Height of towers	55 m
	24 m
	32 m
	62 m
Radius of rope saddle	32 m
Number of hauling rope rollers	120
Diameter of hauling rope rollers	400 mm
Number of intermediate supports	32
Distance between intermediate supports	approx 150 m
Track gauge: Lower terminal	8,1 m
Tower 1, 2, 4	9,0 m
Tower 3	9,5 m
Upper terminal	6,5 m

2.1.5. Vehicles

Number of vehicles	2
Carrying capacity	5 tons
Distance between track rope and load platform	8,0 m
Number of rollers per carriage	24
Roller diameter	315 mm

Weights

Empty weight	6500 kg
Payload	5000 kg
Total vehicle weight	11500 kg
Max roller pressure	442 kg
Length of platform	5,5 m
Width of platform	3,0 m

2.1.6. Mechanical equipment of the stations

Track cable anchoring in	Upper terminal
Total rope load on station	4 x 66 tons
Track gauge	6,5 m
Distance between track cables	600 mm
Track cable tensioning in	Lower terminal
Length of roller chain	4 x 18 m
Track gauge	8,1 m
Counterweight	4 x 54 tons
Lift of counterweight	approx 18 m
Hauling rope drive in	Lower terminal
Type of drive	2 x ⌀ 2800 mm
Number of grooves	2 each
Arc of contact	2 π
Requested coefficient of friction	0,149/0,200
Gear ratio	68,4 : 1
Service brake, diameter	⌀ 2800 mm
Safety brake, diameter	⌀ 2800 mm
Hauling rope tensioning device in	Upper terminal
Number and diameter of sheaves	2 x 2800 mm
Requested counterweight	54 tons
Lift of counterweight	7 m

2.1.7. Electrical equipment

Tension and cycles	to be determined
Type of drive motor	DC
rmp	1400
Drive system	Thyristor or Ward Leonard
Peak output of DC-Motor	660 KW
Continuous output	330 KW
Control	hand, automatic, remote

2.1.8. Telephone and safety installation

System	contactless from vehicles, over telephone rope from station to station
Number of phones	6
Number of emergency switches	6
Telephone rope:	
Number and length	1 x 3420 m
Diameter	15 mm
Type	Spiral
Weight	1,09 kg/m
Tensile strength of wires	180 kg/mm2
Breaking strength	19700 kg

2.1.9. Sundries

Roping down apparatus	
Number	4
Requested length of rope	90 m

2.2. Section II: Lowari-Pass - Ziarat

2.2.1. Topographical data

Lower terminal	Ziarat
Elevation	2363 m
Upper terminal	Lowari-Pass
Elevation	3142 m
Longitudinal profile	9/10.51119
Horizontal distance	3429 m
Difference in level	779 m
Inclined length	3545 m
Maximum slope of track	76 %
Max distance between vehicle and ground	approx 140 m

2.2.2. Operational data

Number of load platforms	2
Carrying capacity each	5 tons
Speed: - max	6 m/sec
- over towers	6 m/sec
Time of travel	636 sec
Time for unloading / reloading	100 sec
Number of trips/hr	4,89
Carrying capacity	24 tons/hr
Max wind pressure	
- in operation	30 kg/m2
- not in operation	125 kg/m2

2.2.3. Ropes

Number of track cables	2 x 2
Length of each track cable	3750 m
Diameter	47 mm
Type	fully locked coil
Weight	12,35 kg/m
Breaking strength	232500 kg
Tensile strength of wires	180 kg/mm2
Safety factor	3,5

Length of the lower hauling rope	3630 m
Diameter	27 mm
Type	Seale 114
Weight	2,52 kg/m
Breaking strength	43700 kg
Tensile strength of wires	180 kg/mm2
Safety factor	5
Diameter ratio rope / deflection sheave	1 : 83

Length of the upper hauling rope	3630 m
Diameter	33 mm
Type	WS
Weight	3,89 kg/m
Breaking strength	66000 kg
Tensile strength of wires	180 kg/mm2
Safety factor	5
Diameter ratio rope / bull wheel	1 : 84,8

2.2.4. Towers and line equipment

Number of towers	6
Type	Central tower
Height of towers	34 m
	32 m
	77 m
	39 m
	26 m
	47 m
Radius of rope saddle	32 m
Number of hauling rope rollers	184
Diameter of hauling rope rollers	400 mm
Number of intermediate supports	32
Distance between intermediate supports	approx 150 m
Track gauge: Lower terminal	6,5 m
Tower 1, 2, 5, 6	9,1 m
Tower 3, 4	10,1 m
Upper terminal	8,1 m

2.2.5. Vehicles

Number of vehicles	2
Carrying capacity	5 tons
Distance between track rope and load platform	10 m
Number of rollers per carriage	24
Roller diameter	315 mm

Weights

Empty weight	6500 kg
Payload	5000 kg
Total vehicle weight	11500 kg
Max roller pressure	442 kg
Length of platform	5,5 m
Width of platform	3,6 m

2.2.6. Mechanical equipment of the stations

Track cable anchoring in	Upper terminal
Total rope load on station	4 x 60 tons
Track gauge	6,1 m
Distance between track cables	600 mm
Track cable tensioning in	Lower terminal
Length of roller chain	4 x 18 m
Counterweight	4 x 50 tons
Lift of counterweight	approx 10,1 m
Hauling rope drive in	Upper terminal
Type of drive	2 x ø 2800 mm
Number of grooves	(1 x 2) + (1 x 1)
Arc of contact	2 π
Requested coefficient of friction	0,161/0,213
Gear ratio	34,2 : 1
Service brake, diameter	2800 mm
Safety brake, diameter	2800 mm
Hauling rope tensioning device in	Lower terminal
Number and diameter of sheaves	2 x 2240 mm
Requested counterweight	14 tons
Lift of counterweight	approx 5,4 m

2.2.7. Electrical equipment

Tension and cycles	to be determined
Type of drive motor	DC
rpm	1400
Drive system	Thyristor or Ward Leonard
Peak output of DC-Motor	720 KW
Continuous output	360 KW
Control	hand, automatic, remote

2.2.8. Telephone and safety installation

System	contactless from vehicle; over telephone rope from station to station
Number of phones	6
Number of emergency switches	6
Telephone rope:	
Number and length	1 x 3560 m
Diameter	15 mm
Type	Spiral
Weight	1,09 kg/m
Tensile strength of wires	180 kg/mm2
Breaking strength	19700 kg

2.2.9. Sundries

Roping down apparatus	
Number	4
Requested length of rope	approx 150 m

Station buildings

Layout

All four station buildings have been designed for the Lowari-Pass Ropeway and can be seen from the enclosed drawings as follows:

Section I:	- Lower station Lowari Village	0/1051151 a
	- Upper station Lowari-Pass	1/1051152 a
Section II:	- Lower station Ziarat	1/1051154 a
	- Upper station Lowari-Pass	0/1051153 a

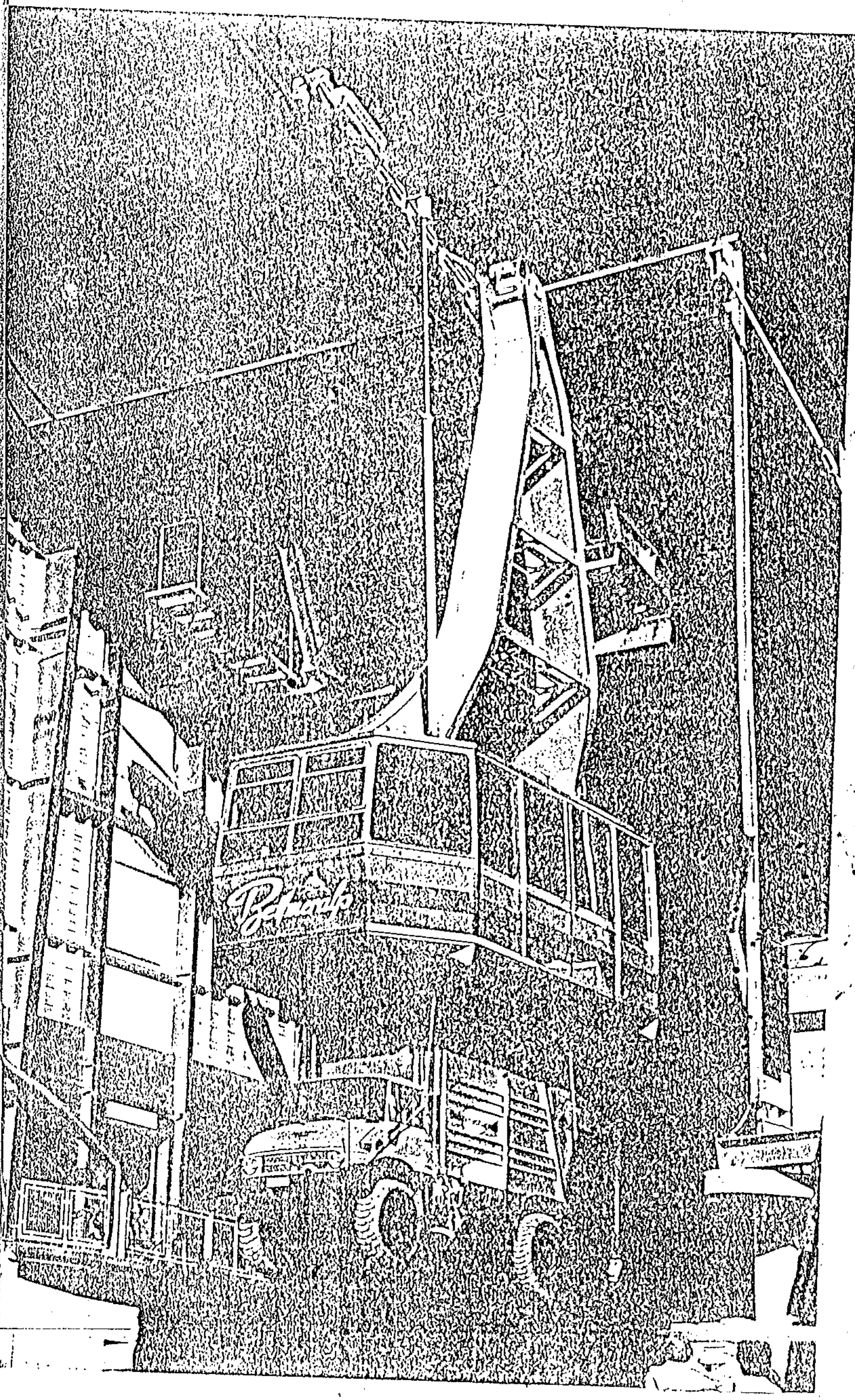
The layout shows the minimum space required for the technical parts of the ropeway. However, additional room for special purposes may be subject to discussions (e.g. transformer stations workshops, truck garage etc.).

All dimensions are indicated in meters, millimeters and the forces in metric tons.

Civil engineering

On the basis of these drawings with indicated forces the actual design of the buildings must be made by a civil engineer. He will calculate the foundations according to the soil conditions of the respective site. Furthermore a feasibility study must be made, whether the upper part of the station building will be built cheaper in concrete or structural steel. The costs will depend to a great extent on the price relationship concrete - structural steel and on the transportation costs of gravel, sand, cement and structural steel.

The picture on page 34 shows a recently built 10 ton installation forcombined freight / passenger service. This lower station building (only tensioning equipment, no drive) was built in its lower part in reinforced concrete, while the part above the platform was built in structural steel.



For this building, which was built on good soil, the following amount of concrete and reinforcing steel (structural steel not considered) was used:

Concrete	1063 m3
Reinforcing steel	96 tons

The upper station of the same installation, which has to take bigger forces and which is housing the drive, shows the following figures:

Concrete	1600 m3
Reinforcing steel	156 tons

. Earthquakes

All the buildings must be designed according to local earthquake specifications.

VI Tower foundations

Two types of tower foundations are usually used for anchoring ropeway towers.

The most applied solution is to cast at each leg a concrete block, whose size depends on the forces and the soil conditions. The structural steel of the tower is fixed by special anchor bolts.

If the tower has to be built on rock, it is in many cases more feasible to cast only a little platform in concrete and to anchor the forces by means of prestressed cables.

A local civil engineering firm will have to decide which solution may be better after having examined all tower sites.

II Costs of the ropeway

1. Costs of the mechanical and electrical components

The costs of this ropeway were calculated in detail on the basis of the carried out engineering. All items indicated in the technical description of the electro-mechanical parts were considered.

The prices refer to October 1, 1976 and are given in Swiss Francs.

They are indicated as follows:

- Mechanical and electrical parts, delivered ex works in Europe.
- Erection costs for a European crew of 10 skilled erectors including 1 supervisor, erection material such as winches and special tools for a period of 1 year (for each section).
- Erection ropeways.

Not included in these prices are:

- All civil engineering work such as station buildings and tower foundations.
- Improvement of access road to Lowari Village, reinforcement of bridges.
- Transport of the material from Europe to the site.
- Power lines to the drive stations.
- Tranformer sub-stations.
- Eventually needed avalanche protections.
- Local erection helps (approx 20 to 40 people).

1.1. Maximum solution

Prices for material ex works Europe
(in Swiss Francs)

	Section I	Section II
Ropes	2'370'000.--	2'350'000.--
Towers and line equipment	1'290'000.--	1'820'000.--
Mechanical parts	2'400'000.--	2'410'000.--
Electrical parts	895'000.--	975'000.--
Vehicles	820'000.--	820'000.--
Tools and spare parts	120'000.--	120'000.--
Total	7'895'000.--	8'495'000.--

Prices for erection

	Section I	Section II
Estimated erection time	9 - 11 months	10 - 12 months
Erection costs incl. tools	1'380'000.--	1'500'000.--
Erection ropeways	300'000.--	800'000.--
Total	1'680'000.--	2'300'000.--

1.2. Minimum solution

Prices for material ex works Europe
(in Swiss francs)

	Section I	Section II
Ropes	1'270'000.--	1'275'000.--
Towers and line quipment	1'150'000.--	1'690'000.--
Mechanical parts	1'850'000.--	1'835'000.--
Electrical parts	595'000.--	620'000.--
Vehicles	595'000.--	595'000.--
Tools and spare parts	115'000.--	115'000.--
Total	5'575'000.--	6'130'000.--

Prices for erection

	Section I	Section II
Estimated erection time	7 - 9 months	8 - 10 months
Erection costs incl. tools	1'090'000.--	1'210'000.--
Erection ropeways	300'000.--	800'000.--
Total	1'390'000.--	2'010'000.--

1.3. Summary of prices (in Swiss Francs)

Maximum solution

Material	Section I	SFrs	7'895'000.--
	Section II		8'495'000.--
Erection	Section I		1'680'000.--
	Section II		2'300'000.--
Total		SFrs	20'370'000.--

Minimum solution

Material	Section I	SFrs	5'575'000.--
	Section II		6'130'000.--
Erection	Section I		1'390'000.--
	Section II		2'010'000.--
Total		SFrs	15'105'000.--

2. Costs of the civil engineering parts

The costs of the following items have to be calculated

- 4 station buildings
- 10 tower foundations

As already indicated in paragraph V and VI it will be necessary to contact a local civil engineering office to get a cost estimat for this part of the ropeway installation.

3. Costs for power lines and transformer stations

Today electric power is available in Dir. However, the capacity of this power line is too small for the drives of the ropeway. Therefore a new pover line has to be built and extended to both drive stations at Lowari Village and Lowari-Pass.

A transformer sub-station has to be installed in each of these stations. It will change the high voltage to a lower level.

Ziarat will not need to be connected with this power line; at least not as long as the power line will be extended to the Chitral-Valley.

A small Diesel-Generator set will supply electric energy for light, hoists etc.

The costs for these items or part of them must also be considered for the ropeway.

4. Costs for road improvements and reinforcement of bridges.

The access road to Lowari-Pass will have to be improved on certain sections. The construction of this ropeway requests the trasportation of heavy parts such as ropes, transformers, electric motors and gears.

The road should carry under normal conditions loads up to 30 tons. This will need the reinforcement of certain bridges.

The track ropes will be heavier than 30 tons. But if special measures are taken (two reels, unwinding over bridges etc.) it should be possible to transport them to the site in spite of the above mentioned load restrictions.

The same applies to the tunnel clearance, which may have to be widened.

The costs for these works should be considered too.

VIII Operation costs

1. Electric power (Maximum solution)

Assuming both sections are operation 16 hours daily (two shifts, each 8 hours) the following electric power consumption has to be considered:

Number of trips / day: 16 . 3,86 = 62 trips / day

Total operating time / day: 62 . 740 sec = 764 min

Total operating time / year: 764 . 360 = 4584 hours

The power used per operating hour depends to a great extent on the load carried.
Assuming that the ropeway is loaded as follows

1/3 of operating time fully loaded up, empty down,
1/3 of operating time empty up, fully loaded down,
1/3 of operating time fully loaded up and down

the total installed electric power can be multiplied by a factor of 0,25 - 04 to get the hourly consumption - (for this example 0,3).

Total installed electric power in both drive stations:
900 + 770 KW = 1670 KW

Hourly consumption: 1670 . 0,3 = 501 KWh

Total consumption /year: 4584 . 501 = 2'300'000 KWh

Costs per year

(according to WAPDA, rates for industry, high tension supply)

Fixed charges

For 1 KW installed power: Rs 18.50 / KW / month

Per year: 1670 . 18.50 . 12 = Rs 370'740.--

Energy charges

11,0 Paisa / KWh

Per year: 2'300'000 . 11 = Rs 253'000.--

Total:		
	Fixed charges	Rs 370'740.--
	Energy charges	Rs 253'000.--
	Total	Rs 623'740.--

2. Spare parts (per year)

Roller liners

Towers		
50 % of 1 set:	200 rollers each SFrs 90.--	18'000.--
Carriage		
1 set:	112 rollers each SFrs 130.--	14'560.--
Deflection sheaves		
50 % of 1 set:	8 each SFrs 2'000.--	16'000.--
		48'560.--

Miscellaneous

Grease, small spare parts, electric spare parts

approx 30'000.--

Total SFrs 78'560.--

3. Labour

(Salaries indicated August 1974, Islamabad)

Employees	Salary per year	Total
1 Superintendant	Rs 10'000.--	Rs 10'000.--
1 Representative	8'000.--	8'000.--
4 Electricians	6'000.--	24'000.--
2 Mechanics	6'000.--	12'000.--
20 Cabin attendants	4'000.--	80'000.--
20 Auxiliary personnel	3'000.--	60'000.--
	Total	Rs 194'000.--

4. Summary

	Rs	SFrs
4.1. Electric power	623'740.--	approx 207'000.--
4.2. Spare parts	approx 235'500.--	78'560.--
4.3. Labour	194'000.--	approx 65'000.--
Total	Rs 1'053'240.--	SFrs 350'560.--

5. Operating costs per hour / ton

5.1. Per hour

Operating time: 4584 hours

Costs / hour: $\frac{1'053'240}{4584}$ = 230 Rs

5.2. Costs per ton transported from Lowari Village to Ziarat

Transported tons: 360 . 16 . 3,86 . 18 = 400'205 tons

Costs / ton: $\frac{1'053'240}{400'205}$ = 2,63 Rs

The transported volume is only considered in one direction. Theoretically both ways can be outloaded. Consequently the indicated amount of the costs will be cut into half.

Remarks:

This calculation does not consider any interest or depreciation costs.

The life times of the main ropeway parts when being used 2 shifts a day can be indicated as follows:

Structural elements (buildings, towers etc.)	over 20 years
Track cables	over 20 years
Vehicles	15 to 20 years
Drives (mechanical and electrical)	15 to 20 years
Hauling ropes	5 to 10 years

IX Construction programme

This programme is based on the assumption, that a decision will be made up to Mai 1977.

It is obvious, that the construction programme is directly depending on the conditions of the access road. Therefore this road should have a first priority to be improved.

1977

- Start access road improvements to be finished from the south side up to Lowari Village in spring 1978.
- Design and construction of the power line. To be finished up to Lowari Village in October 1978.
- Call tenders for the mechanical and electrical parts and award contracts to supplier not later than September 1977.
- Call tenders for the civil engineering parts and award contracts end of 1977.

1978

- As soon as the road is clear from snow, improvements should be made up to Lowari-Pass.
- Start building lower terminal section I to be finished in September 1978.
- Install small ropeways by supplier of mechanical and electrical equipment to tower sites where road access is impossible. Operational July 1978.
- Start tower foundations section I to be finished September 1978.
- As soon as road is improved up to Lowari-Pass start building upper terminal section I. To be finished October 1978.
- supplier of electro-mechanical equipment to work as follows:

- Start tower erection in August to be finished in October.
- Prepare pulling the ropes to be finished before end of the year.
- Start erection of mechanical and electric parts in the stations to be finished end of 1978.
- Start test runs and finish section I in January / February 1979.

1979

- Install the auxiliary ropeway to Ziarat as soon as weather and snow conditions permit this work. To be operational in June 1979.
- Start building upper terminal of section II. To be finished September 1979.
- Start building tower foundations and lower terminal Ziarat as soon auxiliary ropeway is operational. Tower foundations to be finished in September 1979. Lower terminal to be finished October 1979.
- Supplier of electro-mechanical equipment must start erection of drive and towers as soon as buildings resp. foundations are ready.
- Construction of power line to Lowari-Pass to be finished in September 1979.
- Section II to be operational end of 1979 / January 1980.

C-3551

X Conclusions

1. The main purpose of this study is to get cost figures for the ropeway.

The longitudinal profile survey has allowed to get figures of the electro-mechanical parts and the operating costs.

To contact an engineering firm to get budget figures for the buildings and tower foundations is the next step to be done.

Parallel to the above mentioned investigations the costs of the power line and the road improvements must be determined. If these figures are available the cost share for the ropeway must be fixed to get a complete idea of the total capital investment for this project.

2. The decision has to be made whether the maximum or the minimum solutión should be carried out.

The cost difference is small compared with the difference of transportation capacity. It can be expected that the same cost ratio applies also to the civil engineering parts of the ropeway.

3. If the decision is in favour of this project the following actions have to take place:

- A project management must be set up.
- The project must be cleared in all details.
- The construction concept for all parts must be fixed.
- Preparation of tender documents.
- Tender call.
- Award of contracts.

-3653 Oberhofen, January 31, 1977