

GENERAL MECHANICS

ADVANCES IN ENGINEERING SOFTWARE FOR LIFT TRANSPORTATION SYSTEMS*

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ABSTRACT. In this paper an attempt is performed at computer modelling of ropeway ski lift systems. The logic in these systems is based on a travel form between the two terminals, which operates with high capacity cabins, chairs, gondolas or draw-bars. Computer codes AUTOCAD, MATLAB and Compaq-Visual Fortran – version 6.6 are used in the computer modelling. The rope systems computer modelling is organized in two stages in this paper. The first stage is organization of the ground relief profile and a design of the lift system as a whole, according to the terrain profile and the climatic and atmospheric conditions. The ground profile is prepared by the geodesists and is presented in an AUTOCAD view. The next step is the design of the lift itself which is performed by programmes using the computer code MATLAB. The second stage of the computer modelling is performed after the optimization of the coordinates and the lift profile using the computer code MATLAB. Then the co-ordinates and the parameters are inserted into a program written in Compaq Visual Fortran – version 6.6., which calculates 171 lift parameters, organized in 42 tables. The objective of the work presented in this paper is an attempt at computer modelling of the design and parameters derivation of the rope way systems and their computer variation and optimization.

KEY WORDS: Computer modelling, lift transportation systems, design, rope way systems, lift transportation systems.

1. Introduction

In this paper the work and experience in design of lift transportation systems is presented. This investigation is related to design, manufacturing and mounting of rope way transportation systems in the following areas:

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- Surface Ski lift
- Fix-Grip Chairlift
- Detachable Chairlift
- Group Gondola
- Detachable Gondola
- Reversible Ropeways.

Surface lift (T-Bar) system (see Figs 1 and 2) includes mono-cable with fix grip, a drive station and a return station with the last European technology. This Cable Car designs [1] allow speed control for operators and about passengers, they will move to stations comfortably and safety by carriers according to EN 2000/9/EC last ropeway standards [2].



Fig. 1. Surface ski lift (T-bar) – general view



Fig. 2. Fix-Grip Chairlift

These systems that are both preferable in winter and summer tourism (see Fig. 3), are conspicuous with their high transporting capacities and comfortable designs. The system takes its name from the type of coupling of the grip to the rope. The chairs can be with 2 / 4 / 6 person according to the type of the project. With this type of ropeway of which working speed can reach 2–3 m/sec, it is possible to transport 3000 people/hour according to the type of the line and the chair. It is possible to add a middle station in case of long rail lines. As in this case, this type of system can slow down on the upper and lower stations to provide a comfortable getting on/off for the passengers.

The passing system makes it possible, to slow down the speed in the stations to take the passenger with the carrier chair at a certain point and accelerate the speed to 5 m/sec on the line. With these systems that are designed for ski-centres, the capacity can reach 4000 p/h. The detachable grip that provides high speed on the line can be adoptable to 2 / 4 / 8 person chairs. The passengers can be easily and safely transported even at high speeds with the wind protector on the chairs.



Fig. 3. Detachable chair lift – driving station



Fig. 4 Detachable gondola – general view

In these systems the passengers can either sit or stand during the travel. With 4 / 6 / 12 person modern gondolas, with Gondolas (see Fig. 4) and Group Gondolas. That's why the gondolas decelerate and stop in the stations and then accelerate on the line again.

This type of systems that combine high speed and quality with safety is an ideal choice for the resort complexes. In these systems, that are both preferable in winter and summer tourism, capacity of the gondolas varies from 6 to 15 persons. The most important property of the modern designed gondolas is the possibility of carrying the bags with the passengers. Due to its detachable grip, the system can decelerate in the stations and provides a safety landing for passengers though the system can speed up to 6 m/sec on the line. The transporting capacity of 3600 p/h can vary according to the system and the type of gondola.

1.1. Reversible ropeways

The logic in this system is based on a to and fro travel form between the two terminals, which operates with one or two high capacity cabins. They move on a single main carrier rope and two tracking ropes. Depending on the size of the line speed, line length and the cabins, the transport capacity are 2,000 persons per hour. The speed of this Ropeway System is 12 m/s.

The objective of the work presented in this paper is an attempt at computer modelling of the design and the parameters of the rope way systems and their computer variation and optimization.

The rope systems computer modelling is organized in two stages in this paper. The first stage is organization of the ground relief profile and a design of the lift system as a whole, according to the terrain profile and the

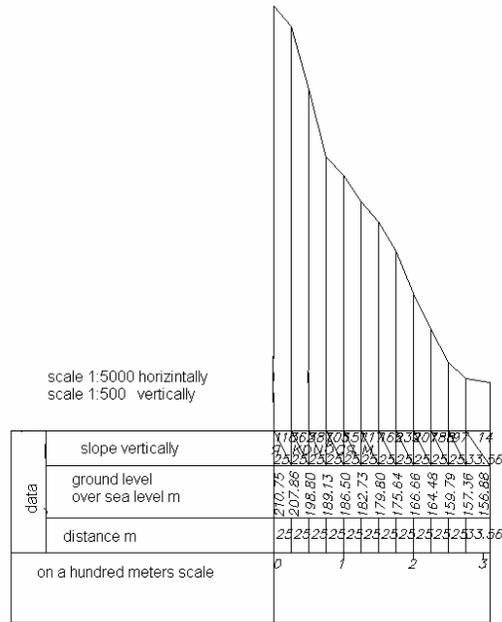


Fig. 5. Profile for a real chair lift – an AUTOCAD plot

climatic and atmospheric conditions. The ground profile is prepared by the geodesists and a few profile views in AUTOCAD are presented in Figs 5, 8 and 11. The profile itself is a two co-ordinate graphic, showing the horizontal distance of the profile and the vertical axis is the distance above sea level. In this way the ground terrain is defined and ready for design of the ropeway transportation system. The next step is the design of the lift itself which is performed by programmes using the computer code MATLAB. Versions of the ski lifts performed by the computer code MATLAB are presented in Figs 6, 7, 9, 10 and 12. The lift profile is designed by means of entering the co-ordinates of the ground relief and the positions of the lift posts which define the rope allocation and its standing above the ground. The program picks up automatically the co-ordinate and by means of re-entering of the new or desired co-ordinates an optimization of the ropeway system can be performed.

The second stage of the computer modelling happens after the optimization of the co-ordinates and the lift profile using the computer code MATLAB. Then the co-ordinates and the parameters are inserted into a program written in Compaq Visual Fortran – version 6.6. This is the program written

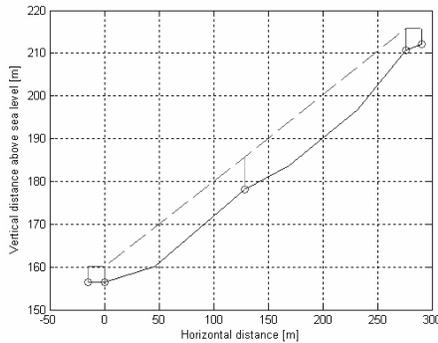


Fig. 6. Design for a chair lift for the profile presented in Fig. 5 – a variant with 5 posts, using a MATLAB program

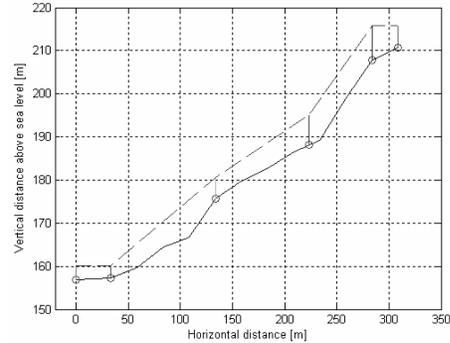


Fig. 7. Design for a chair lift for the profile presented in Fig. 5 – a variant with 6 posts, using a MATLAB program

in Fortran 77 presented in [1] and converted in Compaq Visual Fortran – version 6.6 and adapted to the up to date mathematical requirements [6, 7, 8]. References [3, 4 and 5] were used as a general knowledge. This program calculates 171 lift parameters, organized in 42 tables. A parametrical optimization is possible by variation of the input data.

The objective of the work presented in this paper is an attempt at computer modelling of the design and the parameters of the rope way systems and their computer optimization.

2. Computer modelling of the ground profile and the lift profile using the computer code MATLAB.

The first stage of the computer modelling gives the ground relief profile. The ground profile is prepared by the geodesists and a few profile views in AUTOCAD are presented in Figs 5, 8 and 11.

A design of the transportation lift system as a whole according to the terrain profile and the climatic and atmospheric conditions is modelled using the computer code MATLAB. It includes the proper selection of the allocation of the lower station, the upper station as well as where to place the drive station and the proper number and height of the lift posts. In Figs 6, 7, 9, 10 and 12 are presented different versions of lift profile designs and a computer optimization is possible in order to obtain the optimal ski lift profile and also to pick up the co-ordinates of the posts and the rope profile. The MATLAB program code is presented in the Appendix. It gives the possibility to pick up

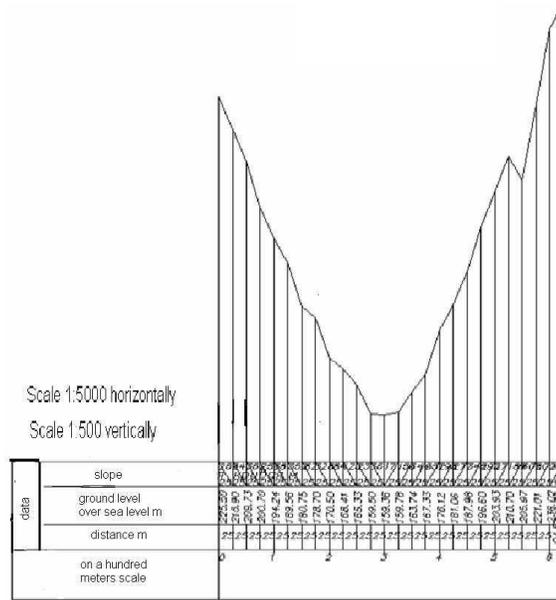


Fig. 8. Profile for a real chair lift – a profile with double slopes, an AUTOCAD plot

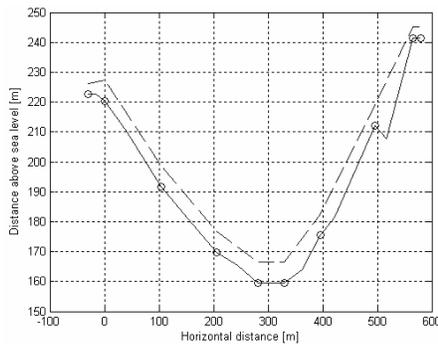


Fig. 9. Design for a real chair lift – a strange profile with double slopes presented in Fig. 8 – variant with 10 posts and middle station at the bottom of the profile using a MATLAB program

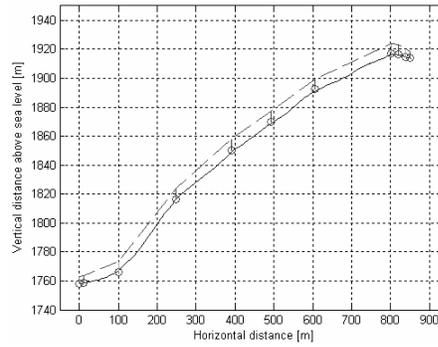


Fig. 10. A design for a ground ski lift (T-bar) – a variant with 11 posts using the MATLAB program

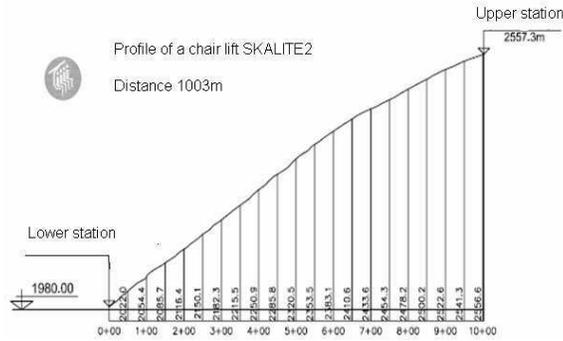


Fig. 11. Profile of a seat chair lift SKALITE2 – an AUTOCAD plot

the co-ordinates automatically and then to insert them as initial data into the program in Compaq Visual Fortran – version 6.6.

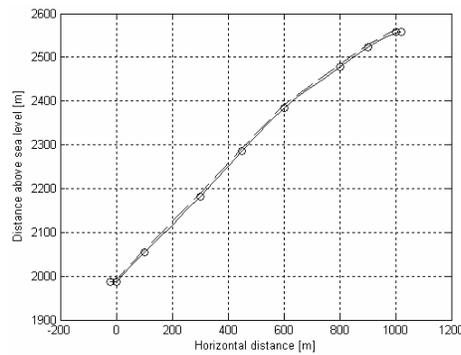


Fig. 12. Design variant for the seat chair lift SKALITE2 – a variant 10 posts using the MATLAB program

3. Computer modelling of the lift parameters using the computer code Compaq Visual FORTRAN – version 6.6.

The selected optimal ski lift co-ordinates and the parameters are inserted into a program [1] written in Compaq Visual Fortran – version 6.6, which calculates 171 parameters of the lift transportation system, organized in 42 tables. The program represents the main calculating body and is very big and complicated. It comprises over two thousand operators based on geometric

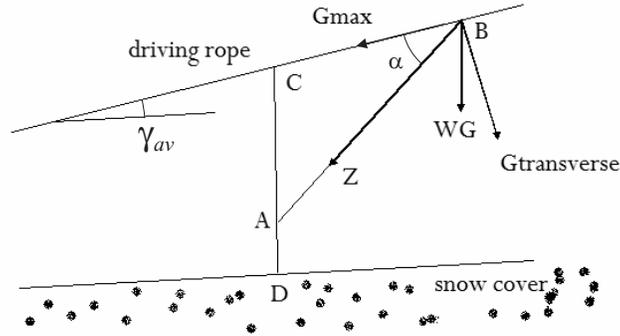
and trigonometric relations and here are presented some of the main points of the calculation procedure and namely as follows:

3.1. Orientation calculation and selection of the driving rope

The force Z of the rope of the T-bar is (please refer to Fig. 13):

$$(1) \quad Z = G \frac{\sin(\gamma_{av} + \rho)}{\cos(\alpha - \rho)},$$

where $G = 2P = 160$ daN is the weight of the skiers; $\rho = 5^\circ 43'$ – friction angle between the skies and the snow (friction coefficient between the skies and the snow is assumed to be $f = 0.1$).



$$\begin{aligned} AC &= a_1; \quad AB = l_{\max} = 9 \text{ m}; \quad AD = 0.8 \text{ m}; \\ G_{\text{transverse}} &= Z \sin \alpha + WG \cos \gamma_{av}; \\ G_{\max} &= Z \cos \alpha + WG \sin \gamma_{av}; \end{aligned}$$

Fig. 13. Loading of the driving rope by the T-bar

The minimal force in the driving rope is defined by the relation:

$$(2) \quad \frac{G_{\text{transverse}}}{S_{\min}} = \frac{1}{15}; \quad S_{\min} = 15 \cdot G_{\text{transverse}}.$$

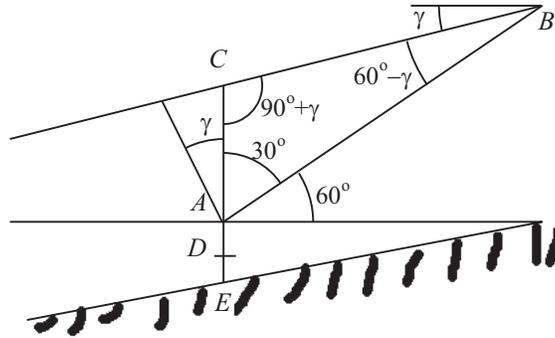
3.2. Highest admissible location of the driving rope and regions of the ground profile

The ground profile is divided in regions on the basis of the following conditions:

- In one region cannot be build up several chords of openings between the posts, which differ according to the slope angle not much (up to 4° to 5°);

- Height difference between the boundary points in one region not to exceed 70 m, and exceptionally around 90 m.

In this case the number of the regions is five – I, II, III, IV and V (please refer to Fig. 15). The boundaries and the number of the regions are defined approximately.



$$(3) \quad AB = 9 \text{ m}; \quad AD = h = 0.8 \text{ m}; \quad DE = C_1 = 0.3 \text{ m}; \quad AC = AB \frac{\sin(60 - \gamma)}{\cos \gamma}.$$

Fig. 14. Highest position of the driving rope

3.3. Calculation of the forces in the rope of the T-bar

Calculations are performed for the climbing up part of the rope way system and full T-bars with average depth of the snow cover, measured vertically $C = 0.8$ m and height from the snow cover to the force application point (to the T-bar), measured also vertically $h = 0.8$ m. A basis for calculations is Figs 15 and 16 and the following signs are used:

γ_j – angle of the slope of the chord for distance between posts j ;

H_{avj} – average vertical distance of the aperture j between the ground and the leading rope. The length of the aperture is divided into five equal parts and from the drawing of the longitudinal profile they are defined as it is shown in Fig. 15 graphically H_1, H_2, H_3 and H_4 . Then we can write:

$$(4) \quad H_{avj} = \frac{H_1 + H_2 + H_3 + H_4}{4};$$

$a_{ij} = H_{avj} - C - h = H_{avj} - 1.6$ for each opening the T-bar is pulled maximally and we have:

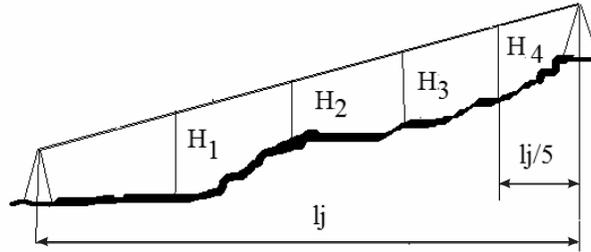


Fig. 15. Height above the ground profile

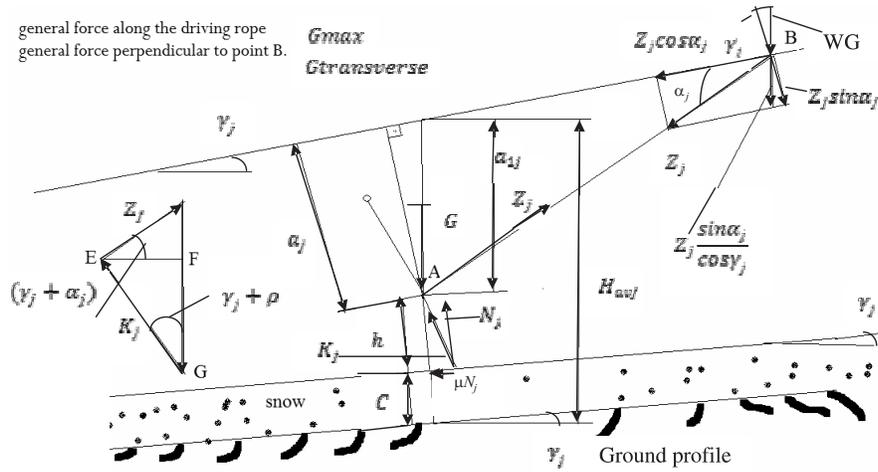


Fig. 16. Force definition

$$(5) \quad \sin \alpha_j = \frac{a_{1j} \cos \gamma_j}{l_{\max}}; \quad Z_j = G \frac{\sin(\gamma_j + \rho)}{\cos(\alpha_j - \rho)};$$

$$(6) \quad G_{\max} = Z_j \cos \alpha_j + WG \sin \gamma_j; \quad G_{\text{transverse}} = Z_j \sin \alpha_j + WG \cos \gamma_j;$$

$$AB = l_{\max}; \quad a_j = a_{1j} \cos \gamma_j.$$

$l_{\max} = 9$ m, the weight of both skiers is $G=160$ daN; According to calculations of the existing Order Form No 24 of the National Committee of Standardization [2] for design and safety exploitation of rope way transportation systems (in Bulgaria) $G=150$ daN.

$Z_j \cdot \cos \alpha_j$ – component of the useful loading (skiers) along the axis of the driving rope;

$Z_j \cdot \sin \alpha_j$ – component of the useful loading (skiers), perpendicular to the axis of the driving rope;

$\frac{Z_j \cdot \sin \alpha_j}{\cos \gamma_j}$ – vertical loading by the skiers;

$QG = \frac{Z_j \cdot \sin \alpha_j}{\cos \gamma_j} + WG$ – vertical concentrated loading by the skiers and the T-bars;

$\frac{QG}{W} = \frac{\frac{Z_j \cdot \sin \alpha_j}{\cos \gamma_j} + WG}{W}$ – evenly distributed vertical loading from the useful load and the T-bar on a unit length of the rope;

$QQ = \frac{\frac{Z_j \cdot \sin \alpha_j}{\cos \gamma_j} + WG}{W} + Q$ – evenly distributed vertical loading from the rope, the useful loading and the T-bar on a unit length of the rope;

$WG \sin \gamma_j$ – component of the loading of the T-bar along the axis of the driving rope;

$G_{\tan} = Z_j \cos \alpha_j + WG \sin \gamma_j$ – component from the useful loading and the T-bar along the rope axis;

$B_1 = \frac{G_{\tan}}{W}$ – evenly distributed loading on a unit length of the rope, the useful loading and the T-bar;

$B_2 = \frac{WG \sin \gamma_j}{W}$ – evenly distributed loading on a unit length of the rope from the T-bar for an empty region (this value is only for an empty region).

3.4. Angles and forces over a post definition

The angle of folding is α (ALFA) upon a post. It can be positive in the case of supportive and negative in the case of a pressing down battery (please refer to Fig. 17).

$$(7) \quad a_j = \varphi_{\text{right}(j-1,j)} - \varphi_{\text{left}(j,j+1)},$$

D – force, loading the roll battery from bending of the driving rope. It is positive with the supportive and negative with the pressing down battery.

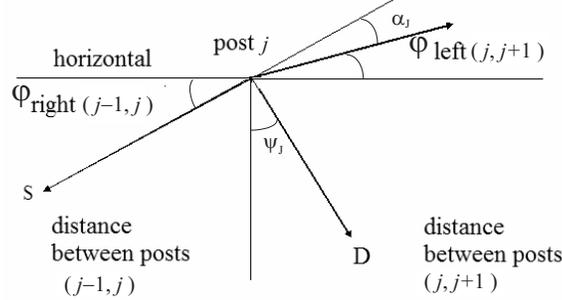


Fig. 17. Angles and forces upon a post

ψ_j – an angle between the force D and the vertical, and it can be defined following the relation below:

$$(8) \quad \psi_j = 0.5 [\varphi_{\text{right}(j-1,j)} + \varphi_{\text{left}(j,j+1)}],$$

$\psi > 0$, when the force is in the second or in the fourth quadrant. The exact quadrant in which the force is located is defined by the value of the signs of φ_{left} and φ_{right} .

3.5. Optimization procedure

The optimization procedure of the design of the proper lift profile goes through several steps and namely:

Step 1. The first stage of the computer modelling gives the ground relief profile. The ground profile is prepared by the geodesists and a few profile views in AUTOCAD.

Step 2. A design of the transportation lift system as a whole according to the terrain profile and the climatic and atmospheric conditions is modelled using the computer code MATLAB. It includes the proper selection of the allocation of the lower station, the upper station as well as where to place the drive station and the proper number and height of the lift posts.

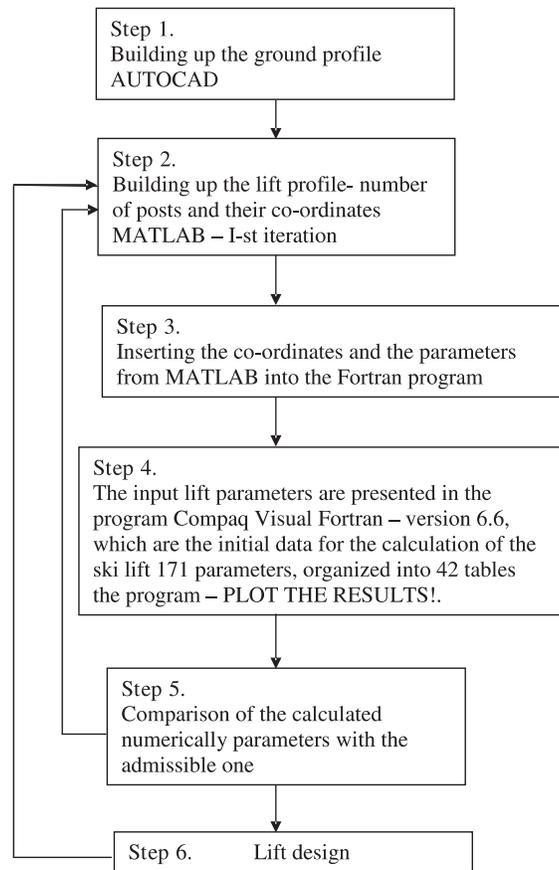
Step 3. The selected optimal ski lift co-ordinates and the parameters are inserted manually into a program [1] written in Compaq Visual Fortran – version 6.6.

Step 4. The program calculates 171 parameters of the lift transportation system, organized in 42 tables. The program represents the main calculating body and is very big and complicated. It comprises over two thousand operators based on geometric and trigonometric relations.

Step 5. Comparison of the calculated numerically parameters with the admissible one.

Step 6. Lift design. This is a very complicated work considering so many parameters, situation of the chords of the ropes over the ground and between the posts, height of the ropes over the ground and so on. Usually, the designer has to change some of the parameters and goes back to **Step 2** for another calculation procedure and so on, after a few iterations the proper lift profile should be build up successfully.

An optimization flowchart is presented in Fig. 18, given below:



Note: The co-ordinates between steps 1, 2 and 3 are inserted manually

Fig. 18. Optimization flowchart

The computer program [1] written in Compaq Visual Fortran – version 6.6 is given in the Appendix. In Table 1 are presented the input lift parameters, which are the initial data for the calculation of the ski lift 171 parameters, organized into 42 tables, starting with Table 1 and Table 2, presented below:

Table 1. Marking of the used constants

A – horizontal distance (m);
 B – evaluation ground (m);
 C – evaluation lower rope edge (m);
 B_1 – distributed load along the rope axis for the loaded area (daN/m);
 B_2 – distributed load along the rope axis for the unloaded area (daN/m);
 QQ – evenly distributed load for the loaded area (daN/m);
 QG – vertical load from a skier and a draw-bar (daN);
 STR – laterally loading by the skier (daN);
 Q – linear load of the transportation rope (daN/m);
 RQ – friction force for loaded area (daN);
 RW – friction force for unloaded area (daN);
 DQP – dynamic force at starting for loaded area (daN);
 DQS – dynamic force at stopping for loaded area (daN);
 DWP – dynamic force at starting of unloaded area (daN);
 DWS – dynamic force at stopping of unloaded area (daN);
 S_2 – dynamic force for the rope pulling definition for loaded area (daN);
 S_3 – dynamic force for the rope pulling definition for unloaded area (daN);
 WG – weight of an empty draw-bar (daN);
 W – distance between the draw-bars (m);
 QW – evenly distributed load for unloaded area (daN/m);
 $ALFD$ – admissible angle of folding over a single roller (RAD);
 A_0 – maximal admissible loading over a roller from a supporting battery (daN);
 A_1 – maximal admissible loading over a roller from a pushing up battery (daN);
 DB – windward diameter of the transportation rope (m);
 $FTEG$ – windward area of an empty draw-bar (m²);
 $VETR$ – velocity pressure of the wind in a working condition (daN/m²);
 VET – velocity wind pressure for not working condition (daN/m²);
 S_4 – dynamic force for the rope strain definition for the sloping down area at starting position (daN);
 S_5 – dynamic force for the rope strain definition for the sloping down area at stopping position (daN);
 N – number of posts plus 4, where 4 is for a representative of lower axis (DO), lower station (DC), upper station (GC) and upper axis (GO).

Remarks: 1. Filling up the data for S_2 , S_3 , S_4 , S_5 must be placed a sixth force according to the place of the driving and the pulling up systems
 2. Values of all the constants are inserted in the program.

Values of the assigned constants

$Q = 1.070$	$S_2 = 2034.000$	$DB = 0.0175$		
$S_5 = 2774.000$	$S_3 = 2776.000$	$FTEG = 0.170$		
$RQ = 57.000$	$WG = 30.000$	$VETR = 36.000$		
$RW = 48.000$	$W = 32.960$	$VET = 144.000$		
$DQP = 174.000$	$QW = 1.981$	$S_4 = 3516.000$		
$DQS = 174.000$	$ALFD = 0.080$	$N = 12$		
$DWP = 49.000$	$A_0 = 250.000$			
$DWS = 49.000$	$A_1 = 240.000$			
$A = 27.000$	$B = 1668.750$	$C = 1673.200$	$B_1 = 0.000$	$B_2 = 0.000$
$A = 30.000$	$B = 1668.840$	$C = 1673.200$	$B_1 = 1.601$	$B_2 = 0.188$
$A = 133.910$	$B = 1688.270$	$C = 1695.150$	$B_1 = 1.361$	$B_2 = 0.150$
$A = 193.380$	$B = 1699.550$	$C = 1705.070$	$B_1 = 1.974$	$B_2 = 0.250$
$A = 252.540$	$B = 1716.190$	$C = 1721.990$	$B_1 = 1.770$	$B_2 = 0.417$
$A = 333.010$	$B = 1737.000$	$C = 1742.040$	$B_1 = 2.915$	$B_2 = 0.000$
$A = 422.570$	$B = 1780.510$	$C = 1788.210$	$B_1 = 2.976$	$B_2 = 0.419$
$A = 529.990$	$B = 1838.000$	$C = 1843.830$	$B_1 = 2.263$	$B_2 = 0.297$
$A = 540.030$	$B = 1840.860$	$C = 1847.290$	$B_1 = 1.455$	$B_2 = 0.163$
$A = 558.180$	$B = 1844.460$	$C = 1850.580$	$B_1 = 0.722$	$B_2 = 0.042$
$A = 603.050$	$B = 1846.020$	$C = 1852.640$	$B_1 = 0.000$	$B_2 = 0.000$
$A = 605.050$	$B = 1846.200$	$C = 1852.640$	$B_1 = 0.000$	$B_2 = 0.000$
$QQ = 1.981$	$QG = 30.000$	$STR = 0.000$		
$QQ = 2.656$	$QG = 52.284$	$STR = 20.000$		
$QQ = 2.656$	$QG = 52.276$	$STR = 40.000$		
$QQ = 2.802$	$QG = 57.081$	$STR = 40.000$		
$QQ = 2.974$	$QG = 62.747$	$STR = 40.000$		
$QQ = 3.752$	$QG = 88.409$	$STR = 40.000$		
$QQ = 3.181$	$QG = 69.575$	$STR = 40.000$		
$QQ = 2.775$	$QG = 56.212$	$STR = 40.000$		
$QQ = 2.506$	$QG = 47.333$	$STR = 40.000$		
$QQ = 2.258$	$QG = 39.152$	$STR = 40.000$		
$QQ = 1.981$	$QG = 30.000$	$STR = 20.000$		
$QQ = 0.000$	$QG = 0.000$	$STR = 0.000$		

Examples of some of the other tables is given in the Appendix, please refer to Tables 10 and 11.

4. Conclusions

An attempt at computer modelling of the design and parameters of the rope way systems and their computer optimization is revealed in this paper. Analysis of the all derived results gives us the opportunity to define the following conclusions:

Table 2

1	2	3	4	5
Post	Horizontal distance	Evaluation ground	Evaluation lower rope edge	Rope over the ground
No	m	m	m	m
<i>DO</i>	27.00	1668.75	1673.20	4.45
<i>DC</i>	30.00	1668.84	1673.20	4.36
1	133.91	1688.27	1695.15	6.88
2	193.38	1699.55	1705.0699	5.51
3	252.54	1716.1899	1721.99	5.8
4	333.01	1737.00	1742.04	5.04
5	422.57	1780.51	1788.21	7.70
6	592.99	1838.00	1843.83	5.83
7	540.03	1840.86	1847.29	6.43
8	558.18	1844.46	1850.58	6.12
<i>GC</i>	603.05	1846.02	1852.64	6.62
<i>GO</i>	605.05	1846.20	1852.64	6.44

- The computer modelling gives the opportunity of a very fast designing and optimization of both the ground and lift profiles.
- The computer modelling gives the opportunity of a very fast calculation and optimization of the lift parameters.
- There is a very good agreement between the theoretical, computer calculated and experimental-test results.

The verification of the results achieved by the computer modelling of the lift transportation systems gives us the opportunity any further investigations in this field to be performed with confidence.

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Appendix

Computer program written in MATLAB

```
{\%} This is a program for drawing a profile for a lift called drag{\_}drop77
{\%} B - horizontal distance
{\%} A - distance above sea level
{\%} D - horizontal distance of the tower positions
{\%} C - distance above sea level of the tower positions
{\%} E - distance above sea level of the rope
function drag{\_}drop
dragging = [ ];
orPos = [ ];
new{\_}point = [ ];
index1 = [ ];
B=[-15 0 46 129 169 231.56 276 291]{\%}co-ordinate x-profile
A=[156.5 156.5 160.233 178.167 183.7667 196.83 210.7676 212.2]{\%}coordinate
y-profile
D=[-15 0 129 276 291];{\%}co-ordinate x-tower position
C=[156.5 156.5 178.167 210.7676 212.2]{\%}co-ordinate y-tower position
E=[160.1 160.1 185.7667 215.8 215.8]{\%}co-ordinate lower edge of the rope
x1=[-15 -15 ]
y1=[156.5 160.1 ]
x2=[ 0 0]
y2=[ 156.5 160.1]
x3=[129 129]
y3=[ 178.167 185.7667]
x4=[276 276]
y4=[ 210.7676 215.8]
x5=[291 291]
y5=[212.2 215.8]
f = figure('WindowButtonUpFcn',@dropObject,'units','normalized',
'WindowButtonDownFcn',@moveObject);
g = plot(B,A,D,E,'--',D,C,'o',x1,y1,x2,y2,x3,y3,x4,y4,x5,y5',
'ButtonDownFcn',@dragObject);
xlabel('Horizontal distance [m]')
ylabel('Vertical distance above sea level [m]')
grid on
{\%}f = figure('WindowButtonUpFcn',@dropObject,'units','normalized',
'WindowButtonDownFcn',@moveObject);
```

```

{\%}a = annotation('textbox','position',[0.2 0.2 0.2
0.2],'String','Hello','ButtonDownFcn',@dragObject);
ax = gca;
{\%} get the figure handle
fig = get(ax,'Parent');
{\%} get all of the lines' handles
lines = findobj(ax,'type','line');
{\%} if there aren't any lines, display message and return
if isempty(lines)
disp('No lines found in the axes.')
return
end

```

Computer program written in Compaq Visual Fortran – version 6.6

C MAIN PROGRAM

```

DIMENSION A(40), B(40), C(40)
DIMENSION B1(40),B2(40),QQ(40),QG(40),STR(40),P(4000)
CHARACTER*70 AA(5)
Q=1.070 ! linear load of the transportation rope (daN/m)
WG=30.000 ! weight of an empty draw-bar (daN)
W=32.960 ! distance between the draw-bars (m)
A0=250.000 ! maximal admissible loading over a roller from a supporting battery
(daN)
A1=240.000 ! maximal admissible loading over a roller from a pushing up battery
(daN)
DB=0.0175 ! windward diameter of the transportation rope (daN)
FTEG=0.170 ! windward area of an empty draw-bar (m2)
VETR=36.000 ! velocity pressure of the wind in a working condition (daN/m2)
VET=144.000 ! velocity wind pressure for not working condition (daN/m2)
S2=2034.000 ! tow force for the rope pulling definition for loaded area (daN)
S3=2776.000 ! tow force for the rope pulling definition for unloaded area (daN)
S4=3516.000 ! tow force for the rope definition for the sloping down area at
starting (daN)
S5=2774.0 ! tow force for the rope definition for the sloping down area at
stopping (daN)
RQ=57.000 ! friction force for loaded area (daN)

RW=48.000 ! friction force for unloaded area (daN)
DQP=174.000 ! dynamic force at starting for loaded area (daN)
DQS=174.000 ! dynamic force at stopping for loaded area (daN)
DWP=49.000 ! dynamic force at stopping of unloaded area (daN)
DWS=49.000 ! dynamic force at stopping of unloaded area (daN)

QW=1.981 ! evenly distributed load for unloaded area (daN/m)
ALFD=0.080 ! -- admissible angle of folding over a single roller (RAD)

c Number of posts N                A(3)=133.91
N=12                                A(4)=193.38
c Horizontal distance from the starting point
A(5)=252.54
A(6)=333.01
A(1)=27.                            A(7)=422.57
A(2)=30.                            A(8)=529.99

```

A(9)=540.03
 A(10)=558.18
 A(11)=603.05
 A(12)=605.05
c Evaluation foundation
 B(1)=1668.75
 B(2)=1668.84
 B(3)=1688.27
 B(4)=1699.55
 B(5)=1716.19
 B(6)=1737.00
 B(7)=1780.51
 B(8)=1838.00
 B(9)=1840.86
 B(10)=1844.46
 B(11)=1846.02
 B(12)=1846.20
c Evaluation lower rope edge
 C(1)=1673.200
 C(2)=1673.200
 C(3)=1695.15
 C(4)=1705.07
 C(5)=1721.99
 C(6)=1742.04
 C(7)=1788.21
 C(8)=1843.83
 C(9)=1847.29
 C(10)=1850.58
 C(11)=1852.64
 C(12)=1852.64
c Distributed load along the rope axis for loaded area
 B1(1)=0.
 B1(2)=1.601
 B1(3)=1.361
 B1(4)=1.974
 B1(5)=1.77
 B1(6)=2.915
 B1(7)=2.976
 B1(8)=2.263
 B1(9)=1.455
 B1(10)=0.722
 B1(11)=0.
 B1(12)=0.
c Distributed load along the rope axis for unloaded area
 B2(1)=0.
 B2(2)=0.188
 B2(3)=0.15
 B2(4)=0.25
 B2(5)=0.22
 B2(6)=0.417
 B2(7)=0.419
 B2(8)=0.297
 B2(9)=0.163
 B2(10)=0.042
 B2(11)=0.
 B2(12)=0.
c Evenly distributed load for loaded area
 QQ(1)=1.981
 QQ(2)=2.656
 QQ(3)=2.656
 QQ(4)=2.802
 QQ(5)=2.874
 QQ(6)=3.752
 QQ(7)=3.181
 QQ(8)=2.775
 QQ(9)=2.506
 QQ(10)=2.258
 QQ(11)=1.981
 QQ(12)=0.
c Vertical loading from a skier and a draw-bar
 QG(1)=30.
 QG(2)=52.284
 QG(3)=52.273
 QG(4)=57.081
 QG(5)=62.747
 QG(6)=88.409
 QG(7)=69.575
 QG(8)=56.212
 QG(9)=47.333
 QG(10)=39.152
 QG(11)=30.
 QG(12)=0.
c Laterally loading by the skier
 STR(1)=0.
 STR(2)=20.
 STR(3)=40.
 STR(4)=40.
 STR(5)=40.
 STR(6)=40.
 STR(7)=40.
 STR(8)=40.
 STR(9)=40.
 STR(10)=40.
 STR(11)=20.
 STR(12)=0.

```

do 10 i=1,N
10 continue
c Evoking the subroutine DON
CALL DON(Q,S5,RQ,RW,DQP,DQS,DWP,DWS,S2,S3,WG,W,QW,ALFD,AO,
*A1,DB,FTEG,VETR,VET,S4,N,A,B,C,B1,B2,QQ,QG,STR,P)
STOP END

```

Table 10

6	37	38	39	40	41	42
Distance between posts	folding	Slope of pulling full load full	Tang (FI) LEFT	Tang (FI) RIGHT	FI LEFT	FI RIGHT
Number	+ -				RAD	RAD
DO - DC		0.0015	-0.0015	0.0015	-0.0015	0.0015
DC - 1		0.067	0.1443	0.2782	0.1433	0.2714
1 - 2		0.0349	0.1319	0.2017	0.1312	0.1990
2 - 3		0.0364	0.2496	0.3224	0.2446	0.3119
3 - 4		0.0480	0.2011	0.2972	0.1985	0.2889
4 - 5		0.0724	0.4431	0.5879	0.4171	0.5315
5 - 6		0.0645	0.4533	0.5823	0.4256	0.5273
6 - 7		0.0043	0.3403	0.3489	0.3280	0.3357
7 - 8		0.0064	0.1748	0.1877	0.1731	0.1856
8 - GC		0.0138	0.0321	0.0597	0.0321	0.0596
GC - DO		0.0005	-0.0005	0.0005	-0.0005	0.0005

Table 11

1	43	44	45	46
POST	ALFA	$2*\sin(ALFA/2)$	D	PSI
Number	RAD		Kg	RAD
DO	0.0000	0.0000	0.0000	0.0000
DC	-0.1418	-0.1417	-288.3532	0.0724
1	0.1402	0.1401	317.8352	0.2013
2	-0.0456	-0.0456	-108.7406	0.2218
3	0.1134	0.1133	288.5600	0.2552
4	-0.1282	-0.1282	-351.9984	0.3530
5	0.1059	0.1058	331.0529	0.4785
6	0.1993	0.1989	714.7200	0.4276
7	0.1627	0.1625	588.9737	0.2544
8	0.1534	0.1533	561.2581	0.1088
GC	0.0601	0.0601	223.3023	0.0295
GO	0.0000	0.0000	0.0000	0.0000