

# TECHNICAL GUIDELINES FOR GRAVITY GOODS ROPEWAY



Ministry of Local Development  
Department of Local Infrastructure  
Development and Agricultural Roads  
(DoLIDAR)



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# CONTENTS

<b>FOREWORD</b>	<b>v</b>
<b>PREFACE</b>	<b>VI</b>
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 Historical background	1
1.2 Importance of technology	3
1.3 Ropeway mechanics	4
1.4 Features of gravity ropeway	5
1.5 Limitations	6
<b>2 SITE SURVEY</b>	<b>8</b>
2.1 Technical survey	8
2.2 Detailed topographical survey	10
2.3 Soil investigation	13
2.4 Photographs	15
2.5 Miscellaneous data collection	15
2.6 Survey instruments and tools	15
2.7 Human resources	16
2.8 Survey report	16
<b>3 DESIGN</b>	<b>17</b>
3.1 Wire ropes	17
3.2 Mechanical components	23
3.3 Foundation design	25
3.4 The design team and qualification	26
<b>4 DRAWING</b>	<b>27</b>
4.1 Drawing and design verification	27
<b>5 ESTIMATING AND COSTING</b>	<b>28</b>
5.1 Estimating	28
5.2 Costing	28
<b>6 PLANNING AND SCHEDULING</b>	<b>29</b>
6.1 Types of planning	30
<b>7 EXECUTION AND INSTALLATION</b>	<b>32</b>
7.1 Layout	32
7.2 Excavation for foundation and anchor block	33
7.3 Construction of masonry wall	33
7.4 Construction of gabion wall	34

7.5	Mixing, placing and curing concrete	34
7.6	Sheave alignment fixing	37
7.7	Erection of wire ropes	37
7.8	Sheds	39
7.9	Landing platform	39
<b>8</b>	<b>CONSTRUCTION RECORDS</b>	<b>41</b>
8.1	Time sheets	41
8.2	Design modification or work alteration record	41
8.3	Site instruction book	42
8.4	Site diary	42
<b>9</b>	<b>OPERATION AND MAINTENANCE</b>	<b>43</b>
9.1	General safety precautions	43
9.2	Components needing special care	44
9.3	First aid	46
9.4	Tools	46
<b>10</b>	<b>COMMUNICATION</b>	<b>47</b>
10.1	Telephone	47
10.2	Hoarding/notice boards or information board	48
<b>11</b>	<b>INSTITUTIONAL ARRANGEMENT</b>	<b>49</b>
11.1	Policy level	49
11.2	Planning level	50
11.3	Implementation level	50
11.4	Institutional capacity building requirements	52
<b>12</b>	<b>ENVIRONMENTAL ASSESSMENTS</b>	<b>53</b>
12.1	Socioeconomic and cultural impact	53
12.2	Biological impact	54
12.3	Physical impact	54
12.5	Recommended mitigation measures	54
12.6	Check list for environmental parameters	54
<b>ANNEXES</b>		<b>55-129</b>
<b>ACRONYMS</b>		<b>130</b>
<b>GLOSSARY OF TERMS USED</b>		<b>131-134</b>



Government of Nepal  
Ministry of Local Development  
Department of Local Infrastructure Development and Agricultural Roads

(DoLIDAR)

Jawalakhel, Lalitpur

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## FOREWORD

Physical isolation is one of the major development challenges of Nepal. Until the 1950s, trails and mule tracks were the only means of transportation for accessing services including delivery of farm produce. The situation is similar for many mountain districts even today. The harsh topography hinders the construction of transport infrastructures forcing people to carry their loads physically to transport their goods. An estimated 36 per cent of Nepal's population live at least two hour walk from the nearest all season road, 50 per cent live at least four hours walk from the nearest dry season road where a bus or jeep may transit; and only about 30 per cent have access to all season transportation services.

Despite huge efforts from DoR, Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR) and various other organizations working in transport sector, the conventional way of access (roads, bridges etc.) is unlikely to meet the tremendous need for immediate improvement in access due to very scattered settlements and other natural obstructions. Construction of roads is generally capital intensive and time consuming, thus complementary access infrastructures may be a viable solution for isolated communities in the rural hills of Nepal. The Local Infrastructure Development Policy 2061 and Agricultural and Local Level Road Implementation Guideline 2063 devised by Government of Nepal (GoN) Ministry of Local Development has recognized gravity goods ropeway as one of the local means for access and is categorized under class "E".

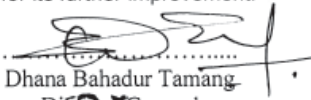
It is in our notice that Practical Action Nepal Office, in association with International Centre for Integrated Mountain Development (ICIMOD), successfully demonstrated first gravity goods ropeway technology in Marpha, Mustang District in 2001. The gravity goods ropeway helped transport apples from orchards to trail heads. Since then Practical Action Nepal Office has been promoting gravity goods ropeway technology as a complementary means of transport systems in Dhading, Gorkha, Tanahu, Kalikot and Achham Districts and has already installed 12 gravity goods ropeway systems.

Thus gravity goods ropeway, due to its intrinsic characteristics, seems to be one of the promising alternatives to improve access in rural Nepal from social, economic and environmental aspect. Major advantages of gravity goods ropeway technology over conventional access are:

- High social acceptance since it overcomes mountainous and hilly terrain adversities
- Lower installation, operation and maintenance cost
- Does not require any external power to operate
- No adverse effect in the environment
- Does not disturb existing ecology since it neither destabilises mountain slopes nor spoils nature's beauty and resources

Indeed, I am very delighted that the long awaited guidelines is ready for use now. This "Technical Guidelines for Gravity Goods Ropeway" is jointly developed by DoLIDAR and Practical Action on the basis of Practical Action's hands on experiences in gravity goods ropeway installation in Nepal to help rapid development of such simple infrastructure for enhanced access in the isolated areas. This guideline aims to facilitate in survey, design, construction and operation and maintenance of gravity goods ropeway technology within and outside Nepal in similar mountainous terrains.

On behalf of DoLIDAR, I would like to express my sincere gratitude to Practical Action for this initiative and all members of the technical and working team for their effort to standardisation of gravity goods ropeway technology within the department. We will welcome any constructive suggestions for its further improvement.

  
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## PREFACE

Good access to resources is the most fundamental requirement for securing sustainable livelihoods. In the past road building has often played a central role in interventions aimed at improving access. But in Nepal, the construction of roads is exceptionally challenging, technically, economically and environmentally. Nepal's rugged terrain and rich but fragile ecosystem make connecting settlements by road often ill advised both in terms of resource use and with regard to environmental conservation. Furthermore, roads alone cannot guarantee access to services for the most marginalised and therefore are not effective at combating poverty. In order to improve access for the poor, innovative solutions must be sought.

Complimentary means of transport offer the opportunity to have immediate effect on the poor's access to resources. For marginalised people in the hills and the mountains, complimentary means of transport build on the benefits of the existing transport infrastructure to link them to essential resources in ways that road building cannot.

Practical Action Nepal Office commenced its transport programme, focusing on complementary means of transport in 1998. Suitable technology, affordable and easy to maintain by local communities themselves, and thus sustainable, is the cornerstone of the programme. The gravity goods ropeway is one example, designed to link villages in hilly and mountainous locations to the wider transport infrastructure, using only the power of gravity.

Complimentary means of transport have supported better market linkages, increased income generating opportunities, improved access to health and education services, and has fostered better community relations.

Over the course of the installation of over a dozen gravity ropeways in Nepal, from the first in Mustang District in 2002-03, Practical Action Nepal Office has learnt from its experiences, continually improving the design of the systems, making their operation more efficient and safer. Practical Action Nepal Office is convinced that this technology needs wider application to bring about positive changes to countless more rural people's lives. The growing interest in this technology from many donor organisations and government department is testament to its vast potential. Practical Action Nepal Office welcomes these organisations' approaches for technical assistance to upscale the technology.

Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR), fully convinced of the technology worth after discussions and meetings with Practical Action Nepal Office, began promoting it by forming a technical committee comprising of specialists from both the organisations. The results are these technical guidelines which reflect DoLIDAR's commitment to integrate the technology into its annual programme. Practical Action Nepal Office is confident that the guidelines will be a milestone in promoting complementary means of transport, and gravity goods ropeway technology in particular, and will have a considerable impact on the lives of many rural people.

Finally, I express my sincere thanks to the working team of DoLIDAR, technical team of Practical Action Nepal Office and Fundraising and Communications Unit for finalising language, layout and coordinating production of this publication.

Achyut Luitel  
Country Director



# INTRODUCTION

1

## 1.1 Historical Background

The ropeway – a rope based transport system – is one of the oldest means of transportation system. The principle of rope based transport system was known even in ancient times. The early Chinese historical drawing in Figure 1 shows, this technology has been in use for goods and human transportation since early 250 B.C.

Modern ropeways started in Europe, particularly in Germany, Austria and Switzerland and later, in Italy and France. Fausto Veranzio of Venice developed a bi rope passenger ropeway in early 1616. Later, in 1664, Wybe Adam, a Dutchman, constructed the first successful operational ropeway system. Ropeways developed rapidly with the introduction of wire ropes and later with the electricity driven ones. Extensive use of tramways during World War I between Italy and Austria in mountainous terrain paved ways for developing and adapting this technology into reliable transportation system for carrying goods and people.

During the course of the industrial revolution, the invention of steel ropes by the German mining official, Albert in 1834, opened up the rapid development of various types of rope based transportation systems.

The first ropeway in Nepal was constructed in 1924 to carry stones from the quarry from Halchowk

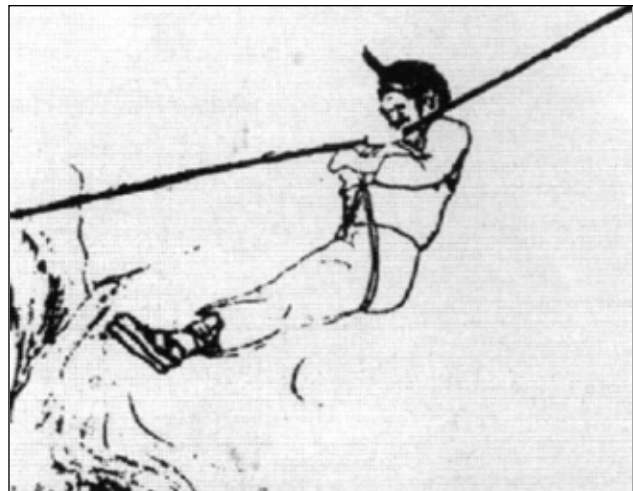


Figure 1. Brush drawing of a Chinese aerial ropeway dated 250 B.C.

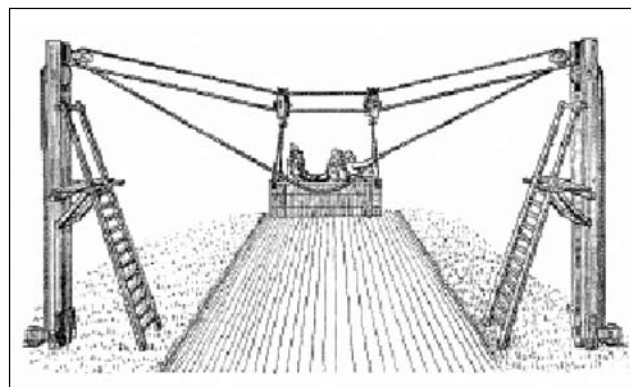


Figure 2: Ropeway of Faustus Verantius on historical example (16<sup>th</sup> century)



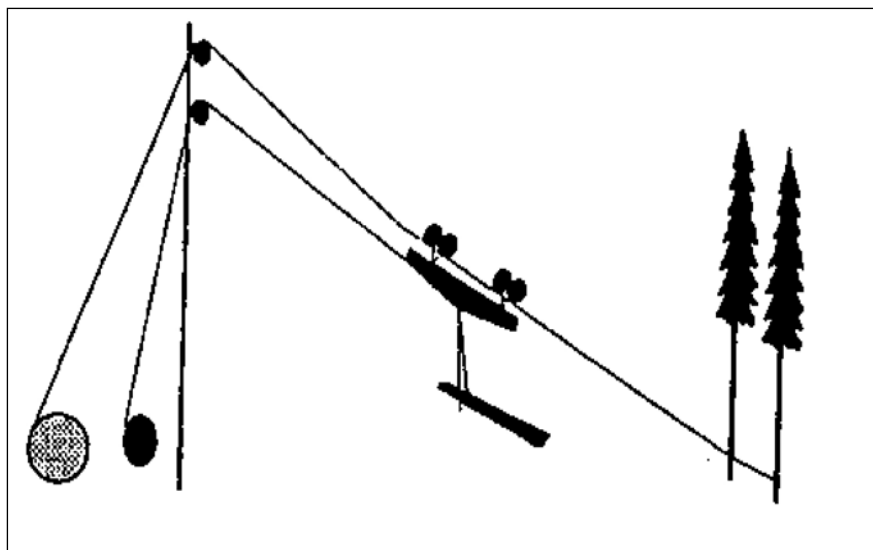


Figure 3 : Anton Trzesnioswski, wood transport in steep terrain

to Lainchour (4 km) for the construction of Rana palaces.

The second ropeway (22 km) was constructed in 1927 from Dhorsing (Bhimphedi) to Matatirtha (Kathmandu). Later in 1947, it was extended to Teku (+6.5 km).

The third ropeway replacing the second started to operate from Hetauda to Kathmandu (45 km) in 1964 to transport cement from the factory in Hetauda to Kathmandu which owned and operated by the then Nepal Government. Due to issues related to management, and operation and maintenance, the ropeway is not currently in operation.

Practical Action Nepal Office (then ITDG) initiated a study on ropeways in 1994. The first conceived project for Ghandruk to Syauli Bazaar (4 km) did not materialise. However, in 1998, it succeeded to construct Barpak - Rangrung goods ropeway (2.5 km) operated by a microhydro power plant in Gorkha District. Due to operational negligence, a fatal accident resulted in the death of a person who was travelling on the trolley. From then on, the ropeway is not in operation.

Nevertheless, its application is not limited to forestry/mining sector alone as it is also being used for transportation of local produces to markets and road head. Gravity ropeways are operational at many places in Himachal and Uttaranchal states of India for transportation of goods.

In 2001, Practical Action Nepal Office, in association with International Centre for Integrated Mountain Development (ICIMOD) successfully demonstrated gravity goods ropeway technology in Marpha of Mustang District. It was first of its kind in Nepal which was used for apple transportation directly from the orchards to the trail heads. With this start, Practical Action is promoting this technology as a complementary means of transport systems in rural Nepal by modifying and advancing it for increased safety and technical efficiency.

Gravity ropeway is the simplest form of rope-based transportation system. Over hundreds of years, gravity ropeways of various types have been used for timber transportation in mountainous countries like Switzerland. Gravity ropeways are still important means of timber (from forests) and stone (from quarries) transportation in various parts of the world. These systems are still being used to cross rivers and valleys in Columbia and Latin America.



Photo by Paul Starkey

Photo 1: Rope transport used for crossing valley at Chirajaya, Bogotovillavicencio, Columbia

## 1.2 Importance of Technology

Nepal is characterised by its hills and mountainous topography and highly difficult hydrogeological conditions. Eighty three per cent of the country's area consists of mountains and hills. Difficult terrain, poor accessibility coupled to sparse and scattered settlements is a major hurdle in delivery of essential services and rural development. Up to the late 1950s, foot and mule trails were the only means of transport throughout Nepal. Since then, efforts have been made to connect various parts of the country by developing road networks. The efforts largely remain inadequate and progress is sluggish. According to road statistics, Nepal's main strategic road network is about 18,828 km with a road density of 12 km per 100 km<sup>2</sup> and the population served per kilometre is therefore approximately 1400 (DOR, 2006/07). In addition, there are about 5,000 km of village and agriculture roads, bringing the total road network to around 24,000 km. This however varies significantly in urban and rural areas. About 60 per cent of this road network is concentrated in the plain areas of the country. Earthen roads in the hills and mountains become unsuitable for vehicular traffic during the rainy seasons. Unregulated plying of all kinds of heavy vehicles and inadequate maintenance make the roads unserviceable. Some six million people still need to walk a minimum of four hours to reach the nearest road head.

In the present context when some district headquarters still remains to be connected by the road network, it is unlikely that the road network will expand to each remote settlements of Nepal for several decades from now. So, it is

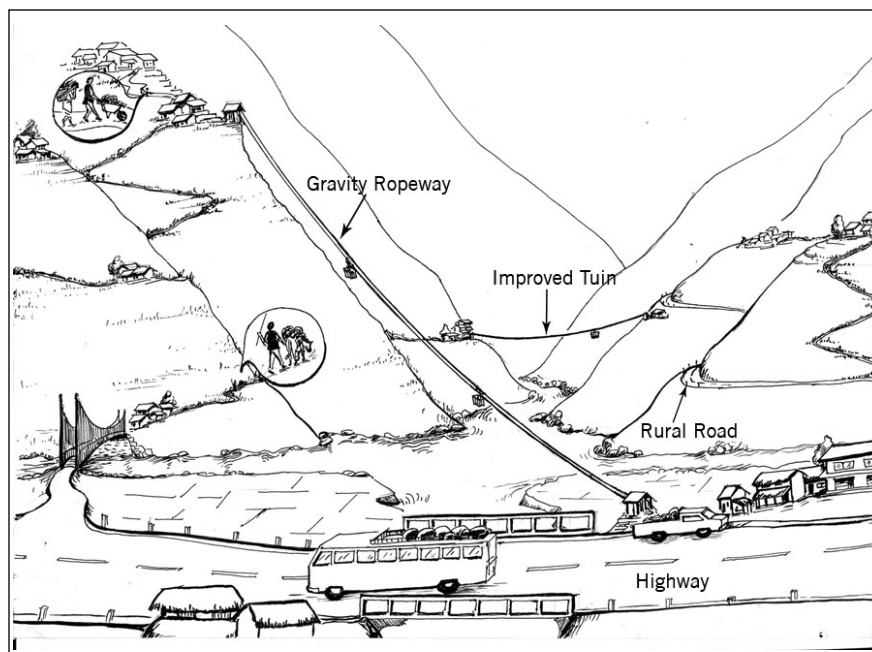


Figure 4: Niche of ropeway on overall rural transportation scenario

imperative to introduce a more affordable means of transportation to lessen the burden and reduce the frustration of the rural communities.

Gravity ropeway, due to its intrinsic characteristics, is one of the promising alternatives to improve access in rural Nepal from the social, economic, geographical and environmental point of view. This technology taps the comparative advantages of the mountainous and hilly terrains to overcome their adversities. As it is relatively lower in cost in comparison to building roads and employs a very simple technology, it is both affordable and adaptable. Gravity ropeways neither require any external fuel or power nor are they polluting. The operating costs are lower as compared to other technology such as building roads and rails. The environment is less adversely affected as it requires less construction works on the ground except for laying out of simple foundations to anchor the ropes. It neither destabilises the mountain slopes nor spoils nature's beauty and resources. Moreover, it causes no harm to the existing ecology.

Rural economy in Nepal is largely based on subsistence agriculture. Without allocation of resources by the central government, infrastructure development at the local level is almost impossible. Due to this fact, the rural communities from ages are facing rather exhausting, time consuming and often dangerous journeys to access basic services like administrative, health and education facilities, and access to markets to sell their produces. Each year substantial quantities of surplus agricultural produces perish due to lack of adequate infrastructures and facilities to transport them to the markets in time. As such, rural communities survive with subsistence agriculture despite the huge economic and market potentials. Gravity ropeway facilitates the transport of local produces to the road heads and market centres, thus encouraging the communities to engage in commercial farming.

As the travel time is less than two minutes to bring down the goods from village to markets downhill, perishable goods can be transported to the markets in no time which considerably prevents them from getting rotten. Gravity ropeway can be an economical solution to transport goods to the hills and valleys and vice-versa. Export of greater quantity of local produces from the village and import of lesser quantity of outside materials to the village will be an ideal condition to install a gravity ropeway which will ultimately promote local produces and help boost the local economy.

Gravity goods ropeway is not an alternative to road transportation but it rather add values to the existing road network by complementing it in goods transportation from the remote locations to the road head. Therefore, gravity ropeways should be an integral part of the District Transport Master Plan (DTMP) for the mountainous and hilly districts.

### 1.3 Ropeway Mechanics

The mechanics of the gravity ropeway works on a very simple pulley system. It consists of two trolleys, rolling over two separate steel wire ropes (track ropes) supported and suspended over two separate towers at the top and bottom ends. The two trolleys that slide on the track rope are connected to a single looped wire rope (hauling rope) of a smaller diameter by means of rope ties. This hauling rope passes around a cast iron sheave at the top and bottom stations. When the loaded trolley rolls down by its own weight along one track rope from the upper station, another trolley with lighter weight at the bottom station hauls up along the next track rope as they are connected to the hauling rope. A simple brake with a rubber/wooden brake shoe is fitted to the sheave at the lower station to regulate the speed of the moving trolleys.

As a rule of thumb, the weight ratio of downward to upward moving load is 3:1. However, the ratio varies according to the slope of the site and precision maintained during installation of gravity ropeway. Hence, the proper loading ratio per site should be carefully evaluated after the gravity ropeway comes into operation and should always be maintained within the ratio prescribed.

Theoretically, the velocity of trolleys at each point along the route corresponding to the given loading ratio can be obtained from the following equations or relations.

Let us suppose  $m_1$  be the mass of downward moving trolley with load and  $m_2$  be mass of upward moving trolley with load. Here,  $m_1$  is always greater than  $m_2$ .

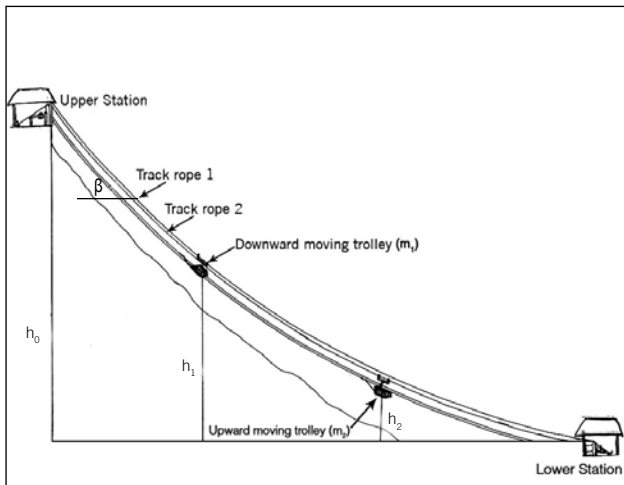


Figure 5

Here,

- I. Initial potential energy of downward moving trolley ( $PE_0$ ) =  $m_1gh_0$ , where  $h_0$  is the elevation difference between the upper and lower saddles;
- II. Potential energy of downward moving trolley at the point of consideration ( $PE_1$ ) =  $m_1gh_1$  where  $h_1$  is the height of the first trolley from lower saddle at the time of consideration;
- III. Potential energy of upward moving trolley at the time of consideration ( $PE_2$ ) =  $m_2gh_2$ ,  $h_2$  is the height of  $m_2$  from lower saddle at the time of consideration;

IV. Combined work done by the masses against the friction ( $W_1$ ) =  $0.25(m_1+m_2) \cos\beta S$  where  $S$  is the rope length covered by the trolleys at the time;

V. Combined Rotational Energy of sheaves ( $W_2$ ) =  $I \omega^2$ , where  $\omega = v/r$ ,  $I = \frac{1}{2} mr^2$  where  $r$  and  $m$  are the radius and mass of the sheave respectively.

Now, as per the principle of conservation of energy,

$$0.5 (m_1+m_2+m_h) v^2 = PE_0 - PE_1 - PE_2 - W_1 - W_2$$

Here,  $m_h$  is the mass of the hauling rope.

From this relationship, the velocity of moving trolleys at specified time and point along the route can be calculated. The actual velocity for a given loading condition is usually less than the velocity obtained from this relationship. As the track rope and hauling rope are not parallel to each other in vertical plane, the hauling rope is pulled towards the track rope while the gravity ropeway is in operation. This leads to the excessive friction between the hauling rope and the sheave which leads to the loss of velocity. Nevertheless, the idea of tentative approaching velocity of the trolley helps to calculate the maximum possible impact load which is very important for the rope design.

## 1.4 Features of Gravity Ropeway

The followings are the features of gravity ropeway which makes it suitable in the hills and mountains of Nepal.

- **Cost effectiveness:** Construction and installation cost of gravity ropeway is lesser than other conventional means of transport like roads and railways. The approximate cost of the gravity ropeway is Rs. 1,400,000 where as per kilometre construction cost of a four metre

wide earthen road in the hills is approximately Rs. 3,000,000.

- **Time saving:** As goods can be transported through gravity ropeway within few minutes, it is efficient and time saving.
- **Short route:** In the case of roads or railways, alignments are usually winding to acquire required gradient which makes the route

longer and costlier. Unlike those, as the rope of gravity ropeway is suspended in the air, the alignment is straight which results in a short route.

- **Energy efficient:** Gravity ropeway operates solely from the gravitational force. It does not require any external power or fuel. This is very important for a country like Nepal where we can save costs by reducing the import of fossil fuels for air and surface transports.
- **Environment friendly:** Gravity ropeway is environment friendly technology. It neither causes noise nor air pollution. It does not disturb ambient environment and the existing ecology. It has no or negligible impact on the surrounding environment as it does not require heavy cuts and fills as in case of building motorable roads. The alignments are worked out very carefully in order to avoid the

clearance of trees and vegetation. Being a low cost technology, as per existing regulation, the Initial Environmental Examination (IEE)/ Environmental Impact Assessment (EIA) for gravity ropeway installation is not required.

- **Simple technology:** Gravity ropeway employs very simple and robust technology which can be operated and maintained by local communities. It does not require external experts apart from the inputs and technical facilitation in surveying and designing, which can also be done by local engineers and technicians.
- **Nominal operation and maintenance cost:** As the gravity ropeway does not require any fuel or highly skilled manpower for its operation and maintenance, its running and maintenance costs are nominal.

## 1.5 Limitations

Like all other technologies, gravity ropeway also has some limitations which are discussed below:

- **Span:** Through the learning experience of Practical Action, the span of gravity ropeway is currently limited to 1500 metres for operational efficiency and safety. When the span exceeds over 1500 metres, the tension due to the self load of the wire rope increases as it is suspended between two points only. In addition, the energy loss due to the friction will be more in longer span ropeways. Therefore, for safety and efficiency, the span of gravity ropeway is recommended to the limit of 1500 metres only.
- **Slope:** One of the limitations of gravity ropeway is that it cannot be operated in a gentle slope. Experience shows that it requires at least 15 degrees of slope to operate smoothly. The

upper limit can go as high as 40 degrees if proper loading ratio is maintained and an arrangement to prevent derailing of the trolleys from the track ropes is placed. However, according to current practice, preferable slope for gravity ropeway is from 20 to 30 degrees.

- **Up hauling capacity:** Gravity ropeway is mainly for transporting produces from hilly villages to the road/trail head markets. It has very limited capacity to haul up goods from the market to the villages up in the hills. As a rule of thumb, the downward moving load should be three times heavier than the upward moving load.
- **Loading ratio:** The speed of the trolley in gravity ropeway is mainly dependent on the slope and loading ratio along with several other factors including application of lubrication in the pulleys and wire ropes, and application

of brakes. The loading ratio should be well maintained so that the trolleys approach the respective stations with minimum speed but will not stop in between. Actual loading ratio should be carefully evaluated after the test operation of the gravity ropeway and the recommended ratio should always be maintained. If the loading ratio is not properly maintained, the trolley moving downward may approach with excessive speed. Failing to apply brake can result in a ramming impact at the bottom station risking the safety of

the haulage rope and other accessories and even endangering the life of the operator. Sometimes because of loading imbalance, the trolleys do not move with required speed and energy to haul loads up and down the stations requiring manual pulling of the hauling rope. Therefore, the operators need to be fully trained to make proper load balance between two trolleys while operating the gravity ropeway. Measuring/weighing equipment are essential to weigh the loads at both stations before it is put into operation.



# 2

## SITE SURVEY

Survey is the basis for needs assessment, proper site identification, and design and planning of gravity ropeway which forms the main source of guidelines for its construction. Social, economic and environmental factors, and technical parameters are assessed during the survey to ensure that the gravity ropeway is technically sound, economically viable and socially acceptable, and has little or no impact on the surrounding ecology and environment. As the main objective of the gravity ropeway is to improve the reach of rural agricultural commodities to the markets, information regarding the production potential from the villages, their potential markets and market linkages are equally important. Therefore, these components are also given due importance during the gravity ropeway survey. A sample of gravity ropeway survey form/check list is given in Annex 1. The survey form is designed to collect following information:

- Technical datas
- Spatial information including maps with elevations
- Socioeconomic data
- Institutional capacity
- Existing transportation facilities
- Market and market linkages
- Environmental information

Social acceptability and economic viability are the pre conditions for gravity ropeway installation. Therefore, socioeconomic survey should precede technical survey and the latter should be carried out only after ascertaining economic viability of the site. The social and economic aspects of the gravity ropeway are dealt in separate guidelines. This guideline focuses only on the technical aspects of the gravity ropeway.

### 2.1 Technical Survey

#### 2.1.1 Site selection

A rigorous site assessment is necessary to identify the suitable alignment for gravity ropeway. The alignment should be routed so effectively that it does not compromise with any technical parameters and has minimal impact on existing ecology and environment. When designing the

route of the gravity ropeway, due regard shall be given to the effect on/from existing neighbouring build up areas such as roads, electric power lines, buildings, bridges, slope stability, and natural habitats. Adequate consultations with concerned organisations and most importantly with local communities should be done during site selection.

### 2.1.2 Alignment

The following points must be considered while selecting an alignment for the gravity ropeway:

#### A) Profile

- As far as possible, the ropeway line should intersect the contour lines at right angles. If the cross slope is unavoidable, the line must be on the lower part of the cross slope (refer to the attached schematic diagram).

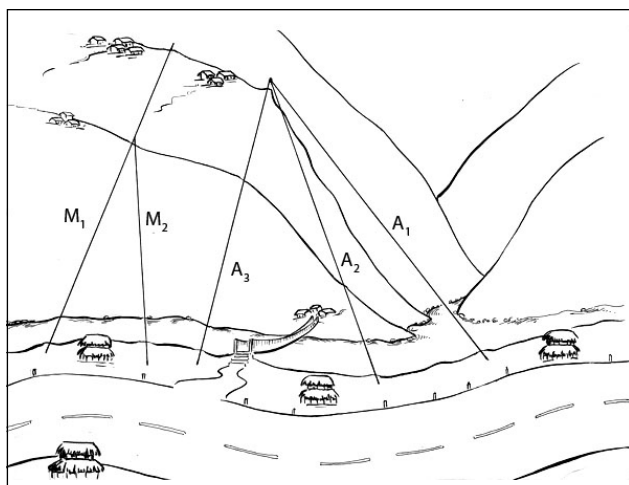


Figure 6

A= Single span ropeway

M = Multi span ropeway

A1- Preferred alignment

A2 - Less preferred (ok only in unavoidable condition)

A3 - Not preferred

M1= Correct alignment for multi span ropeway

M2 = Wrong alignment for multi span ropeway

- Maximum gradient of the rope shall not exceed 45 degrees at the highest possible loading conditions.
- In a multi span ropeway, the ropeway alignment should be in a straight line in plan. However in special cases, deflection up to two per cent per support/tower may be provided where the support/towers are located in a very gentle arc having minimum radius of 5000 metres.

- The position of the lower station is usually selected in the neighbourhood of a road or market centre. Similarly, the upper station is preferred on a suitable plateau near the hill top with close vicinity to villages.

#### B) Clearance

One of the main difficulties in planning the ropeway layout along its alignment is to ensure suitable clearance between the base of the trolleys and the ground level or the structure above the ground.

- The minimum clearance between the ground and the base of the trolley while moving above the ground shall not be less than five metres even in the most unfavourable operating conditions.
- Wherever the ropeway passes over the forests, a minimum clearance of 7.5 metres should be maintained on either side of the route.

#### C) Crossing

The alignment of the gravity ropeway should maintain suitable lateral clearance with all possible structures that can be affected by installation of ropeway such as settlements, electric transmission lines, trails and roads, bridges, cultivated land and other service infrastructures. This requirement is necessary to avoid any risk of accidents like objects falling from the moving trolleys and breakage of wire rope. If the crossing is unavoidable, proper risk assessment should be carried out and appropriate safety measures should be guaranteed during its installation and operation.

### 2.1.3 Site geology and bank stability

- It is important to locate the gravity ropeway stations on visibly stable and flat land. The areas exposed to the dangers of natural forces (avalanches, landslide, rock fall and storms) shall be avoided as far as possible. If the danger is unavoidable, suitable protection measures need to be taken.

## 2.2 Detailed Topographical Survey

The detailed topographical survey of a gravity ropeway site serves the following two important functions:

- It provides the detailed map of the ropeway site and surrounding areas, giving all the details of those features which are important while designing gravity ropeway. Existence of adjoining structures, obstructions and terrain characteristics are obtained from the site tachometric survey.
- The site tachometric survey provides definite, secured and well documented axis pegs. These pegs will be used while laying out the foundation blocks of the gravity ropeway during construction.

If the ropeway alignment is perpendicular to the contour, then the survey of profile along the centre line will be sufficient. But in case of transverse slope, the surveyor needs to record the cross sections at certain intervals of the cross sections or slope.

### 2.2.1 Tachometric survey:

Tachometric survey calculates the elevations at different points along the alignment of ropeway to get the ground profile for the centre line of

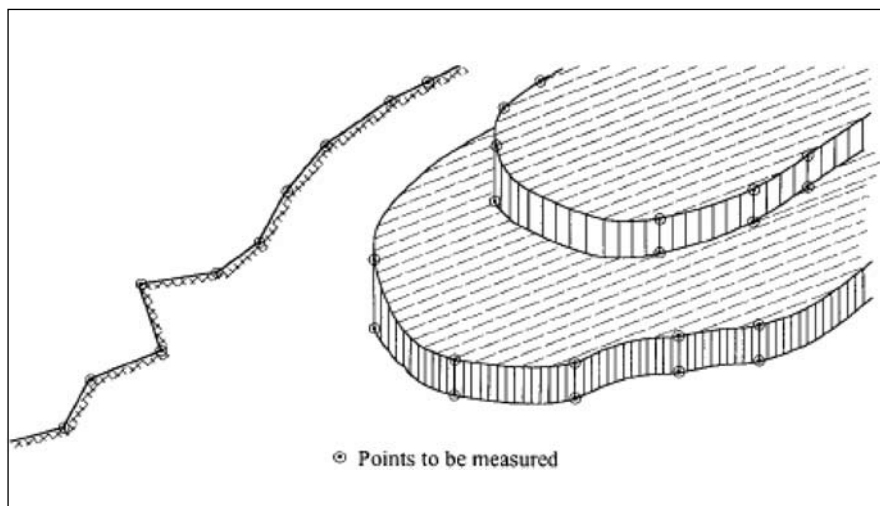


Figure 7



Figure 8: Schematic diagram of Theodolite

the ropeway alignment. The survey points (staff points) should be taken at different intervals of slopes, terraces, fields and other features representing the actual topography of the ground as shown in the sketch below in figure 7.

The procedure for survey is as follows:

- Once the ropeway alignment is finalised, fix the centre line of the gravity ropeway securing two permanent pegs A and B at the estimated position of the sheave at each station. The pegs should be firmly fixed into the ground so that it remains intact throughout the construction period. For each peg A and B, choose at least three point of references each in 10 metres intervals. Measure the horizontal distances from the points of

references to the pegs, using a measuring tape. Record the position of peg points from the reference points and sketch the details.

- Set up the theodolite on the permanent peg point A or B and sight another peg point.
- Set the zero reading of a horizontal circle and measure the height of the instrument.

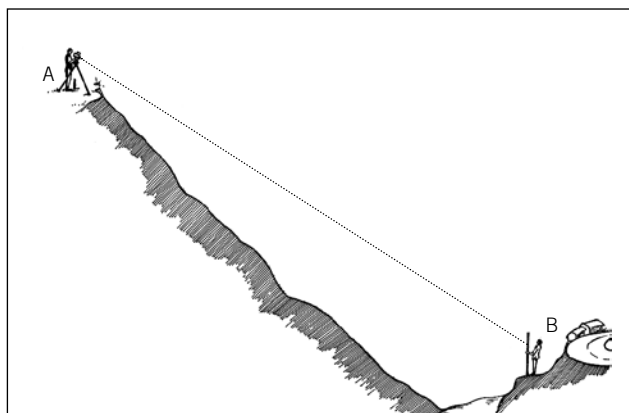


Figure 9

- Locate surveying point 1 with the help of ranging rod/staff and take the readings of the vertical circle, the top hair, the middle hair and the bottom hair, after proper sighting to the respective survey point.
- Record the readings into the “tachometry” survey sheet as shown in table 1.

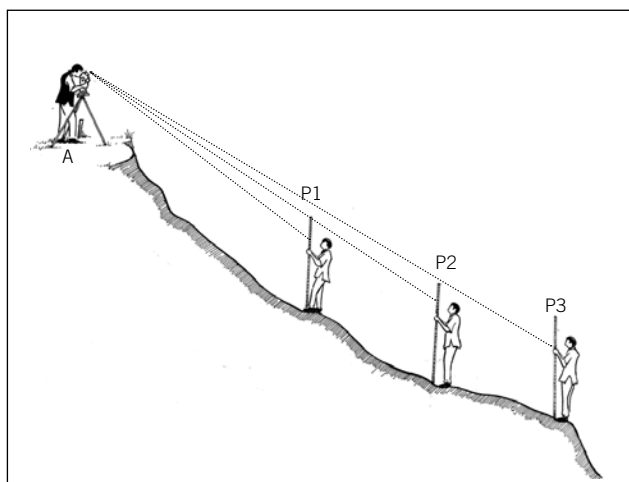


Figure 10

- Cover as many points as possible along the axis from the station, then shift the instrument to the last surveying point.
- Set up the theodolite on the point and sight towards previous station and set zero. Then, measure the instrument height (HI).
- Transit the theodolite and locate a survey point on the axis.

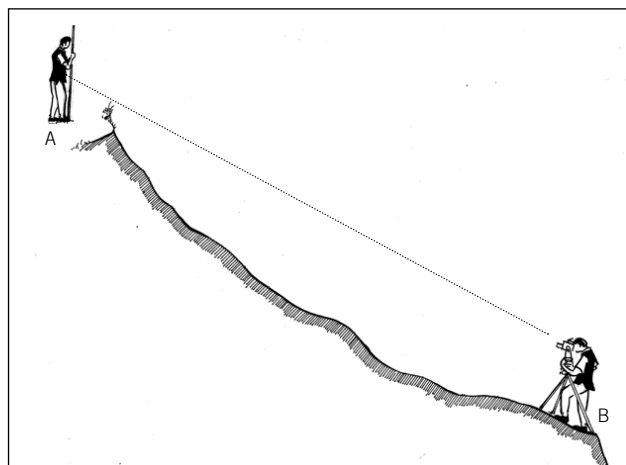


Figure 11

- Take the reading of the vertical circle, the top hair, the middle hair and the bottom hair, after proper sighting at respective survey points.

10. Now, repeat the steps 5, 6, 7 and 8 throughout the axis of the ropeway.

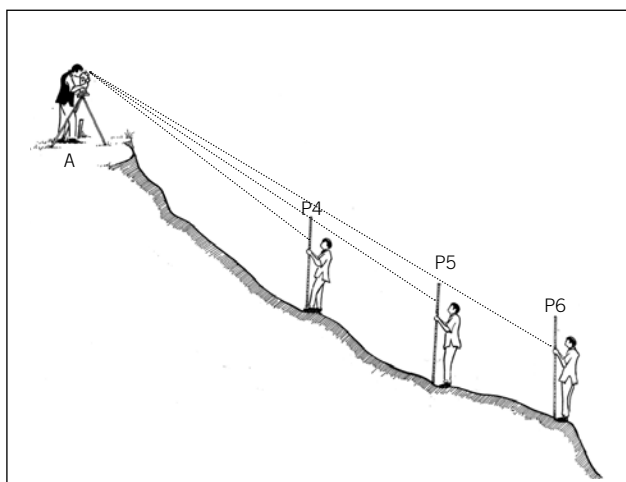


Figure 12

Table 1: Tachometry survey sheet

$$\ell = \ell_1 - \ell_2$$

$$D = 100 \times \ell \times \cos^2 \phi = 100 \times \ell \times \sin^2 \beta$$

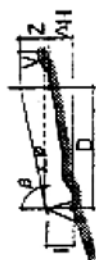
$$V = 50 \times \ell \times \sin 2\phi = 50 \times \ell \times \sin 2\beta$$

$$\text{or } V = D \times \tan \phi = \frac{D}{\tan \beta}$$

$$H = \text{R.L. of Station} \pm \Delta H$$

$$\Delta H = V + Z + I$$

$$\Delta H = V + Z - I$$



STATION	HEIGHT OF INSTRUMENT, I m	HORIZONTAL CIRCLE		VERTICAL CIRCLE		TOP HAIR $\ell_1$ m	MIDDLE HAIR z m	BOTTOM HAIR $\ell_2$ m	STAFF INTERCEPT $\ell$ m	HORIZONTAL DISTANCE D m	VERTICAL DISTANCE +/- V m	DIFF. IN ELEVATION +/- ΔH m	REDUCED LEVEL H m	REMARKS (Description of Staff Station)
		g/°	c/°	g/°	c/°									
B/1-17		3928	680	107	07	45	120	85	60	2	13	116	-0189	10026
A		0000	000	100	31	13	700	73	50	1	27	0	-0138	10077
R/B		3946	70	102	47	0	193	0	126	50	60	1	-0525	09690
4		3924	20	103	38	21	43	0	76	50	10	1	-0664	09550
5		3924	18	104	12	0	150	0	85	00	20	1	-0807	09408
6		3947	08	104	82	0	168	81	04	40	0	1	-0958	09256
7		3915	40	107	48	0	147	0	83	50	20	0	-1445	09270
8		3945	20	107	15	0	134	0	72	00	10	0	-1332	09283
9		3972	60	106	32	0	127	80	68	30	10	0	-1222	09293
10		3951	3	108	96	2	130	00	75	00	20	0	-1486	09229
11		3982	77	110	23	6	111	60	60	80	10	0	-1549	09266
12		3920	53	111	56	11	20	61	00	40	0	1	-1759	09455
13		3968	50	106	44	15	50	92	50	30	0	1	-1228	09387
14		3980	80	106	24	0	189	81	29	30	70	0	-1179	09335
Axis		0000	000	105	26	0	176	00	118	00	60	0	-0955	09260
Axis		0000	000	104	75	2	158	00	79	10	20	0	-0839	09375
Axis		0000	000	103	30	17	00	109	50	50	0	1	-0619	09596
18		3983	26	104	41	2	140	00	80	00	20	0	-0792	09423
19		0043	40	103	57	0	128	00	79	00	10	0	-0622	09593
20		0074	30	102	66	0	188	00	129	00	70	0	-0487	09718
21		0111	27	100	37	0	196	01	33	00	70	0	-0089	09126
22		0128	52	099	07	8	165	00	87	50	30	0	-0215	09430



The surveying points should be chosen where there is a change in slope. The distance between the two consecutive surveying points should not be more than 30 metres unless there is an abrupt change in slope. In case of vertical drop, it is mandatory that the readings of top and bottom of the drop be taken. All the readings should be taken for the same face left or right, more conveniently on face left position. To minimise the error, take two way readings and plot the profile in graph simultaneously.

The distance and elevation of the surveying points at each station are calculated using the formula shown in Table 1. Summing up all the data, the elevation and distance of the surveying points along the axis and the permanent peg point at upper or bottom station are obtained. These are then plotted in the graph to get the profile of the ropeway alignment along the centre line.

## 2.3 Soil Investigation

Soil investigation is very important for foundation design of ropeway. For foundation design, soil parameters like the specific weight of soil ( $\gamma$ ), angle of internal friction ( $\Phi$ ) and cohesion ( $c$ ) of the base soil and back filling material are needed. For evaluating these parameters, it is necessary to have the following information:

- Soil type, origin and particle size
- Approximate particle grading
- Plasticity of soil
- Compactness
- Grain shape
- Rough estimate about the moisture content in soil
- Percentage of boulders > 60 mm and rock types of boulders

### 2.3.1 Common methods of soil investigation

#### a) Exploratory pit method

The simplest method for subsoil investigation is by trial pitting. This method involves manually excavating trial holes at identified test points. The subsoil will then be investigated by carrying out field strength tests as well as by visual assessments of the trial holes. Number of trial holes that needs to be dug depend on the variability of the subsoil

around the site and the experience and judgment of the investigating engineer.

Field investigation procedures:

- The position of each trial hole should be confirmed before commencing excavations. The trial holes will be excavated using hand-picks and shovels. The local community can be mobilised to carry out this work.
- Each trial hole should be at least 80 x 150 cm vertically excavated. The soil profile should be visually assessed and logged by the engineer during the course of excavation. These visual assessments will determine the need for further tests on the soil samples in the laboratory.
- The Dynamic Cone Penetrometer (DCP) test is carried out at one metre depth intervals from ground level until a point of required strength is recorded or until the danger of sides collapsing makes the excavations unsafe for those people digging. The ground strength should be deemed adequate if the required DCP penetration rate is achieved for at least three sets of 10 blows before each reading. The required soil strength should be determined from the adopted standard charts.



In general, a DCP penetration of 8 to 10 mm per blow gives adequate founding ground. If the soil strength is still very low at depths greater than three metres, then the foundation should be treated as poor soil. The empirical relationship between DCP penetration and equivalent ground bearing capacity are given in figure 13.

- With loose sands and silts, there is a great danger of the excavation site collapsing, especially if there is a flow of underground water. The sides of the excavations should be braced with timber to avoid the soil from collapsing into the water. The investigating engineer should design a suitable and safe shoring method on the site.
- If the water table is high and there is a continuous inflow of water into the excavations, the water should be pumped out using ordinary buckets tied strongly by ropes manually or through mechanised pumps.
- The visual assessment by the investigating engineer will determine whether disturbed soil sample needs to be recovered from the field for further testing in the laboratory.

From the pit, following information can be collected:

- Ground strength
- Soil type
- Soil gradation
- Compactness
- Grain shape
- Estimation of percentage of boulder greater than 60 mm diameter in soil
- Ground water condition
- Geological domination

### 2.3.2 Laboratory test

In cases where, on site visual assessments have shown potentially active subsoil, the soil activity should be assessed further by carrying out

laboratory tests of the soil samples. The soil sample should be tested according to the relevant code of practice. The laboratory tests will include, following:

- Particle size distribution: This test includes wet and dry sieve analysis method combined with the hydrometer analysis for the clay fraction. The grading envelope will be plotted from these tests. The coarseness and fineness index, and clay fraction will be determined from the particle size distribution test.
- Plasticity index test: The liquid and plastic limit test is carried out to find the plasticity index.
- Free swell test: This test determines the free swell of the clay samples.

The criteria for potentially active clay is checked from the above tests. If the soil is expansive, it is highly recommended to change and relocate the site for the stations or extensive sub soil treatment may be required.

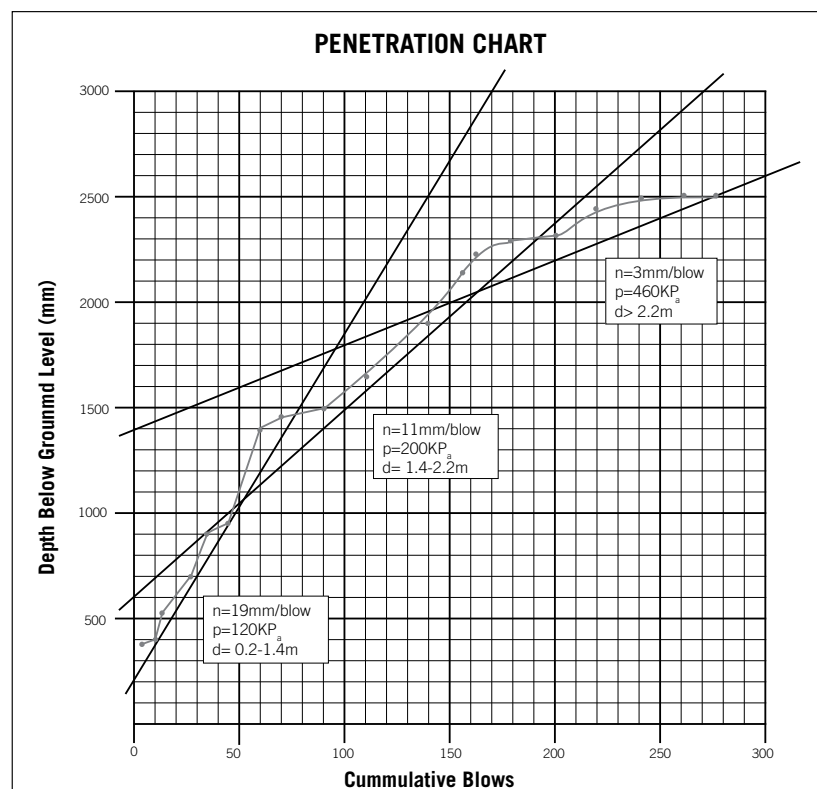


Figure 13: Penetration chart

## 2.4 Photographs

It is recommended to take photographs considering following views during surveying the sites.

- Proposed upper and bottom station
- Ropeway alignment from upper and bottom station
- Exploratory test pits
- Any other additional views that will enhance the topographic survey. The photographer's position and the direction in which the photographs are taken should be indicated on a sketch.

## 2.5 Miscellaneous Data Collection

The surveyor has to collect the information about the availability of construction materials such as boulders, natural gravel, sand and cement including their locations and transportation distances. The availability of local labour (skilled

and unskilled), and their district and local rate should also be recorded. Likewise, it should also include the portage distance and rate if human portage is required.

## 2.6 Survey Instruments and Tools

The lists of the items required at this stage of the survey are as follows:

- Digital theodolite/total station
- Graduated staffs ( 2 sets )
- Measuring tape (50 m and 3 m )
- Dynamic Cone Penetrometer (DCP)
- Clip board
- Calculator
- Field survey book
- Graph papers
- Pencils
- Erasers
- Red enamel paint and brush
- Camera
- Ranging rod
- Hand picks
- Shovels
- Scale
- Axe
- Survey manual
- Roll of cord

## 2.7 Human Resources

The surveying should be carried out under the direct supervision and involvement of a qualified and experienced civil engineer. Recommended surveying team composition is as follows:

- A civil engineer with three years of experience in surveying and designing of gravity ropeway or trail bridge including rope design work
- A civil overseer with two years of experience in surveying trail bridges
- A geologist (optional) with two years of experience in soil investigation of bridge or ropeway
- Staff person-two
- Helpers-four

## 2.8 Survey Report

The survey report should include:

- Orderly compilation of all the field data
- Schematic diagram of site
- Profile of the ropeway alignment drawn based on the topographical survey data on graph or on Auto CAD
- Site plan of upper and lower stations showing the permanent pegs and reference points
- Design parameters (soil)
- Site photographs joining them if necessary and clearly describing the details below each photograph and
- Finally, a brief narrative report analysing the findings with prospects and constraints about the technical feasibility of the site

# DESIGN 3

## 3.1 Wire Ropes

A wire rope is made up of a number of fibre or steel wire strands laid helically around a core. The strands themselves are composed of a number of wires laid in various geometrical configurations. Ropes are manufactured from steel wires which are drawn from steel rods melted in open– hearth or electric furnaces. The wire rope construction, types and other terms used in this guideline are described in the glossary.

### 3.1.1 Rope geometry

One of the basic challenges in the design and construction of ropeway is to determine the shape of curve of the loaded rope and to calculate the precise forces acting upon it.

The shape of the rope curve is influenced by the weight of the rope, the weight of the trolley that slides upon it, the load in the trolley, wind load, the friction developed on the supports (towers) and the braking friction at rope or at the stations during stoppage and icing (in cold places). In each case, the curve has to be determined for maximum and minimum conditions i.e. for rope only and the line fully loaded. In these conditions, the maximum sag of the rope and the bending angles due to load on the supporting towers at the two ends must be evaluated. Each rope is exposed to tension caused by initial stresses due to tension weight, the rope's own weight and

the weight of the loaded trolley at its maximum carrying capacity (120 kg in the case of gravity ropeway). The shape of the curve varies according to the way the rope is fixed, its alignment, angle of inclination and the number of spans (if the gravity ropeway has more than one span).

### A) Uniformly distributed load along the rope span in plan

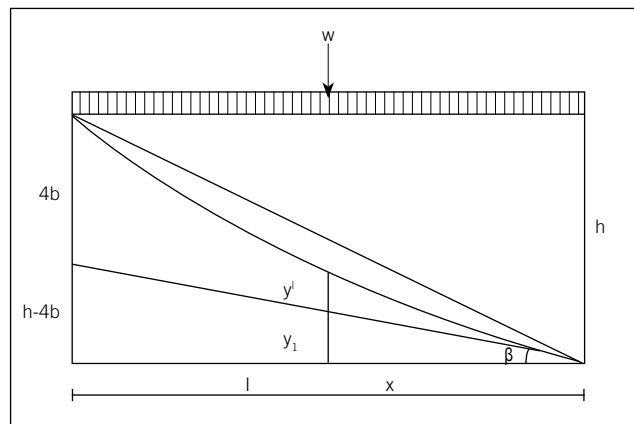


Figure 14: Uniformly distributed load along the rope span in plan

In the above diagram,

$$y = y_1 + y^l$$

$$\text{Where } y_1 = \frac{4bx^2}{l^2} \quad \text{and } y^l = \frac{(h-4b)x}{l}$$

$$\text{Hence } y = \frac{4bx^2}{l^2} + \frac{(h-4b)x}{l} \quad (i)$$

This is equivalent to the parabolic equation,  
 $y = ax^2 + bx$  (ii)

Hence from this relation,  $y$  for each corresponding  $x$  is obtained and the rope curve can be plotted.

Integrating the equation (ii),

$$\frac{dy}{dx} = \tan(\beta) = 2ax + b \quad (iii)$$

This relation gives the slope of the curve at the point of consideration. Hence, we can obtain the tension in the rope anywhere from the following relation,

$$T = H / \cos(\beta)$$

The curve of the rope can be obtained from the following relation too.

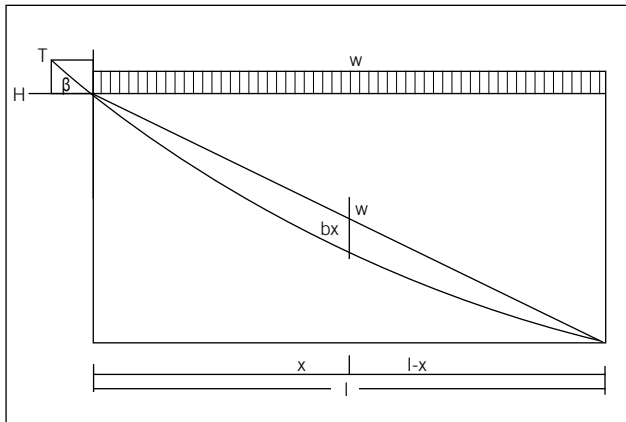


Figure 15

When the chord is horizontal, we know that,  
 $b = \frac{w(l-x)x}{2H}$  (i)

And the rope sag is maximum at  $x = l/2$

$$\text{So, } b_{\max} = \frac{wl^2}{8H} \quad (ii)$$

Now dividing equation (i) by (ii), we obtain the ratio

$$b : b_{\max} = \frac{4 \cdot x}{l} \left( \frac{1-x}{l} \right) \quad (iii)$$

As the maximum sag is known, the rope curve can be plotted from this relation.

The curve shape calculation using the catenary's equation is elaborative and arduous. The errors arising from the approximation when replacing the catenary by parabola do not exceed 2.6 per cent. Therefore, in almost all the cases, it can be assumed with sufficient accuracy that the rope curve is parabolic. For small span and sag, the error due to the assumption amounts to fraction of one per cent. The error varies proportionately with the ratio of  $b/l$ .

With uniformly distributed load over the rope span in the plan view, the error amounts to:

$b/l < 1/20$	error < 0.3%
$b/l = 1/10$	error = 1.3%
$b/l = 1/5$	error = 5%

Some codes for aerial ropeway suggest that the profile of the rope may be considered parabolic if the sag is less than 10 per cent of the span.

### B) Rope curve under single moving load

The total rope sag will be equal to the sum of the sag due to the own weight of the rope and the weight of the trolley  $W$ .

Hence,  $b_{\text{total}} = b_1 + b_2$  where  $b_1$  and  $b_2$  are the rope sags due to the self weight of the rope and the imposed load respectively at the point of consideration in the rope profile

$$\text{And } b_1 = \frac{w x (l-x)}{2H}$$

$$b_2 = \frac{W(l-x)}{H}$$

The sag would be maximum, at  $x = l/2$

$$\text{Hence } b_{\max} = l^2 \left( \frac{w}{8H} + \frac{2W}{l} \right)$$

### 3.1.2 Rope length

For a rope, the horizontal projection length (on base) is =  $l$ , maximum sag =  $b_{\max}$  and the difference in level between supports =  $h$ , the rope length can be calculated from the basic equation of the element of arc as follows:

$$dL = \sqrt{dx^2 + dy^2}$$

Various authors have derived slightly different formula for the rope length, which are as follows:

$$L = l + \frac{h^2}{2l} + \frac{8b_{\max}^2}{3l} \quad \text{Chitary}$$

$$L = l + \frac{h^2}{2l} + \frac{w^2 l^3}{24T^2 \cos^2 \beta} \quad \text{Gulisashvili}$$

When a rope is loaded with trolley, the length of the rope can be calculated using the formula:

$$L = l + \frac{h^2}{2l} + \frac{w^2 l^3}{24T^2 \cos^2 \beta} + \frac{x(l-x)W(W+wl)}{2lT^2 \cos \beta} \quad \text{Gulisashvili}$$

### 3.1.3 Stresses in rope

The rope in the gravity ropeway is subjected to tensile stress due to its own weight and the bending stress caused by the live load.

The maximum stress on the rope,  $\sigma_{\max} = \sigma_t + \sigma_b$

$\sigma_t > \sigma_b$  must be maintained to avoid the loosening of wire rope.

### 3.1.4 Load consideration

The gravity ropeway is subjected to the following loads while in operation:

- Wind load
- Dead load
- Live load
- Temperature stress
- Impact load
- Seismic load
- Dynamic load

The seismic load is not considered in the design whereas dynamic load is partially considered.

Wind load: The maximum wind load is considered as  $1.3 \text{ kN/m}^2$  in lateral direction corresponding to  $160 \text{ km/hr}$  wind speed  $w = 1.05 \cdot \frac{V^2}{16} \left[ \frac{\text{kg}}{\text{m}^2} \right]$  where  $V$  is in metre per second.

For calculating the tension in the rope, the wind load is considered to act at an inclination of  $20^\circ$  to horizontal direction.

Dead load: Weight of the rope, which is considered uniformly distributed.

Live load: It consists of weight of the trolley, weight of the goods and half the weight of the haulage rope. It is considered as point load in calculation.

Temperature stress: This stress is developed in the rope due to the variation in the temperature at the time of operation and at the time of installation. More importantly, the elongation or contraction caused by the temperature variation is important in gravity ropeway as the rope length is usually very high up to  $1.5 \text{ km}$ .

The change in the rope length is expressed as:

$$\Delta l = \alpha \Delta t \cdot L$$

Where  $\alpha$  = Coefficient of thermal expansion which is equal to  $12 \times 10^{-6} / ^\circ \text{C}$

$\Delta t$  = temperature change

Approximate change of sag ( $\Delta b$ ) can be found from the equation:

$$\Delta b = \frac{15 \cdot \Delta L \cdot l}{16b[5 - 24(b/l)^2]}$$

Impact load: Upon sudden application of brake, impact load is produced in the ropeway system. The impact load is mainly carried by the haulage rope so a certain percentage of impact load is to be considered in the haulage rope design. As it is difficult to ascertain the amount of impact load transferred to haulage rope, it is considered to be 50 per cent of the maximum possible impact load.



During the movement, the trolley moves back and forth in the track rope so the minimal impact load is imparted to the track rope. It is considered to be 10 per cent of the total impact load.

As the impact is the change in momentum per unit time, sudden application of brake should be avoided to minimise the impact. For this, a braking distance can be calculated and the operator should be oriented on this to start application of brake when the trolley reaches to the start of the braking distance so that uniform retardation is achieved.

Maximum possible loads: Maximum possible load in track rope = wt. of track rope + wt. of trolley + wt. of downward moving goods + 50 per cent of weight of haulage rope +  $1/3^{\text{rd}}$  of maximum wind load + 10 percent of impact load

Maximum load in haulage rope = wt. of the haulage rope + maximum wind load + 50 percent of impact load.

The rope factor of safety should be checked for the following two loading conditions:

- Dead load + maximum wind load
- Full load +  $1/3^{\text{rd}}$  of maximum wind load + impact load

As the gravity ropeways operate in the hilly terrains, consideration of wind load is very crucial. The operation of the ropeway during heavy storms should be strictly prohibited.

### 3.1.5 Rope tension calculation

For rope tension calculation, first of all the rope sag at dead load is assumed and the rope tension is calculated for the corresponding sag. The full load sag is then obtained from iterative methods but more conveniently from computer analysis like SAP.

Tension in the wire rope is calculated from the following relation.

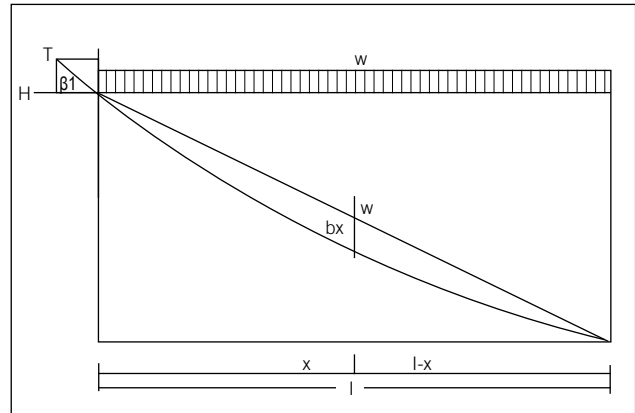


Figure 16

For uniformly distributed load (w)

$$\text{Horizontal reaction at point } x (H_x) = \frac{wx(l-x)}{2bx}$$

$H_x$  is maximum when  $bx = b$

$$\text{Maximum horizontal reaction (H)} = \frac{wl^2}{8b}$$

where  $w$  is weight per metre and  $b$  is the maximum sag.

For point load (w)

When the point load is at  $x$ ,

$$\text{Horizontal reaction (H}_x) = \frac{Wx(l-x)}{bx}$$

The reaction is maximum when the point load is at the centre. Hence,

$$H_{\max} = \frac{WL}{4b}$$

where  $W$  is point load and  $b$  is the maximum sag.

Point and live load in combination

At  $x$ ,

$$H_x = \frac{wx(l-x)}{2bx} + \frac{Wx(l-x)}{bx}$$

When  $bx = b$ ,

$$H_{\max} = \frac{wl^2}{8b} + \frac{WL}{4b}$$

### Rope tension

Maximum rope tension ( $T$ ) =  $H/\cos(\beta_1)$  where  $\beta_1$  is the angle of inclination of rope at upper saddle.

The rope tension should be calculated for both dead load and full load condition. As stated above, the maximum sag corresponding to the full load is calculated either from iterative process or SAP analysis.

### 3.1.6 Factor of safety adopted

At maximum load during the service, the ratio of minimum breaking load of the rope and the maximum rope tension in service, that is the factor of safety shall not be less than the following:

Track rope      3.0  
Haulage rope    3.5

The factor of safety should be checked for the following load combinations:

Track rope

- i) Dead load + full wind load
- ii) Full load +  $1/3^{\text{rd}}$  of wind load + 10 per cent of impact load

Haulage rope

- i) Dead load + full wind load
- ii) Dead load +  $1/3^{\text{rd}}$  of wind load + 50 per cent of impact load

### 3.1.7 Specifications

The rope material, its configuration and other ropeway parts should comply with the following IS code:

IS10887:2001 : Steel wire ropes for winches and ropeways used in forestry and agriculture (1st revision)  
OR,  
IS 10891 (Part 1):1984 : Haulage rope  
IS 10891(Part 2):1986 : Track rope  
IS 1804:1992/1996 : Fibre core for steel wire ropes (second revision)

IS 6594-1977 : Technical supply conditions for wire ropes and strands (first revision)  
IS 9282-1979 : Specification for wire ropes and strands  
IS 9182/II-1979 : Specification for lubrications for wire strands and ropes  
2361:1984 : Bulldog grips – specification  
2315: 1978 : Thimbles for wire ropes

### 3.1.8 Working life of rope

The working life of the rope refers to the time till number of broken wires remains acceptable and distribution of those breakages in the rope is lesser. The number and severity of bends mainly influence the life span of the rope as given in the relation below.

$$N = I \cdot T_d \cdot h \cdot nr$$

Where,

$N$  = number of bends per year  
 $I$  = number of carriage travelling per hour  
 $h$  = number of working hours per day  
 $nr$  = number of carriage pulleys  
 $T_d$  = number of working days per year

In practice, the carrying ropes of goods ropeway can bear approximately 4,000,000 bends. So, the working life of the ropes can be calculated by dividing this value with calculated  $N$ .

### 3.1.9 Tests on wires and ropes

Ropes and wires are subjected to various tests before putting them into operation to avoid undesirable incidents. Regulations call first tests on the wires and then on the ropes.

#### A) Tests on wire

The unstranded wires are subjected to tensile, reverse bend, torsion and fatigue tests.

**Tensile test**

Tensile test must cover the measurement of the tensile strength, the proportional limit (elasticity limit), the plastic limit, elongation of the rod (thread) of 200 mm in length at the breaking point and the Young's modulus. Most important of all is the tensile strength which is determined by the Amsler testing machine with application of breaking forces of 500, 5000 and 10,000 kgs. On completion of this test, it is necessary to discard the following:

- Wires in which the breaking strength differs by more than eight per cent from that of the average strength of the wires
- Wires which fail to comply with the reverse bend and torsion tests
- Wires in which the elongation is 20 per cent lower than the average elongation or which fail to reach the required elongation

The rope should be rejected if the tensile strength, determined from the Amsler testing machine, does not reach the required value.

The proportional limit of round wires lies between 39 to 53 per cent and of cross-sectional wires from 27 to 42 per cent of tensile strength. The elongation close to the breaking point is from 2.5 to 3.7 per cent.

**Reverse bend tests**

These tests should be carried out on 100 mm long samples tensioned by a longitudinal force of 1 to 6 kg (according to diameter) and bent in the vice jaws, over a radius equal to 5 times the wire diameter. The wires are bent back and forth through 180 degree until fracture occurs.

The test should comply with the relevant IS code (IS 1608).

**Torsion tests**

The test should be carried out in the test piece of length equal to 100 times to diameter of the wire in a manner laid out in the relevant IS code.

**B) Test on ropes**

The test assesses the technical properties and strengths of ropes.

Technical tests usually examine:

- the wire arrangement in the strand and of the strands in the rope
- the rope diameter
- the length and direction of lay
- the method of stranding
- the length of the rope and the condition of the wire
- the coating with lubricants
- the strand production
- the wire diameter and the number of wires in the layer
- the grade of the fibre and construction of the core
- tensile strength of wires through tensile, torsion and reverse bends tests and
- the breaking strength of the rope

Tests to examine the position of wire arrangement in the strand and the strands in the rope, the rope diameter, the length and direction of lay and method of rope stranding are carried out on a rope wound on a drum. Similarly, examination of the condition of wires, the state of lubrication, the production of strands, the wire diameter and number of wires in a layer and the constitution of the core are carried out with the sample cut from the rope and un-stranded. The sample should have the length of 30 to 70 rope diameters.

Strength tests examine the measurement of the breaking load, the elongation at breaking point, the kind of fracture and the values of Young's modulus, the proportional limit, and the plastic limit.

**Breaking strength of rope**

To examine the strength of a completed rope, a piece with a minimum length of 30 rope diameters (usually 5 to 7 metres in practice) is cut off from the bundle of rope. To examine the actual breaking load of the rope, the length of the test piece should not be less than 70 rope

diameters. Before cutting off the sample rope, the test sample should be securely seized with wire of 5 rope diameters in length to prevent the slackening of the test length.

Both end of the sample should be capped with white metal cap (zinc caps) and the sample be tested on a suitable tensile test machine until the breakage is obtained. The testing procedures should comply with relevant Indian code.

### 3.1.10 Ordering wire ropes

Wide ranges of ropes are manufactured for various purposes or applications. The details of wire ropes and their application requirements should be clearly mentioned while placing the procurement order for the rope. The order should contain the following information:

- The length of the rope
- The rope construction (type of lay, method of stranding, type of core)
- The rope type (seale, warrington)

- The rope diameter
- The size of the wire (diameter, metallic area and other dimensions)
- The tensile strength of wire
- The rope weight per metre
- The grade of the galvanisation
- Lubrication
- Preforming/non preforming
- Elongation (pre stretched/non pre stretched )
- Rope/wire tests and certification
- Working condition

While placing an order for a rope, an extra allowance of length should be considered for anchoring and laying, and transporting or transferring. Manufacturer's test certificate should be obtained from the manufacturer at the time of rope delivery.

## 3.2 Mechanical Components



Photo 2: Sheavecast Iron

### 3.2.1 Sheave

**Diameter of driving sheave:** The diameter should not be less than 80 times that of the size of wire rope and 800 times that of the outer wire of the wire rope to prevent the sharp bending of the wire

rope at the sheaves. For example, if the hauling rope diameter is 9 mm, the diameter of the sheave should not be less than 720 mm (0.72 m). This is detrimental to the life of the hauling wire rope.

The radius of the sheave groove  $r_g = 0.53 d$

A larger groove diameter leads to flattening of the rope while a small groove diameter causes it to be pinched. The sides of the groove should be sloped at an inclusive angle of 60 degrees so that the ropes rest on the groove by one third of its circumference without touching its sides.

Other requirements:

- Steel shafts with keys for mounting grooved pulley of required diameter
- Self aligning deep groove ball bearings for the shafts

- The deflection of the haulage rope on each sheave shall not exceed 4.5 degrees
- Sheaves shall have a factor of safety of four against the breaking load it is subjected to
- The hauling rope shall loop around the driving sheave with an angle not less than 160 degrees and
- The cast iron should comply with IS standard 1732:1989

### 3.2.2 Bearings

In gravity ropeway, self-aligning ball bearing is used to prevent it from misaligning during the installation and operation period.



Photo 3: Oil seed bearing

The appropriate size of the bearings corresponding to the diameter of the shaft of the sheave is chosen from the table 2 below.

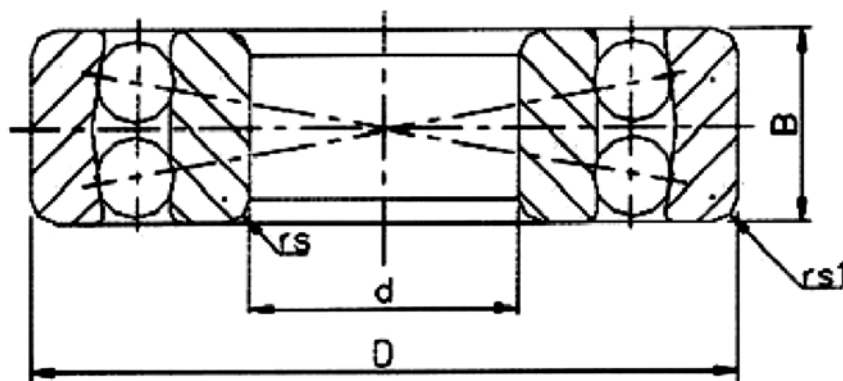


Figure 17: Sectional view of the oil seed bearing

N.B. Oil sealed bearing is preferred than grease sealed for gravity ropeway application.

Table 2: Self-aligning ball bearings of cylindrical bore 10000

Bearing No.	Principal dimensions (mm)				Limiting speeds (rpm)		basic load ratings (kN)		mass (kg)
	d	D	B	rsmin	Grease	Oil	Dynamic	Static	Approx
1203	17	40	12	0.6	12000	16000	6.1	2.4	0.0760
1204	20	47	14	1.0	10000	14000	7.7	3.2	0.1200
1205	25	52	15	1.0	9000	12000	9.3	4.0	0.1400
1206	30	62	16	1.0	7500	9500	12.2	5.8	0.2300
1207	35	72	17	1.1	6700	8500	12.2	6.6	0.3200
1208	40	80	18	1.1	6300	8000	14.8	8.5	0.4100
1209	45	85	19	1.1	5600	7000	16.8	9.6	0.4900
1210	50	90	20	1.1	5300	6700	17.5	9.8	0.5400
1211	55	100	21	1.5	4800	6000	20.5	13.2	0.7200
1212	60	110	22	1.5	4500	5600	23.2	15.5	0.9000
1213	65	120	23	1.5	4000	5000	23.8	17.2	0.9200
1214	70	125	24	1.5	3800	4800	26.5	18.8	1.2900
1215	75	130	25	1.5	3600	4500	29.8	21.5	1.3500
1303	17	47	14	1.0	11000	15000	9.6	3.7	0.1400
1304	20	52	15	1.1	9500	13000	9.6	4.0	0.1700

### 3.2.3 Trolley

The trolley should be as light as possible. It is usually fabricated from mild steel (MS) cylindrical or square hollow sections. The size and shape of the trolley should be designed as per the nature of the load to be carried on it. Refer to the photo 4 for a typical trolley that was first used in ropeways constructed by Practical Action.

### 3.2.4 Brakes

Brake consists of a 50 mm wide metallic strip which is pinned to the channel of a sheave frame at one end and to the wooden handle at the other end. The strip should cover at least one quarter of the circumference of the sheave. It usually has a wooden lining but at times, rubber linings are also used in addition to the wooden lining.

### 3.2.5 Radius of the support saddle

In order to avoid the sharp bending of the track rope at the support towers, the radius of the support saddle should be minimum value of 100 to the rope diameter.



Photo 4: Example of a typical ropeway trolley



Photo 5: Ropeway operator waiting to apply brake

## 3.3 Foundation Design

### 3.3.1 Introduction

Design and analysis of foundations must guarantee that all loads (live and dead) acting from the ropeway superstructure on the foundations are safely transferred to the ground. For the foundation design, following geotechnical parameters should be known and accurately established from the survey data.

#### Parameters:

Angle of internal friction –  $\phi$

Specific weight of soil/rock –  $\gamma$

Maximum ground bearing pressure –  $\sigma$

The foundation design is checked for the following four failure modes:

### 3.3.2 Sliding failure

The earth or soil around the footing must be able to mobilise enough passive resistance to prevent the footing being slid off by the ropes. The factor of safety adopted should be greater than 1.5.

$$Fsl = \frac{\text{Retaining Forces}}{\text{Driving Forces}} > 1.5$$

$$= \frac{TCOS(\beta)}{(W-TSIN(\beta))TAN(\phi)} > 1.5$$

where,

T= Rope tension

$\beta$ = Rope inclination

$\phi$ = Angle of internal friction



### 3.3.3 Toppling/over turning failure

The anchor block should be checked against toppling. The resisting moment must be at least 1.5 times the overturning moment.

$$F_t = \frac{\text{Retaining moment}}{\text{Over turning moment}} > 1.5$$

$$= \frac{TCOS(\beta) \times h + TSIN(\beta) \times b_1}{W \times 0.5b} > 1.5$$

where,

$h$  = the depth of toe from the point of application of tension in the vertical post  
 $b$  = breadth of the anchor block  
 $b_1$  = the horizontal distance from the point of application of rope tension to the toe of the block

### 3.3.4 Ground shear failure/bearing capacity

The pressure transmitted to the ground from the imposed loads must be less than the bearing capacity of the soil,

$$\sigma = \frac{W + E_{av}}{b \cdot l} + \frac{M \cdot b}{l \cdot 2}$$

where, moment of inertia =  $\frac{l \cdot b^3}{12}$

Moment at bottom centre,

$$M = TCOS(\beta) \times Xh + \frac{E_{ah} \times h}{3} - E_{av} \times b$$

$$E_{ah} = 0.5 \lambda \gamma h^2 \quad E_{av} = E_{ah} \times \tan(\delta),$$

$$\delta = 2/3\phi$$

$\sigma$  should be less than the safe bearing capacity of soil.

Similarly, the safety of anchorage post should be checked against the shear stress and the plumb concrete.

### 3.3.5 Shear force in the vertical posts

The size of the anchorage post and the reinforcement provided should be designed in a way that the permissible shear force is more than the shear force on the vertical posts due to the rope tension.

$$\text{Shear force due to rope tension } (\tau) = TCOS(\beta) / (\pi d^2 / 4)$$

$$\text{Permissible shear force} = \frac{\pi D^4 \tau_c + \tau_r \pi d^2}{4}$$

where,  $\tau_r$  and  $\tau_c$  are the permissible shear stress of concrete and rods respectively.

### 3.3.6 Stress in plumb concrete

The tensile and compressive stress developed in the plumb concrete of the anchorage blocks should also be checked against its permissible stress.

Stress on the plumb concrete,

$$\sigma = \frac{TCOS(\beta) \times Xh}{d \cdot h} + \frac{M \cdot h}{l \cdot 2}$$

N.B Refer to the relevant soil engineering/ foundation design book for details on foundation design.

## 3.4 The Design Team and Qualification

The design team should consist of two professionals having following qualifications and experiences:

- Civil engineer – A civil engineer having minimum of five years of experience in survey design of trail bridges and/or two years of experience in ropeway designing. He/she should have sound knowledge of rope and

should be aware of prevailing standards, norms and codes of practices for ropeway.

- Mechanical engineer – A mechanical engineer having sound knowledge of ropeway accessories with two years of experience in designing of ropeway accessories/parts.

# DRAWING 4

The ropeway design should be supplemented with the drawings in appropriate scales. The recommended scale of the drawing is as mentioned below:

- Profile 1:500 to 1:300
- Plan 1:50
- Sectional views 1:50
- Reinforcement details 1:25
- Mechanical components 1:10

The drawing should have clear dimensions of all components and the specifications of the materials to be used. A set of typical drawing of gravity ropeway is attached in Annex 4

## 4.1 Drawing and Design Verification

A complete set of drawings and designs is to be submitted and verified by a recognised and responsible designer prior to fabrication and construction. The designer should verify the followings:

- The design is safe as per the established norms and codes
- There is no ambiguity in the calculations and the procedures are self- explanatory and
- All the safety factors are clearly established and justified

# 5

## ESTIMATING AND COSTING

### 5.1 Estimating

The quantities of materials is extracted from the standard drawings as detailed in the working drawings. The estimate will include but not necessarily be limited to the following items:

#### A) Civil component

- Site clearance
- Earth work
- Boulder soling
- Masonry work in cement mortar (1:6)
- Plain cement concrete (PCC) in 1:2:4
- 40 per cent plumb concrete in 1:3:6
- Reinforcement steel
- Truss post
- Roofing materials (CGI sheet)

#### B) Mechanical component

- Wire ropes
- Structural steels
- Machinery parts
- Bearings
- Shafts and sheaves
- Brakes and braking systems
- Connecting accessories – bull dog grips and thimbles
- Galvanisation

Refer to DoLIDAR/Suspension Bridge Division's Norms (SBD) for quantity estimation and rate analysis.

A sample of Bill of Quantities is shown in Annex 3. Changes to the provided format may be made as per the engineer's own requirement.

### 5.2 Costing

After the quantity estimation, costing is done with reference to the latest quotation rate, prevailing market rates of materials and the approved district rates. The cost of structural steel and wire ropes are based on the latest quotation rates obtained from the manufacturers or the

authorised dealers whereas the cost of the non-local materials like cement, steel reinforcements, CGI sheets should be consistent with the market rates. The labour and local materials rate should be analysed and confirmed to the approved district rates adopted at the place of construction.

# PLANNING AND SCHEDULING

## 6

Planning, in general, means laying out of activities in an orderly sequence in advance, defining the project methods/ principles and prescribing the ultimate disposition of the results to be accomplished. Proper and effective planning can lower the project costs and construction period significantly through efficient mobilisation of labour, equipment and materials. This ensures that the resources are used to their maximum productivity. In executing gravity ropeway projects, it is also necessary to adopt comprehensive project planning steps which should cover the following areas:

- Planning the project work
- Planning the human resources and organisation
- Planning the financial resources
- Planning the information system

Planning aims at achieving successful project completion by using time and resources effectively. Project planning requires both operational and strategic thinking including timely decision making. It is characterised by creativity, innovation and ability to think rationally and prospectively.

Project planning is a multi stage process and is enumerated as:

- Establishment of objectives
- Establishing assumptions based on facts
- Establishing the logical sequencing of activities
- Searching and evaluating alternative course of action
- Identification of time and resources
- Assignment of responsibilities and
- Finalisation of project plan

There are a number of factors affecting how, when and in what order the works can be carried out. A checklist of these factors is as follows:

- Performance of staffs
- Availability of labour, equipment and materials
- Holidays, festivals and other seasonal variations such as weather conditions
- Access to site
- Availability of funds
- Site geology and topography and
- Social mobilisation and public relation

## 6.1 Types of Planning

Mostly three types of planning are involved in gravity ropeway construction.

- Time planning
- Resource planning and
- Technical planning

### 6.1.1 Time planning

Time planning simply means to manage the time effectively to get more work done in less time. It means utilising minimum time to accomplish the goals. More time consumption means more cost. Time planning involves preparation of project activities schedule using bar chart. Preparation of project implementation schedule in the initial stage is always helpful. A typical Critical Path

Network (CPN) diagram will be very useful to know what activities are in critical path and allows for effective time planning of activities ahead. Additionally, the chart can be used for optimising resources (labour, equipment and material) by distributing them in a balanced way. A typical time planning chart is shown in table 3.

Furthermore, this will also be a key tool for monitoring progress by tracking the planned versus actual milestones reached - both for particular activities and for the overall project implementation activities. If required such chart may require revision as construction progresses.

**Table 3: A typical time planning chart**

SCHEDULING			TIME PLANING																			
Items	Details	Time/ weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A) Agreement	MOU Signing		■																			
	Project Management training		■																			
B) Local materials collection and preparation	Sand		■	■	■	■	■	■														
	Gravel		■	■	■	■	■	■	■													
	Stones		■	■	■	■	■															
	Wood					■	■	■														
C) Excavation	Site clearance and layout			■	■																	
	Excavation				■	■	■															
D)Procurement	Cement and reinforcement rod					■	■															
	Fabrication and supply of steel parts			■	■	■	■	■	■	■												
	Wire ropes			■	■	■	■	■	■	■												
E) Transportation	Cement and reinforcement rod						■	■														
	Structural steel										■	■										
	Wire ropes																	■	■			
F) Execution	Masonray work							■	■	■	■	■	■	■								
	Plumb concrete									■	■	■										
	RCC work										■	■	■									
	Roofing											■	■	■								
	Sheave anchoragefixing												■	■								
	Curing and finishing works													■	■	■	■	■				
	Alignment clearance for cable laying																■	■	■			
	Cable laying and hoisting																		■	■		
	Shave fixing and trolley installation																			■	■	
	Test operation																				■	■
G) Testing and Commissioning	Operation and maintenance training and commissioning																					■

Source: Access for Opportunities Project, Practical Action Nepal Office

### 6.1.2 Resource planning

Resource planning refers to the planning of funds, materials and labour required for the project. Among them, planning and scheduling of labour is discussed below.

#### Labour resources planning and scheduling

Local human resources are optimally mobilised in gravity ropeway construction work. In most cases, the local communities contribute unskilled and semi skilled labour and their time. Their contribution leads to local ownership of the ropeway system in the community. Since events like holidays, festivals, plantation and harvest seasons, and monsoons might significantly affect the work schedule, the number of people and days required for installation of each ropeway

should be worked out depending upon the time availability of the labour inputs and working hours. The estimated number of people for each activity and time taken for each task are then reconciled to give the exact number of person days required for that activity. This is very important as the work supervisor or construction committee should ensure the required person days within a given time. A typical person days scheduling is shown above in the figure accompanied by the graph showing weekly variation of person days.

### 6.1.3 Technical planning

The technical planning includes the time planning for survey, design and revisions. Following figure shows the typical technical planning in table 4.

**Table 4: A typical technical planning for gravity ropeway**

Activities	Details	Time /Weeks	1	2	3	4
1) Survey and design	Detailed Technical survey					
	Deign and estimation					
	Design hecking and approval					

Source: Access for Opportunities project, Practical Action Nepal Office

# 7

## EXECUTION AND INSTALLATION

### 7.1 Layout

Before laying out the ropeway site, clearance should be done as a part of any site preparation. However, it is already indicated in earlier chapters that the ropeway alignment should be chosen in such a way that there is no or minimum damage to the existing ecology which includes clearing off the trees, rocks and soil.

For layout, set the theodolite at permanent peg point of either upper station (A) or bottom station (B). Then sight another permanent peg at another station and set zero. Then transit the theodolite and locate a point well beyond the estimated location of outer wall of the anchorage block and fix a peg firmly. Now, rotate the theodolite 90 degrees in a horizontal plane, and locate another point at few metres distance from the side wall of the shed and secure a peg. Then again, transit the theodolite to find a point few metres distance from the outer wall of the shed on the other side and fix another peg after which the horizontal and lateral reference lines perfectly

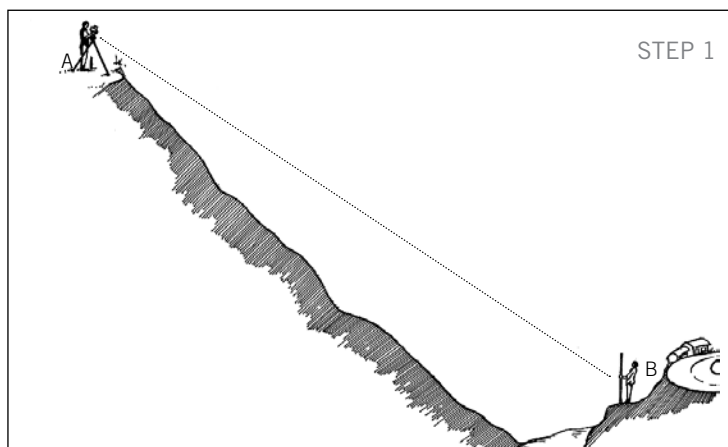


Figure 18

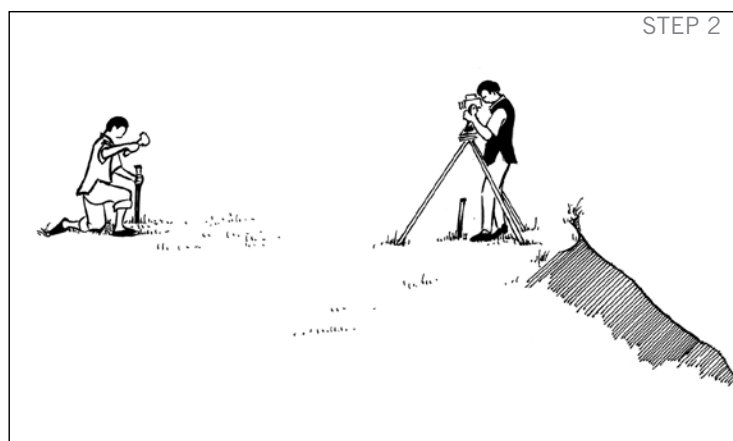


Figure 19



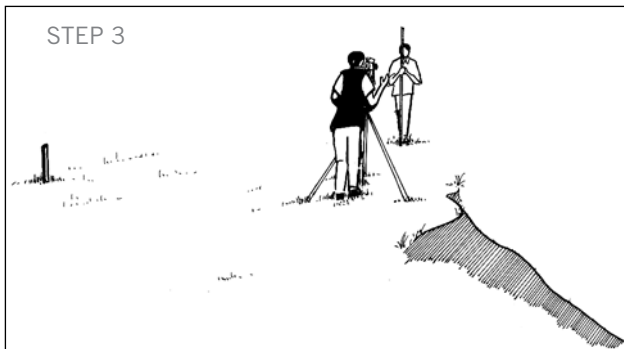


Figure 20



Figure 21

perpendicular to each other are obtained. These pegs should be kept intact throughout the construction period for the reference. Now, 3, 4, 5 (Pythagoras theorem) method can be employed for further layout of the anchorage blocks, sheave anchorage foundation and tower base.

Repeat the same procedure in another station.

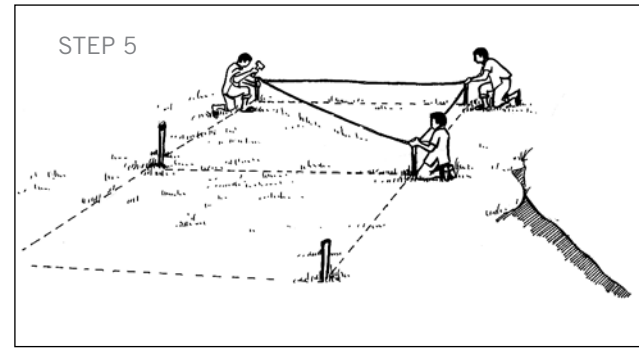


Figure 22

## 7.2 Excavation for Foundation and Anchor Block

Before starting the earthwork, the excavation area should be marked out. While excavating in the decomposed rock or firm ground, only the planned area of the footing or anchor block should be excavated. For unstable sites, the excavation dimensions may be increased from bottom outwards by stepping or sloping the excavation sides.

If an excavation reveals a need to go deeper than the recommended level, then a mass concrete backfill should be used to bring the level back to the soft level. The inclination of the sides

varies with earth quality. Exact limit should be adhered to when excavating in rock or firm soil to avoid the use of excessive masses of concrete.

Excavation deeper than 1.5 metres, especially in unstable soil, should be braced or shored using a standard method. The slope may be banked if shoring is not possible but a safe back slope must be maintained. A minimum slope of 1:1 in non-cohesive materials to the slope of 1:3 in well-consolidated materials should be adopted to avoid the collapsing of the sides.

## 7.3 Construction of Masonry Wall

The masonry wall is constructed with cement mortar. The cement mortar ratio of 1:6 is used in the construction of walls for the anchorage blocks where as the ratio may have to be increased up

to 1:4 in case of retaining wall, tower foundation and parapet walls. The width of the wall should be as per the design but minimum breadth of 30 centimetres should be maintained.

## 7.4 Construction of Gabion Wall

Gabion walls are usually provided for slope protection at upper and bottom stations. The standard slope of the gabions should be in the ratio of at least 1:2 in horizontal. The gabion should be filled from strong and solid rock laid

very closely and packed without gaps to maximise the weight. The gabions should be firmly anchored into the ground by founding the gabions below the expected scour depth and should be tied together to give a monolithic finish.

## 7.5 Mixing, Placing and Curing Concrete

### 7.5.1 Placing steel reinforcement

Following points should be kept in mind while placing the reinforcement:

- Steel will bond well with concrete only if it is clean and free of grease and scaling rust. The reinforcement should be cleaned using wire brush to remove any scaling rust.
- Ensure the minimum lap length, as recommend by the IS code. The minimum lap length ensures that the steel bars join and perform as continuous bars in load transmission.
- The steel reinforcement bars should be tied as shown in the working drawings. The reinforcements should be tied and placed by a qualified or experienced person. The site in charge should inspect the quality of all the steel fixings before the concrete is placed.
- The vertical reinforcement should be provided with L shaped toes on construction joints to ensure the stability of the steel cage during the pouring of the concrete and also to ensure proper anchorage of the steel in the concrete.

#### ■ Specifications

Reinforcement steel should comply with the following IS codes:

IS 1786-1986

High strength deformed steel bars for concrete reinforcement

IS 456-1978

Plain and reinforced concrete

Steel grade, Fe 415, High yield strength Deformed Bars.

### 7.5.2 Concrete constituents

Concrete is composed of four constituents: cement, sand, aggregate and water. The cement creates adhesion between the concrete components as well as fills the voids between them. The aggregate forms the main body of the concrete, whilst water acts as a catalyst and allows the mix to be worked. The aggregate and cement together provides the concrete strength.

#### Cement

Cement must meet requirement of the Nepal standard (NS). The commonly used cement is Portland cement of grade 55. It should neither be exposed to moisture nor be stored for a lengthy period to keep the strength of the cement intact.

#### Aggregates

The aggregate made of parent rock quality is suitable for concrete but it should be approved by the site engineer. The aggregates from rock like mica, sandstone, marl, conglomerates,

decomposed rock, gypsum and coal are not suitable because of inferior quality. These rocks tend to reduce the strength and hardening qualities of concrete and the quality of weather resistance as well. The aggregates can be sourced from river deposits. However, coarse aggregates of the right quality may not be readily available in required quantities from the river deposits. Purity of aggregates is of prime importance to the quality of concrete. Clayey and loamy materials cling to the aggregate thereby reducing the bonding strength of the concrete.

### **Sand**

The sand must not contain more than 3 per cent of dust and organic impurities like humus, peat, plant remains, wood, and coal. For a quick check, a sample when squeezed together in the hand should crush and flow freely when let go. If the sample sticks together or leaves a powdery trace in hand, then it is an indication of contamination with loam or it contains too many fine-grained components. The presence of organic impurities may be checked in the laboratory.

### **Water**

Water acts as catalyst to the concrete chemical reactions as well as ensures the workability of the concrete mix. The points to be noted for water to be used are as follows:

- **Suitability:** Water which contains organic matter should not be used. Mineral water may jeopardize the bonding and the stability of the concrete. Water containing sulphates, chlorides, sugar, organic impurities, oil and grease reduce the quality of concrete and therefore should be avoided. Generally, water, which is suitable for drinking, is also suitable for concrete.
- **Water content:** The water content of the concrete mix is the combined sum of the mixing water and the moisture content of the aggregates. The water content is

normally specified from the water ratio for a particular concrete grade.

- **Consistency and workability:** The consistency of concrete is the degree of density and liquidity and the workability is based on the density and liquidity. The workability is the ease with which the concrete can be made to fill the formwork shapes. It depends on the water content and is controlled from the slump test.

## **7.5.3 Mixing of concrete**

### **Weigh batching of constituents**

The various concrete constituents may be mixed in proportions defined by their masses. The ratios of the constituents are given in the standard mix design in mass per sack mix (50 kg) of cement on the basis of required strength. The proportions of sand and aggregates required will then be weighed using scales for the standard mix proportions. The mass of the water may also be weighed.

### **Volume batching of constituents**

For remote sites, it may be difficult to use weigh batching of constituents. In that case, the mix proportions may be specified per cubic metre of concrete in which case the mix proportions are given as volumes to make up specified target strength. This method is not ideal because of the imprecision in calculating the exact volume of constituents, especially with the type of equipments that are used at site for volume batching i.e. wooden boxes, shovels, and wheelbarrows. The "levelling off" and "heaping" specifications for each volume batch are at the discretion and judgment of the operator. With this method, concrete of varying qualities are likely to be produced. River sand shows a very high degree of bulking with moisture content. Thus, the result of concrete with the volume of sand used in volume batching very much depends on the sand moisture content.

### **Concrete mixing methods**

The quality and consistency of concrete will depend

on the adopted mixing method. There are usually two methods of concrete mixing mechanical mixing and manual mixing. As mechanical mixing is not possible in remote ropeway sites, concrete mixing is done manually. Concrete may be mixed using ordinary hand shovels. The consistency and uniformity of the concrete mix will depend on the degree of control and experience of the labour force. Hand mixing method is very unlikely to produce uniform quality concrete but this method is satisfactory for gravity ropeway as the concrete volume required is less.

#### 7.5.4 Casting of concrete

Casting of concrete has to be done immediately after mixing but in unavoidable situation it can be casted within two hours of mixing to avoid setting of the concrete mix. Before casting the concrete, the formwork should be thoroughly cleaned. In construction joints, the previously concreted surfaces must also be cleaned with water. Loose stones and debris must be removed. Ideally, the surface should be rough, clean and damp. The concrete can be transferred from the mixing place manually in steel dishes and should be placed in the excavations in such a way that the concrete does not fall freely from heights of more than one and a half metre. Concrete falling from greater heights leads to the segregation of the aggregates and a loss in consistency of the concrete mix. Guiding chutes should be used when it has to be poured from higher than recommended levels. The concrete should be vibrated during the placing. Usually a electric vibrator is used, but in remote places where basic infrastructures like electricity, fuel and generators lack, uniform hand tamping can be done using pieces of timber or steel rods. To attain good compaction and an acceptable concrete quality, a high degree of control is required. While compacting, the thickness of the concrete layers should be 150 to 200 mm and the layers be tamped until an air tight surface is achieved.

#### 7.5.5 Curing concrete

When concrete sets, it releases a lot of heat. The chemical reactions take place when concrete sets are exothermic, where the concrete dries quickly and may develop shrinkage cracks. The concrete therefore needs to be kept wet until the setting is complete.

#### 7.5.6 Prescribed concrete mixes

In most of the cases, there is a lack of expertise in the rural areas to calculate a proper concrete mix design in which case prescribed mixes commonly used in the construction industry may be adopted. The mixes do not give an accurate grade of concrete but the results are generally accepted being within the reasonable target strengths. The commonly used mixes are specified in terms of fixed volumes.

The grades of concrete and mix prescribed for the ropeway are given in table 5:

**Table 5: Grades of concrete and its proportions**

Grade	Classification	Mix proportions	Use
M10	Low strength	1:3:6	Plumb concrete, floor
M15	Standard concrete	1:2:4	Tower, Column, Post, and sheave anchorage

Concrete should comply with the following IS codes:

- IS 456-1978 Plain and reinforced concrete
- IS 269-1989 Ordinary Portland cement
- IS 383-1970 Coarse and fine aggregate

## 7.6 Sheave Alignment Fixing

Alignment of sheave at one station with respect to the sheave at the other station is very important in gravity ropeway. If the sheaves are not perfectly aligned, eccentric moment will arise which may cause breakage of bracket/bearings/shaft and substantially decreases the efficiency of ropeway by reducing the upward load carrying capacity or causing stoppage of carriage at midway. Further, due to the unaligned sheaves, the haulage sway towards the sides of the sheaves groove while in operation resulting in continuous friction

between the sheaves and the rope. This will not only cause continuous abrasion of sheaves and ropes but also reduces the life of the rope. So, meticulous care should be given while placing the sheaves. It is recommended that instead of placing the sheave simultaneously at both stations, first place it in one station and then the next. This will provide opportunity to readjust the alignment of the next sheave with respect to the earlier one if any discrepancy occurs in the alignment of the earlier sheave.

## 7.7 Erection of Wire Ropes

Wire ropes are the most important parts of the ropeway therefore, it should be handled with great care to avoid kinks and splicing. Kinks and splicing reduce the rope breaking tension. Rope accessories must meet the required standards and must be transported together with the ropes and handled carefully at the installation sites.

### 7.7.1 Wire transportation

#### Unloading, unreeling and uncoiling

Suitable precautions should be taken to prevent dropping of reels or coils during unloading and moving. If the reel collapses, it may be difficult to unreel and uncoil the rope which may result serious damage to the ropes.

Uncoiling of the rope is very crucial since most of the ropes damages due to mishandling during this process. To avoid kinking and permanent damage to the rope standard procedures should be followed while uncoiling as shown in Fig. 24. The reel should be mounted on a jack/turntable/spool so that it will rotate freely. It should be uncoiled straight and under enough tension to keep it straight and prevent a loop formation.

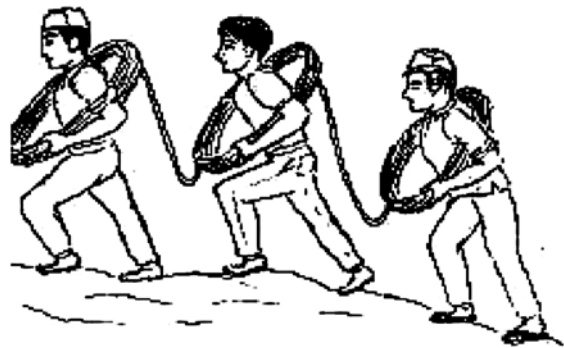


Figure 23: Transportation of rope

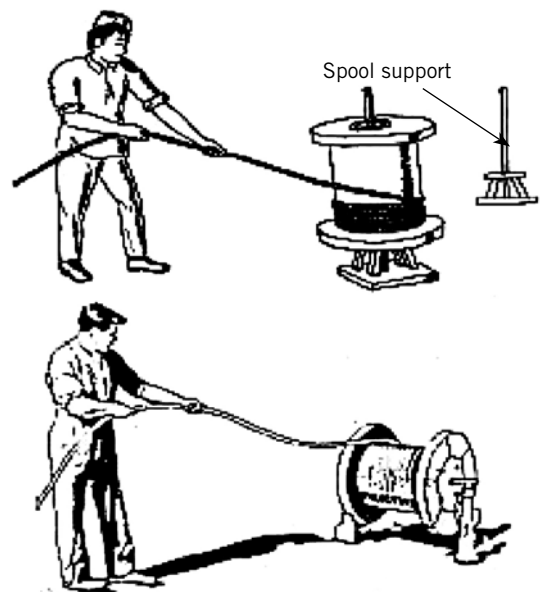


Figure 24: A typical jack/turntable/spool

### Rope laying

Points to remember while laying the wire ropes along the alignment:

- Clear the bushes, trees or other obstacles before pulling the ropes
- Follow the marked alignment while transporting the ropes from bottom station to the upper station (leave the mark at the alignment while surveying)
- Do not uncoil ropes from a stationary coil or reel. Use rotating wheel, drum or disk to avoid kinking
- First, pull the haulage rope along the alignment then pull the track rope
- If there is a river or stream across the route, do not dip the rope into water while hoisting

#### 7.7.2 Sag checking

The designed sag can be accurately provided by marking the saddle points and centre point of rope before installation.

As the rope inclination is directly proportional to the sag provided, the required sag can also be provided by monitoring the rope inclination at upper saddle ( $\beta$ ).

#### 7.7.3 Rope terminals

##### A) Terminals with drums in concrete

Ropes may be anchored directly into the foundations with the help of bollards (drums made out of reinforced concrete) and secured with bulldog grips. The ropes should be wound three times around the drum in order to reduce the tensile force and to be secured. The minimum diameter of the drums should be 0.4 m.

##### B) Terminals with sockets

Sockets should be manufactured from structural steel (standard quality) conforming to IS 226 1975 specifications having a tensile strength

of 420 to 640 N/mm<sup>2</sup> and normalised after the completion of machining operations and hot dip galvanised.

Socketing should be made with pure zinc according to IS 3937 1974 (Part 1), recommended for socketing of wire ropes.

Sockets can be used as an alternative to thimbles and bulldog grips for all rope anchorages.

### C) Terminals with thimble and bulldog grips

#### Bulldog grips

These should conform to IS 2361 1970 specifications. The bridges must be drop forged and suitably scored to grip around strand rope of right hand lay having six strands. Bridges, eurobonds and nuts should be hot dip galvanised.

Bulldog grips, when properly applied, afford a simple and effective mechanical means of securing the ends of wire ropes, but have to be inspected after some loadings.

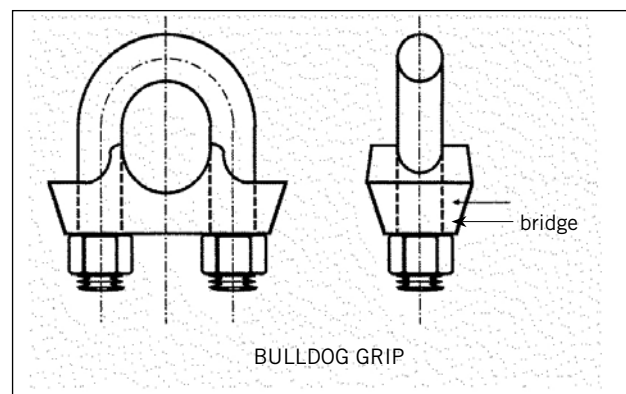


Figure 25: A bulldog grip

#### Thimbles

Thimbles are of open type, conforming to specifications of IS 2315 1978. They must be forged and hot dip galvanised. The pin must support the thimbles. They are necessary to give lateral support to the strands of the rope at the bend.

The bridge of the grip must be fitted on to the working part of the rope and the U bolt on to the rope tail. The first grip must be fitted as close as possible to the thimble. Grips should be spaced



at a distance of approximately six times the rope diameter. The rope end should be protected from fraying with binding wire and should be fixed to the working part of the rope if it is too long.

#### 7.7.4 Splicing

Splicing is used to connect two lengths of ropes. In case of gravity ropeway, this is used to connect two ends of haulage rope so as to make it a loop on two sheaves.

Splicing should only be done by artisans with proven ability. The dimension of the splice may be in accordance with the recommendations of the rope-manufacturer as long as the specifications are in line with the OITAF recommendations such as:

- The total length of a long splice shall not be less than 1,200 x rope diameters
- The minimum distance between two successive splices shall not be less than 3,000 x rope diameters
- The loop for a hauling rope should not have more than two splices
- A single damaged strand may be replaced as long as the damage is limited to that particular strand only. The length of the replaced strand shall be at least 300 x rope diameter or 25 per cent of the total new splice length, whichever is greater
- At any splice or replaced strand, the rope diameter shall not vary more than + 10 per cent of the nominal diameter of the wire rope.

### 7.8 Sheds

The construction of shed should comply with the Nepal National Building Codes (NBC 000 to NBC: 114, NBC 201 to NBC 2008). As the upper station is always at ridge of the hill, the wind velocity is normally high, therefore, due consideration should be given to the wind load while designing the roofing and selecting the roofing materials. The shed is constructed for shielding the sheaves and other mechanical components to protect those from adverse climatic conditions and weathering. It also provides shelter to the operator and user

during the time of ropeway operation. The shelter should be designed to have enough space for storing and bulking up of goods. The shape and size of the shed in each station can be modified as per the local requirement but its height depend on the inclination angle of rope. The CGI sheet is commonly used as the roofing material but is not mandatory. For the truss and posts, if available local wooden posts are recommended but steel posts and trusses can also be used as alternatives.

### 7.9 Landing Platform

The landing platform should have enough space for safe and convenient loading and unloading of goods. Enough space should be planned for allowing the landing platforms at both ends to be

comfortable enough to hold people (operators), load, unload and store goods and keep records. Therefore, proper judgment is required while selecting the sites for upper and lower station,

for lateral and vertical positioning of sheaves and track rope saddles, and for allowing enough space for landing and other activities. In some cases depending on the landscape, the depression of existing land or providing retaining walls could be unavoidable. But all of these depend upon the topography of the site, therefore, site specific design is required.



Photo 6: A down hill ropeway station in Fisling, District Chitwan

# CONSTRUCTION RECORDS

## 8

### 8.1 Time Sheets

During the construction work, the supervisor should maintain a time sheet to monitor time and activity of each worker on site. The main components of time sheets are:

- Date: The date (day, month and year) for each operation day
- Activity: This describes in detail the work done on a particular day. When different tasks are performed on the same day, the tasks are separated with the time inputs on each operation
- Labour and time: The number and skill/type of people involved on a particular operation are detailed. The time spent by each number and type of labour in a particular operation is calculated as a total
- Production: The quantifiable output for each particular task is given. The output is quoted in per unit rate for each operation
- Remarks: This section allows for any comments or remarks pertinent to the tasks

### 8.2 Design Modification or Work Alteration Record

No matter how accurately the design and working drawings have been made, sometimes due to unavoidable situation changes may occur in the design and drawings as construction progresses. These changes must be consulted with the design engineer or expert. All those changes made while execution should be reflected on the design sheets

and working drawings, and separate amended design and drawings need to be produced. The amended design and drawings together with any on site instructions thereof will constitute the "As Built" or completion drawings verified by the project engineer/supervisor.

### **8.3 Site Instruction Book**

During construction, a site instruction book must be kept on site to record those instructions issued by the supervisor, engineer and suggestions given by other inspectors visiting the site.

### **8.4 Site Diary**

The site supervisor should keep a site diary in which notes of daily operations are documented. The diary will also include the records of visitors to the site, decisions made at the site and any occurrences like rainfall, climatic conditions, labour shortfall, and delay in material transport which are likely to affect the administration of the project.

# OPERATION AND MAINTENANCE

# 9

## 9.1 General Safety Precautions

Gravity ropeway is usually operated by local communities and operators in remote areas having no or limited facilities for repair and retrofitting. Following points should be considered in ropeway operation to avoid undesirable incidents:

- Apart from the design with suitable Factor of Safety (FOS), rigorous installation practices should be specified for on site installation
- Where the yearly use factor is low, the mechanical system should be given careful preventive maintenance treatment and provided with shelter to protect from changing weather, rain and snow, both for the machines and the operators
- Operating instructions should be rigorously drilled into the operators to avoid any accidents. The instructions should be displayed in written forms at both the lower and upper stations and mechanisms to deal with emergency situations should also be listed
- Effective communication between upper and lower station is essential for preventing accidents. Mobile phone or any other available communications means (land telephone line, signalling by hitting the rope) may be used to communicate between upper and lower stations
- A detachable handle should be provided at the lower station so that the trolley can be winched down by rotating the handle through a coupling provided for this purpose;
- Platforms of adequate sizes should be provided at both stations for loading and unloading conveniences
- The sheave system should be adequately isolated in an enclosure for the safety of those working around

## 9.2 Components Needing Special Care

### 9.2.1 Wire ropes

#### a) Inspection of wire ropes

Wire ropes in use should be inspected on a regular basis. There is a high stake involved with equipment and human lives if the periodic inspection of ropes is ignored. Wire rope must be replaced before there is any risk of failure. A rope broken in service can destroy machinery, curtail production or threaten health and life of an operator.

The purpose of inspection is to accurately estimate the service life and strength remaining in a rope so that maximum service can be taken within the limits of safety allowed by design. Results of the inspection should be recorded to provide a history of rope performance on a particular job. The person assigned to inspect the wire ropes should have good and thorough knowledge of wire ropes and their operations. Inspections should be made regularly and the results properly recorded. When inspecting the rope, the condition of the anchorage posts, sheaves, rope clamps and other end fittings should be noted. The condition of these parts affects rope wear and tear therefore, any defects detected must be repaired on time.

The operator is the most reliable person to give factual information about the condition of the ropes as he/she is the one who observes each operation. In case of any accident involving the ropes, the operator should immediately suspend the operation and report to the concerned management committee/authority. The wire ropes must then be thoroughly inspected by a competent person either for repair, maintenance or replacement depending upon the degree of its wear and tear. Normally, the ropes must be inspected once in three years for the following:

- Loosening of wires or the strands
- The amount of wear showing on the surface of the rope, which shall not

exceed one third of the original diameter of outside individual wire

- The degree of corrosion present in the rope or the number of broken ropes
- The condition of splices in the ropes and
- Extension of a rope lay, averaged from a minimum of 10 lays

Simple visual observation of the rope is not enough. The inspector needs to check on cross sectional dimensions of ropes at various intervals to check on the extent of wear and tear. By this the inspector can quickly determine where the rope is rubbing or contacting with other ropeway accessories.

#### b) Rope replacement

The rope is to be replaced under any of the following conditions:

- The diameter of the rope has been reduced by 10 per cent of its original diameter at the time of installation;
- The number of broken wires in any stretch of the rope length equals to 30 times the diameter of the rope and exceeds 10 per cent of the total number of wires in the wire rope;
- Estimated loss of strength is 20 per cent of the breaking strength of the wire rope for any reason;
- Excessive wear and tear on outer wires which has reduced their diameters (in radial direction) by approximately 20 to 30 per cent;
- Wires becoming loose;
- Distortion of the rope;



- Excessive corrosion
- The condition of the rope or its performance leaves any doubt as to its integrity and safety in operation

### c) Measure the widest diameter

Ropes and sheave grooves must be precisely fitted to each other to get the maximum service out of wire ropes. Measurement of rope diameter is a crucial part of any inspection activity. There is only one right way to measure rope diameter - use Vernier's Calipers and make sure that the widest diameter is measured. These drawings demonstrate both the right and the wrong way of measuring the ropes diameter. This method is not only useful for measuring the diameter of a new rope, but also for determining the amount of wear and compression that has occurred while the rope is in use. Accurate recording of this information is essential in deciding to replace the wire rope.

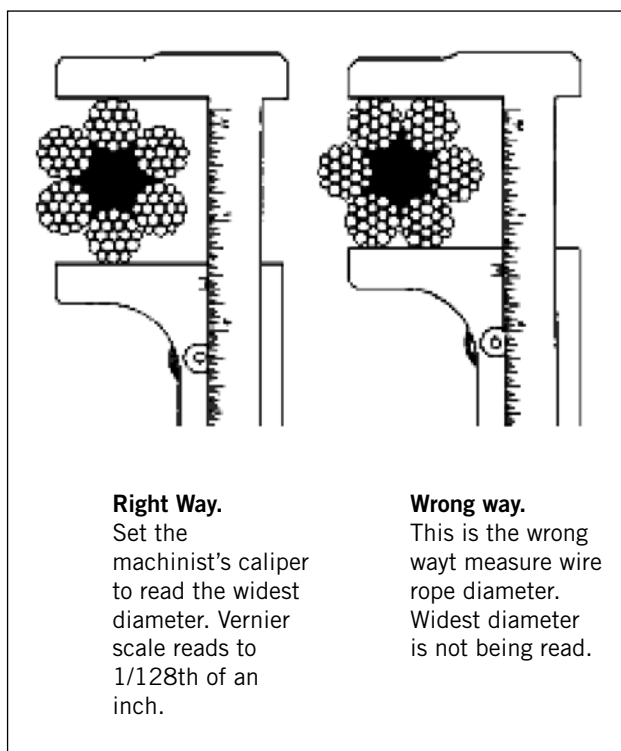


Figure 26: Measurement of rope's widest diameter

### d) Lubrication

Wire ropes have a fibre or steel core depending on the types chosen and are impregnated with oil which forms an oil film between the strands. There is a need for periodical lubrication of the rope to avoid deterioration of the core. The oil reduces the exposure of ropes to the weather elements thereby limiting the damage to corrosion. The life of the rope can be increased by timely application of lubrication after every 120 to 150 hours of operation. All the dirt accumulated over the rope surface, especially the dust, should be cleaned before the application of grease/lubricant. Approximately 30 to 40 grams of grease is required to lubricate each metre length of rope. Regular maintenance of the rope with proper lubrication increases the life of the rope by two to three times. The lubricant/grease heated to 60 to 70 degrees temperature may be used.

## 9.2.2 Sheaves

### a) Sheave inspection

Sheaves should be checked for:

- Correct groove diameter
- Roundness or contour to give proper support to the rope;
- Small holes, cracks, uneven surfaces, or other defects that might be detrimental to the rope; and
- Extreme deep wear.

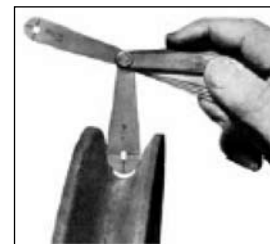


Photo 7

Sheaves should also be checked to make sure that it turns freely, is properly aligned, has no broken or cracked flanges and has bearings that work properly.

## 9.2.3 Brakes

Brake is a very important component of the gravity ropeway, if it does not come into effect at the right time, the loaded trolley will ram into the

thrust pillar - the concrete tower. It may cause damage to the trolley, the pillar and may harm the operator as well. The brake shoes, which are the only elements for decelerating the sliding down of the loaded trolley from upper station to lower station, should be well maintained. A set of spare brake shoes should always be kept at the lower station.

#### 9.2.4 Others

- The surface of the sheave and the track rope anchorage post, which touches the ropes, should be examined. If these surfaces are scored, then it will wear/tear the rope. Either replace such sheave or scrap off the worn surfaces
- The anchor blocks with hook for each track rope and the thrust tower at upper and lower station should be concreted carefully
- The U bolts connection for friction locking of the track rope should be checked
- Due attention should be given to the size of the shaft and the quality of the bearings because very large number of intermittent cycles need special care in harsh weather.
- The link between the loaded trolley and the hauling rope should be well adjusted so as to accommodate change in function from loaded mode to counter weight mode of operation

### 9.3 First Aid

A first aid box is to be kept at the site during the construction to provide primary care and treatment in case of incidences of accidents during its construction and operation at each station.

### 9.4 Tools

One set of tools and accessories, for both at the lower and upper stations is required at each gravity ropeway site for its operation and regular maintenance.

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>i. Weighing machine</li> <li>ii. Screw/slide wrench 12"</li> <li>iii. Pipe wrench 400mm</li> <li>iv. Ring spanner set</li> </ul> | <ul style="list-style-type: none"> <li>v. Double ended spanner set</li> <li>vi. Handle for manual operation</li> <li>vii. Screw driver</li> <li>viii. Oil can</li> <li>ix. Water cans at upper station</li> <li>x. Small grease gun</li> <li>xi. Brake shoes at bottom station (spare)</li> <li>xii. Griphoist (Typhor) machine or chain pulley</li> <li>xiii. Spare bulldog grips</li> </ul> |
|---|---|

# COMMUNICATION 10

There is a constant need to maintain adequate communication between the two operators at top and bottom stations to ensure smooth operation of gravity ropeway and to avoid any undesirable accidents. Similarly, community should be made aware of the risks associated and safety precautions while operating a ropeway. Following

forms of communication equipments and methods may be employed to ensure effective communication between user communities and the operators, both at the top and the bottom stations. Especially, during emergencies, effective communication is more important.

## 10.1 Telephone

Telephone/mobile phones are the most effective communication means that can be used to establish communication between the two operators at the top and bottom stations. In absence of telephone network, conventional communication methods such as hitting the rope to transmit the signal can be applied. Some gravity ropeways are already using this method and is found to be effective so far. When the rope is hit once, it means the loads are ready above. The load comes down after hitting twice from

top station and same response is given from the bottom station after the goods are unloaded. It is imperative to communicate with each other prior to each operation for balancing the loads in both the trolleys which is very crucial for ropeway operation. Likewise, it is equally important to know about the nature of load being loaded at the top station beforehand so that the activities like transferring, storing, trading and marketing of the goods can be pre-planned at the bottom station.

## 10.2 Hoarding/Notice Boards or Information Board




The following notice/information shall be posted in a prominent place in each station and shall be kept in readable condition at all times. These information/hoarding boards should contain the following information:

- General information about ropeway, span, angle of elevation, capacity of ropeway and cost of the project
- Points to remember (dos and don'ts) while operating a ropeway
- Cautions and safety precautions
- Warning and danger

- Minor repair and maintenance tips
- Contact details of manufacturers, repair and maintenance service providers
- The ways to deal with emergencies.

The information should be more elaborative and visually illustrated so that a layman or a non-professional can understand them. They should be written in simple Nepali and local language, whatever seems appropriate and possible. Below is a sample of hoarding/information board. Appropriate signs shall be posted where they are easily visible and readable by all users. Illustrative provision shall be made for the people who cannot read.

Example 1: A typical hoarding board

युरोपेली संघ र होमो फाउण्डेसन को आर्थिक सहयोग तथा प्राविधिक एकरान र किडकि कालीकोटको साकेदरीमा संघालित पहुँच कार्यक्रम अन्तर्गत ..... समुहद्वारा निर्मित सामान दुवानी गर्ने ग्राभिटी रोपवे	
<b>योजनाको विवरण</b> स्थान: माथिल्लो स्टेशन....., र तल्लो स्टेशन..... रोपवे को लम्बाई: ..... मिटर, भिरलोपना (Slope angle): ..... डिग्री भारवहन (तील) क्षमता: ..... के.जी. माथिबाट र..... के.जी तलबाट सम्पन्न मिति: .....	<b>लागतको विवरण</b> १. उपभोक्ताको जनश्रम रु..... (स्थानीय सामग्री तथा सहयोगी कामदार) २. युरोपेली संघ तथा प्राविधिक एकरान: रु..... (बाह्य सामग्री, दुवानी तथा दल कमदार) ३. .... रु..... <b>जम्मा लागत: रु.....</b>
<b>रोपवे चलाउदा ख्याल राख्नु पर्ने कुराहरू</b> १. माथिल्लो र तल्लो स्टेशनको अपरेटर बीच खबर आदान प्रदान गर्नु पर्छ मात्र रोपवे चलाउने। २. धमता भन्दा बढी सामान दुवानी गरेमा घुर्चटना हुन सक्ने तथा रोपवे नै विग्रन सक्ने भएकाले अनिवार्यरुमा सामान तौलेरमात्र दुवानी गर्ने र सामान कोको भन्दा बाहिर फुट्ट्याएर नराख्ने। ३. रोपवे चलाउनेको अवस्थामा अपरेटरको ध्यान पूर्ण रूपमा कोकोको गति वा गुडहामा केन्द्रित गर्ने र गति अत्यधिक छिटो भएमा बीचबीचमा ब्रेक लगाउने र स्टेशन नजिकबाट पुग्न लागे पछि पूरा ब्रेक लगाई रोक्ने। ४. कोको रोपवे पछि तार डोरी घुमाउने पांखा वा चिनीलाई घुम्न नसिन बन्द गर्ने र कोकोलाई गुड्न नसिन डोरी वा रडले नडुक्नुने। ५. अत्यधिक वर्षा र हवा चलेको बेला रोपवे नचलाउने। ६. रोपवे सञ्चालन सक्नुपछि वा बन्द अवस्थामा तल्लो तथा माथिल्लो दुवै स्टेशनमा तार डोरी घुमाउने पांखा वा चिनीलाई राम्रो संग साँच्चो लगाई बन्द गर्ने।	<b>नियमित मर्मत खर्चा</b> १. रोपवेको तारडोरी तथा चिनी। पुल्लीमा ३ महिनामा एकचोटी अनिवार्यरुमा गीन वा डढेको सोध्न लगाउने। चिनीको ब्रेक लगाउने भागमा क्लेन्चपिन गीन वा मोहिल प्रयोग नगर्ने तर त्यसको बेरिङमा नियमित तेल हाल्ने। २. कोको र घुम्ने तार डोरी बीचको जोडाइ, कुलडय गीप, नटबोल्ट अप्रैलाई लाई नियमित निरीक्षण गरी घुम्नुको भएमा कस्ने। ३. तारडोरीहरू कोहिलएमा सम्बन्धित संस्थाको प्राविधिकको सल्लाह दिएर टाईमरेर वा चेनपुल्लीको सहायताले तन्कउने। ४. रोपवेको घाटपुर्जा, नट बोल्टहरू तथा बेरिङ समय समयमा जाँच गरि आवश्यक परेमा मर्मत गर्ने वा फेर्ने। ५. चिनी, ब्रेक, ब्रेक शु तथा ब्रेक ड्रेन्डल समय समयमा जाँच गरि आवश्यक परेमा मर्मत गर्ने वा फेर्ने। सम्पर्क फोन माथिल्लो स्टेशन: ..... सम्पर्क फोन तल्लो स्टेशन: .....
<b>! सावधान !</b> ताम्रिम प्राप्त अपरेटर बस्नेको रोपवे चलाएमा, रोपवेको तारडोरी, चिनी वा पांखा, कोको र ब्रेक वरीपरी गई चलाए खेलेमा तथा कोकोमा चढेमा घुर्चटना हुन सक्ने भएकाले कुनै पनि हालतमा अपरेटर बाहिर नसुने यो रोपवे चलाउने निषेध गरिएको छ। साथै यो रोपवे सामान दुवानीको लागि मात्र भएकोले मानिसको लागि निषेध गरिएको छ। निषेध गरिएका कुरालाई बेवास्ता गरी वा सावधानी नबपनाई कुनै घुर्चटना भएमा व्यक्ति स्वयं जिम्मेवार हुनेछ।	
<b>This Ropeway is constructed with the support of European Union</b>	
 युरोपेली संघ	 होमो फाउण्डेसन स्पेन
 प्राविधिक एकरान, फोन ०१ ४४४६०१५	

# INSTITUTIONAL ARRANGEMENT

11

For smooth implementation, sustainable operation and up scaling of gravity ropeway, proper institutional arrangements should be made defining clear roles and responsibilities of central government, local government, private sectors,

NGOs and the beneficiary community. The following schematic diagram has been proposed to explain the roles and responsibilities of the stakeholders involved in various level of gravity ropeway project cycle.

## 11.1 Policy Level

At the policy level, the central government should be responsible to formulate policies related to gravity ropeways and have them established at the national infrastructure for transport sector development policy and plans.

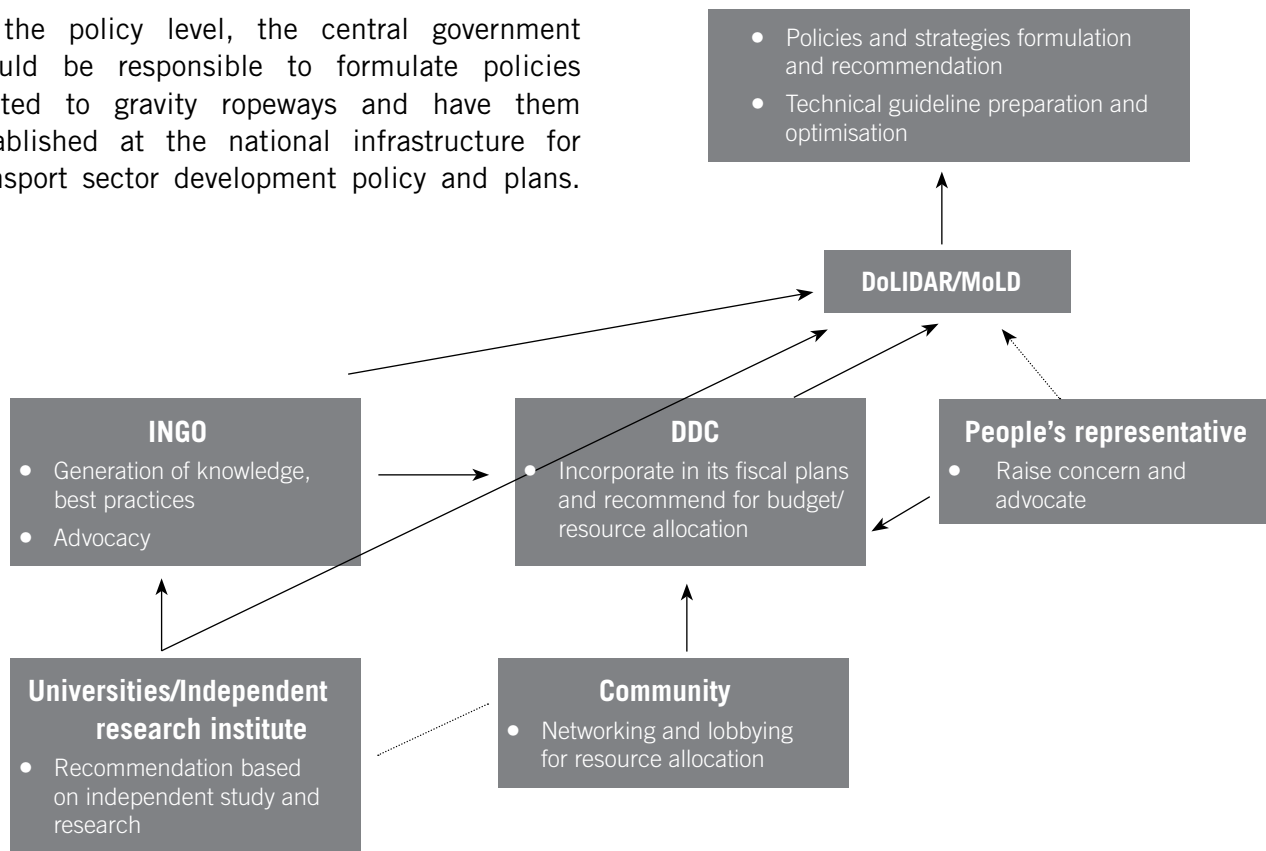


Diagram 1: Roles and responsibilities of the stakeholders involved

## 11.2 Planning Level

The planning level mostly involves the local governments, NGOs/INGOs as facilitators, local line agencies and other agencies as coordinators and communities as primary beneficiaries. The planning should follow bottom up approach with the involvement of beneficiary communities from identifying project need to decision making.

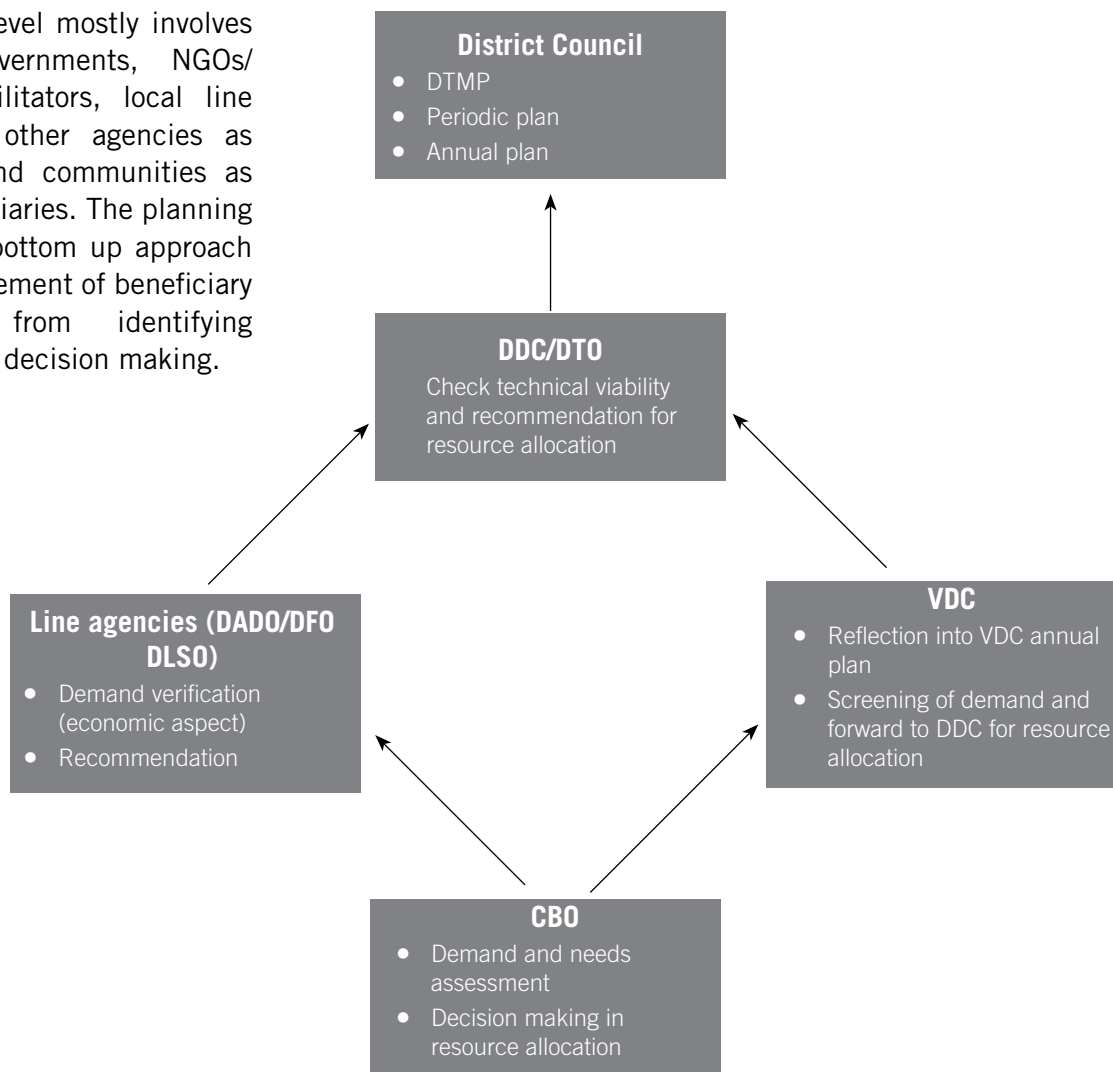


Diagram 2: Levels of planning

## 11.3 Implementation Level

At this level, it is envisioned that the local government should be involved more in facilitating technically to the Community Based Organisations (CBOs) in installing the gravity ropeway including resource allocation and monitoring of effective use of allocated resources.

The schematic diagram 3 for implementation below gives a brief overview of how each stakeholder should be involved.



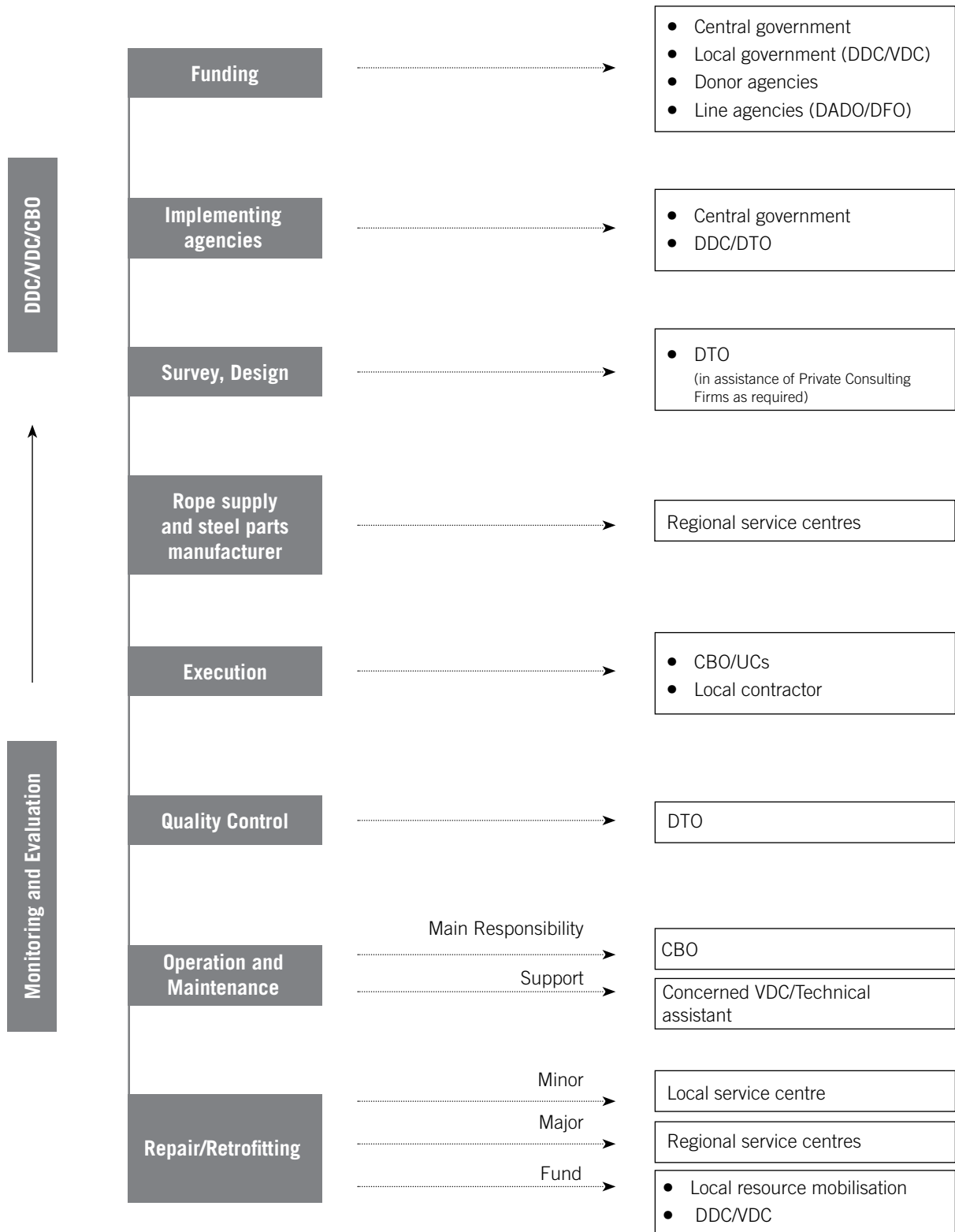


Diagram 3: Schematic diagram for implementation

## 11.4 Institutional Capacity Building Requirements

Various technical and management capacities of different stakeholders involved at different stages (from planning and installation to operation and maintenance) of gravity ropeways are required. The chart below gives a brief overview of capacity building requirements to various stakeholders.

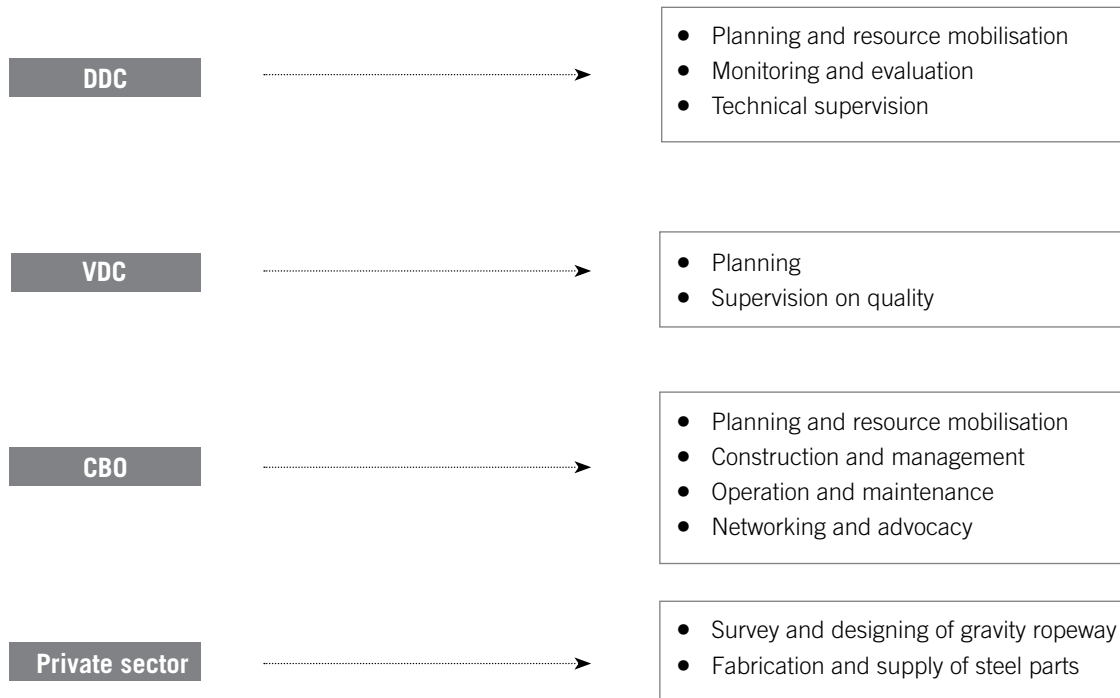


Diagram 4: Overview of capacity building requirements

# ENVIRONMENTAL ASSESSMENTS 12

Gravity ropeway is an environmental friendly technology as it leaves no or negligible impact on existing environment. Nevertheless, it is important to conduct required environmental assessments to identify the likelihood of any adverse impact due the installation/operation of the ropeway and to ensure that adequate mitigation measures are taken, if necessary.

The objectives of the environment assessment are to:

- Collect information on the existing environment
- Identify the potential micro level environment impact

- Analyse the significance of the potential impacts
- Recommend preventive and mitigation measures
- Identify alternatives to the proposed project location, if needed

The environmental assessment will include analysis of the possible impact due to the intervention of gravity ropeway in the following broad areas:

## 12.1 Socioeconomic and Cultural Impact

According to the National Environmental Impact Assessment (EIA) guideline, 1993, any alteration in social and cultural setting brought by the project (gravity ropeway in this case) on the existing social and economic condition of communities is considered as socioeconomic impact which may be both positive and negative. For example, the ropeway installation will significantly reduce the

transportation cost which is the positive impact while the local porters may loose their immediate and prominent source of cash income which is a negative consequence. Hence, the negative and positive impacts of gravity ropeway should be carefully evaluated before installation. Similarly, any impact on culture of the communities should also be evaluated.

## 12.2 Biological Impact

Possible impact of gravity ropeway on existing vegetation, forest resources, wild life and crops should be assessed. These may include cutting of trees along the ropeway alignment, loss of cropping due to change in land use among others.

## 12.3 Physical Impact

The possible hazards or disturbances on the existing geological stability should also be checked.

## 12.5 Recommended Mitigation Measures

After the assessment, mitigation measures are to be identified for each adverse impact. The mitigation measures will depend upon the severity of the impact, costs involved and resources available. Gravity ropeways are small in scale and the cost involved is less compared to other large scale infrastructure projects. Thus, it cannot afford huge and costly mitigation measures. Generally, it is recommended to change the alignment if it demands huge mitigation efforts or measures.

## 12.6 Check List for Environmental Parameters

**Table 5: Checklist for environmental parameters**

Action affecting environmental resources	Possible impacts on environment	Recommended mitigation measures
Alignment selection	<ul style="list-style-type: none"> <li>Loss of agricultural land</li> <li>Encroachment of local forest</li> <li>Land dispute</li> <li>Crossing or proximity to public facilities/ infrastructure like road, bridge and electric transmission line</li> </ul>	<ul style="list-style-type: none"> <li>Involvement of local communities during the alignment selection</li> <li>Avoid public facilities/infrastructure and agricultural land as far as possible during selection of alignment</li> <li>Risk assessment should be carried out and proper and satisfactory safety measures should be provided</li> </ul>
Survey	<ul style="list-style-type: none"> <li>Loss of agricultural products</li> <li>Loss of forest resources and vegetation</li> </ul>	<ul style="list-style-type: none"> <li>Carry out the survey during off-season</li> <li>Avoid agricultural land as far as possible</li> <li>Minimise the disturbance to forest and natural vegetation during surveying</li> </ul>
Construction	<ul style="list-style-type: none"> <li>Soil erosion</li> <li>Possibility of land slides</li> <li>Loss of agricultural land or crops</li> <li>Loss of forest resources and vegetation products</li> <li>Disturbance to the wildlife</li> </ul>	<ul style="list-style-type: none"> <li>Control/limit cut and fill and debris during the construction</li> <li>Carry out the construction work during off farming and/or festive season if possible</li> <li>Plan the construction period with community</li> </ul>
Operation	<ul style="list-style-type: none"> <li>Displacement of local porters</li> <li>Social conflict on benefit sharing</li> <li>Change in land use and land values</li> </ul>	<ul style="list-style-type: none"> <li>Support them to adopt alternative profession</li> <li>Ensure equitable distribution of benefit</li> </ul>

## PRACTICAL ACTION NEPAL OFFICE Gravity Ropeway Feasibility Study: Survey Form and Check List

### 1. SPATIAL INFORMATION

#### 1.1. Project area

VDC/Township	
Ward no	
Districts	
Zone	
Region	

#### 1.2. Location of proposed stations

Location	Upper station	Bottom station
Name of the place		
Ward		
VDC		
District		
Zone		

#### 1.3. Settlements served by the gravity ropeway

Settlements	Approximate distance from upper station	Approximate distance from bottom station	Travel time from upper station	Travel time from bottom station

## 2. SOCIOECONOMIC DATA

### 2.1. Demography

SN	Beneficiaries settlements	H/H				Population			Target household		
		DAG	Janajati	Other	Total	Male	Female	Total	H/H having disable member	Conflict affected HH	HH with single women
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

### 2.2. Educational status

Educational Status	Male		Female		Total	
	(N)	(%)	(N)	(%)	(N)	(%)
Illiterate						
Total Literate						
Total						
Literate						
Primary						
Lower Secondary						
Secondary						
Higher Secondary						
Graduate and above						
Not Stated						
Total						

### 2.3. Occupation

Occupation	Male		Female		Total	
	(N)	(%)	(N)	(%)	(N)	(%)
Agriculture						
Animal husbandry						
Hereditary Profession						
Household Job						
Industry & Commerce						
Labour						
Others						

Service						
Study						
Others (Specify )						
Total						

## 2.4. Total land size and its distribution

Land size	H/H
Up to 5	
6-16	
11-20	
20+	
Total	

## 2.5. Migration for employment

2.5.1. No of household from where at least one person is away from home for more then 6 months:

2.5.2. Seasonal migration (Approximation of whole influence area)

Month	% of Total HH	Destination	Purpose
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

## 2.6. Major crops , vegetable Livestock and NTFP products production and export

Name of major productions	Land (Ropani)	Production (kg )	Sale (Kg)	Unit price in settlement		Unit price in nearest market		Wastage
				During season	During off season	During season	During off season	




## 2.7. Goods imported to project area

Name of goods	Average quantity transported per annum (KG)	Per kg cost at nearby market	Per kg cost in the village	Remarks

List down the potential crop and vegetable in the area for future endeavour

- a)
- b)
- c)

## 2.8. Tick the major problems in agriculture

Problems	Tick
No money for investment	
Consumption market far	
Scarcity of high grade seed	
Disease	
Transportation	
Inconvenient road to go to Agri Service Centre	
Others (Specify )	

## 2.9. Poverty orientation/food sufficiency by months

Months	HH
1 to 3 Months	
3 to 6 Months	
6 to 9 Months	
9 to 12 Months	
12 plus Months	

## 2.10. Livestock production and its sales and total income (Rs.)

Livestock	Total income of sample group
Ox & Cow	
Buffalo	
Milk, Ghee, Curd, etc.	
Lamb	
Goat	
Boar	
Horse/Mule	
Duck, Chicken, Egg	
Bee Hive Honey	
Others	
Total (Rs.)	
Average annual income	

## 2.11. Major problems of livestock production by ranking (percentage)

Problems	Tick
No investment money	
Market far	
Lack of improved seeds	
Birds infection	
Lack of grazing	
Can't cross the river to go to Birds Service Center	
Inconvenient road to go to Birds Service Center	
Others ( Please specify)	

## 2.12. Existing services and infrastructures

Please tick the appropriate column

SN	Service/Infrastructure Categories	Yes	No	If present outside the influence area , approximate distance ( KM ) or time ( Hr )
1	Education			
	Campus			
	High school			
	Primary school			
2	Health			
	Hospital			
	Health post			
3	Communication			
	Telephone			

	Fax			
	Wireless			
	Post office			
	Internet			
4	Electricity supply			
	National grid			
	Microhyrdro			
	Solar			
	Others (Specify )			
5	Business and commerce			
	Hotel and lodges			
	Restaurants and tea stalls			
	Grocery shops			
6	Drinking water			
	Gravity flow scheme			
	Tube wells			
	Direct from stream/wells			
7	Irrigation schemes			
	Surface irrigation			
	Ground water			
	Others (Specify)			
8	Bridges			
	Suspension bride			
	Wooden bridge			
	Motorable bridge			
9	Industry			
	Rice and flour mills			
	Weaving industry			
	Other industries (Specify)			
10	Financial institutions			
	Commercial banks			
	Agriculture bank			
	Cooperatives			
11	Community use			
	Hatia/Bazar			
	Community centre			
	Others (Specify)			

### 2.13. Community/social resource map

In addition to the above information, a social resource map is to be prepared by the community member in a participatory manner. It is an important tool for need assessment, planning and monitoring and evaluation. So, ensure the participation of as many community members as possible with proper representation and balance of gender, class, caste and ethnicity. The social map is to be prepared in a seperate sheet.

### 3. INSTITUTION

#### 3.1. Detail of existing Community Based Organisation in the community (CBO/FUG/SHG/Local Clubs /farmers group/cooperatives)

SN	Name of CBO	Date of CBO		No CBO members	List of major activities initiated by CBO name of support organisation	Remarks
		Formed	Registered			

#### 3.2. List the potential vendors/supplier in the project area (if any)

SN	Name of the supplier/vendor	Location	Major item	Distance form project site

#### 3.3. List down the potential manufacturer/fabricators

SN	Name of the supplier/vendor	Location	Major work /scale	Distance form project site

#### 3.4. Local DDC/VDC support/commitment

Do the DDC and the project VDC agree with the selected site? What is their commitment for the project?  
Interview the authorised staff or members of DDC/VDC

SN	Name	Address	Function	Remarks

*In addition, get a letter of confirmation regarding the site selection from VDC secretary or Chairperson.*

- 3.5. In the village or nearby there may be local bridge builders who have already built some bridges/gravity ropeway. Their skill can be utilised in the construction of the proposed gravity ropeway. If such people are available, record their names.**

Names	Skill	Village	Remarks

- 3.6. Prevailing wage rate as per the local practice and approved district norms**

Type of labour	Wage as per local practice (per day)	Wage as per approved district norms (per day)	Remarks
Skilled labour			
Unskilled labour			

- 3.7. Availability of land for stations**

**3.7.1. Land type**

Upper station:

Government: ☐ Public: ☐ Private: ☐ Others (Please specify): ☐

Lower station

Government: ☐ Public: ☐ Private: ☐ Others (Please specify): ☐

- 3.7.2. If the land is private , Is the land owner willing to provide the required land for free ? Yes: ☐ No: ☐**

If no, is the community committed or able to manage buying the land ?

(Get a no objection letter or ownership transfer letter from land owner and if it is owned by the government get a written consent from the concerned department)

- 3.8. Possible level of people's participation (Tick the appropriate box)**

SN	Type of participation	Level of participation			Remarks
1	Cash contribution				
2	Free labour				
3	Women's participation				
4	Social mobilisation				
5	Construction supervision				
6	Others (Specify) .....				

## 4. EXISTING TRANSPORTATION SITUATION

### 4.1. Existing mode of transport

SN	Mode of transport	Average daily traffic (Passenger)		Average daily traffic (goods)				Remarks
		Peak period	Slack period	Peak		Slack		
				To village	From village	To village	From village	
1	Bus							
2	Truck /Tractor							
3	Bicycles							
4	Rickshaws/tricycles							
5	Carts pulled/pushed by human beings							
6	Mule carts or horse drawn carts							
7	Pack animals and mules							
8	Potters							

### 4.2. Goods transported (imported) in to the influence area

Months	Name of goods	Approximate quantity/month	Mode of transport	Per kg rate of transport	Remarks

**4.3. Goods transported (exported) outside to the influence area**

Months	Name of goods	Approximate quantity/month	Mode of transport	Per kg rate of transport	Remarks

**4.4. Travel time**

Mode of transport	Travel time (Village to road)		Road to village	
	Laden	Un-laden	Laden	Un-laden

**4.5. Name of the nearest road (from bottom station):**

4.5.1. Class of road: National highway ☐ District road ☐ Village road ☐

4.5.2. Category of Road: Black topped ☐ Gravel ☐ Earthen ☐

**4.6. If the village is already not connected by road network, is there any possibility of road extension network or other type of transportation within five years ?**

(N.B: Refer District Transport Master Plan of the district and make inquiry with the local government (DDC, VDC) and local dignitaries to know about the road extension plan)

**4.7. Describe the general difficulties associated with the current mode of transportation system and facilities (e.g. not sufficient to cope with demand, operational problems , risky, time consuming, costly, service not guaranteed etc)****4.8. Expected change/improvement in the transportation status due to the intervention of gravity ropeway in the project area?**



## 5. MARKET ASSESSMENT

5.1. Is the location close to any major urban market/cities/township? Yes: ☐ No: ☐

If yes, list them

5.2. Are there any major market places closes by (haat bazaar, wholesale market, collection centre)?

Yes: ☐ No: ☐

If yes, name them

5.3. Name major market for the local produces

Existing

Potential

5.4. Other market information:

Criteria	Yes	No	Remarks
Access to services			
Do the target groups have access to critical services (inputs, loans, advices, etc?)			
Please check those that easily accessible to target groups			
Public extension service/ government agency			
Private agro-vets and para-vets			
Finance (loans, savings, insurance) – MFIs, Banks, Coops			
Collection centres and information centres			
Market knowledge			
Do the target groups have access to market information? Prices, quality, variety, demand etc.			
Do they know where to go to sell their products beyond the local market?			
Collaboration and coordination			
Are they currently selling their products individually?			
Are they currently buying their inputs individually?			
Is there a bulking point? Collection centre?			
Are there any specific individuals/ group providing market related services?			
Please check those that easily accessible to target groups			
Bulking service for products (Collection centres)			
Storage services (chilling centres, cellar storages)			

Criteria	Yes	No	Remarks
Transportation services (porters, trucks and vehicles)			
Mediation and match making (finding buyers and traders)			

## 6. ENVIRONMENTAL EXAMINATION

### 6.1. Biological impact

**6.1.1. Does the proposed gravity ropeway location fall inside or proximate to (tick the appropriate one)**

National parks, wildlife reserves, hunting reserve  
 Conservational areas  
 Other protected areas  
 None

**6.1.2. Does the gravity ropeway alignment pass through forest ? Yes: ☐ No: ☐**

If yes, tick the appropriate one

State Forest  
 Community Forest  
 Religious forest  
 Private forest

**6.1.3. Are there any public facilities (e.g. road, settlements, main trail etc) below or proximate to the gravity ropeway alignment? Yes: ☐ No: ☐**

If yes, list them

**6.1.4. Does fertile land come under the Ropeway alignment? Yes: ☐ No: ☐**

If yes, mention the type of cultivation

### 6.2. Social, cultural, historic and archaeological sites

**6.2.1. Does the proposed gravity ropeway have any negative impact in the followings?**

Palace, forts, monuments, inscriptions (pillars, stone etc)  
 Temple, monasteries, mosques etc  
 Sites for mela, jatra, radi etc  
 Ford, hhautari  
 Spots of mineral deposit  
 Local infrastructure (Suspension bridge, water mills, irrigation structures etc)

Please tick the appropriate and mention the severity of the impact?

### 6.3. Physical impact

Please check if any of the following risk are present at proposed stations?

- Active and passive landslide spots at stations
- Soil erosion
- Flood prone, active or susceptible to undercutting of slope toe by rivers/streams which lead to instability
- Low laying areas/risk of water logging, stagnant water pool
- Weak geological formations, loose deposits, susceptible to instability due to a minor disturbance
- Tick the imminent risk and access the magnitude of the risk.

### 6.4. Socioeconomic

**6.4.1. How may households (HH) have embraced the pottering for their livelihood? How many of them will loose their job after installation of gravity ropeway?**

**6.4.2. Is there any risk of displacing the processing plants if any in the village after the installation of gravity ropeway?**

**6.4.3. Will there be any negative implication to the village (inside village) market after the gravity ropeway links the village with the major market/road? Explain**

**6.4.4. List other socioeconomic (negative) implication of gravity ropeway if any.**

**6.4.5. Check list for environmental parameter**

Action affecting environmental resources	Possible impact on environment	Recommended mitigation measures
Alignment selection		
Survey		
Construction		
Operation		

## 7. TECHNICAL

### 7.1. Availability of local resources

SN	Resources	Adequate	Some	None	Remarks
1	Construction materials				
	Boulder/Stone				
	Sand				
	River gravel				
	Aggregate				
	Brick				
	Timber				
	Stone dust				
	Others (Specify)				
2	Human Resource				
	Skilled				
	Unskilled				
	Others (Specify)				Local supervisor (etc)

### 7.2. Transportation of local materials

SN	Construction material	Upper station					Upper station				
		Haulage distance (KM)	Time (hr)				Haulage distance (KM)	Time (hr)			
			To	Collection	Return	Total		To	Collection	Return	Total
1											
2											
3											
4											

### 7.3. Transportation of non local materials

SN	Construction material	Mode of transportation	Place		Distance (KM/hr /days)			Rate
			From	To	To	From	Total	
1		Truck						
2		Tractor						
3		Mule						
4		Pottering						

## 7.4. Slope study and site selection (stations)

### 7.4.1. Slope and stability

7.4.2. Smooth ☐ Partially cut out ☐ Cut out ☐ Strongly cut out ☐

7.4.3. Average inclination:      degree

7.4.4. Land available: Length = m and Breadth = m

7.4.5. Vegetation Cover on the slope: Heavy ☐ Moderate ☐ Few ☐ None ☐

### 7.4.6. Erosion

Bank erosion: Heavy ☐ Moderate ☐ Light ☐ None ☐

Gully erosion: Heavy ☐ Moderate ☐ Light ☐ None ☐

Sheet erosion: Heavy: ☐ Moderate: ☐ Light: ☐ None ☐

7.4.7. Water run off on the slope : Yes ☐ No ☐

7.4.8. Presence of swampy area: Absent ☐ Permanent ☐ Seasonal ☐

7.4.9. Transverse open cracks: Absent ☐ Permanent ☐

7.4.10. Longitudinal open cracks: Absent ☐ Permanent ☐

### 7.4.11. Fallen blocks or rock fall on slope and bank

Absent ☐ Present ☐ Few ☐ Numerous ☐ Seasonal ☐ Rounded ☐

7.4.12. Landslide ☐ Dormant ☐ Absent ☐

7.4.13. Landslide or fallen Debris ☐ Present ☐ Absent ☐

7.4.14. Weathering of rock: Sound ☐ Fair ☐ High ☐

## 7.5. Impression

Judgment of bank	Action to be taken
Good	Proceed with further investigation
Acceptable	Proceed with further investigation propose protective measures
Questionable	Consult with geologist
Unstable	Choose a new site

## 7.6. Geological investigation

### ROCK INVESTIGATION

NAME:

LOCATION:

Description	Sample number			
	1	2	3	4
1. General information				
Location				
Bank				
Sample depth				
Photo no.				
GPI no.				
2. Layers				
Hammer sound test (hardness)				
Bonding of grains/layers				
Quartz test (scratch hammer)				
Calcit test (Hcl reaction)				
Texture (grain size & shape)				
colour				
Fracture pattern				
Bedding (with thickness)				
Special characters				
3 Rock type				
4. Weather grade				
5. Photograph no.				

Remarks

1.a Tower, main anchorage (MA)

1.e GPI= Geological plane investigation

2.a no/yes laminated/foliated/banded

2.b brittle/dull

2.c well/not well

2.d no/fine/strong

2.e no/yes, slight/strong.very strong, at joint or at rock mass

2.f coarse/mediym/fine/very fine, angular/rounded

2.h planer/curve, regular/irregulr

2.i lear/not so clear/not clear

## 7.7. Soil investigation

NAME:

[illegible]

## 7.8. Tacheometry

NAME:

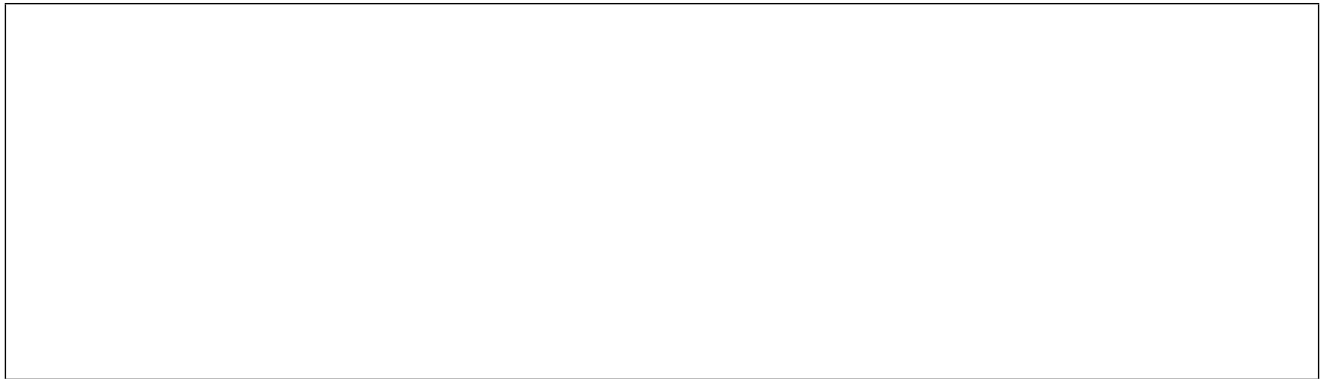
LOCATION

[illegible]



**7.9. Prominent climatic adversity in the area?**

Climatic condition	Severity			Remarks
	High	Medium	Low	
Wind				
Rain				
Snow				

**8. LOCATION MAP**

**9. PHOTOGRAPHS**

UP STATION	DOWN STATION

**10. LIST DOWN THE EXPECTED BENEFITS FROM THE INSTALLATION OF GRAVITY ROPEWAY**

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**11. OVERALL IMPRESSION OF SURVEYOR**

--

**12. SURVEYED BY**

Name	Signature	Date

# Annex 2

## Chhimkeswori Gravity Ropeway Rope Design - Track Rope

### INPUT

Horizontal distance between upper and lower saddles	l	842.60 m
Vertical distance between upper and lower saddles	h	500.00 m
Sag of the rope, hanged between two saddles (dead sag)	b	50.00 m

Rope specification	Size, f mm	Weight kg/m	Breaking load, kN	Construction	Core
Track rope	12 mm	0.590	91	6x19 (9/9/1)	WS
Hauling rope	9 mm	0.302	47	6x19 (9/9/1)	FC

Point loads	Trolley	Max allowable load	Accidental load due to hauling rope	Maximum possible load
Downward moving load, W2	30.00 kg	120.00 kg	70.39 kg	220.39 kg
Upward moving trolley	30.00 kg	40.00 kg	70.39 kg	140.39 kg
Weight of one line hauling rope between saddles				281.57 kg

Wind load	
Wind load corresponding to 160 km/hr wind speed (at 20 inclination)	0.005kN

Temperature	
Expected temerature variation	20.00*c
Co-efficient of thermal expansion	1.20E-05

### DESIGN

A) Rope length				
Saddle to saddle rope length	Backstay distance	Anchorage Length	Additional rope length	6x19 (9/9/1)
998.86 m	20.00 m	12.00 m	140.00m	6x19 (9/9/1)

**A) Rope inclination at saddles at dead load**

Saddles	Angle
Higher( $\beta_1$ )	39.72 degree
Lower ( $\beta_2$ )	19.60 degree

**B) Rope inclination at saddles at full load**

Full load sag (Imported from Sap analysis )	Saddles	Angle
58.50m	Higher( $\beta_1$ )	41.06 degree
	Lower ( $\beta_2$ )	17.52

**C) Tension Calculation****Dead load**

Horizontal Tension, HTC	10.47 kN
Tension on higher side, TTC1	13.61 kN
Tension on lower side, TTC2	11.12 kN
Safety Factor of ropes	6.68

**100% wind load**

Horizontal Tension, HTC	9.47 kN
Tension on higher side, TTC1	12.31 kN
Tension on lower side, TTC2	9.47 kN

**Live load (including accidental load )**

Horizontal Tension, HTC	7.94 kN
Tension on higher side, TTC1	10.52 kN
Tension on lower side, TTC2	8.32 kN
Safety Factor of ropes	

**1/3 wind load**

Horizontal Tension, HTC	2.69 kN
Tension on higher side, TTC1	3.57 kN
Tension on lower side, TTC2	2.83 kN

**Impact load**

Impact load	3.49KN
-------------	--------

**Temperature variation**

Deformation	0.24m
Change in Sag	0.770500287

## Load combination 1

Dead load+ full wind load	25.920kN	Remark
Factor of safety	3.51	Safe

## Load combination 2

Dead + live +1/3 of wind +10% impact	28.06kN	Remark
Factor of safety	3.24	Safe

## Chhimkeswori Gravity Ropeway Rope Design - Haulage Rope

## INPUT

Horizontal distance between upper and lower saddles	l	843.18 m
Vertical distance between upper and lower saddles	h	366.39 m
Sag of the rope, hanged between two saddles (dead sag)	b	55.00 m

Rope specification	Size, fmm	Weight kg/m	Breaking Load, kN	Construction	Core
Hauling Rope	9m	0.3	47	6x19 (9/9/1)	FC

## Wind load

Wind load corresponding to 160 kM/hr wind speed (at 20 inclination)	0.004kN
---	---------

## Temperature

Expected temerature variation	20.00*c
Co-efficient of thermal expansion	1.20E-05

## OUTPUT

## A) Rope length

Saddle to saddle rope length	932.35 m
------------------------------	----------

## B) Rope inclination at saddles at dead load

Saddles	Angle
Higher( $\beta_1$ )	34.82 degree
Lower ( $\beta_2$ )	9.85 degree

## C) Tension Calculation

## Dead load

Horizontal Tension, HTC	4.85 kN
Tension on higher side, TTC1	5.90 kN
Tension on lower side, TTC2	4.92 kN
Safety factor of ropes	7.96

## 100% wind load

Horizontal Tension, HTC	6.46 kN
Tension on higher side, TTC1	7.87 kN
Tension on lower side, TTC2	6.46 kN

## 1/3 wind load

Horizontal Tension, HTC	2.13 kN
Tension on higher side, TTC1	2.60 kN
Tension on lower side, TTC2	2.16 kN

## Impact load

Impact load	3.49kN
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## Temperature Variation

Deformation	0.22m
Change in Sag	0.66m

## Load combination 1

Dead load+ full wind load	13.776kN	Remark
Factor of safety	3.411655622	

## Load combination 2

Dead load+ 1/3 wind load + 50% of Impact	10.250kN	Remark
Factor of safety	4.585558162	Safe

# Annex 3



## PRACTICAL ACTION NEPAL OFFICE Access for Opportunities SALIENT FEATURE: Chhimkeswori Gravity Ropeway

Item#	Items	Unit	Quantity		Total	Remarks
			Upper Station	Lower Station		
1	Site clearance	m <sup>2</sup>	45.00	26.00	71.00	
2	Earth work in excavation	m <sup>3</sup>	159.56	44.50	204.06	
3	Rubble stone masonry(1:6)	m <sup>3</sup>	17.87	22.21	40.08	
4	Rubble stone masonry(1:4)				0.00	
5	Sand filling				0.00	
6	Boulder soling		5.04	5.04	10.08	
7	Salwood		1.65		1.65	
8	26 gauge CGI sheet colour		46.92	50.31	97.23	
9	PCC for RCC work (1:2:4)	m <sup>3</sup>	5.74	4.89	10.63	
10	Plumb concrete (1:3:6) + 40% boulders	m <sup>3</sup>	6.21	6.02	12.23	
11	Plaster in 1:4 C/M	m <sup>2</sup>			0.00	
12	Reinforcement steel	kg	211.13	145.35	356.48	
13	Binding Wire @1% of reinforcement	kg	2.11	1.45	3.56	
14	Gabion work	no	4.00	2.00	6.00	
15	J hooks	no	141		141	9.4
16	Nuts and bolts	no	141		141	14.1
17	Washer	no	281		281	1.4



**PRACTICAL ACTION NEPAL OFFICE**  
**Access for Opportunities**  
**STEEL PARTS SUMMARY: Chhimkeswori Gravity Ropeway**

	Items	Unit	Quantity	Remark
1	Rope	m		
	Track	m	2360.00	
	Haulage		2160.00	
2	Structural steel	kg	354.83	
3	Machining part	kg	163.24	
4	Bearing			
	Track pullies -6203-2 Z	no	4	
	Dummy pullies 6000-2 Z	no	4	
	Sheave bearing 1212	no	4	
5	Housing for 1212 bearing	no	4	
6	Nut bolts	kg	1.43	
7	Bulldog grip	no		
	9mm	no	12	
	12mm	no	18	
8	Thimble	no		
	9mm	no	5	
	12mm	no	5	
9	Truss post	kg	472.09	

**PRACTICAL ACTION NEPAL OFFICE**  
**Access for Opportunities**  
**QUANTITY ESTIMATE: Chhimkeswori Gravity Ropeway**

SN	Description	No	Length m	Breadth m	Height m	Quantity	Unit
<b>A</b>	<b>Upper Station</b>						
1	Site clearance					45.00	m <sup>2</sup>
2	Earth work in excavation						m <sup>3</sup>
	Anchorage block	1	3.20	5.10		16.32	
	Platform	1	4.00	6.70		26.80	
	RCC Pillar at front	2	1.4	1	1.2	3.36	
	Side walls foundation	2	6.40	8.50		108.8	
	Back wall	1	4.00	0.50	1.60	3.2	
	Sheave anchorage	1	2.40	1.50	0.30	1.08	
						<b>159.56</b>	
3	Rubble stone masonry(1:6)						m <sup>3</sup>
	Anchorage block						
	Long wall back	1	3.20	0.30	1.80	1.73	
	Short wall	2	1.50	0.30	1.53	1.37	
	Main					0.00	
	Front wall	1	4.00	1.00	0.25	1.00	
	side walls	2	6.40	0.50	1.20	7.68	
	Back wall	1	4.00	0.50	1.60	3.20	
	Pillar	2	1.40	0.50	0.65	0.91	
	Sheave anchorage						
	Long wall	2	2.40	0.30	1.00	1.44	
	Short wall	2	0.90	0.30	1.00	0.54	
					<b>Total</b>	<b>17.87</b>	
4	PCC for RCC work (1:2:4)						m <sup>3</sup>
	Pillar basement	2	1.40	1.40	0.20	0.78	
	Pillar	2	3.80	0.45	0.45	1.54	
	Beam	1	3.00	0.45	0.45	0.61	
	Post	4	0.40	0.40	0.60	0.38	
	Anchorage post	2	1.80	0.13		0.45	
	Sheave anchorage	2	0.90	0.40	0.80	0.58	
	Floor	1	6.40	3.00	0.08	1.54	
	Deduction		(2.35*1.5)X.08			-0.14	
					<b>Total</b>	<b>5.74</b>	
5	Plumb concrete (1:3:6) +40% boulders						m <sup>3</sup>
	Anchor block	1	2.60	1.50	1.53	5.97	
	Sheave anchoring block	1	0.90	0.76	0.80	0.70	

	Deduction		2@3.14 (.4)2/4X1.6			-0.45	
					<b>Total</b>	<b>6.21</b>	
6	Reinforcement steel						Kg
	Beam - 16 mm	4	4.00	1.58		25.25	
	Concrete column - 16mm dia rod	8	4.40	1.58		55.56	
	Pillar basement 12mm dia rod	20	1.40	0.89		24.92	
	Sheave anchorage 12mm dia rod	8	0.64	0.89		4.55	
	Anchorage post 16mm dia rod	12	1.95	1.58		36.97	
	Link/Stiruups 8mm						
	Beam 400mm*400mm	25	1.80	0.39		17.55	
	Piller 400mm*400mm	50	1.80	0.39		35.10	
	Anchorage post (300 dia Circular)	24	1.20	0.39		11.23	
					<b>Total</b>	<b>211.13</b>	
	Binding wire @1% of reinforcement					2.11	
7	Stone soling	1	4.00	4.20	0.30	5.04	
8	Supplying and fitting of salwood						
	(A) Truss						
	Tie beam	3	4.30	0.15	0.15	0.29	
	Rafters	6	2.30	0.12	0.12	0.20	
	King post	3	1.00	0.15	0.15	0.07	
	Struts small	6	0.50	0.15	0.15	0.07	
	Vertical post	4	3.70	0.2	0.2	0.59	
	(B) Purlins						
	Purlins No=2*4=8	8	7.60	0.075	0.075	0.34	
							m <sup>3</sup>
	© Supplying and fitting of 25mm Th. Eves board						
	Eves board	1	24.40	0.025	0.15	0.09	m2
						1.65	
9	Tor steel reinforcement bar						
	Quality as per attacehd paper						
10	(A) Roofing with C.G.I sheet of 26 gauge and colour						
	Roofing for building	1	7.60	2.97		22.57	
	Do next side	1	7.56	2.97		22.45	
							m2
	(B) Do but G.I plan sheet on ridge of 26 gauge and colour						
	Ridge for roofing	1	7.56	0.25		1.89	m2
						46.92	
	J hooks	140.7456				141	nos
	Nuts and bolts	140.7456				141	nos
	Washer	281.4912				281	nos

11	Gabion work						
	2x1x1	4				4	no
B) Bottom station							
1	Site clearance					26.00	m <sup>2</sup>
2	Earth work in excavation						m <sup>3</sup>
	Anchorage block	1	3.20	5.63		18.02	
	Front wall	1	5.36	0.69		3.70	
	RCC pillar (Left)	1	1.4	1.4	1.1	2.156	
	RCC pillar (Right)	1	1.4	0.44		0.616	
	Post foundation	4	0.90	0.90	1.20	3.888	
	Side walls foundation	1	7.49	0.50	1.00	3.745	
	Back wall	1	4.90	0.50	2.70	6.615	
	Sheave anchorage	1	3.10	1.50	0.81	3.7665	
	Gabion work	1	4.00	0.50		2	
						44.50	
3	Rubble stone masonry(1:6)						m <sup>3</sup>
	Anchorage block						
	Long wall - front	1	4.90	0.50	1.75	4.29	
	Long wall - back	1	3.20	0.30	1.80	1.73	
	Short wall	2	1.50	0.30	1.80	1.62	
	Main					0.00	
	Front wall	1	4.90	0.50	0.90	2.21	
	Deduction						
	Front wall	1	4.40	0.50	0.45	0.99	
	side walls	2	7.49	0.50	0.93	6.97	
	Pillar	2	1.40	0.45	0.80	1.01	
	Post	8	0.96	0.96	0.32	2.36	
	Sheave anchorage						
	Long wall	2	3.10	0.30	0.80	1.49	
	Short wall	2	0.90	0.30	0.80	0.43	
	Deduction						
	Post	8	0.96	0.11		-0.87	
					<b>Total</b>	<b>22.21</b>	
4	PCC for RCC work (1:2:4)						m <sup>3</sup>
	Piller	2	0.45	0.45	2.90	1.17	
	Piller basement	2	1.40	1.40	0.20	0.78	
	Post	8	0.30	0.30	0.60	0.43	
	Anchorage post	2	1.80	0.13		0.45	
	Sheave anchorage	2	0.40	1.10	0.70	0.62	
	Floor	1	6.00	3.90	0.08	1.87	

	Deduction		(2X.45x.45+3.1*1.5) X.08			-0.44	
					Total	4.89	
5	Plumb concrete (1:3:6) +40% boulders						m³
	Anchor block	1	2.60	1.50	1.48	5.77	
	Sheave anchoring block	1	1.50	1.10	0.70	0.70	
	Deduction		2@3.14 (.4)2/4X1.8			-0.45	
					Total	6.02	
6	Reinforcement steel						Kg
	Concrete pillar - 16mm dia rod	8	3.50	1.58		44.19	
	Pillar basement 12 mm	20	1.40	0.89		24.92	
	Sheave anchorage 12 mm	8	0.65	0.89		4.62	
	Anchorage post	12	2.00	1.58		37.92	
	Stiruups 8mm						
	Piller (400 mm* 400 mm )	32	1.80	0.39		22.46	
	Anchorage post (300 mm diameter)	24	1.20	0.39		11.23	
					Total	145.35	
	Binding wire @1% of reinforcement					1.45	
7	Stone soling	1	4.00	4.20	0.30	5.04	
8	Steel poles						
	(A) Truss						
	Horizontal	4	4.40	2"			
	Rafters	8	3.10	2"			
	King post	4	1.30	2"			
	Struts small	8	0.73	2"			
	Inclined struts	8	1.30	2"			
	Vertical post	8	3.75	2.5"			
	(B) Purlins						
	Purlins No=2*4=8	8	7.56	1.5"			
							m³
	© Supplying and fitting of 25mm Th. Eves board						
	Eves board	1	26.28	0.025	0.15	0.10	m2
						0.10	
9	Tor steel reinforcement bar						
	Quality as per attacehd paper						
10	(A) Roofing with C.G.I sheet of 26 gauge and colour						
	Roofing for building	1	7.80	3.1		24.18	
	Do next side	1	7.80	3.1		24.18	
							m2

	(B) Do but G.I plan sheet on ridge of 26 gauge and colour						
	Ridge for roofing	1	7.80	0.25		1.95	m2
						50.31	
	J hooks	150.93				151	nos
	Nuts and bolts	150.93				151	nos
	Washer	301.86				302	nos
11	Gabion work						
	2x1x1	2				2	no

# PRACTICAL ACTION NEPAL OFFICE

## Access for Opportunities

### QUANTITY ESTIMATE STRUCTURE: Chhimkeswori Gravity Ropeway

#### 1) Wire ropes

S.No.	Materials	Specification	Size (9mm)	Unit wt	Sinle length	No of reel	Total length	Total weight
1	Track Rope	6x19(9x9x1)	12	0.59	1180	2	2360	1392.4
2	Haulage rope	6x19(9x9x1)	9	0.302	1080	2	2160	652.32
								2044.72

#### 2) Sheave and sheave anchorage frame

S.No.	Materials	No.	Lenth	Unit wt	Total wt	Remarks
Upper Station						
a)	<b>Sheave</b>					
	Fly wheel (Cast Iron)	1		52.00	52	Machining part
	Shaft	1		6.31	6.31	
	Bush				0	
	Total				58.31	
b)	Bearings					
	Track pulleys 6203-ZZ	2				
	Dummy pulleys 6000-ZZ	2				
	Sheave bearing 1212	2				
	Housing for 1212 bearing	2				
c)	Sheave Frame					
	ISLB 150	2	2.3	14.20	65.32	Structural steel
	ISLB 150	2	2	14.20	56.8	
	ISMC	2	1.35	9.56	25.812	
	Connecting plate , PL 10	2	400 mmx400mm	12.56	25.12	
	Connecting plate , PL 10	2	400 mmx200mm	6.28	12.56	
	PL 5	3	30 mm x280mm	0.33	0.9891	
					186.60	
Bottom station						
a)	<b>Sheave</b>					
	Fly wheel (cast Iron)	1		74.00	74	Machining part
	Shaft	1		10.41	10.41	
	Bush				0	
					84.41	
	<b>Bearings</b>					

	Track pulleys 6203-ZZ	2				
	Dummy pulleys 6000-ZZ	2				
	Sheave bearing 1212	2				
	Housing for 1212 bearing	2				
c)	<b>Sheave Frame</b>					
	ISLB 150	2	1.8	14.20	51.12	
	ISLB 150	2	0.6	14.20	17.04	
	ISMC	2	2	9.56	38.24	
	Connecting plate , PL 10	2	400 mmx400mm	12.56	25.12	
	Connecting plate , PL 10	2	400 mmx200mm	6.28	12.56	
					92.96	
d)	<b>Brake</b>					
	Connecting plate, PL5	2	30mm x 343mm	0.40	0.80	
	Brake plate, PL5	1	50mm x 850mm	1.67	1.67	
	Wooden brake shoe	1		0.90	0.90	
	Bracket	1		0.95	0.95	
	Bracket	1		1.04	1.04	
	Rect. Casing for wooden handle,PL5	1		1.87	1.87	
					7.23	
3	<b>Bucket/ Trolley</b>					
	Rectangular pipe 38x25x2	4	602	1.15	4.61	
		4	804	1.54	6.16	
	Square pipe 25x25x1.5 mm	4	562	0.85	3.39	
	Hanger angle					
	ISA 50x50x6	2	1200	5.64	11.28	
		2	700	3.29	6.58	
	Connection plate	2		0.74	1.48	
	PL 93x30x6	4		0.13	0.52	
	Hanger arm	1			7.75	
					34.02	
	Total weight of 2 trolleys				68.04	
	Pulleys					
	Pulley f 150 x 30mm	4.16	kg/unit	4.00	16.64	
	Pulley f 60 x 30mm	0.67	kg/unit	4.00	2.66	
	Pin f 17 x 70mm	0.12	kg/unit	4.00	0.49	
	Pin f 10 x 70mm	0.04	kg/unit	4.00	0.17	
	Hinge pin f 25 x 73mm	0.28	kg/unit	2.00	0.56	
					20.52	
	Bolts f 16x 170mm	0.27	kg/unit	1.00	0.27	
	Bolts and nuts M16 x 50mm	0.14	kg/unit	8.00	1.10	
	Nut, M14	0.03	kg/unit	2.00	0.06	
					1.43	



	Connecting accessories					
	A) Plate for wooden truss at upper station	LS			50	
	Bulldog grips					
	9mm	no			12	
	12mm	no			18	
	Thimble					
	9mm	no			5	
	12mm	no			5	
4	Plate for wooden truss at upper station	LS			50	
	Circular post					
a)	Vertical poles	8	3.7	3.75	111	
	Horizontal	4	4.4	2.75	48.4	
	Rafter	8	2.62	2.75	57.64	
b)	King post	4	1.43	2.75	15.73	
	Struts	8	0.66	2.75	14.52	
	Purlins	8	7.8	2	124.8	
C)	Plate and other accessories				50	
					472.09	
1	Structural steel	354.83				
2	Machining	163.24				
3	<b>Bearing</b>					
	Track pulleys 6203-ZZ	4				
	Dummy pulleys 6000-ZZ	4				
	Sheave bearing 1212	4				
4	Housing for 1212 bearing	4				
5	Truss posts	472.09				
6	Nut bolts	1.43				
	<b>Bull dog grips</b>					
	9mm	12				
	12mm	18				
	<b>Thimble</b>					
	9mm	5				
	12mm	5				

**PRACTICAL ACTION NEPAL OFFICE**  
**Access for Opportunities**  
**TRANSPORTATION: Chhimkeswori Gravity Ropeway**

Sn.	Description	From	To	Km	Weight kg	Rate	Amount	Remarks
1	By truck							
	Non local material (Cement, rod, tools)	Damuli	Bhaludhunga	0.00	9174.61	1.50	13761.910	
	Steel parts	Butwal	Bhaludhunga	0.00	990.16	3.00	2970.49	
	Rope	Chitwan	Bhaludhunga		2044.72	1.00	2044.72	
							<b>18777.12</b>	
2	By porter (lower station to upper station)							
	Sand - 360bag				18000.00	2.5	45000.00	( per bag - 50kg assumed )
	Cement - 78 bag				3900.00	2.5	9750.00	
	CGI sheet - 156 kg				156	2.5	390.00	
	Reinforcement steel - 241kg				241	2.5	602.50	
	Structural Steel - 300kg ( approx )				300	2.5	750.00	
							<b>56492.50</b>	
3	By truck (trip)	From	To		Trip	Rate		
	Materials and equipment							
	Materials and equipment							
	<b>Total</b>						<b>75269.62</b>	
<b>TOOLS AND EQUIPMENT</b>								

Sn	Description	Unit	Qty	Rate	Amount	Unit weight	Total weight	Remarks
1	Pick	No.	4	200.00	800.00	3.00	12.00	
2	Shovel	No.	8	200.00	1600.00	2.00	16.00	
3	Lever	No.	4	600.00	2400.00	5.00	20.00	
4	Hammer (1 kg)	No.	6	150.00	900.00	1.00	6.00	
5	Hammer (2 kg)	No.	4	200.00	800.00	2.00	8.00	
6	Nylon ropes	m	500	7.00	3500.00	0.10	50.00	
7	Monkey Wrench	No.	8	300.00	2400.00	1.00	8.00	
8	Spanner 20mm, 16mm, 8mm set	Set	2	700.00	1400.00	1.00	2.00	
9	Chain pulley	No	1	15000	15000	35	35	
	<b>Total</b>				<b>28800.00</b>		<b>157.00</b>	

# PRACTICAL ACTION NEPAL OFFICE

## Access for Opportunities

### Quantity of Materials and Labour: Chhimkeswori Gravity Ropeway

S.N.	Description of Items	Unit	Quantity	Requirement of Materials per unit										Total Materials						Req. of Labour per unit				Total Labour		Remarks
				Cement (bags)	Sand (m3)	Gravel (m3)	Steel rods	Rubble/ bldr (m3)	Mesh wire 10sw kg	Sel. Wire 7sw kg	Bind wire 12sw kg	Cement (bags)	Sand (m3)	Gravel (m3)	Rubble/ bldr (m3)	Steel rods	Mesh wire 10sw kg	Sel. Wire 7sw kg	Bind wire 12sw kg	skilled (MD)	unskilled (MD)	skilled (MD)	unskilled (MD)			
A	Upper Station																									
1	Site clearance	m <sup>2</sup>	45.00																	0.00	0.06	0.00	2.70			
2	Hard clay mixed with gravel	m <sup>3</sup>	159.56																	0.00	2.50	0.00	398.90			
3	Plumb concrete 40%	m <sup>3</sup>	6.21	2.64	0.28	0.54		0.50				16.41	1.74	3.36	3.11				0.50	4.00	3.11	24.86				
4	Rubble masonry 1:4	m <sup>3</sup>	0.00	2.28	0.45			1.10				0.00	0.00	0.00	0.00				1.50	5.00	0.00	0.00				
5	Rubble masonry 1:6	m <sup>3</sup>	17.87	1.50	0.47			1.10				26.81	8.40	0.00	19.66				1.50	5.00	26.81	89.35				
6	Reinf. cement concrete 1:2:4	m <sup>3</sup>	5.74	6.40	0.45	0.85						36.71	2.58	4.88	0.00				1.00	4.00	5.74	22.94				
7	Plain mass concrete 1:3:6	m <sup>3</sup>		4.40	0.47	0.89						0.00	0.00	0.00	0.00				1.00	4.00	0.00	0.00				
8	Cement Plaster 1:4, 20mm thk	m <sup>2</sup>	0.00	0.16	0.02							0.00	0.00	0.00	0.00				0.22	0.22	0.00	0.00				
9	Reinforcement steel	kg	211.13				1.11					0.00	0.00	0.00	0.00	234.35			0.03	0.04	6.33	8.45				
10	Gabion box 3x1x1m	no	2.00					3.30	35.10	4.10	1.60	0.00	0.00	0.00	6.60		70.20	8.20	3.20	0.63	0.88	1.26	1.76	Incl. construc.		
11	Gabion box 2x1x1m	no	0.00					2.20	24.15	3.15	1.50	0.00	0.00	0.00	0.00		0.00	0.00	0.45	0.60	0.00	0.00			Incl. construc.	
						Sub Total						79.92	12.72	8.23	29.36	234.35	70.20	8.20	3.20			43.24	548.96			
B	Lower station																									
1	Site clearance	m <sup>2</sup>	26.00																0.00	0.06	0.00	1.56				
2	Hard clay mixed with gravel	m <sup>3</sup>	44.50																0.00	2.50	0.00	111.25				
3	Plumb concrete 40%	m <sup>3</sup>	6.02	2.64	0.28	0.54		0.50				15.89	1.69	3.25	3.01				0.50	4.00	3.01	24.08				
4	Rubble masonry 1:4	m <sup>3</sup>		2.28	0.45			1.10				0.00	0.00	0.00	0.00				1.50	5.00	0.00	0.00				
5	Rubble masonry 1:6	m <sup>3</sup>	22.21	1.50	0.47			1.10				33.32	10.44	0.00	24.43				1.50	5.00	33.32	111.06				
6	Reinf. cement concrete 1:2:4	m <sup>3</sup>	4.89	6.40	0.45	0.85						31.30	2.20	4.16	0.00				1.00	4.00	4.89	19.56				
7	Plain mass concrete 1:3:6	m <sup>3</sup>		4.40	0.47	0.89						0.00	0.00	0.00	0.00				1.00	4.00	0.00	0.00				

E	Manpower	Unit	Qty	Rate	Amount
1	Skilled	MD	139.97	320.00	44790.08
2	Unskilled	MD	874.38	190.00	166132.43
3	Rope hoisting and installation	MD	LS		74580.00
4	Supervisor and management cost	MD			10000.00

# PRACTICAL ACTION NEPAL OFFICE

## Access for Opportunities

### INPUT SHEET: Chhimkeswori Gravity Ropeway

1	<b>BASIC DATA</b>	नेपालीमा		English	
1.1	Ropeway no.	५		5	
1.2	Type	सामान ढुवानी गर्ने रोपवे		Goods transporting ropeway	
1.3	Name	गुरुत्वाकर्षण रोपवे		Chhimkeswori Gravity Ropeway	
1.4	Lower Station	चण्डिभञ्ज्याङ गाविस चितवन		Chandibhanjyang, ward no. - 7, Chitwan	
1.5	Upper station	छिम्केश्वरी गाविस वडा नं. १		Chhimkeswori VDC, Ward no. - 1, 2, Tanahun	
	Ariel distance between stations	८४२.४२ मी		842.42m	
	Level difference	४९९.०० मी		499.44m	
	Inclined distance in meters	९८९.३४ मी		989.34m	
1.7	No. of track ropes	२		2	
1.8	No. of hauling ropes	१		1	
1.9	No. of tower	-		-	
1.10	River crossing name( If exist in alignment)	त्रिशुली		Trishuli	
1.11	District	तनहुँ		Tanahun	
1.12	Region	पश्चिमाञ्चल		Western Region	
1.13	Type of works	नयाँ निर्माण		New construction	
2	<b>TRANSPORTATION</b>				Km
2.1	Materials and equipment				
	By Truck	From		Damauli	
		To		Bhaludhunga	
		Metalled road		Km	50.00
		Non metalled road			
	By Porter	From		Bato	
		To		Site	0.00
		Days			
2.2	Wire ropes and steel parts				
	By Truck	From		Chitwan	
		To		Bhaludhunga	
		Metalled road			27.00
		Non metalled road			
	By Porter	From		Lower station	
		To		Upper station	
		Portering days	day		

2.3	Wire ropes and steel parts				
	By Truck	From		Chitwan	
		To		Bhaludhunga	0.00
		Metalled road			27.00
		Non metalled road			0.00
	By Porter	From			
		To			
		Portering days			
2.4	Additional haulage distance	Sand		m	100.00
		Rubble, Boulders		m	100.00
		Block stone		m	
		Gravel		m	25.00
		Natural gravel available		%	50.00
3	<b>OFFICIAL RATE FOR FY 2009/10</b>			Fiscal year	2009/10
3.1	Labour rate				
	<b>S.No.</b>	<b>Type</b>	<b>Unit</b>	<b>Rate,NRs.</b>	
	1	Skilled labour	1 manday	320.00	
	2	Unskilled labour	1 manday	190.00	
	3	Carpenter, Mason	1 manday	320.00	
	4	Portering from lower station to upper	kg	2.50	
3.2	Materials				
	Description		Unit	Rates	RateVAT
3.3	<b>Transportation by truck (equip. &amp; mat.)</b>				
	Transportation from Damauli to Bhaludhunga		per kg	1.50	
	<b>Transportation by porter (equip. &amp; mat.)</b>				
	Transportation from bato to site		per kg		
	<b>Transportation by truck (wire rope and non local materials )</b>				
	Transportation from Chitwan to Site			1.00	
	<b>Transportation by porter (wire rope)</b>				
	Transportation from to			1.50	
	Transportation by truck (Black topped)		per kg	0.02	
	Transportation by truck (Gravelled)		per kg/ km	0.04	
	Tata mobile (from Chitwan)		per trip	8,000.00	
	Tata mobile (from Chitwan)		per trip	6,000.00	
3.4	<b>Construction of gabions</b>				
	Gabion Wire, 7,10,12 SWG		kg	95.00	107.35
3.5	<b>Concrete &amp; masonry works all other civil work</b>				

	Cement with NS or ISI mark		bag		650.00
	Sand		m <sup>3</sup>	473.10	
	Gravel (Aggregates)		m <sup>3</sup>	1814.50	
	Rubble stone		m <sup>3</sup>	526.30	
	C.G.I. sheet(26 gauge)		1 Bundle	6300.00	
	J hook		no	12.00	
	Nuts bolt		kg	250.00	282.50
	Washer		no	0.50	
	Formwork nails		kg	107.00	
3.6	<b>Finishing works</b>				
	Red oxide zinc chromate	Red oxide zinc chromate	ltr	130.00	
	Polyurethane enamel	Polyurethane enamel	ltr	230.00	
3.7	Wood sal		m <sup>3</sup>	45903	
4	<b>WEIGHT OF Rope PER METER</b>				
	12 mm				0.59
	14 mm				0.75
	8 mm				0.23
	9 mm				0.30
5	<b>QUOTATION RATE</b>			Rate	VAT Rate
	<b>Wire ropes</b>				
	11 mm		m		0
	12 mm		m		115
	14 mm		m		
	8 mm		m		
	9 mm		m		55
	<b>Supply of steelparts</b>				
	Structural steel		kg		120.00
	Reinforcement steel *		kg		64.00
	Binding wire		kg	97.00	82.00
	Gabion wire				
	Mesh wire 10 SWG		kg	95.00	107.35
	Selvage wire 7 SWG		kg	95.00	107.35
	Binder wire 12 SWG		kg	95.00	107.35
	Nails		kg	85.00	96.05
	<b>Miscellaneous supply</b>				
	Wiremesh netting		m <sup>2</sup>	215.00	242.95
	Bolts, nuts, washers		kg	170.00	192.10
	<b>Rust prevention</b>				
	Hot dip galvanisation		kg	42.00	47.46
	<b>Workshop labor rates</b>				
	Skilled		md	320.00	



	Unskilled		md	150.00	
	Supply and fabrication of structural steel	Kg		115.00	129.95
	Supply and machining works of structural steel	Kg		175.00	197.75
	<b>Bearing for pulleys</b>				
	Track pulleys -6203-2 Z	Nos		300.00	339
	Dummy pulleys 6000-2 Z	Nos		300.00	339
	Sheave bearing 1212	Nos		300.00	339
	Housing for 1212 bearing	Nos		320.00	361.6
	<b>Connecting accessories</b>				
	<b>Supply of thimble</b>				
	9 mm dia	Nos		30.00	33.9
	12mm dia	Nos		75.00	84.75
	<b>Supply of bull dug grips</b>				
	8 mm dia	Nos			0
	9 mm dia				65
	10 mm dia				
	11 mm dia				
	12 mm dia				150
	13 mm dia				
	14 mm dia	Nos		75.00	84.75
	20 mm dia	Nos		95.00	107.35
	<b>Nut bolts</b>	Kg		250.00	282.50

Note : Highlighted cell are subjected to change.

# PRACTICAL ACTION NEPAL OFFICE

## Access for Opportunities

### RATE ANALYSIS: Chhimkeswori Gravity Ropeway

Description	Unit	Unit	Unit	Rate	Total cost of each sources	Local cost	Non local cost
			Quantity		Cost		
<b>Structural steel</b>	<b>Unit: Kg</b>	Rate analysis for : 1 unit					
Material	kg		1.11	0.00	0.00		0.00
Labour	Md		0.11	320.00	35.20		
	Md		0.11	190.00	20.90		56.10
Subtotal					56.10		
Tools and Plants (7%)					3.93		3.93
Total					<b>60.03</b>	<b>0</b>	<b>60.03</b>
VAT @13%							
Rate per unit					<b>7.80</b>		<b>7.80</b>
					<b>67.83</b>	<b>0.00</b>	<b>67.83</b>
<b>Reinforcement steel</b>	<b>Unit: Kg</b>		Rate analysis for : 1 unit			Norms Reference #	
Material	kg		1.11	64.00	71.04		71.04
Labour	Md		0.03	320.00	9.60		
	Md		0.04	190.00	7.60	0.00	
Total					17.20	17.20	
Rate per unit						17.2	71.04
					88.24	17.20	71.04
<b>Site clearance</b>	<b>Unit: m<sup>2</sup></b>		Rate analysis for : 1 unit			Norms Reference #	
Labour	Unskilled	Md.	0.06	190.00	11.40	11.40	
Rate per unit					11.40	11.40	0.00
<b>Earthwork excavation in hard clay mixed with gravel</b>		Unit: m <sup>3</sup>					
Labour	Unskilled	Md	2.50	190.00	475.00	475.00	
Rate per unit					475.00	475.00	0.00

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<b>Gabion box size 2.0mx1.0mx1.0m</b>		Unit: m <sup>3</sup>	Rate analysis for : 1 unit				Norms Reference #	
Material		Mesh Wire 10 SWG	kg	12.08	107.35	1,296.79		1,296.79
		Selvage Wire 7 SWG	kg	1.58	107.35	169.61		169.61
		Binding Wire 12 SWG	kg	0.48	107.35	51.53		51.53
		Rubble	m <sup>3</sup>	1.10	526.30	578.93	578.93	
Labour								
Fabrication of gabions Construction of gabions		Skilled	Md	0.23	320.00	73.60		73.60
		Unskilled	Md	0.10	190.00	19.00		19.00
		Unskilled	Md	0.20	190.00	38.00	38.00	
Rate per unit						<b>2,227.46</b>	<b>616.93</b>	<b>1610.529</b>
<b>Gabion box size 3.0mx1.0mx1.0m</b>		Unit: m <sup>3</sup>	Rate analysis for : 1 unit				Norms Reference #	
Material		Mesh Wire 10 SWG	kg	11.70	107.35	1,256.00		1,256.00
		Selvage Wire 7 SWG	kg	1.37	107.35	147.07		147.07
		Binding Wire 12 SWG	kg	0.43	107.35	46.16		46.16
		Rubble	m <sup>3</sup>	1.10	526.30	578.93	578.93	
Labour								
Fabrication of gabions Construction of gabions		Skilled	Md	0.21	320.00	67.20		67.20
		Unskilled	Md	0.10	190.00	19.00		19.00
		Unskilled	Md	0.20	190.00	38.00	38.00	
Rate per unit						<b>2,152.36</b>	<b>616.93</b>	<b>1535.425</b>

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<b>Gabion box size 2.0mx1.0mx0.3m</b>		<b>Unit: m³</b>	Rate analysis for : 1 unit				Norms reference #
Material		Mesh Wire 10 SWG	kg	22.33	107.35	2,397.13	2,397.13
		Selvaqe Wire 7 SWG	kg	3.75	107.35	402.56	402.56
		Binding Wire 12 SWG	kg	1.08	107.35	115.94	115.94
		Rubble	m³	1.10	526.30	3,494.56	578.93
Labour							
Fabrication of gabions Construction of gabions		Skilled	Md	0.44	320.00	140.80	140.80
		Unskilled	Md	0.20	190.00	38.00	38.00
		Unskilled	Md	0.20	190.00	38.00	38.00
Rate per unit						<b>3,711.36</b>	<b>616.93</b>
<b>Gabion box size 3.0mx1.0mx0.3m</b>		<b>Unit: m³</b>	Rate analysis for : 1 unit				Norms reference #
Material		Mesh Wire 10 SWG	kg	21.94	107.35	2,355.26	2,355.26
		Selvaqe Wire 7 SWG	kg	3.33	107.35	357.48	357.48
		Binding Wire 12 SWG	kg	1.00	107.35	107.35	107.35
		Rubble	m³	1.10	526.30	3,399.01	578.93
Labour							
Fabrication of gabions Construction of gabions		Skilled	Md	0.41	320.00	131.20	131.20
		Unskilled	Md	0.19	190.00	36.10	36.10
		Unskilled	Md	0.20	190.00	38.00	38.00
Rate per unit						<b>3,604.31</b>	<b>616.93</b>
						<b>2987.385</b>	

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<b>Plain lean concrete 1:4:8</b>		<b>Unit: m<sup>3</sup></b>	Rate analysis for : 1 unit				Norms reference #	
Material		Cement	bag	3.40	650.00	2,210.00		2,210.00
		Gravel (5-40mm)	m <sup>3</sup>	0.89	1,814.50	1,614.91		1,614.91
		Sand	m <sup>3</sup>	0.47	473.10	222.36	4,047.26	222.36
Labour		Skilled	Md	1.00	320.00	320.00		320.00
		Unskilled	Md	4.00	190.00	760.00	1,080.00	760.00
Rate per unit							<b>5,127.26</b>	<b>2,917.26</b>
<b>Plain mass concrete 1:3:6</b>		<b>Unit: m<sup>3</sup></b>	Rate analysis for : 1 unit				Norms reference #	
Material		Cement	bag	4.40	650.00	2,860.00		2,860.00
		Gravel (5-40mm)	m <sup>3</sup>	0.89	1,814.50	1,614.91		1,614.91
		Sand	m <sup>3</sup>	0.47	473.10	222.36	4,697.26	222.36
Labour		Skilled	Md	1.00	320.00	320.00		320.00
		Unskilled	Md	4.00	190.00	760.00	1,080.00	760.00
Subtotal							<b>5,777.26</b>	<b>2,917.26</b>
<b>Reinforced cement concrete 1:2:4</b>		<b>Unit: m<sup>3</sup></b>	Rate analysis for : 1 unit				Norms reference #	
Material		Cement	bag	6.40	650.00	4,160.00		4,160.00
		Gravel (5-40mm)	m <sup>3</sup>	0.85	1,814.50	1,542.33		1,542.33
		Sand	m <sup>3</sup>	0.45	473.10	212.90	5,915.22	212.90
Labour		Skilled	Md	1.00	320.00	320.00		320.00
		Unskilled	Md	4.00	190.00	760.00	1,080.00	760.00
Rate per unit							<b>6,995.22</b>	<b>2,835.22</b>
								<b>4,160.00</b>

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<b>Plumb concrete 40%</b>	<b>Unit: m<sup>3</sup></b>	Rate analysis for : 1 unit					Norms reference #	
Material	Cement	bag	2.64	650.00	1,716.00			1,716.00
	Gravel (5-40mm)	m <sup>3</sup>	0.54	1,814.50	979.83		979.83	
	Sand	m <sup>3</sup>	0.28	473.10	132.47		132.47	
	Boulders(225 mm)	m <sup>3</sup>	0.50	526.30	263.15	3,091.45	263.15	
Labour	Skilled	Md	0.50	320.00	160.00		160.00	
	Unskilled	Md	4.00	190.00	760.00	920.00	760.00	
Rate per unit						<b>4,011.45</b>	<b>2,295.45</b>	<b>1,716.00</b>

<b>Form work</b>	<b>Unit: m<sup>2</sup></b>	Rate analysis for : 1 unit					Norms reference #	
Material	Wood	m3	0.01	45,903	459.03		459.03	
	Nails	kg	0.03	96.05	2.88	461.91	2.88	
Labour	Skilled	Md	0.78	320.00	249.60		249.60	
	Unskilled	Md	0.62	190.00	117.80	367.40	117.80	
Rate per unit						<b>829.31</b>	<b>826.43</b>	<b>2.882</b>

<b>Stone packing with sand and gravel</b>	<b>Unit: m<sup>3</sup></b>	Rate analysis for : 1 unit					Norms reference #	
Material	Rubble	m <sup>3</sup>	1.10	1,814.50	1,995.95		1,995.95	
	Sand	m <sup>3</sup>	0.28	473.10	132.47	2,128.42	132.47	
Labour	Skilled	Md	1.00	320.00	320.00		320.00	
	Unskilled	Md	2.00	190.00	380.00	700.00	380.00	
Rate per unit							<b>2,828.42</b>	
<b>Rubble masonry 1:6</b>	<b>Unit: m<sup>3</sup></b>	Rate analysis for : 1 unit					Norms reference #	

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Material	Cement	bag	1.50	650.00	975.00			975.00	
	Sand	m³	0.47	473.10	222.36		222.36		
	Rubble	m³	1.10	526.30	578.93	1,776.29	578.93		
	Skilled	Md	1.50	320.00	480.00		480.00		
Labour	Unskilled	Md	5.00	190.00	950.00	1,430.00	950.00		
	Rate per unit						<b>3,206.29</b>	<b>2,231.29</b>	<b>975.00</b>
Rubble masonry 1:4	Unit: m³	Rate analysis for : 1 unit							Norms reference #
	Cement	bag	2.28	650.00	1,482.00			1,482.00	
	Sand	m³	0.45	473.10	212.90		212.90		
	Rubble	m³	1.10	526.30	578.93	2,273.83	578.93		
Labour	Skilled	Md	1.50	320.00	480.00		480.00		
	Unskilled	Md	5.00	190.00	950.00	1,430.00	950.00		
Rate per unit						<b>3,703.83</b>	<b>2,221.83</b>	<b>1,482.00</b>	
Cement plaster 1:4, 20 mm thick	Unit: m²	Rate analysis for : 1 unit							Norms reference #
	Cement	bag	0.16	650.00	104.00			104.00	
	Sand	m³	0.02	473.10	9.46	113.46	9.46		
	Skilled	Md	0.22	320.00	70.40				
Labour	Unskilled	Md	0.22	190.00	41.80	112.20			
	Rate per unit					<b>225.66</b>	<b>9.462</b>	<b>104.00</b>	
Hoisting of ropes and installation per m, (Incl un/coiling)			Rate analysis for : 1 unit						Norms reference #

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Rope Ø 8mm	Unit: m																		
Labour	Skilled		Md		0.007		320.00		2.24										
		Unskilled		Md		0.06		190.00		10.64									
Subtotal Rope Ø 14mm													12.88	12.88	12.88				
Labour	Skilled		Md		0.01		320.00		2.88										
	Unskilled		Md		0.07		190.00		13.30										
Subtotal									16.18	16.18	16.18								
Rope Ø 20mm																			
Labour	Skilled		Md		0.04		320.00		12.80										
	Unskilled		Md		0.30		190.00		57.00										
Subtotal Rope Ø 36mm													69.80	69.80	69.80				
Labour	Skilled		Md		0.08		320.00		0.00										
	Unskilled		Md		0.61		190.00		0.00										
Rate per unit													0.00	0.00	0.00				

Sand		Unit: m³	Rate analysis for : 1 unit			Norms reference #	
Labour	Collection of sand	Unskilled	Md	1.49	190.00	283.10	
Washing of sand	Additional haulage, m	Unskilled	Md		190.00	0.00	
		Unskilled	Md	0.01	190.00	190.00	
Cost per m³						473.10	

Prepared By:

Checked By:

Approved By:



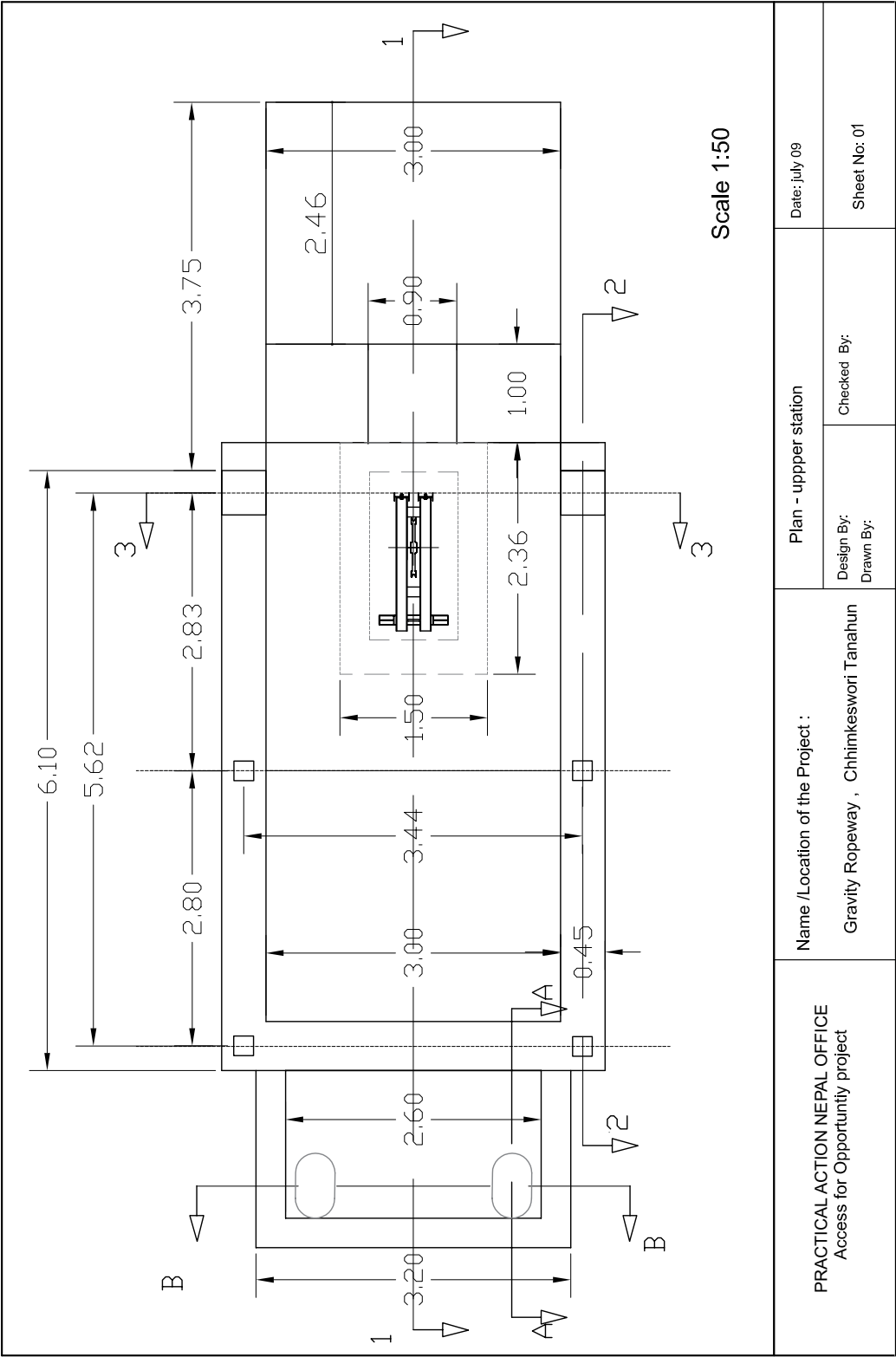
<b>Rubble, boulder</b>	<b>Unit: m³</b>	Rate analysis for : 1 unit			Norms reference #
Labour :Collection of rubble Boulder	Unskilled	Md	0.77	190.00	146.30
	Unskilled	Md	0.02	190.00	380.00
Additional haulage,m 100					
Cost per m³					526.30
<b>Gravel</b>	<b>Unit: m³</b>	Rate analysis for : 1 unit			Norms reference #
Labour:Collection of natural gravel	Unskilled	Md	4.00	190.00	380.00
	Unskilled	Md	14.60	190.00	1,387.00
Breaking of gravel, % 50					
Additional haulage, m 25	Unskilled	Md	0.01	190.00	47.50
Cost per m³					1,814.50
<b>Block stone</b>	<b>Unit: m³</b>	Rate analysis for : 1 unit			Norms reference #
Labour collection & dressing Additional haulage 0	Unskilled	Md	5.63	190.00	1,069.70
	Unskilled	Md	0.02	190.00	0.00
Cost per m³					1,069.70

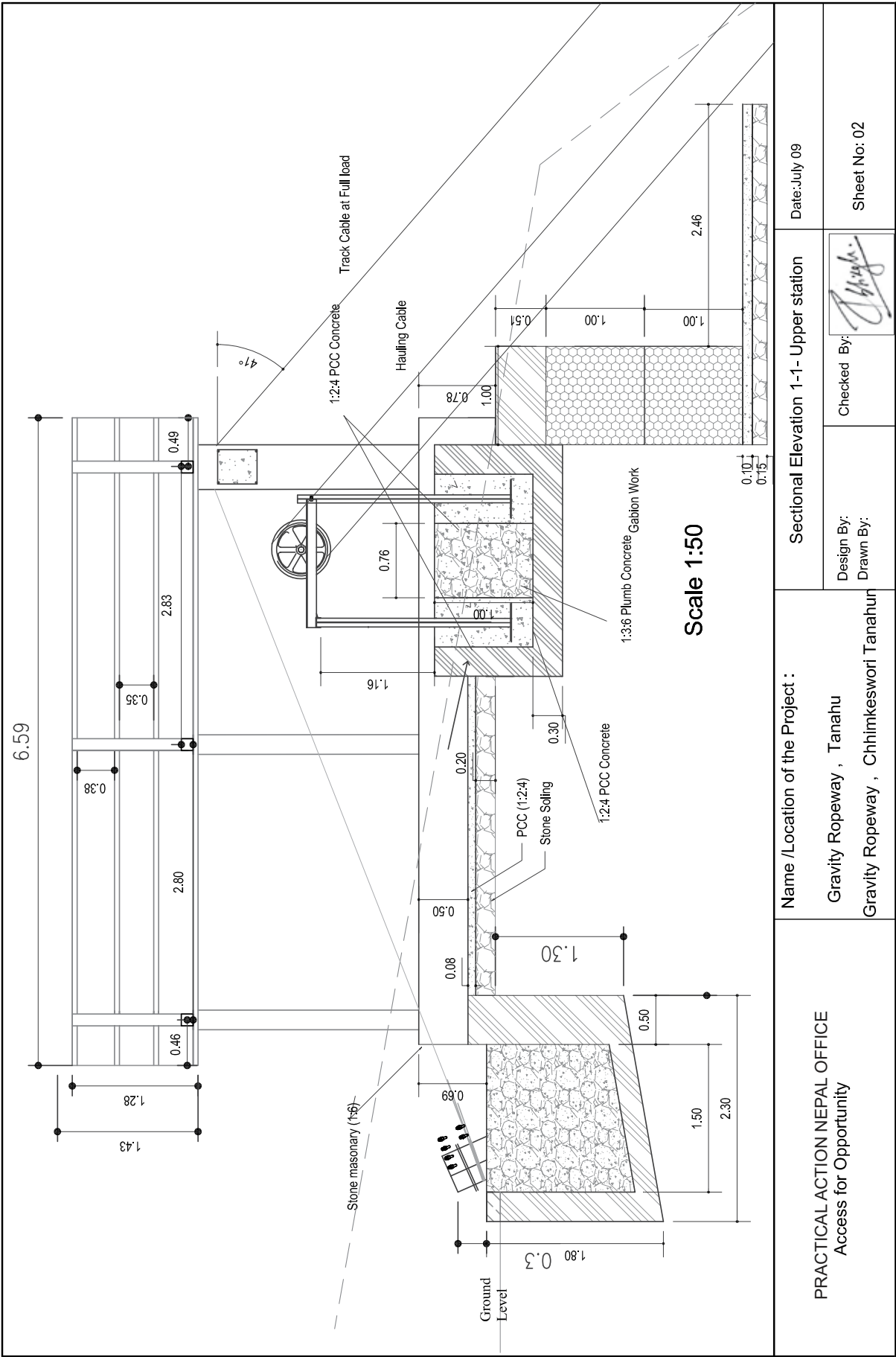
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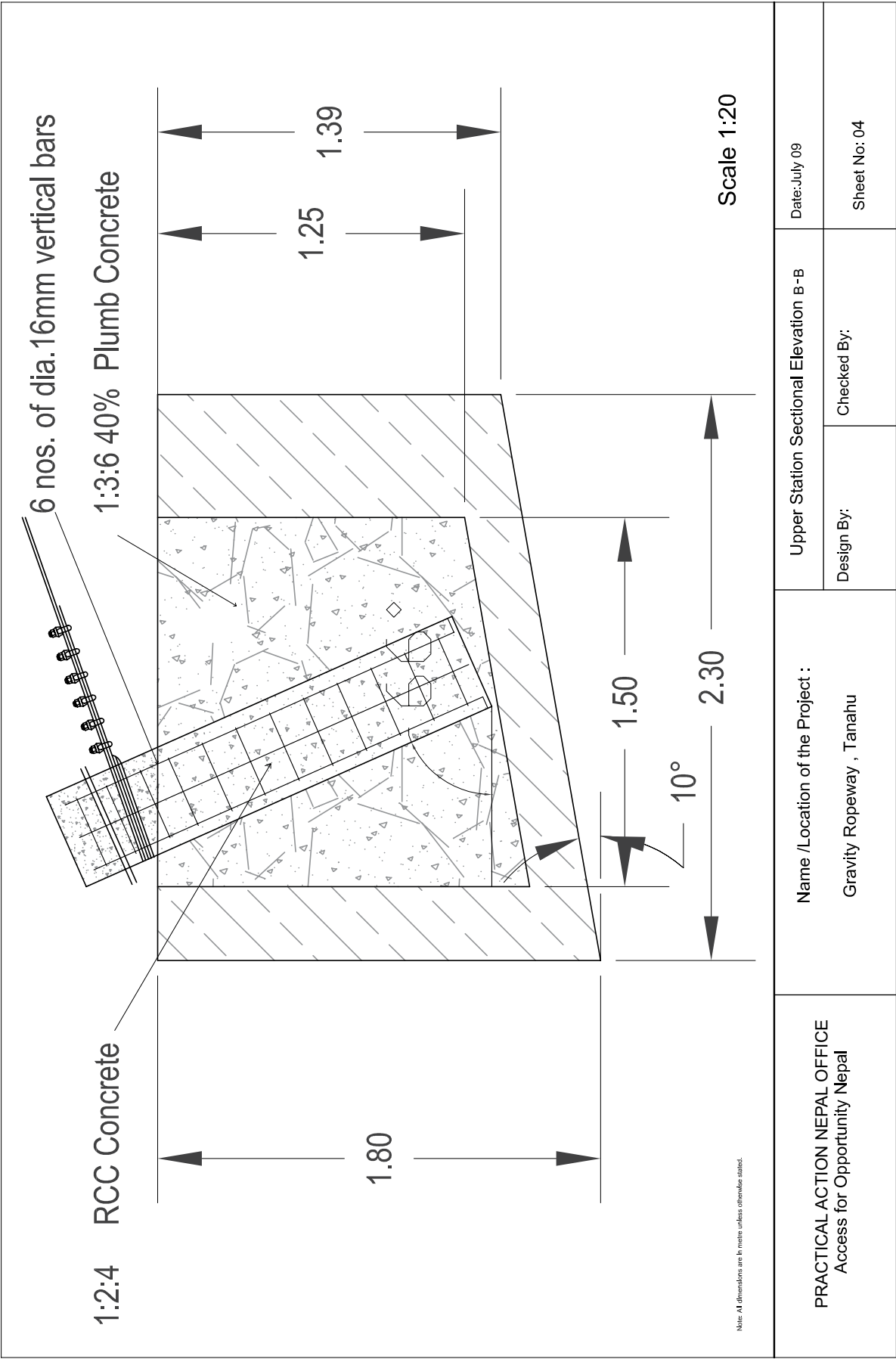
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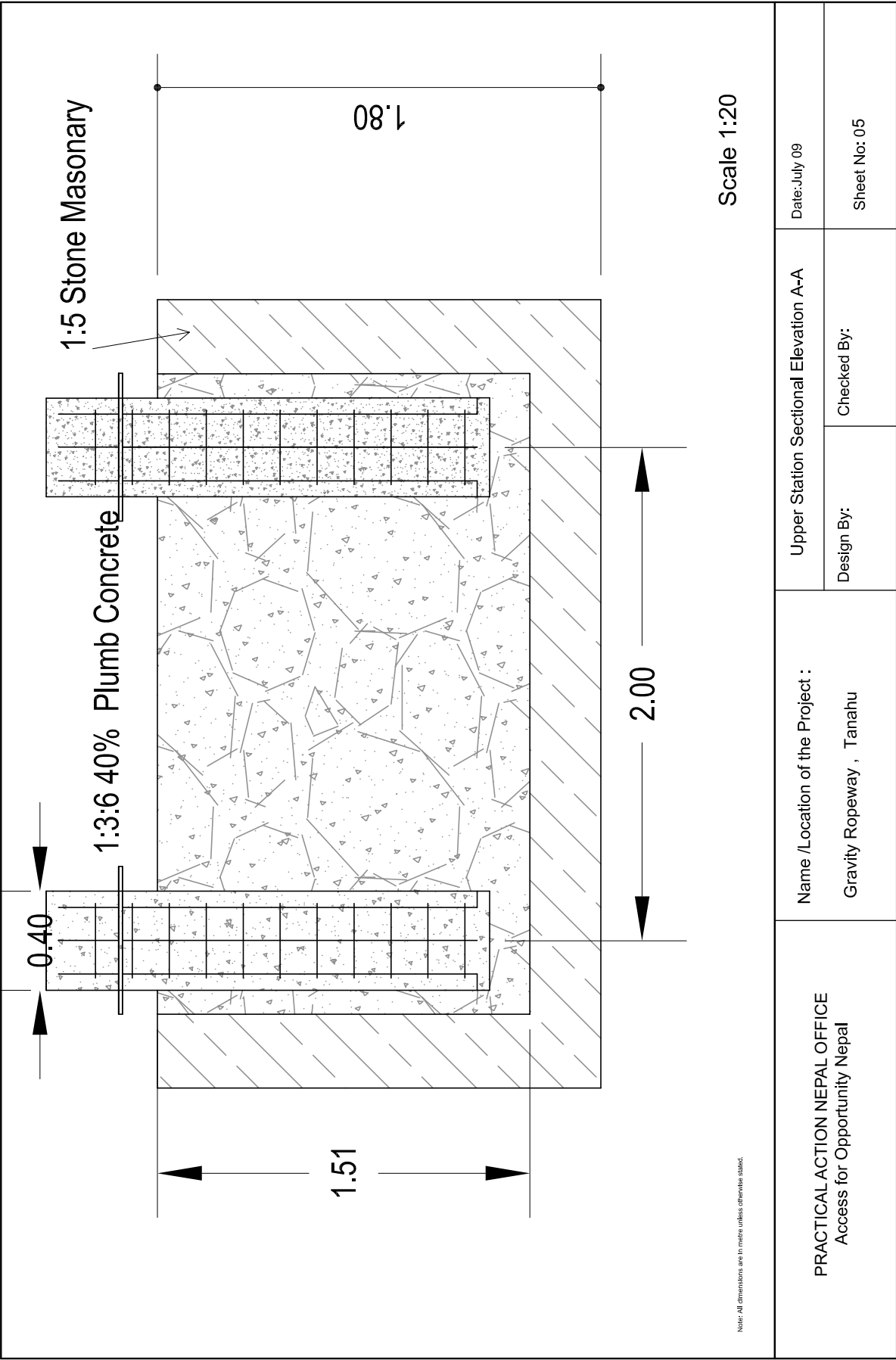
# Annex 4

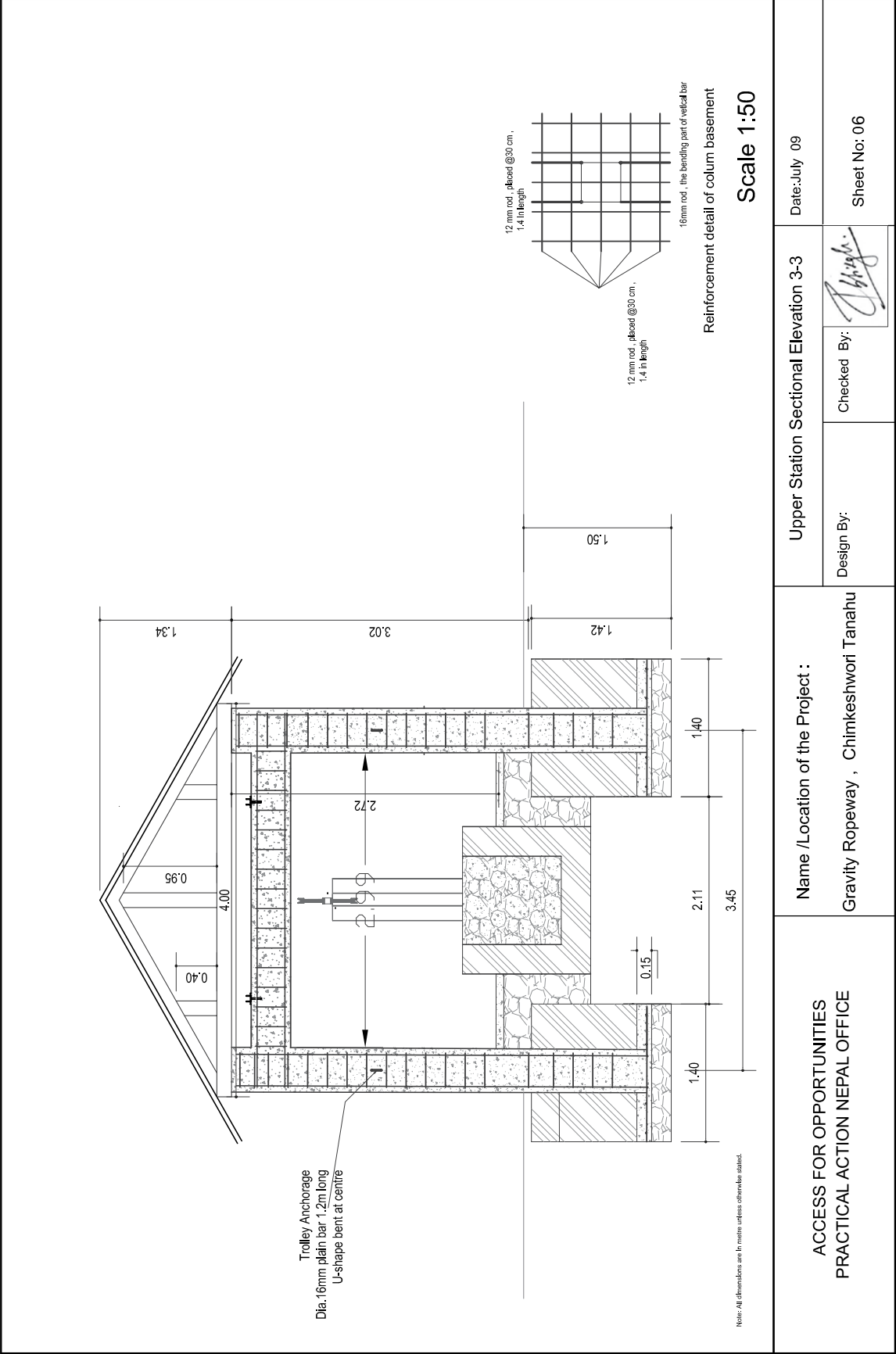


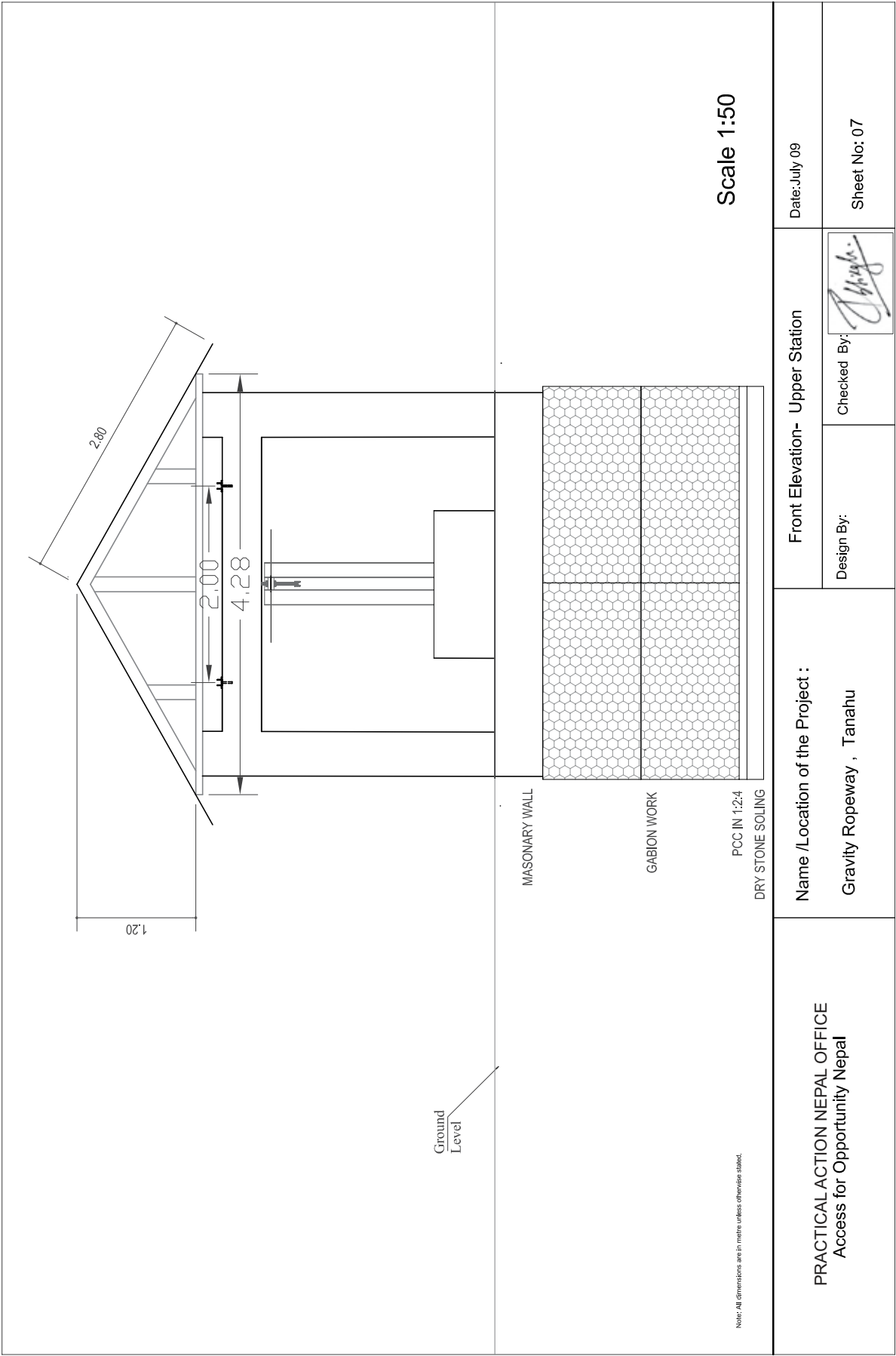




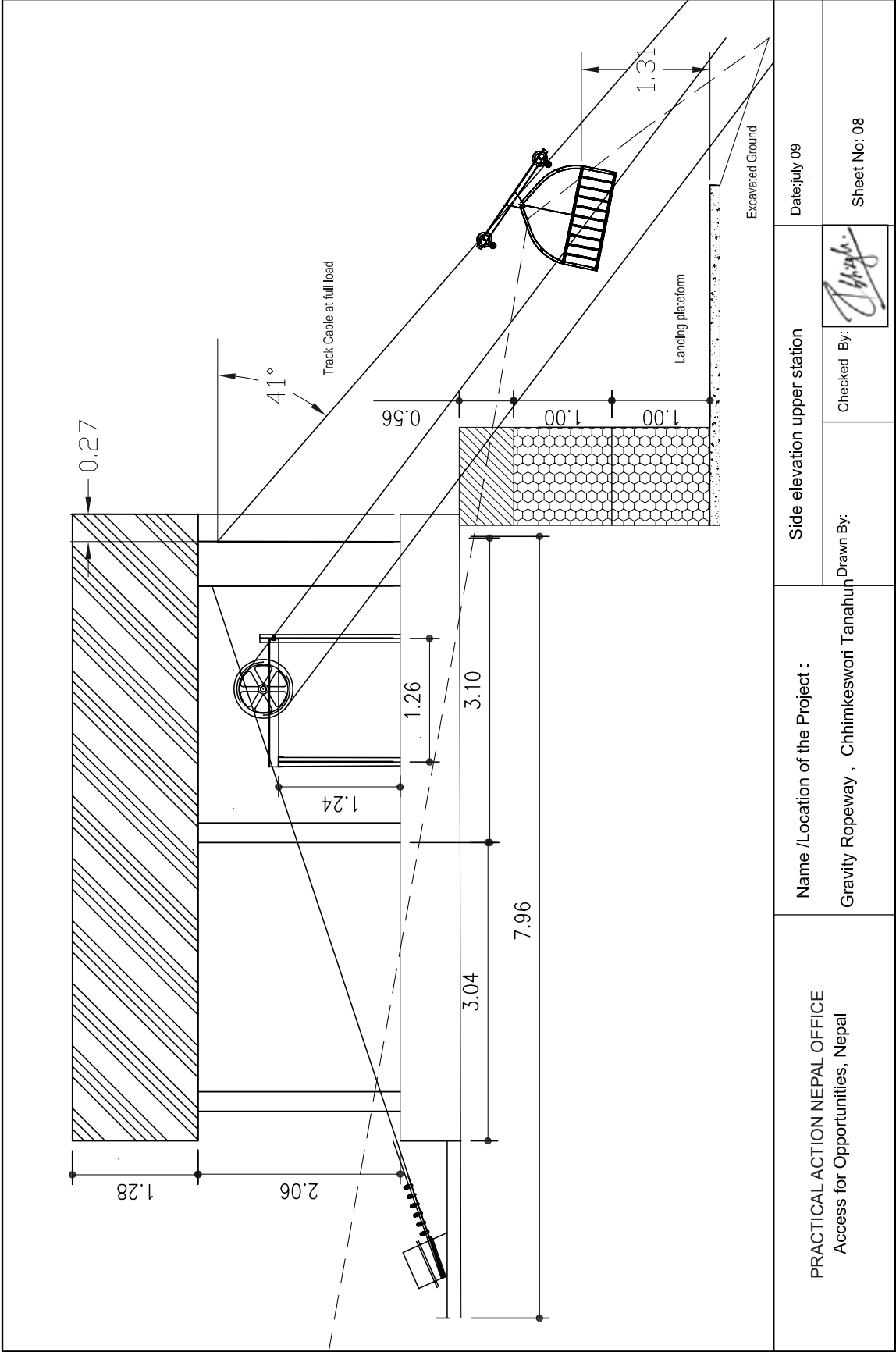




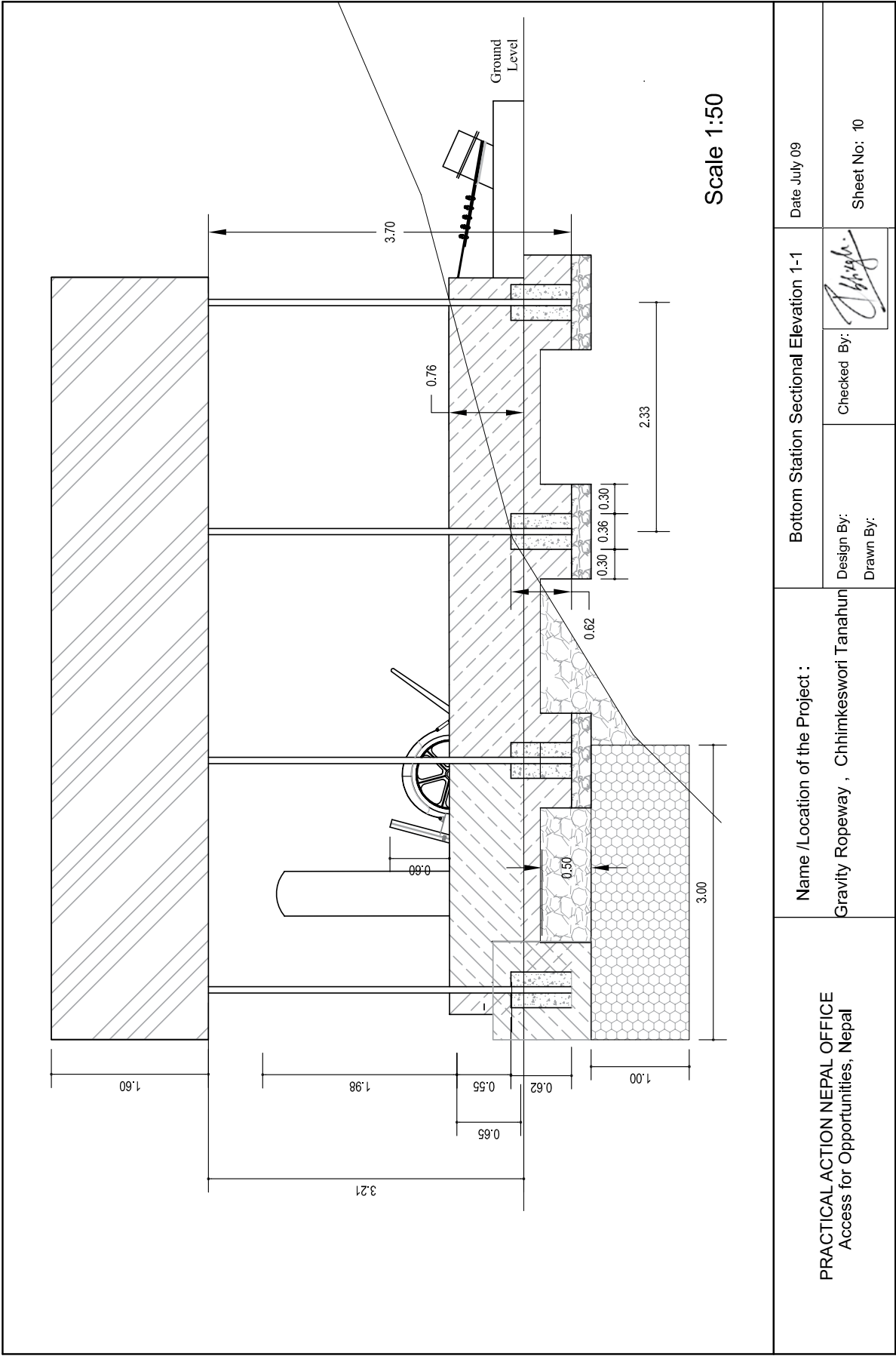


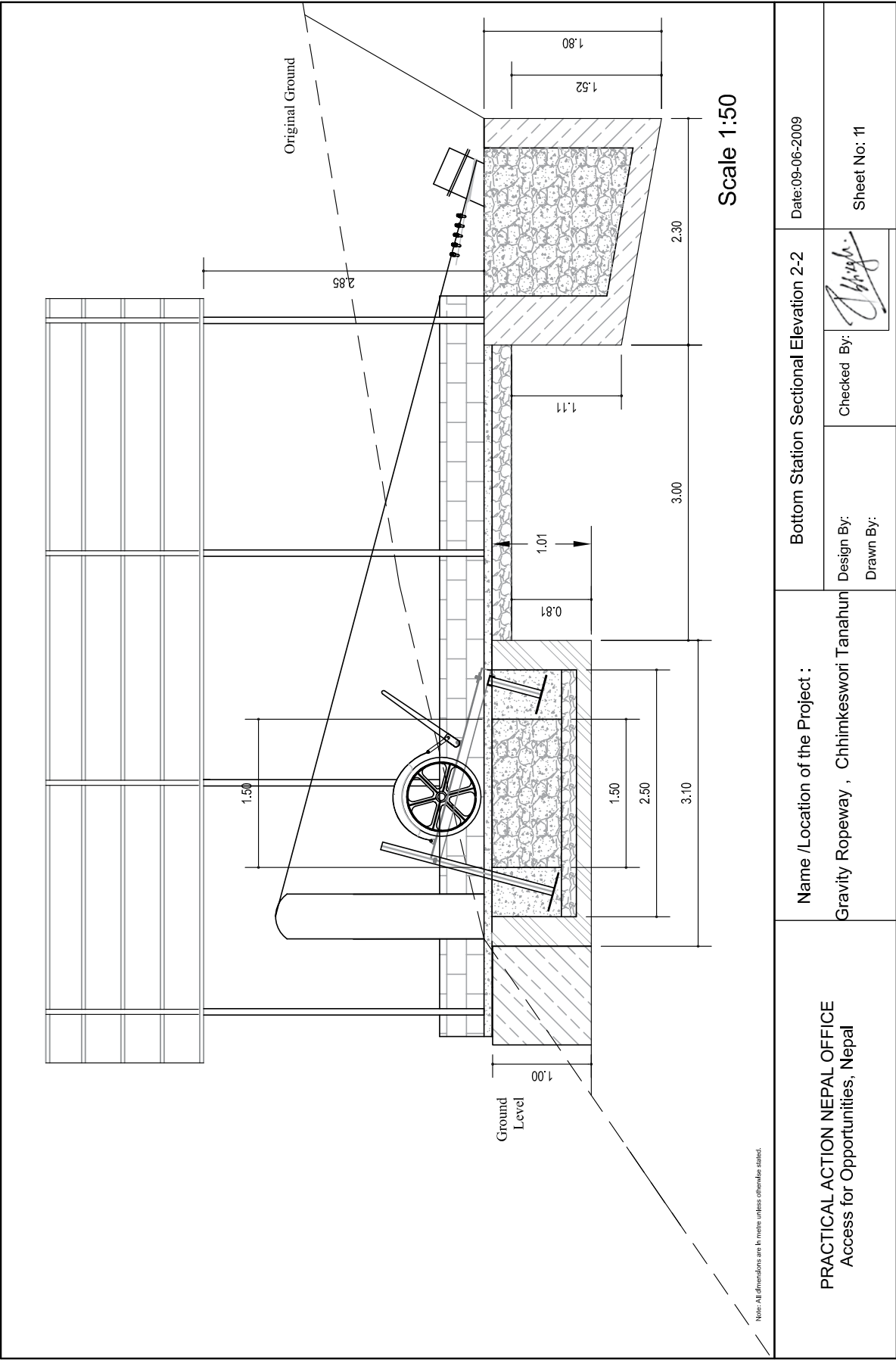


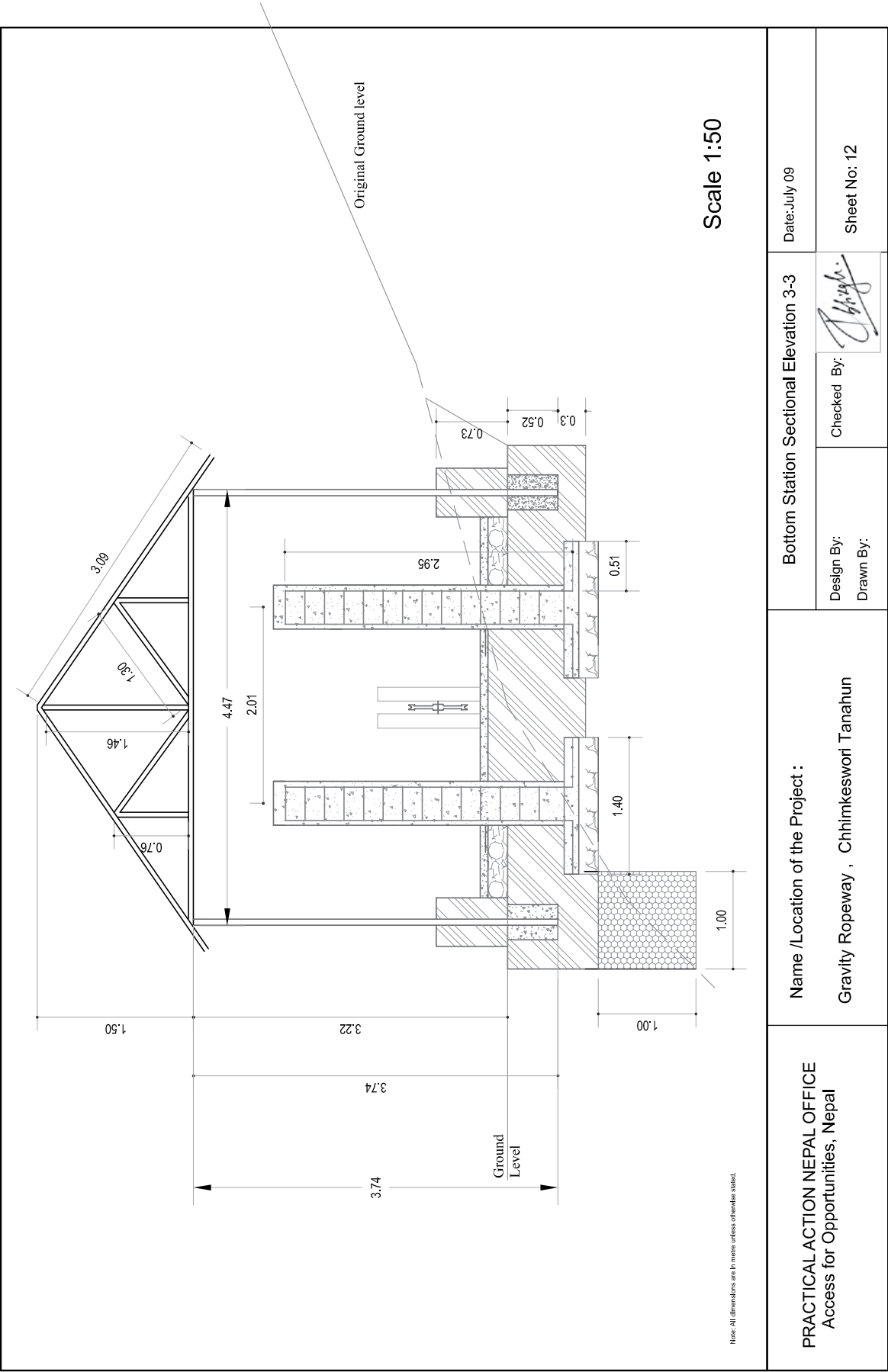


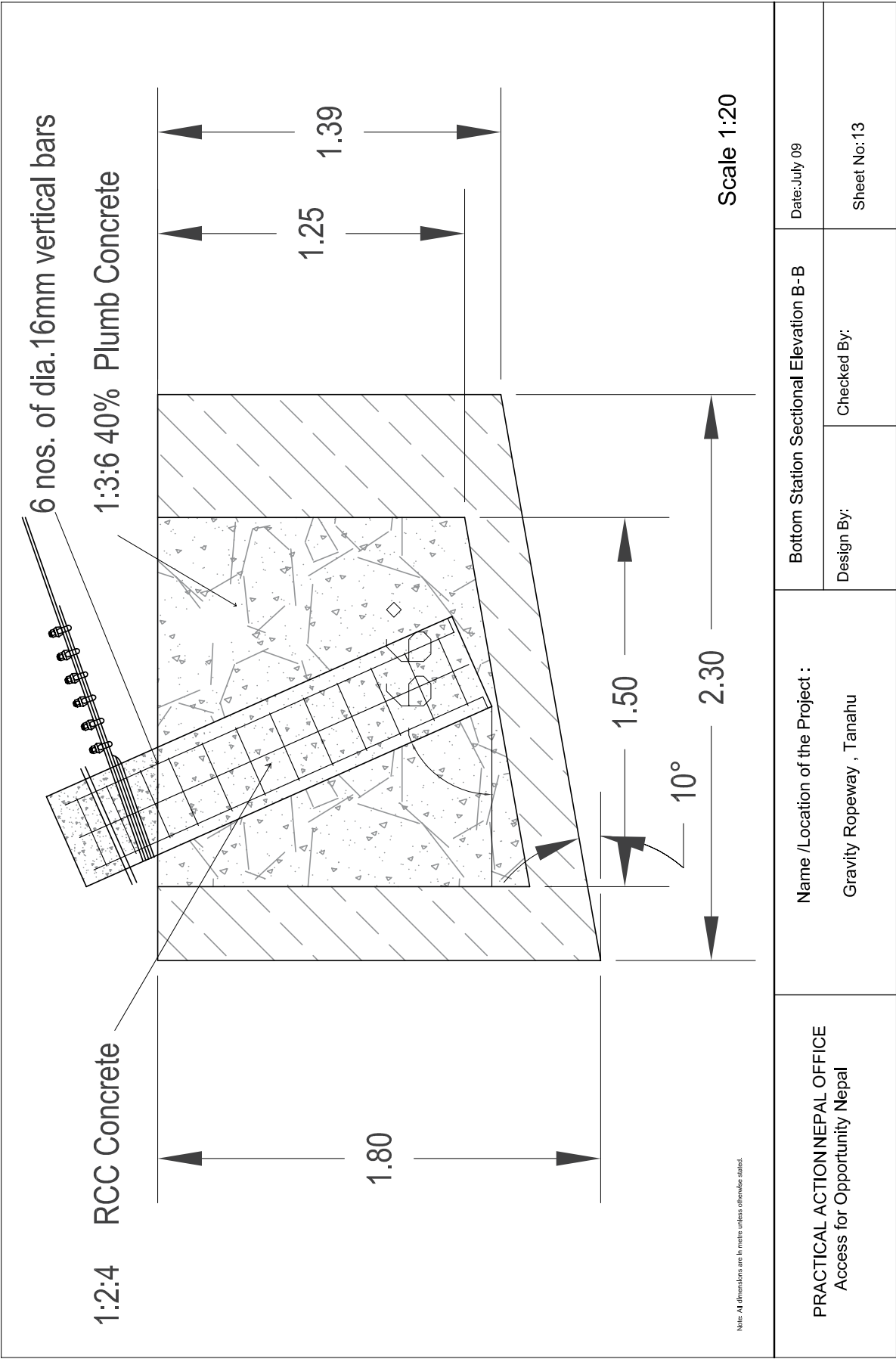


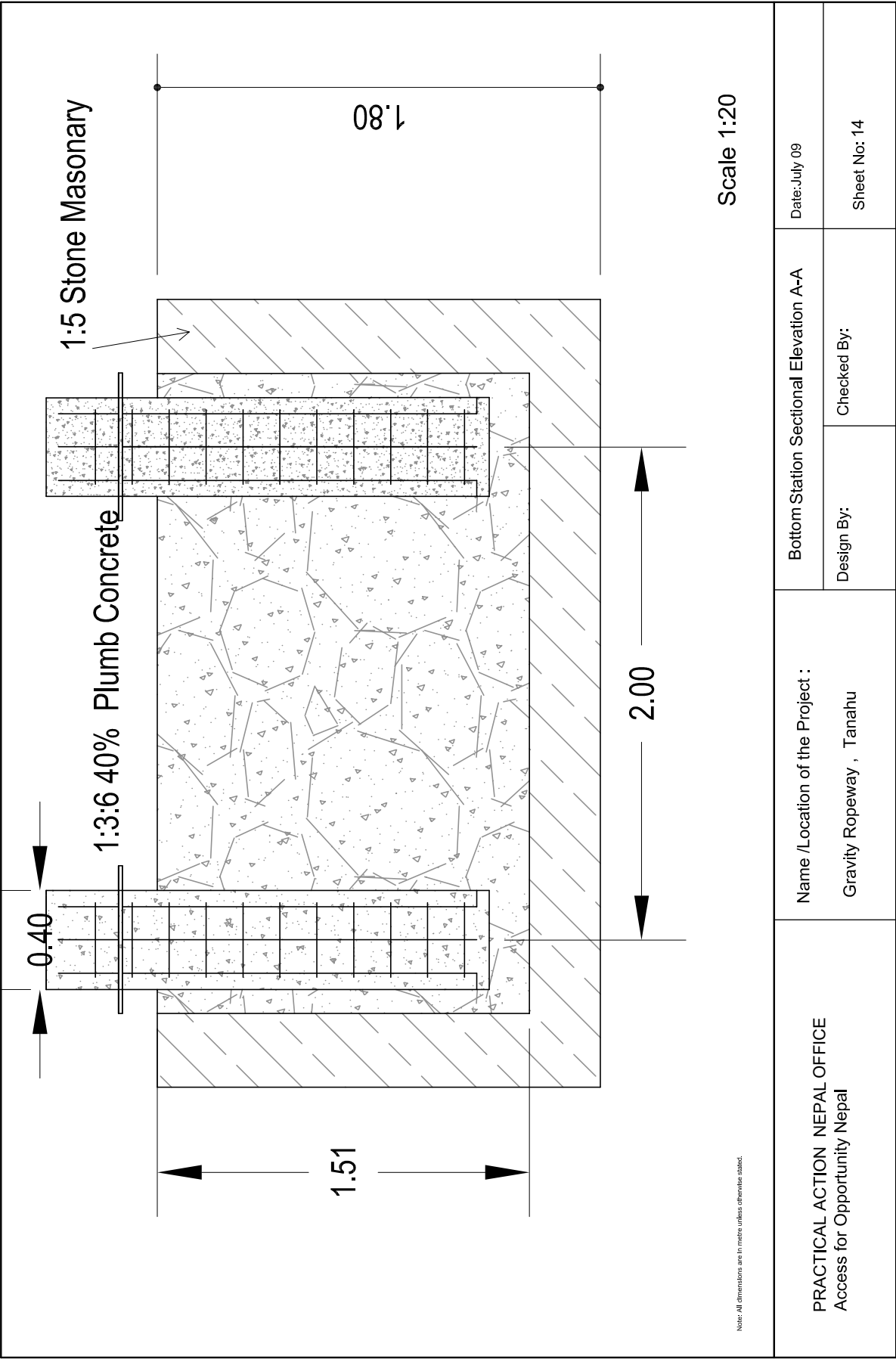


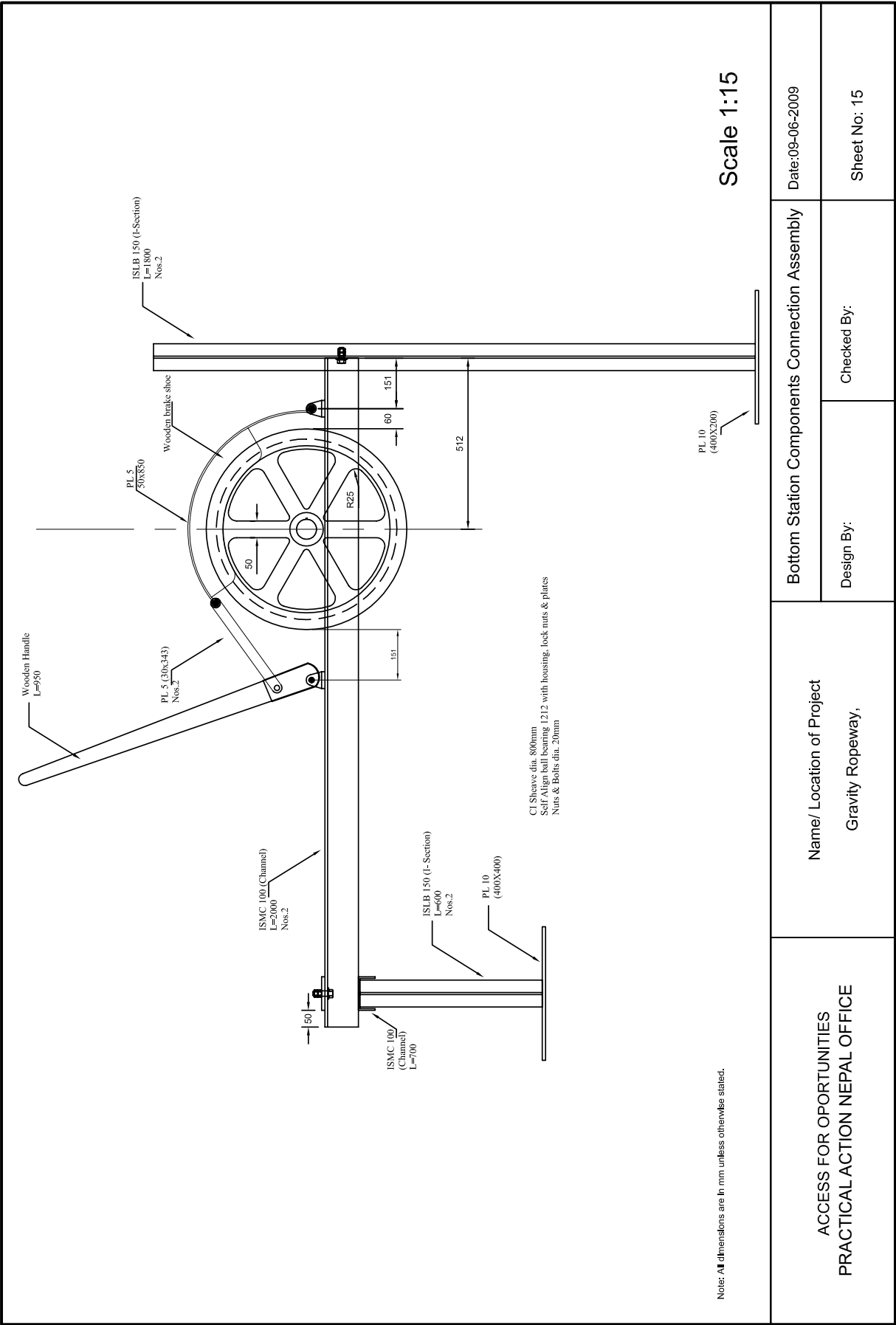




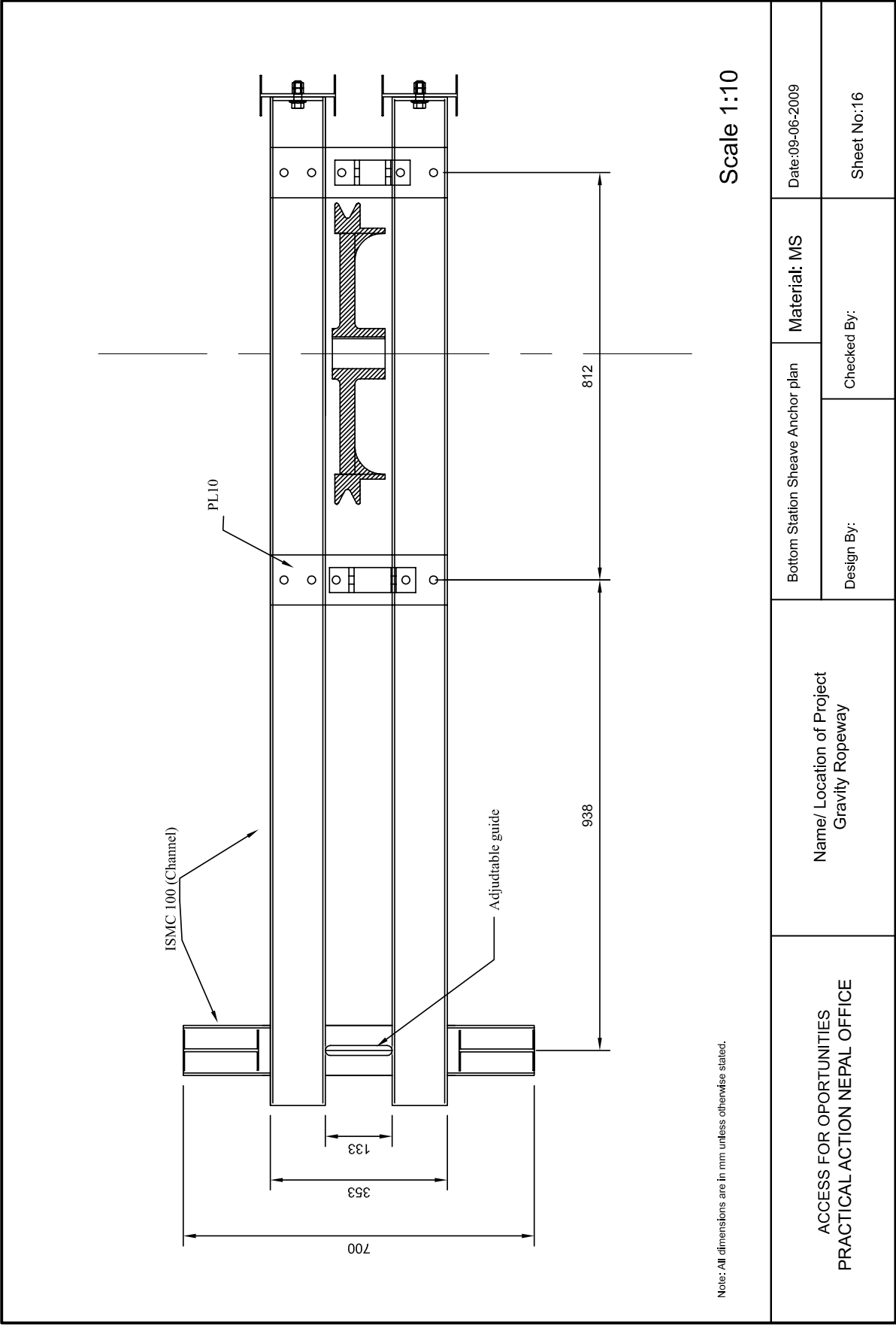


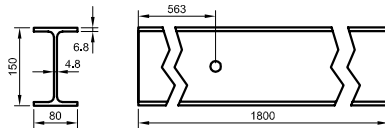
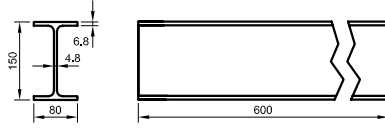
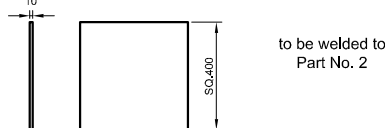
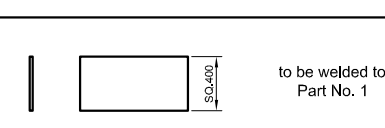
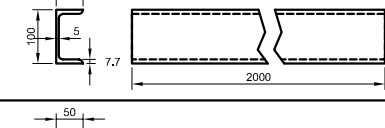
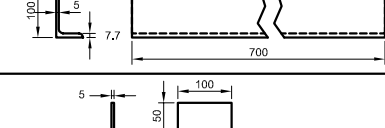
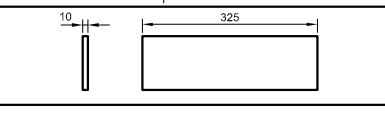

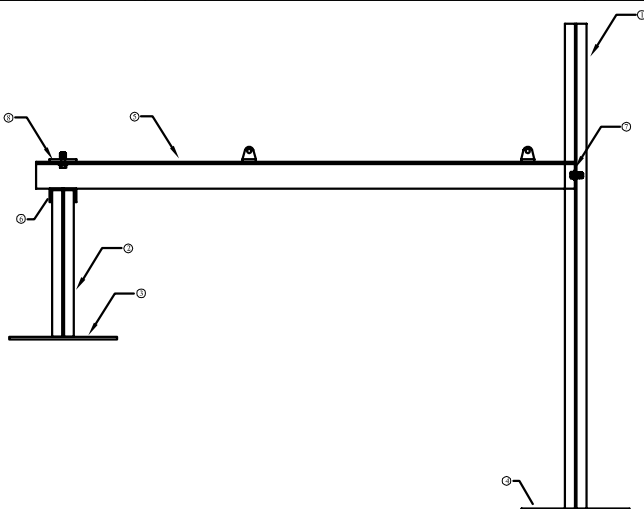




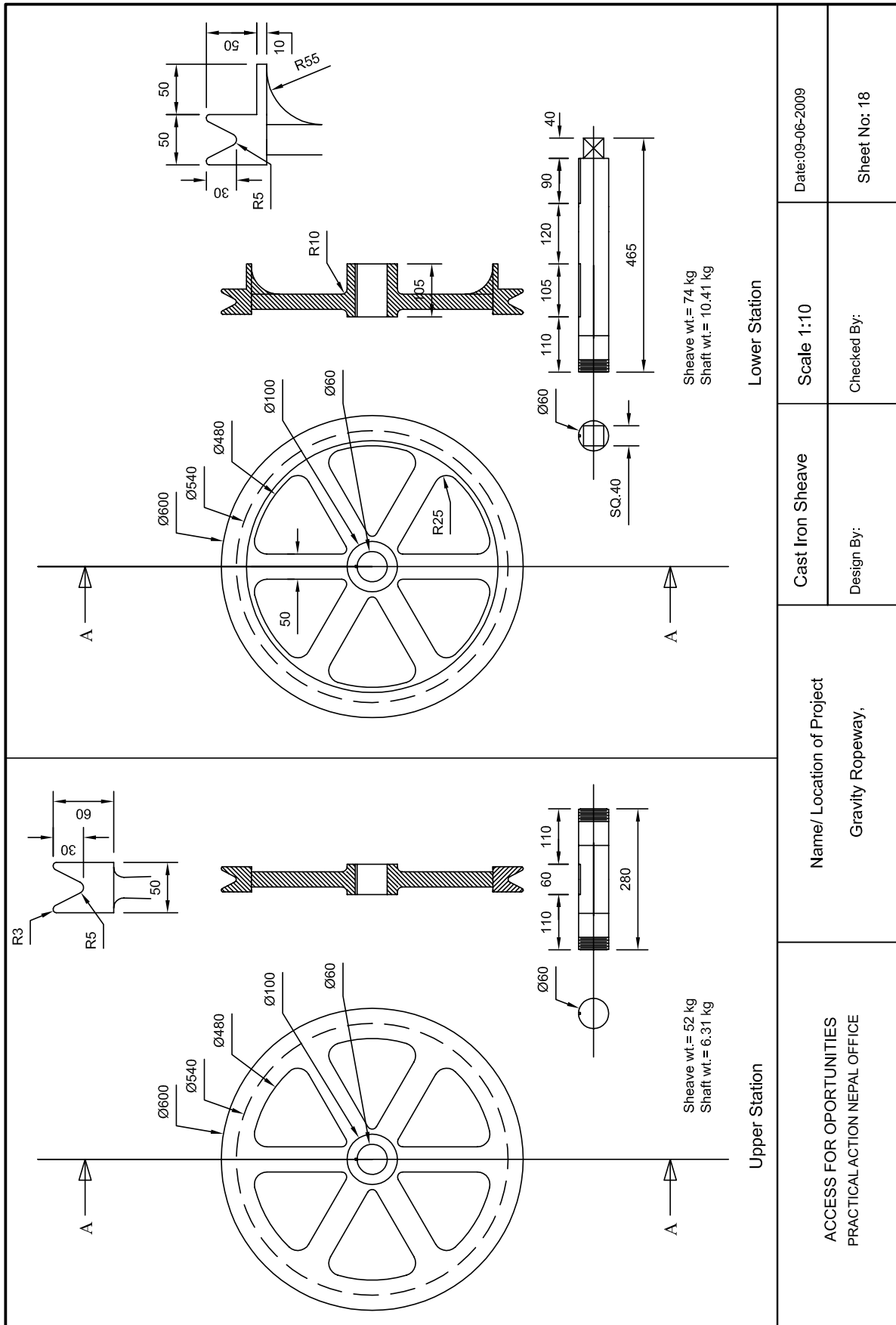


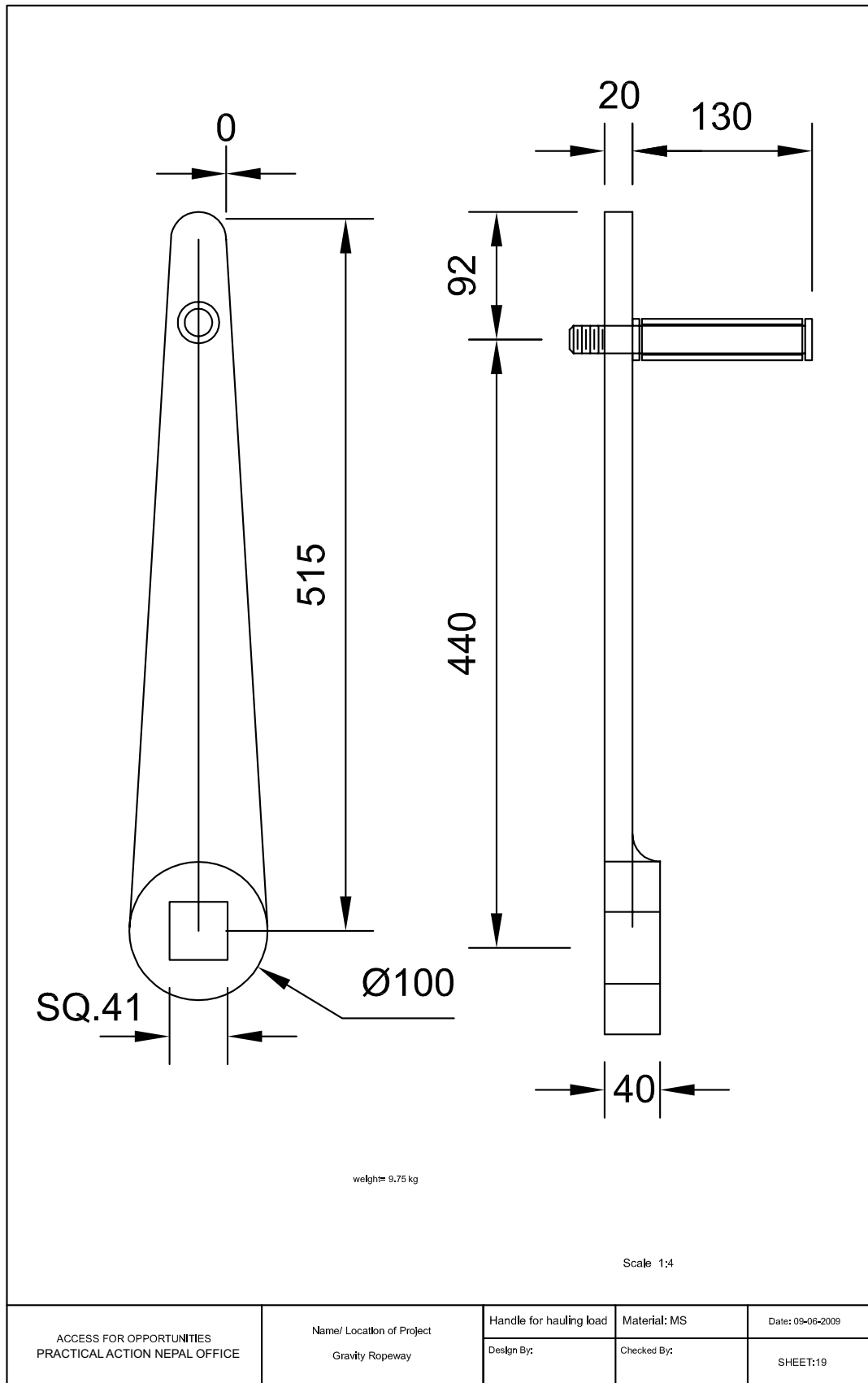


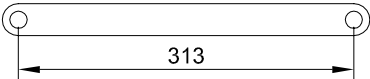
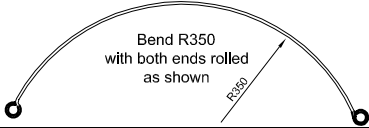
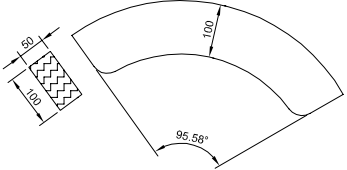
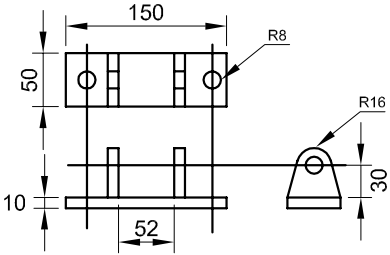
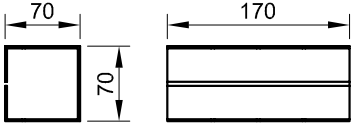
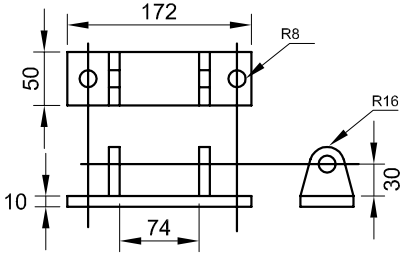
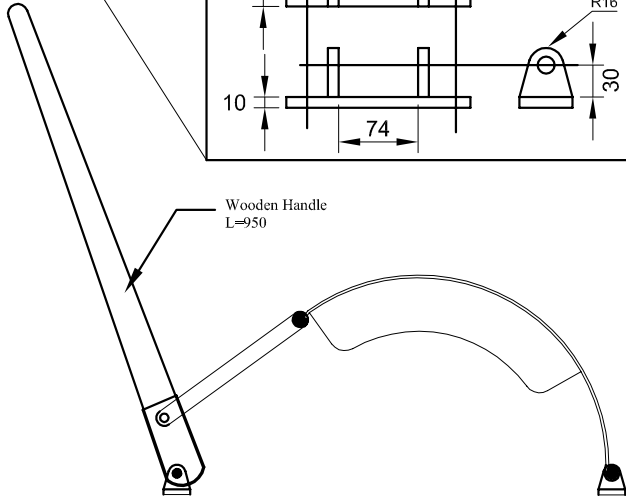


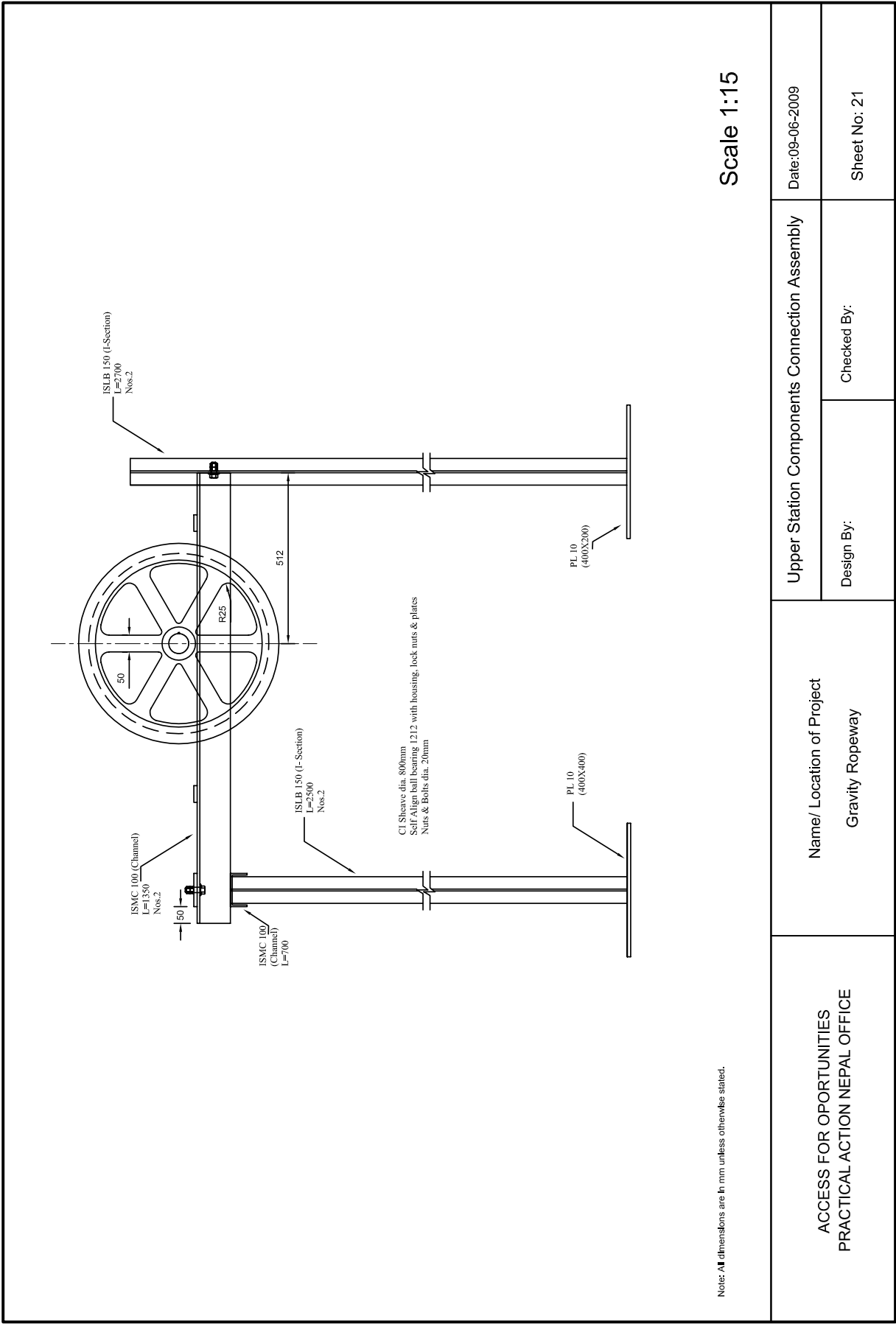
Part No.	Section [mm]	Quantity [nos.]	Working Drawing [not to scale]	Weight	
				kg/pc	Total kg
1	I-Beam (ISLB 150) L= 1800	2		25.56	51.12
2	I-Beam (ISLB 150) L= 600	2		8.52	17.04
3	PL10 400x400	2		12.56	50.24
4	PL10 400x200	2		12.56	50.24
5	Channel (ISMC 100) L=2000	2		19.12	38.24
6	Channel (ISMC 100) L=700	1		6.69	6.69
7	PL5 50x100	2		0.20	0.40
8	PL10 100X325	3		2.55	7.65
					

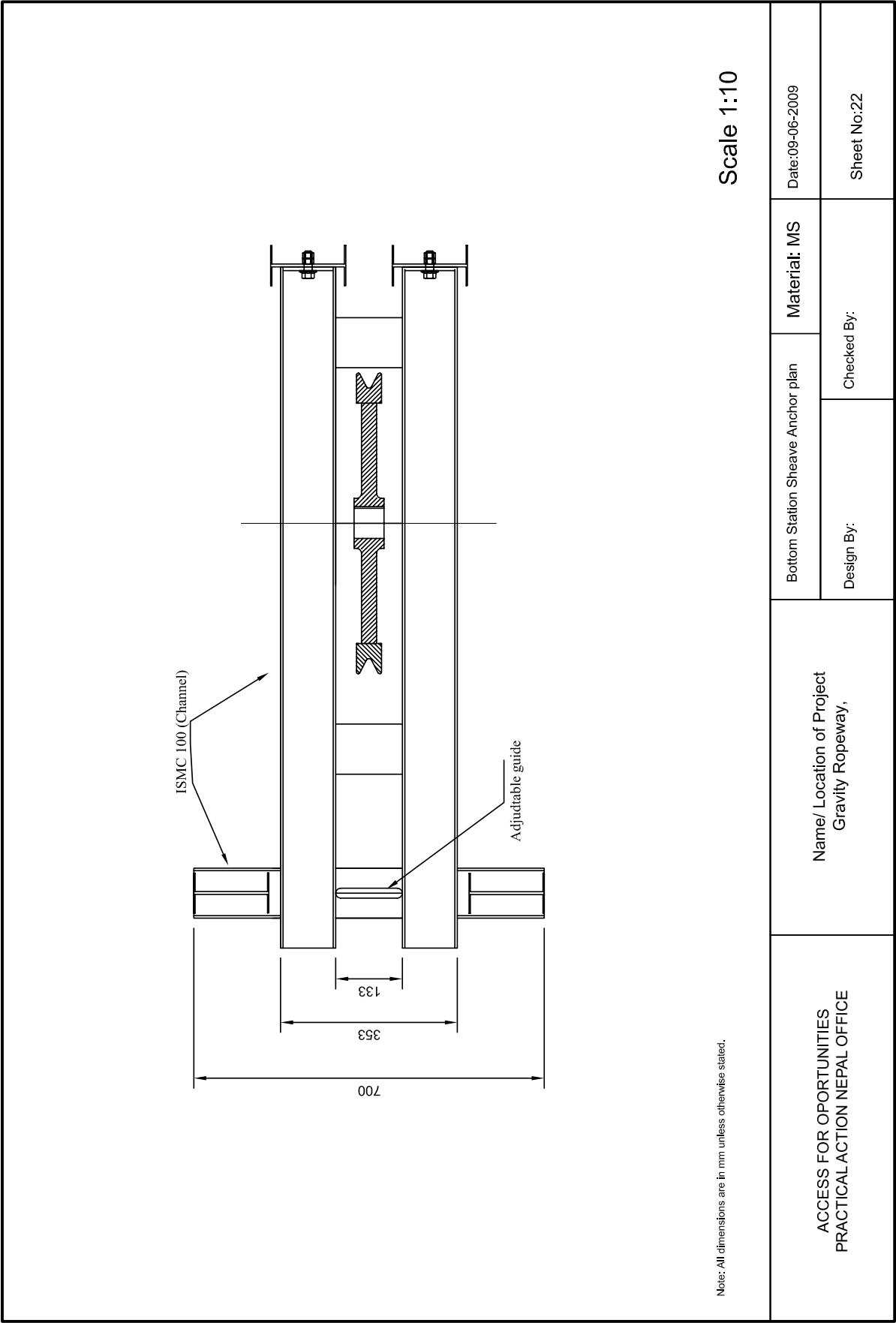
ACCESS FOR OPPORTUNITIES PRACTICAL ACTION NEPAL OFFICE	Name/ Location of Project Gravity Ropeway		Working Drawing for Sheave Anchorage		Date: 09-06-2009
			Design By:	Checked By:	
					Sheet No: 17

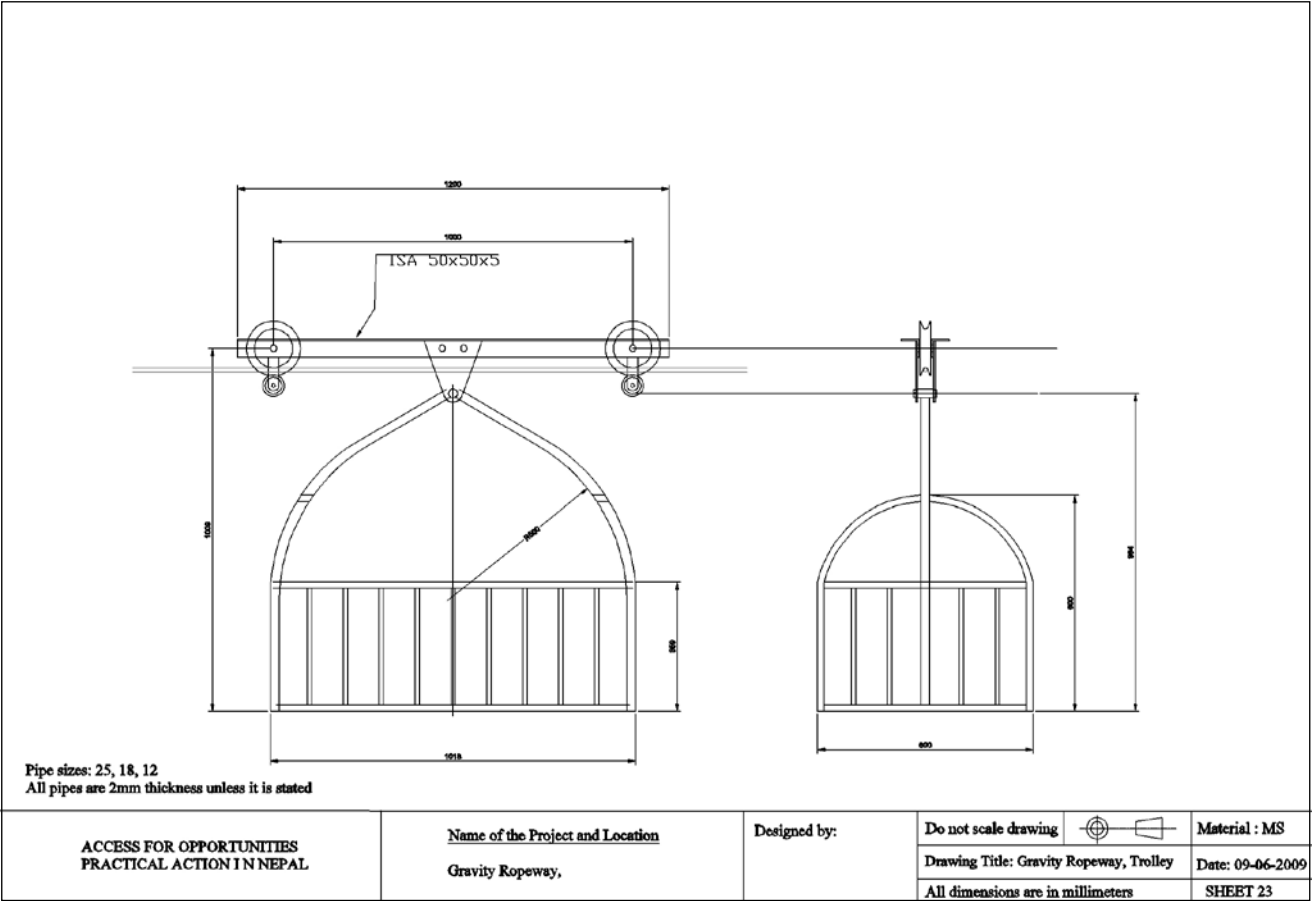




Part No.	Section [mm]	Quantity [nos.]	Working Drawing [not to scale]	Weight	
				kg/pc	Total kg
1	Connecting Plate (30x5) L= 343	2		0.40	0.80
2	External contracting brake plate (50x5) L= 850	1		1.67	1.67
3	Wooden brake shoe	1		0.90	0.90
4	Bracket PL10	1		0.95	0.95
5	PL5 50x100	2		1.87	1.87
6	Bracket PL10	1		1.04	1.04
			 <p>Wooden Handle L=950</p>		
ACCESS FOR OPPORTUNITIES PRACTICAL ACTION NEPAL OFFICE			Name/ Location of Project Gravity Ropeway,		Working Drawing for Braking system Date: 09-06-2009 Design By: _____ Checked By: _____ Sheet No: 20









Part No.	Section [mm]	Quantity [nos.]	Working Drawing [not to scale]	Weight	
				kg/pc	Total kg
1	ISA 50x50x6 L= 1200	2		5.40	10.80
2	Connection Plate	2		0.74	1.48
3	Hinge Pin	1		0.28	0.28
4	Plate 93x30x6	4		0.13	0.52
5	Ø150 Pulley thick=30	2		4.16	8.32
6	Ø60 Pulley thick=30	2		0.67	1.34
7	M17 Nut/ Bolt	2		0.12	0.24
8	M10 Nut/ Bolt	2		0.04	0.08
<p>The plate thickness is to be 6mm unless otherwise stated</p>					
Total 2 Sets					
ACCESS FOR OPPORTUNITIES PRACTICAL ACTION IN NEPAL		Name of project location : Gravity ropeway		Working Drawing for Trolley mounting	
				Drawn By:	Checked By:
				Design By:	Approved By:
				Date:- 09-06-2009	
				Sheet No: 24	

# Annex 5



## List of Fabricator, Manufacturer and Suppliers

### A) Gravity ropeway steel parts fabricators,

1. Inter-Tech P.Ltd  
Butwal Industries Districts  
Butwal Nepal  
Telephone : 00977-71-540147,  
540471/540503  
Fax : 00977-71-548471/543093  
E mail : intertech@wlink.com.np
2. Radha Structure and Engineering works (p)Ltd  
176-Miteri Marg , Baneshwor-34,  
Kathmandu Nepal  
Phone : 00977-1-4472111/4491132  
Fax : 00977-1- 4491030  
Email : info@radhastructure.com  
UTL : www.radhastructure.com
3. Mallika Engineering and Mechanical Works Pvt.Ltd  
Dhangadi , Kailali  
Phone : 00977-91-5222730
4. Ambika Fabrication Pvt .Ltd  
Sallagari, Bhaktapur, Nepal  
Telephone : 00977-1-6610353/6611619
5. Sidhartha Engineering  
Industrial Area, Surkhet Road, Nepalgunj

### B) Steel wire rope manufacturer

1. Bharat Wire Ropes Ltd L.B.S Marg,  
Sonapur, Bandup(West),  
Mumbai - 400078, India  
Tel : (91) (22) 2566 2773/2566 2785  
2566 2527/2566 8671  
Fax ; (91) (22) 2566 9090  
Email : wireropes@veni.com

2. Navin Steel Industries  
Dhangu Road, Pathankot (Pb)  
Phone : +91-733-01893 244690  
Fax: +91- 733-01893 244081
3. Juli Sling Co Ltd  
Xushui Industrial Park, Baoding City  
Hebei Province, China -072550  
Web site : www.juligroup.com

### C ) Wire rope suppliers and dealers

1. KEY PU Enterprises  
P.O.Box :228, Kathmandu, Nepal  
Tel: 00977-1-5541279  
Fax : 00977-1-5523870  
Email : keypu@wlink.com.np
2. Hansaraj Hulaschand Co. Pvt .Ltd  
Head office : Golcha house, Main road,  
Biratnagar, Nepal  
Phone ; 00977-21-525627  
Fax: 00977-21-524395  
Email : brt@golchha.com  
Main office : Golcha house, Ganahabahal,  
PO Box 363, Kathmandu, Nepal  
Phone : 00977-1-4250001  
Fax : 00977-1-4249723  
Email: ktm@golcha.com/import@golcha.com
3. Inter-Tech P.Ltd  
Butwal Industries Districts  
Butwal Nepal  
Telephone : 00977-71-540147,  
540471/540503  
Fax : 00977-71-548471/543093  
E mail : intertech@wlink.com.np

## Reference and Bibliography

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IS Code for aerial ropeways for transportation of passengers (IS 5229:1998)

Code of Practices for passenger ropeways in New Zealand – 1998 edition

Code of practice on the design, manufacture and installation of Aerial Ropeways –

Hong Kong Government, 2002

British Standard BS 2763:1982. Specification for Round Carbon steel wire for wire Ropes

# ACRONYMS

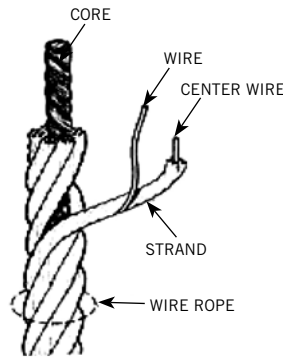


<b>CBO</b>	Community Based Organisation
<b>DADO</b>	District Agriculture Development Office
<b>DDC</b>	District Development Committee
<b>DFO</b>	District Forest Office
<b>DLSO</b>	District Livestock Service Office
<b>DoLIDAR</b>	Department of Local Infrastructure Development and Agricultural Roads
<b>DTMP</b>	District Transport Master Plan
<b>INGO</b>	International Non Government Organisation
<b>IWRC</b>	Independent Wire Rope Core
<b>IS</b>	Indian Standard
<b>NGO</b>	Non Government Organisation
<b>NS</b>	Nepal Standard
<b>OITAF</b>	International Organisation for Transportation by Rope (Organizzaazione Internazionale Transporti a fune)
<b>UK</b>	United Kingdom
<b>VDC</b>	Village Development Committee

# GLOSSARY OF TERMS USED

1. **Haulage ropes:** Ropes which oscillate back and forth in between the sheaves. This provides the traction force and hauls trolleys on the track ropes. The haulage ropes are usually smaller than the track ropes in diameter. The core of the ropes is made up of jute fibre that makes it more flexible.
2. **Track ropes:** Ropes that are designed, manufactured or used solely for supporting trolleys to move on a gravity ropeway. They are ropes along which the trolleys by means of pulleys slide up and down the top and bottom stations of the ropeway system. The flexibility of the track rope is lesser than that of the haulage rope because wire strand or independent wire ropes are used as its core. The diameter of the track rope is designed based on the slope profile and considering the safety factor. The diameter of the track rope is normally larger than the haulage rope.
3. **Trolleys:** These are wooden or mild steel baskets or carriages that are used for carrying the goods in the ropeway system. Trolleys move on pulleys along the track ropes. Their sizes and shapes vary according to the nature of the transportation loads.
4. **Tower/thrust pillars:** These are steel or concrete structures erected at the upper and lower stations to support the track ropes. The saddles are placed on top of the towers to run the ropes. The tower at bottom station also serves as the shock/thrust absorber in the case of brake fail or while the operator fails to apply the brakes in time. It helps to avert the risk to the operator and minimize the breakage of track ropes and other accessories. The tower at the upper station helps to provide the clearance required for the trolleys at the upper landing platform.
5. **Top and bottom stations:** They are loading and unloading platforms at the top and bottom end of the gravity ropeway system. Each station consists of a sheave with bearings at each end, trolley landing platform, space for goods handling (weighing, storing and queuing) and a small office room with a shed (overhead roof) to shield/protect from weather conditions.
6. **Sheaves:** These are the cast iron circular wheels with a groove along its edge for holding hauling ropes. They are fixed at each station of the gravity ropeway, around which the hauling ropes oscillates. These cast iron sheaves can withstand the peripheral velocity of 40 m/sec.
7. **Brake:** It is a simple wooden brake used to control the speed of the moving trolley, which is attached to the sheave at the bottom station. A rubber or wooden brake shoe is popularly used for the brake.
8. **Wire:** The wires in the wire rope are the thin filaments/strings winded in a certain direction

on a wire-centre rod. They are normally drawn from bigger diameter steel rods in such a way that the rods pass through a series of dies which progressively reduces their diameters to form wires. They are usually made up of high steel carbon.



9. **Core:** The core of a wire rope is made up of either textile fibres or steel wires. It provides an elastic bed preventing internal friction and sliding of strands twisting around it.

10. **Strand:** A strand is produced by twisting a bundle of wire in a particular configuration and direction. The number of wires and the number of layers in a strand depend on the usage frequency of the rope. The centre wire of a strand is known as “King wire”.

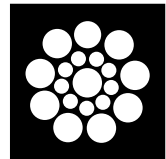
11. **Strand constructions:** Strands are designed with various combinations of wires and wire sizes to produce the desired resistance to fatigue and abrasion. Generally, a small number of large wires will be more abrasion resistant and less fatigue resistant than a large number of small wires. Various types of wire-strands are elaborated below:

- 11.1 **Single size:** This basic strand construction has wires of the same size wound around a centre as shown in the diagram at the right.

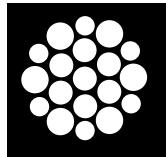


- 11.2 **Seale:** This consists of a number of larger outer wires with the same number of smaller inner wires wound around a core wire. This provides excellent abrasion resistance but less fatigue

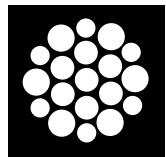
resistance. When used with an Independent Wire Rope Core (IWRC), it offers excellent crush resistance over drums. The Seale type rope construction with IWRC core is commonly used for gravity ropeways.



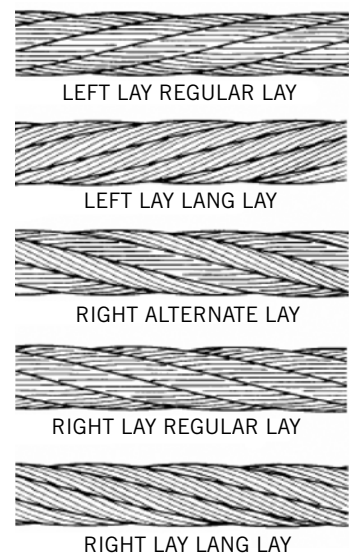
- 11.3 **Filler wire:** This consists of a combination of two layers of the same wires wound around the core wire. Small wires are used to fill spaces between the larger wires to produce crush resistance with a good balance of strength, flexibility and resistance to abrasion.



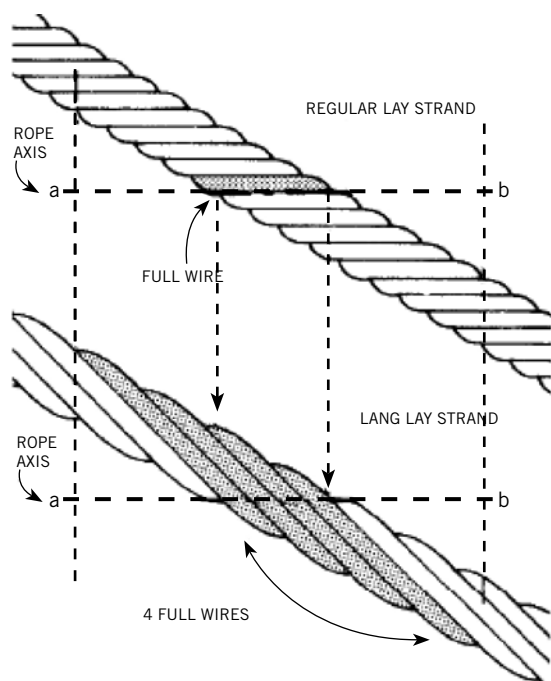
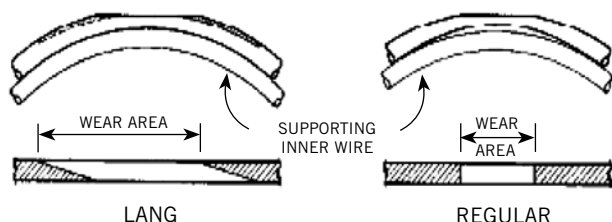
- 11.4 **Warrington:** As in the diagram shown at right, the outer layer of large and small wires placed alternately provides good flexibility and strength but low abrasion and crush resistance.



12. **Lays :** “Lays” of a wire rope is simply a description of direction as how the wires and strands are placed or laid during manufacturing. Right lay means the strands laid from left to the right across the rope. Left lay means just the opposite - strands laid from right to the left. Regular lay and Lang’s lay differentiate the way the wires are laid within each strand.



Regular lay means the wires in the strands are laid opposite in direction to the lay of the strands. Lang's lay means that wires are laid in the same direction as the strands are laid. Mostly, right hand regular lay wire rope is used for gravity ropeway. This specification meets the requirements of most of the applications and equipments. The other lay specifications are considered as exceptions and are not widely used except for very specific purposes. Therefore, particular specifications must be requested when ordering wire ropes. Normally, manufacturers do not tend to produce specific types of wire ropes in small quantities.



Difference in abrasion characteristics of Lang's Lay and Ordinary lay ropes

The differences between Lang's lay and ordinary lay wire ropes are:

1. the number of strands,
2. the construction of strands,
3. the size of the core,
4. the lay direction of the strand versus the core, and
5. the grade of the carbon steel of the wires.

N.B. Lang's lay ropes are preferred over the ordinary lay for the gravity ropeways because it offers more contact area between the wire and the bearing surface which increases the abrasion resistance of the rope as compared to an equivalent ordinary lay rope. Besides, it is more flexible than the ordinary rope with more resistant to bending fatigue resulting to longer service life than the ordinary lay wire rope.

**13. Galvanisation:** Galvanisation means zinc coating of the wires, as the wire ropes are exposed to the external environment all the time, galvanisation is required to prevent it from potential corrosion and rust. The extent of galvanisation depends on the frequency of the rope usage. There are two methods of galvanising:

1. Galvanising after the finished wire has been drawn, and
2. Galvanising before the wire is sent for drawing.

The specification of zinc coating is IS: 4826/68 and API-STD 9A.

Weights of coatings are:

Wire ømm	Heavy Coatings, gm/m <sup>2</sup> "A-type"	Medium Coatings, gm/m <sup>2</sup> (Z -Type)
1.25 – 1.40	180	90
1.40 – 1.60	190	95
1.60 – 1.80	200	95
1.80 – 2.24	210	105
2.24 – 2.80	230	110

**14. Lubrication:** Lubrication prolongs the life of the rope by keeping it free from corrosion. It makes the rope water repellent and friction resistant. During the rope manufacturing, suitable lubricants are used in the core, on strands and on the finished rope to protect it while in transit, storage and haulage. Factory lubrication only is not sufficient to last for the useful life of the ropeway. For lubrication of the gravity ropeway ropes non drying type and non bituminous lubricant should be periodically used to minimise friction between pulleys and rope. Ultimately it prevents the wire from corrosion due to weathering.

**15. Kinks :** As shown in the diagram at right kink damages the strands and wires reducing the life of the rope. The most common form of kink is the formation of a loop of wire/wires pulled out from the rope. Kink can be minimised by careful handling of ropes mainly during uncoiling, hauling, and transferring



**16. Pre-stretching of Wire Ropes and Elasticity:** Pre-stretching is a process of cyclic loading of the rope between 10 and 50 per cent of the minimum breaking load until the

virtual elimination of “initial or construction stretch.” A pre-stretched wire rope has a definite and known Modulus of Elasticity. During the construction a new wire rope is stretched which increase the length of the rope by a certain amount. This stretch is also called “construction stretch” which is caused by the compression of the core due to gradual bedding-in of wires and strands under load. For ropes with steel cores, the stretching increases up to 0.5 to 1.0 per cent of the rope length. The pre-stretched ropes are preferred in the gravity ropeway to prevent frequent slackening of the wire ropes when it is in operation. In a ropeway system, where the clearance between the wire rope and the ground below is just enough, an undue slackening of the wire rope would cause the trolley to touch the ground obstructing the smooth movement of the trolley.

**17. Pre-forming :** Pre-forming is a technique used during the production of a rope where the individual strand is set in a helical form to ensure that it lies in the rope without tending to unwind. This is important to make sure that undue winding does not take place after the wire rope is placed in service. This is more essential in the Lang’s lay rope as the winding tendency is more in it than in the ordinary rope.





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