PISTE BOB, PARABOB, SKELETON, SLITTINO: ASPETTI COSTRUTTIVI, OTTOBRE 2022

prof. LAMBERTO BRISEGHELLA
ex UNIPD E IUAV
lamberto.briseghella@gmail.com

BOB

SKELETON

LUGE

MATT WESTON, YANQING

The Jamaican bobsled team New Sled

FEDERAZIONE IBSF

office@ibsf.org

X BOB E SKELETON

- INTERNATIONAL BOBSLEIGH RULES 2021
- INTERNATIONAL SKELETON RULES 2021
- INTERNATIONAL WOMEN MONOBOB RULES 2021
- TRACK RULES

FEDERAZIONE FIL

office@fil-luge.org

X LUGE

- INTERNATIONAL LUGE REGULATION FOR ARTIFICIAL TRACK, 2020

OUTLOOK

1. TRACKS

2. COSTRUZIONE

3. SHOTCRETE

4. FIBRE NATURALI

5. GELO-DISGELO

6. REFRIGERANTI NATURALI (AMMONIACA, ACQUA)

7. LUGE DYNAMICS

17 PISTE OLIMPICHE + CORTINA

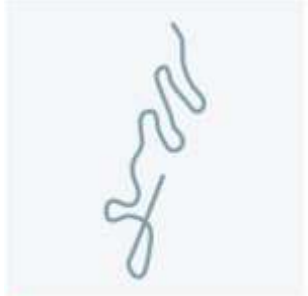
LE 17 PISTE OLIMPICHE IBSF

Altenberg
GERMANY

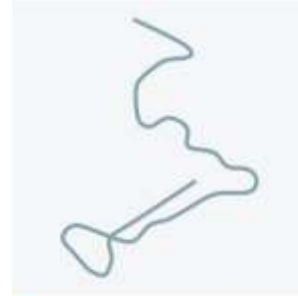
Calgary
CANADA

Innsbruck
AUSTRIA

Königssee
GERMANY



La Plagne
FRANCE



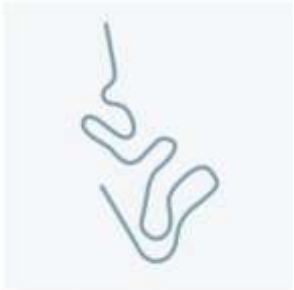
Lake Placid
UNITED STATES

Lillehammer
NORWAY

Nagano
JAPAN

Oberhof
GERMANY

Park City
UNITED STATES



Pyeongchang
SOUTH KOREA

Sigulda
LATVIA

Sochi
RUSSIA

St. Moritz
SWITZERLAND

Whistler
CANADA

Winterberg
GERMANY

Yanqing
CHINA

CORTINA

WHISTLER VANCOUVER 2010

WHISTLER SLIDING CENTER CANADA 2010

Country:	Canada
Track name:	Whistler Sliding Centre
GMT:	-8
WCH's years:	2019 WCH
OWG's years:	2010 OWG
Total length:	1700 m
Competition length:	1450.4 m
Start altitude:	935 m
Finish altitude:	802 m
Maximum gradient:	20.00 %
Average gradient:	9.00 %
Vertical drop:	148.00 m
Number of curves:	16

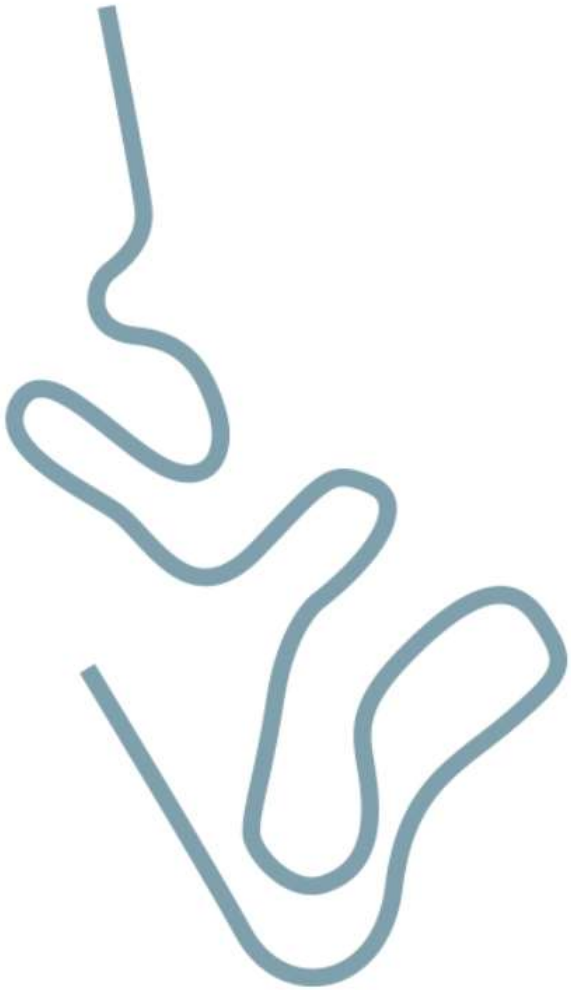
SOCHI RUSSIA 2014

SANKI SLIDING CENTER RUSSIA 2014

Country:	Russia
Track name:	Sanki Sliding Center
GMT:	+3
WCH's years:	2017 WCH
OWG's years:	2014 OWG
Total length:	1814 m
Competition length:	1500 m
Start altitude:	836 m
Finish altitude:	704 m
Maximum gradient:	22.00 %
Average gradient:	20.00 %
Vertical drop:	124.00 m
Number of curves:	17

PYEONGCHANG KOREA 2018

ALPENSIA SLIDING CENTER KOREA 2018



Country:	South Korea
Track name:	Alpensia Sliding Centre
GMT:	+9
OWG's years:	2018 OWG
Total length:	1659 m
Competition length:	1376 m
Start altitude:	930 m
Finish altitude:	850 m
Maximum gradient:	25.00 %
Average gradient:	9.48 %
Vertical drop:	117.00 m
Number of curves:	16

YANQING CHINA 2022

CHINA YANQING 2022 BASELINE WITH 360 DEGREES TURN

Country:	China
Track name:	Yanqing National Sliding Center
GMT:	+8
WCH's years:	-
OWG's years:	Olympic Winter Games Beijing 2022 to come
Total length:	1975m
Competition length:	1615m
Start altitude:	1019 m
Finish altitude:	912 m
Maximum gradient:	18.00 %
Average gradient:	6.00 %
Vertical drop:	121.00 m
Number of curves:	16

RMAX 30M

RETTILINEO, CLOTOIDE, CERCHIO, CLOTOIDE, RETTILINEO


YANQING
NATIONAL SLIDING
CENTER 2022G

YANQING SLIDING CENTER AND VILLAGE

NATHAN CRAMPTON

LADIES START YANQING

YANQING 2022 GEOTECNICA, SHOTBETON

YANQING NATIONAL SLIDING CENTER, LI XINGGANG ARCH., L. 1975 M


WWW.NEWS.CN

YANQING SEMPRE INNEVAMENTO ARTIFICIALE

IOC

YANQING BOBSLEIGH 4 MEN

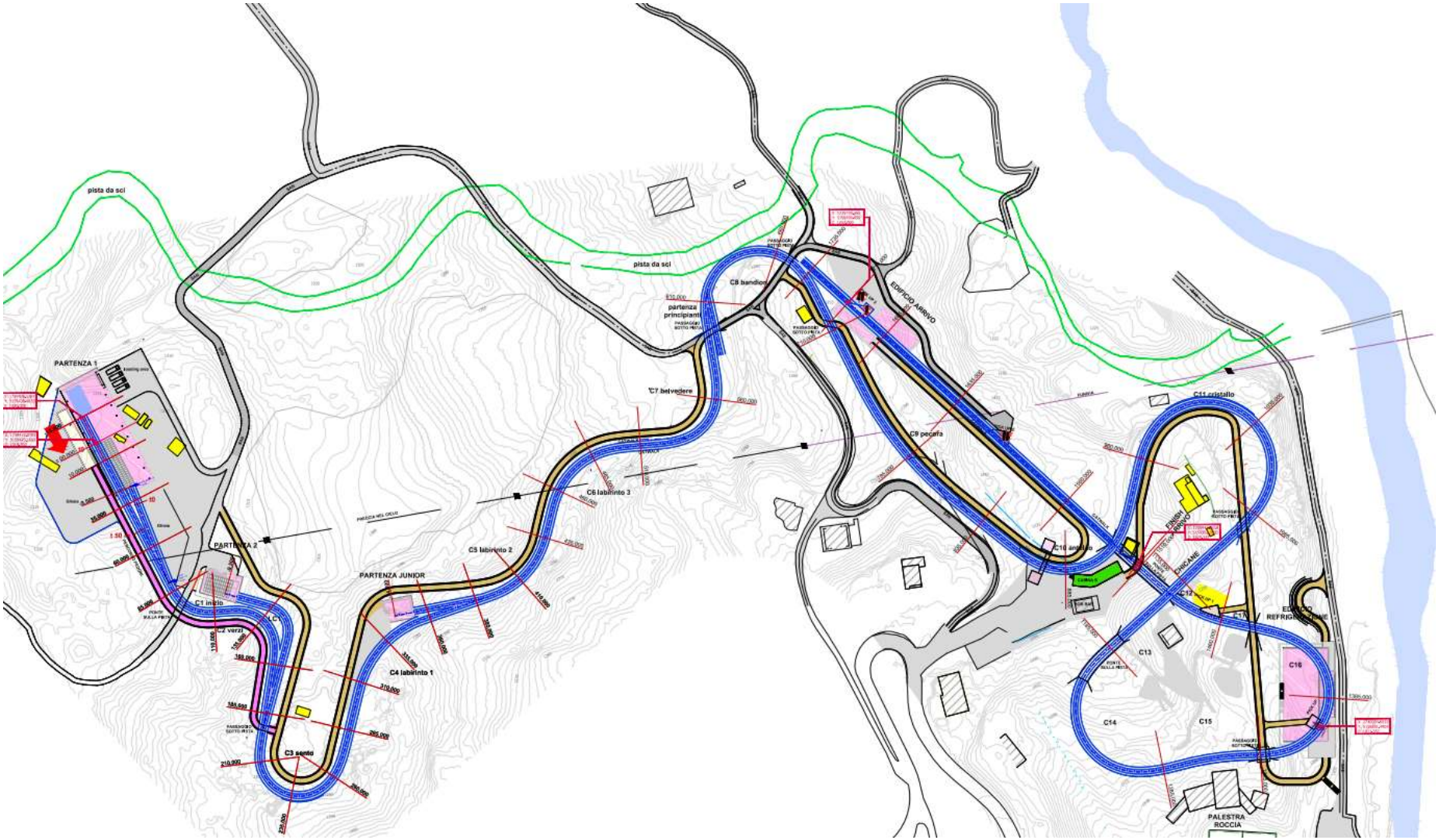
THE BIRD'S NEST NATIONAL STADIUM CHINA
HERZOG & DE MEURON LI XINGGANG

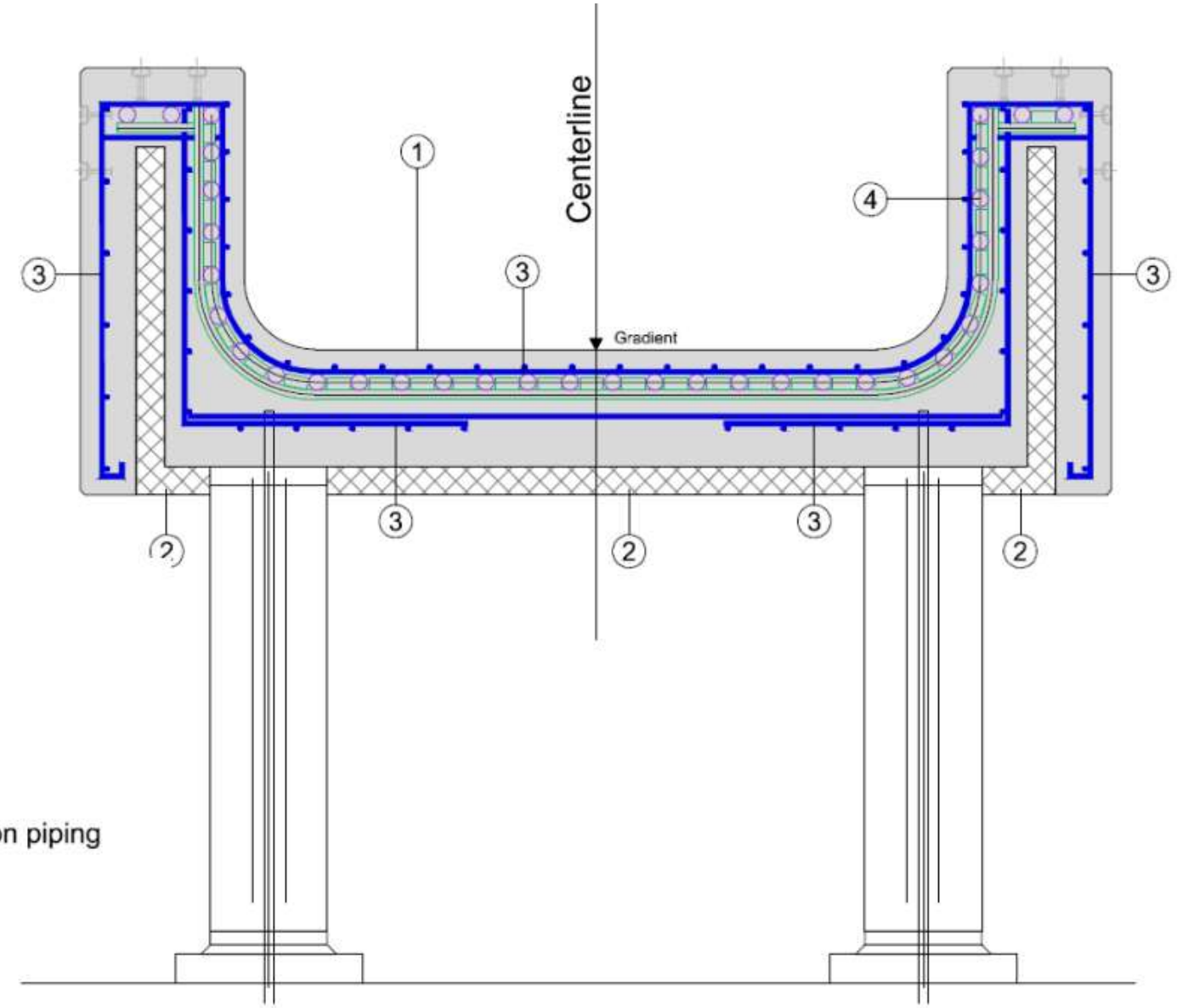
There are 17 banked turns on the Sanki Sliding Center.
The target ice thickness is 2 cm to 4 cm (0.8 in. to 1.5 in.).

BOB A QUATTRO

EUGENIO MONTI E RENZO ALVERA’ 1956

CORTINA 2026 VERS. 2





Legend:

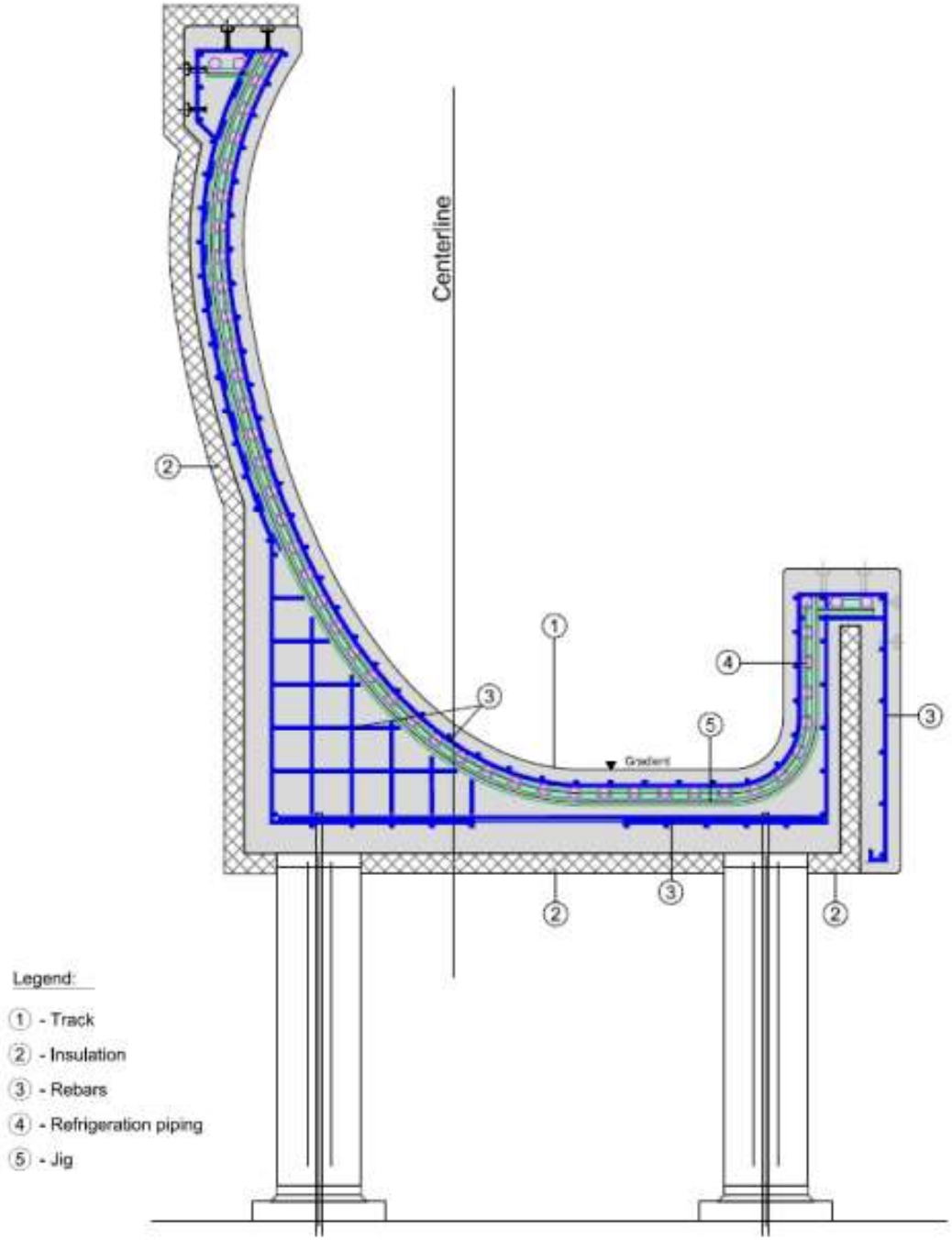
1 - Track

2 - Insulation

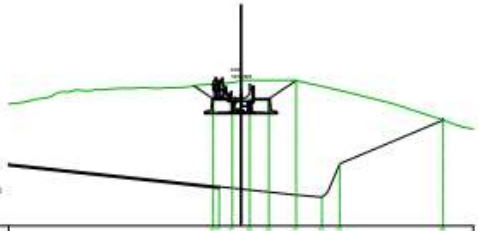
3 - Rebars

4 - Refrigeration piping

5 - Jig


Centerline
Gradient
1
2
3
4
5
Legend:
1 - Track
2 - Insulation
3 - Rebars
4 - Refrigeration piping
5 - Jig

Sezione 37
Prog. = 1+335.000
Q. Rif. = 1302.000



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Dist. Progr. Progetto	
Dist. Parziali	

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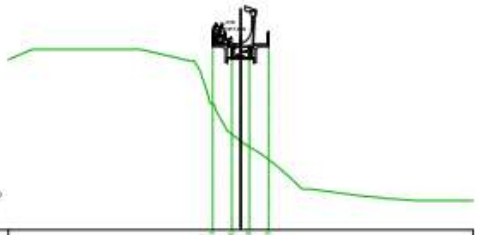
Q. Rif. = 1186.000



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Quote Progetto	
Dist. Progr. Progetto	
Dist. Parziali	

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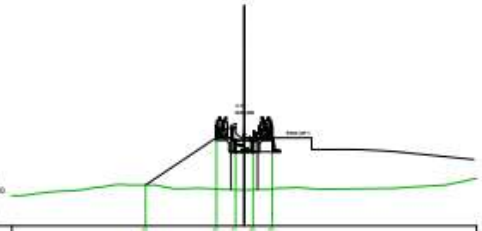
Q. Rif. = 1213.000



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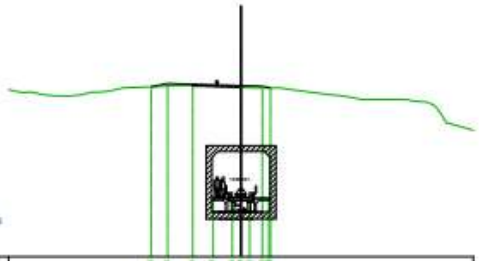
Quote Progetto	
Dist. Progr. Progetto	
Dist. Parziali	

Sezione 40
Prog. = 1+510.000
Q. Rif. = 1233.000



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Dist. Parziali	

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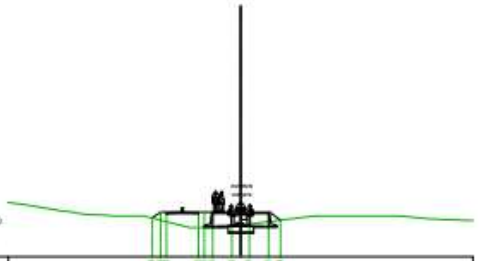
Q. Rif. = 1255.000



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Dist. Progr. Progetto	
Dist. Parziali	

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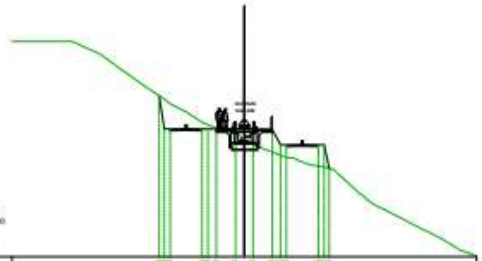
Q. Rif. = 1228.000



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Quote Progetto	
Dist. Progr. Progetto	
Dist. Parziali	

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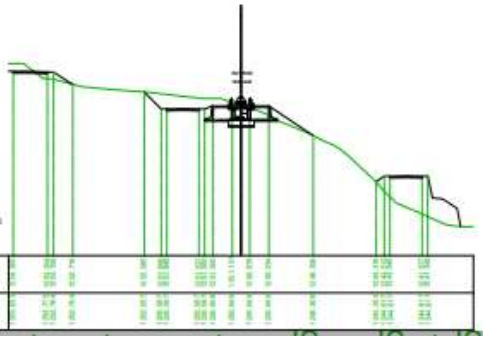
Q. Rif. = 1208.000



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Quote Progetto	

Sezione 44
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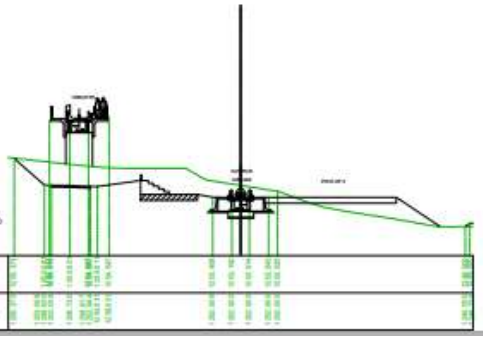
Q. Rif. = 1207.000



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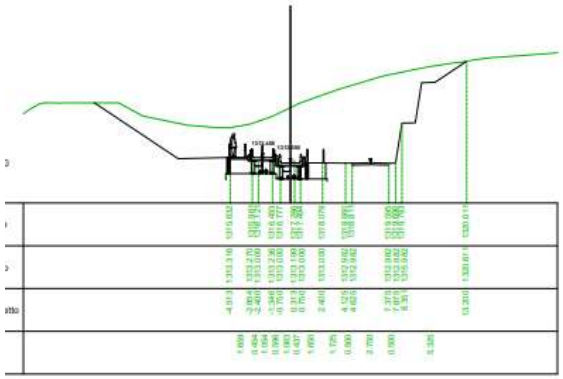
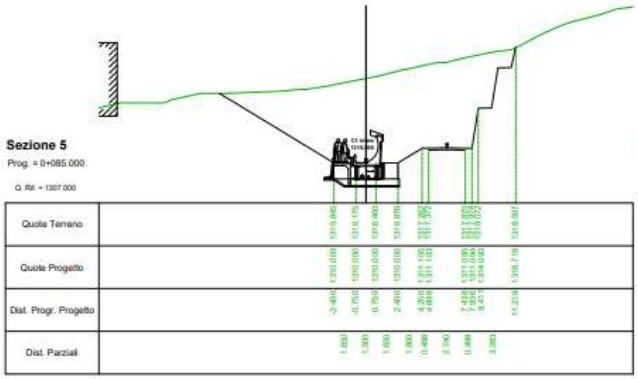
Quote Progetto	





Sezione 5

Prog. = 0+085.000

Q. Rif. = 1307.000

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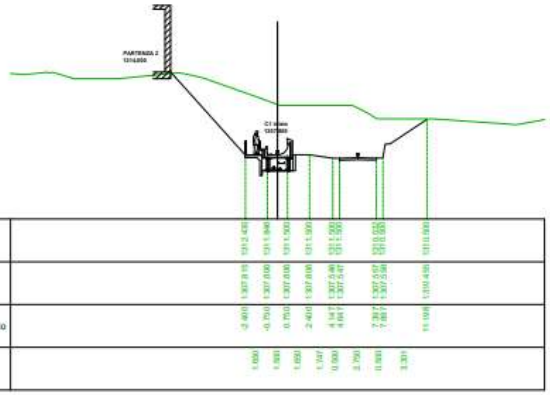
Dist. Progr. Progetto	
Dist. Parziali	



Sezione 6

Prog. = 0+110.000

Q. Rif. = 1303.000

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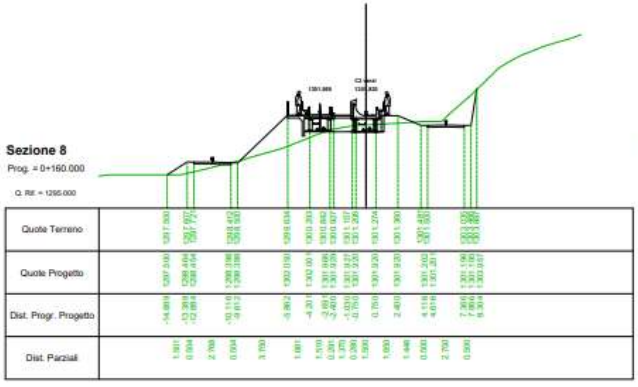
Quote Progetto	
Dist. Progr. Progetto	
Dist. Parziali	



Sezione 8

Prog. = 0+160.000

Q. Rif. = 1295.000

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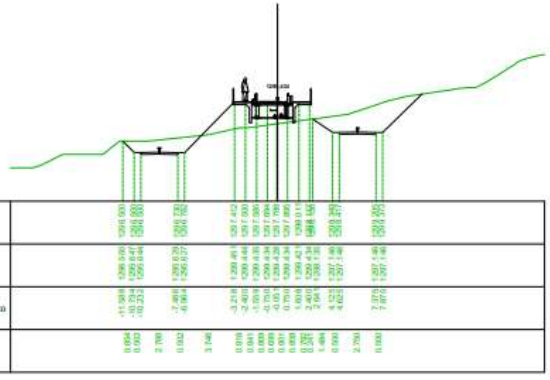
Quote Progetto	
Dist. Progr. Progetto	
Dist. Parziali	



Sezione 9

Prog. = 0+185.000

Q. Rif. = 1292.000

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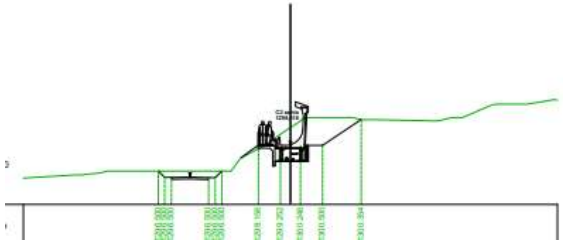
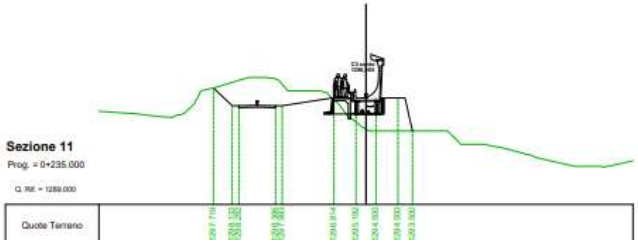
Dist. Parziali	





Sezione 11

Prog. = 0+235.000

Q. Rif. = 1289.000

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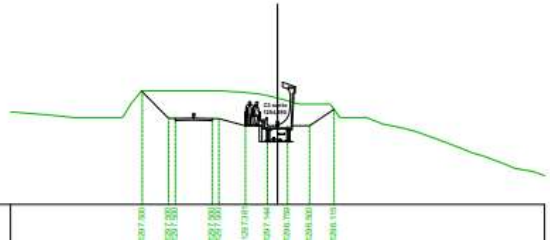


Sezione 12

Prog. = 0+260.000

Q. Rif. = 1289.000

Quote Terreno

YANQING CENTER

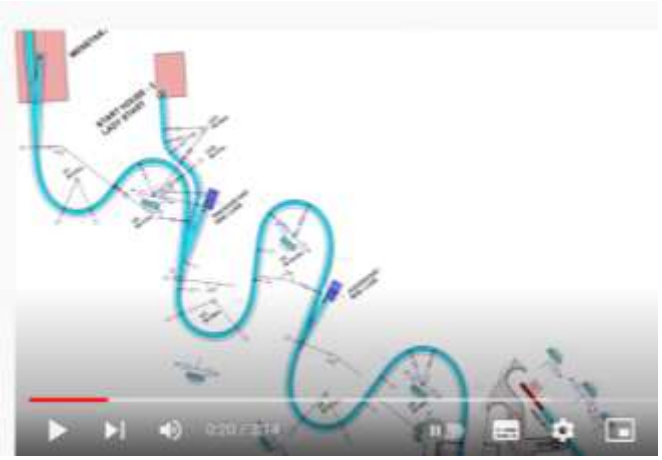
NATIONAL

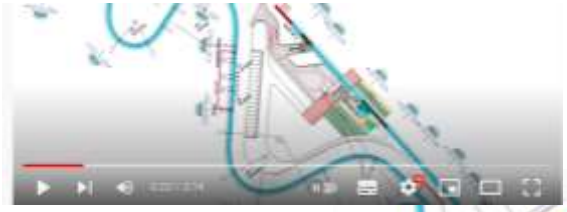
SNOWMOBILE

ICE MAKERS

16 INTERNATIONAL

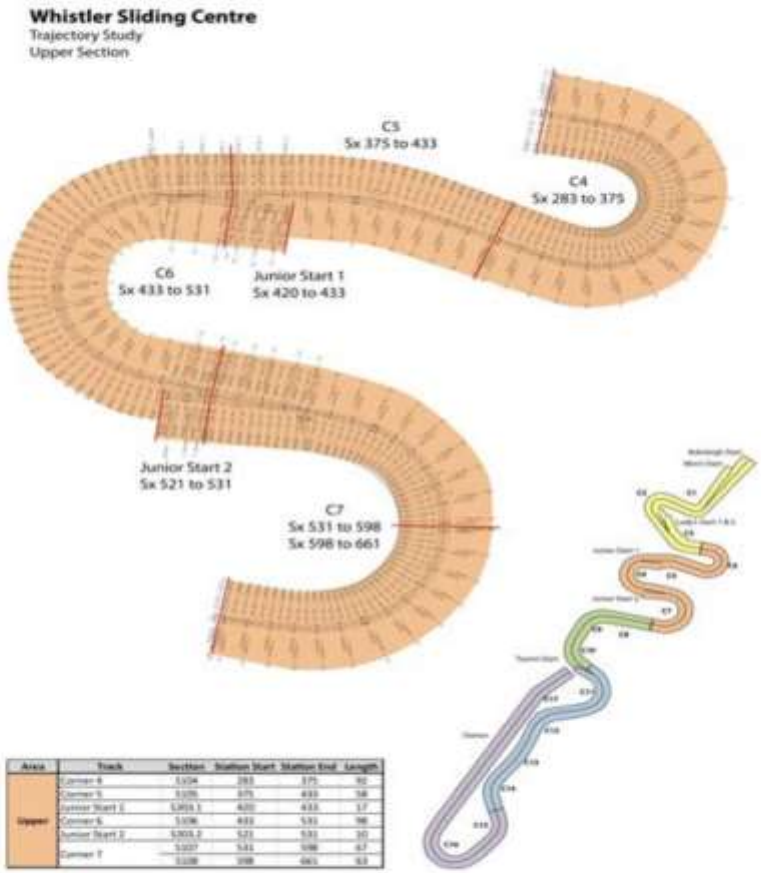
20 CHINESE





COSTRUZIONE
RETTILINEO
CLOTOIDE
CERCHIO
CLOTOIDE
RETTILINEO

WHISTLER SLIDING CENTER CONSTRUCTION DETAILS



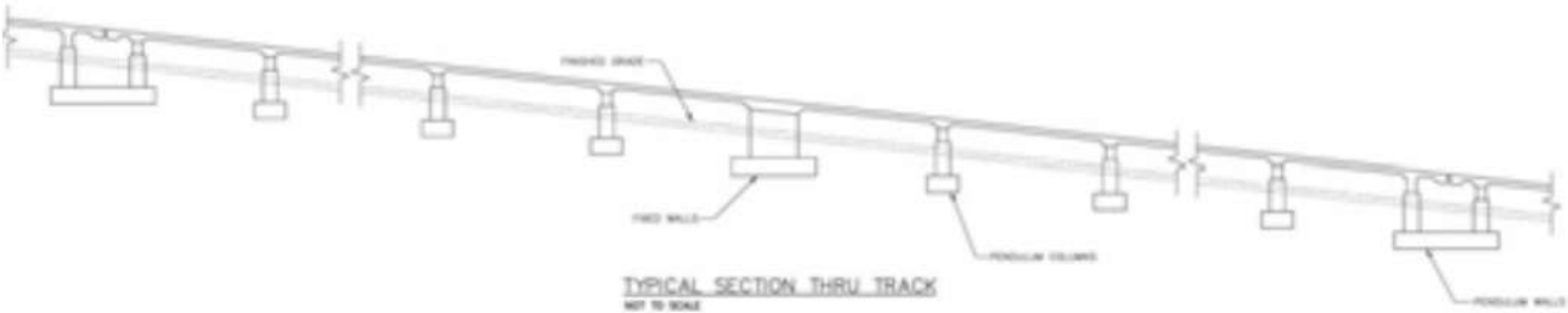


Figure 4.4 Typical section through the track (from Stantec Architecture Ltd. Drawing A0-17.031-26).

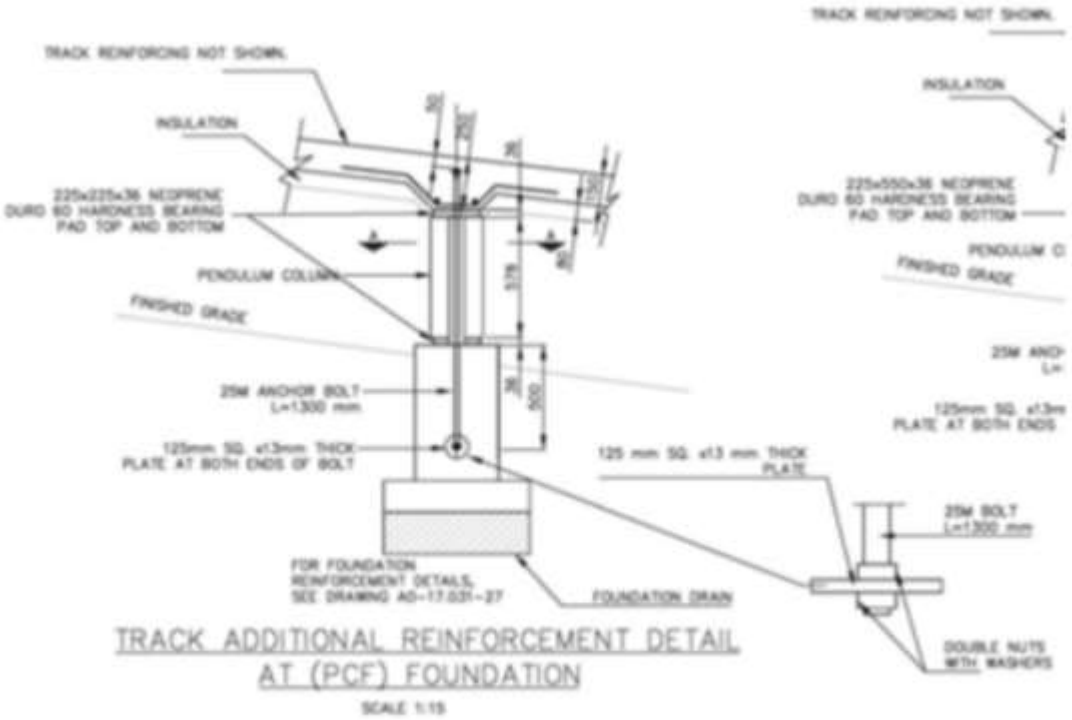
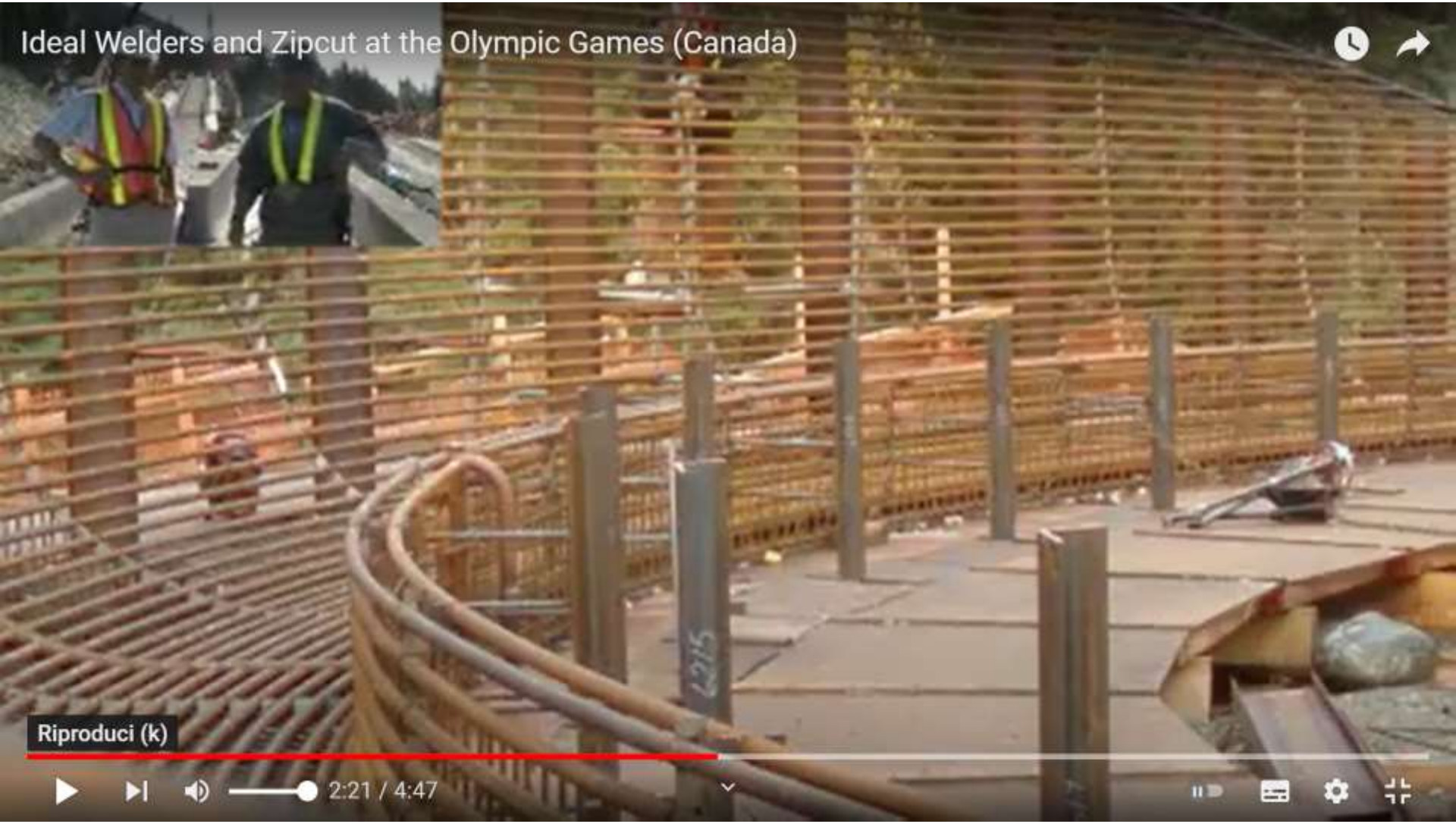


Figure 4.5 Pendulum column foundation (from Stantec Architecture Ltd. Drawing A0-17.031-26).


IDEAL WELDERS


Ideal Welders and Zipcut at the Olympic Games (Canada)
Riproduci (k)
2:21 / 4:47


2:29 / 4:47

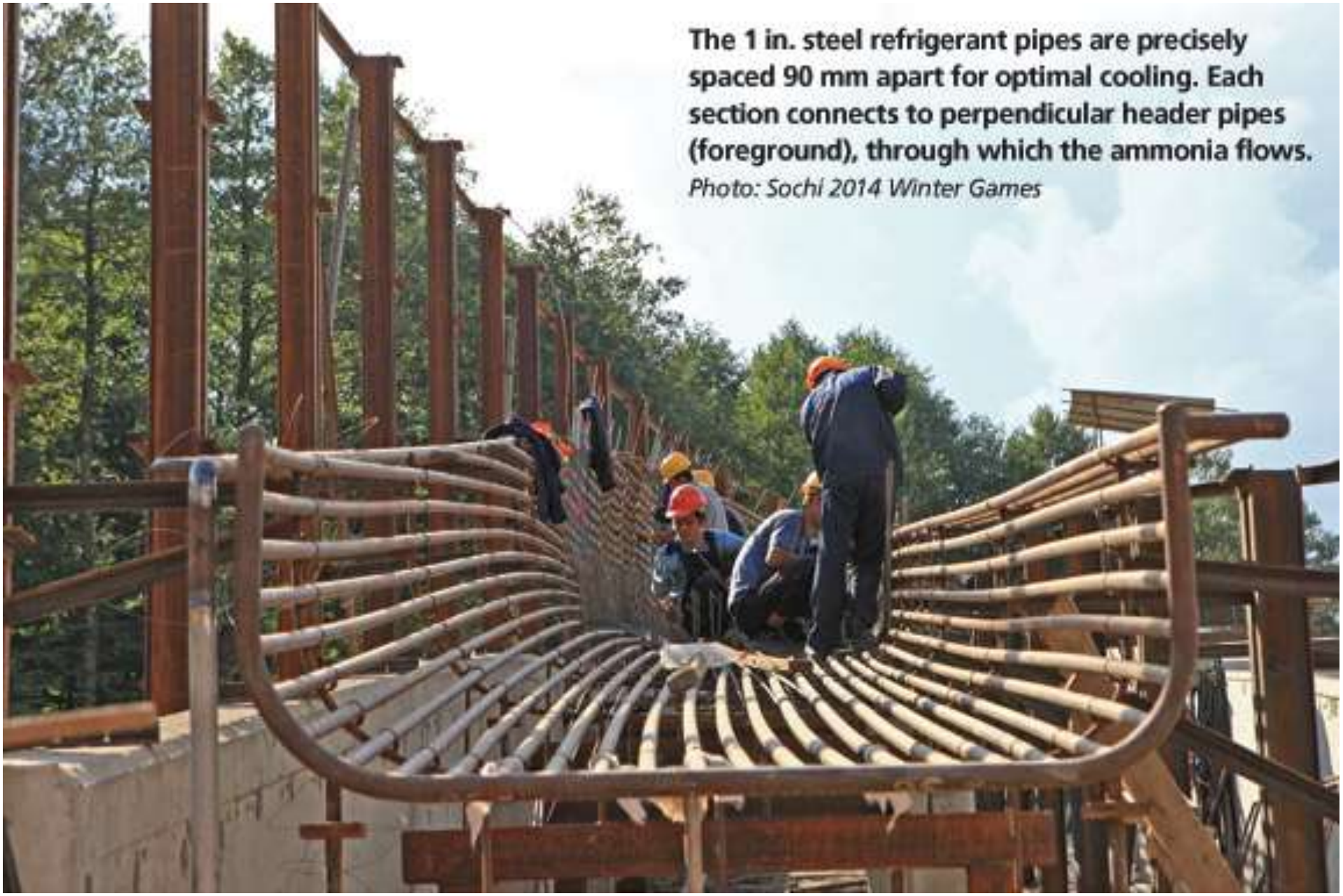

14

Left: After the shotcrete is applied, covering the refrigerant pipes, the track ends up being about 1 ft. thick.

Right: A latticework of 10 mm rebar fortifies the track and is installed diagonally to follow the track's curves. *Photo: ISC/IBG Group*

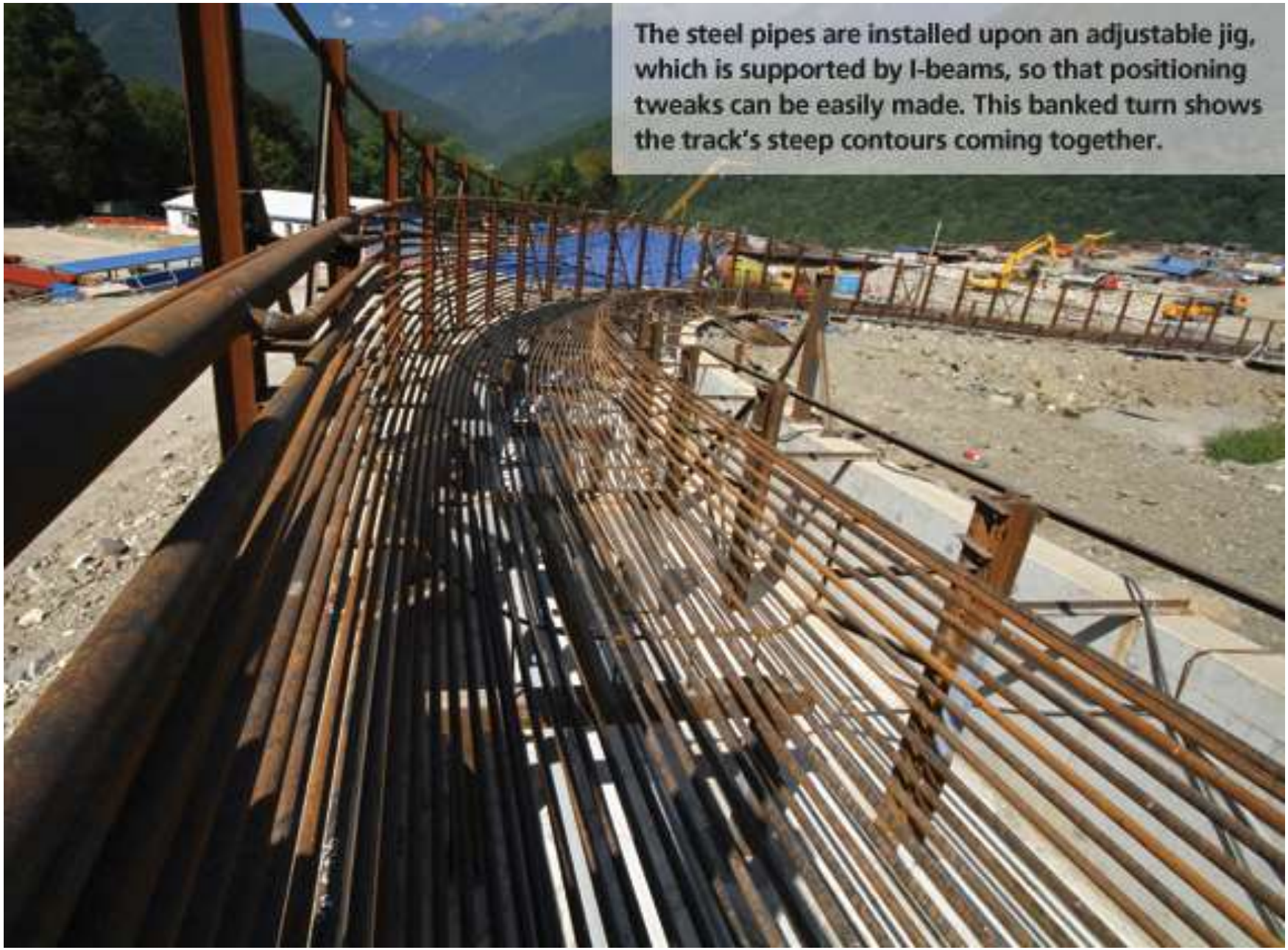
The steel pipes are installed upon an adjustable jig, which is supported by I-beams, so that positioning tweaks can be easily made. This banked turn shows the track's steep contours coming together.

At first glance, the Sanki Sliding Center resembles not much more than a giant concrete Hot Wheels track built into the side of a mountain, adorned with architectural metal and wood flourishes. The track has 17 banked turns, and is the only one in the world to have three negative slopes, where the athletes are sliding uphill. Also known as counter slopes, those sections have no turns, thus reducing speeds and increasing athlete safety. It takes 60 to 70 seconds to travel the entire track. At 1,814 m, it's the longest track of its kind in the world.

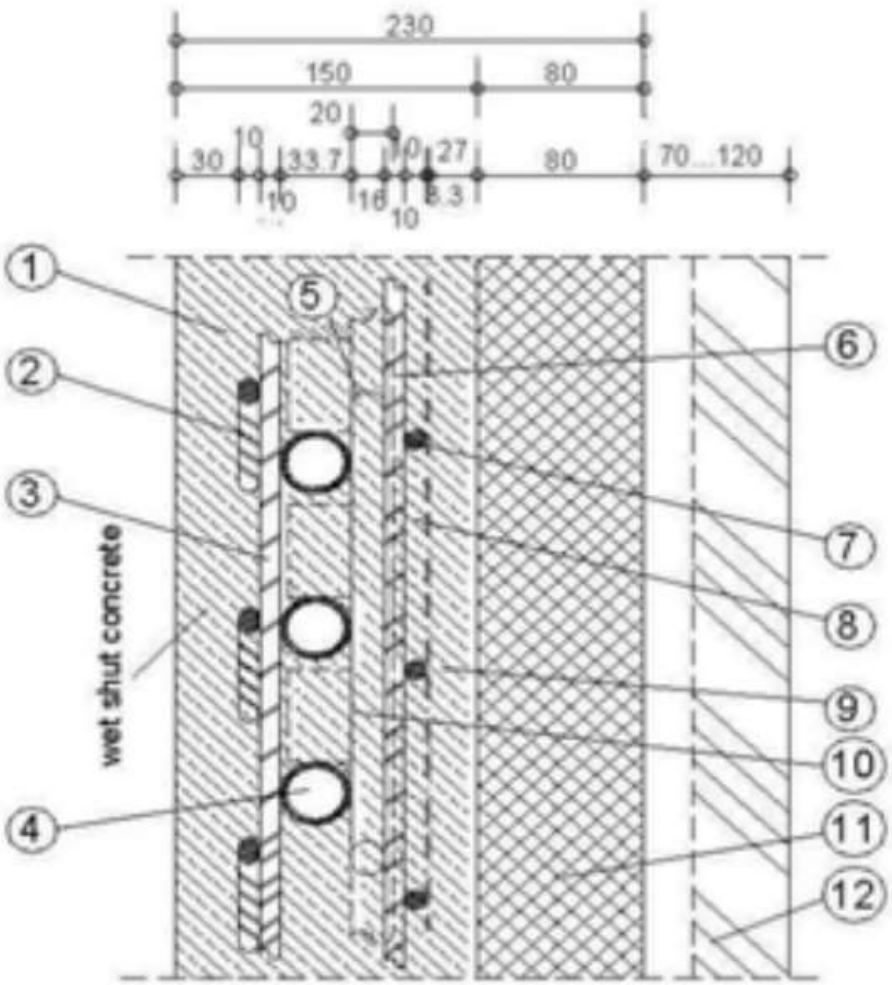


The 1 in. steel refrigerant pipes are precisely spaced 90 mm apart for optimal cooling. Each section connects to perpendicular header pipes (foreground), through which the ammonia flows.

Photo: Sochi 2014 Winter Games



The steel pipes are installed upon an adjustable jig, which is supported by I-beams, so that positioning tweaks can be easily made. This banked turn shows the track's steep contours coming together.



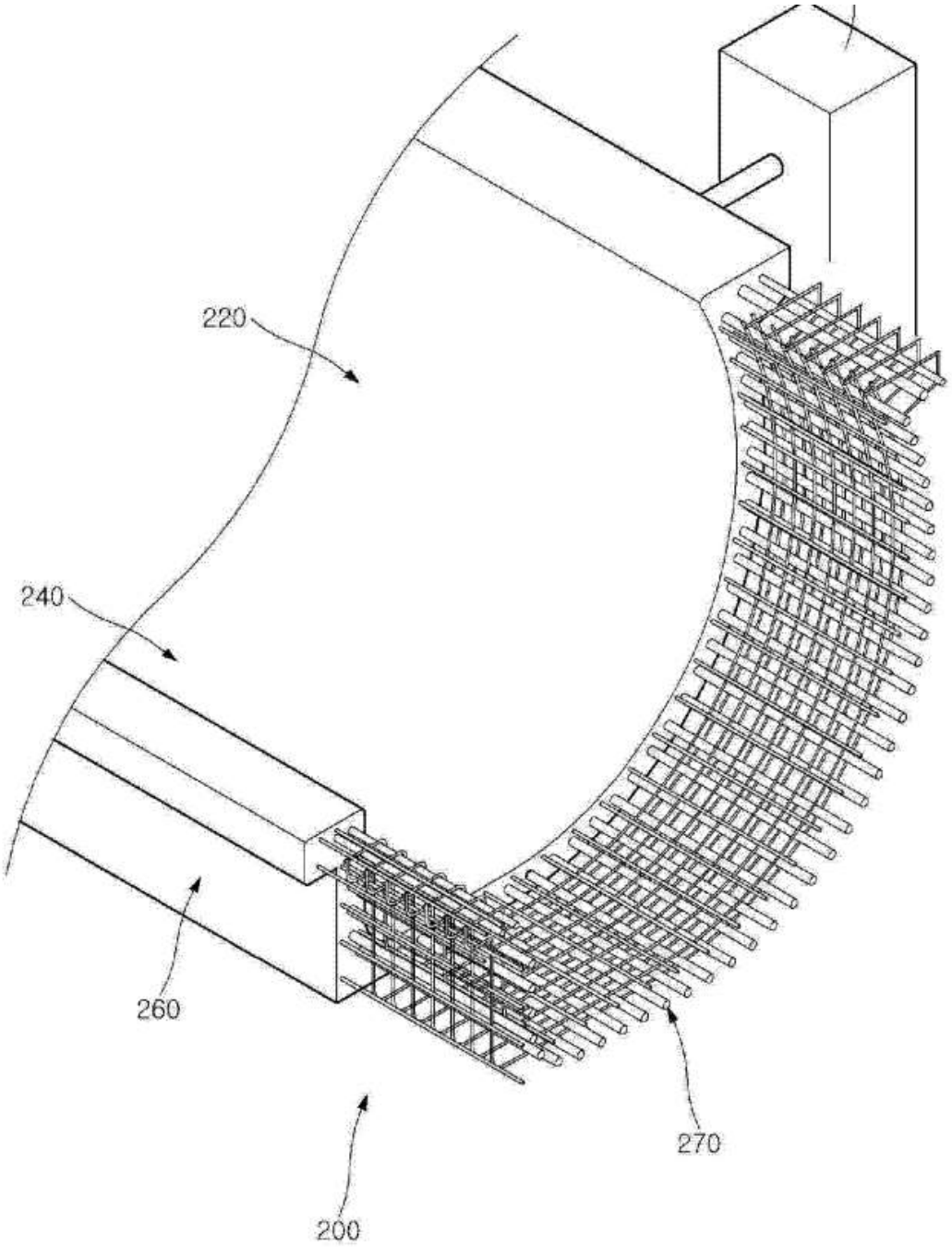
The wall thickness is established from the following parameters :

*1 - 30 mm concrete cover
2 - ϕ 10 mm, reinforcement steel; diagonal distributed
3 - ϕ 10 mm, reinforcement steel; diagonal distributed
4 - ϕ 33,7 mm icing steel pipe
5 - (*) 16 or 20 mm distance, respectively
6 - ϕ 10 mm, reinforcement steel; vertical distributed
7 - ϕ 10 mm, reinforcement steel; horizontal distributed
8 - woven mesh (ϕ 0.8 mm wire, width 4 ..6 mm)
*9 - 27 or 23 mm concrete cover, respectively
10- jig, 20 mm round steel with spacers
11 - 80 mm insulation
12 - wall covering

Figure 4.9 Wall section showing refrigeration pipes and insulation [from IBG (2004), p. 17]


a
a
a
a
alamy

WHISTLER (CANADA) 2010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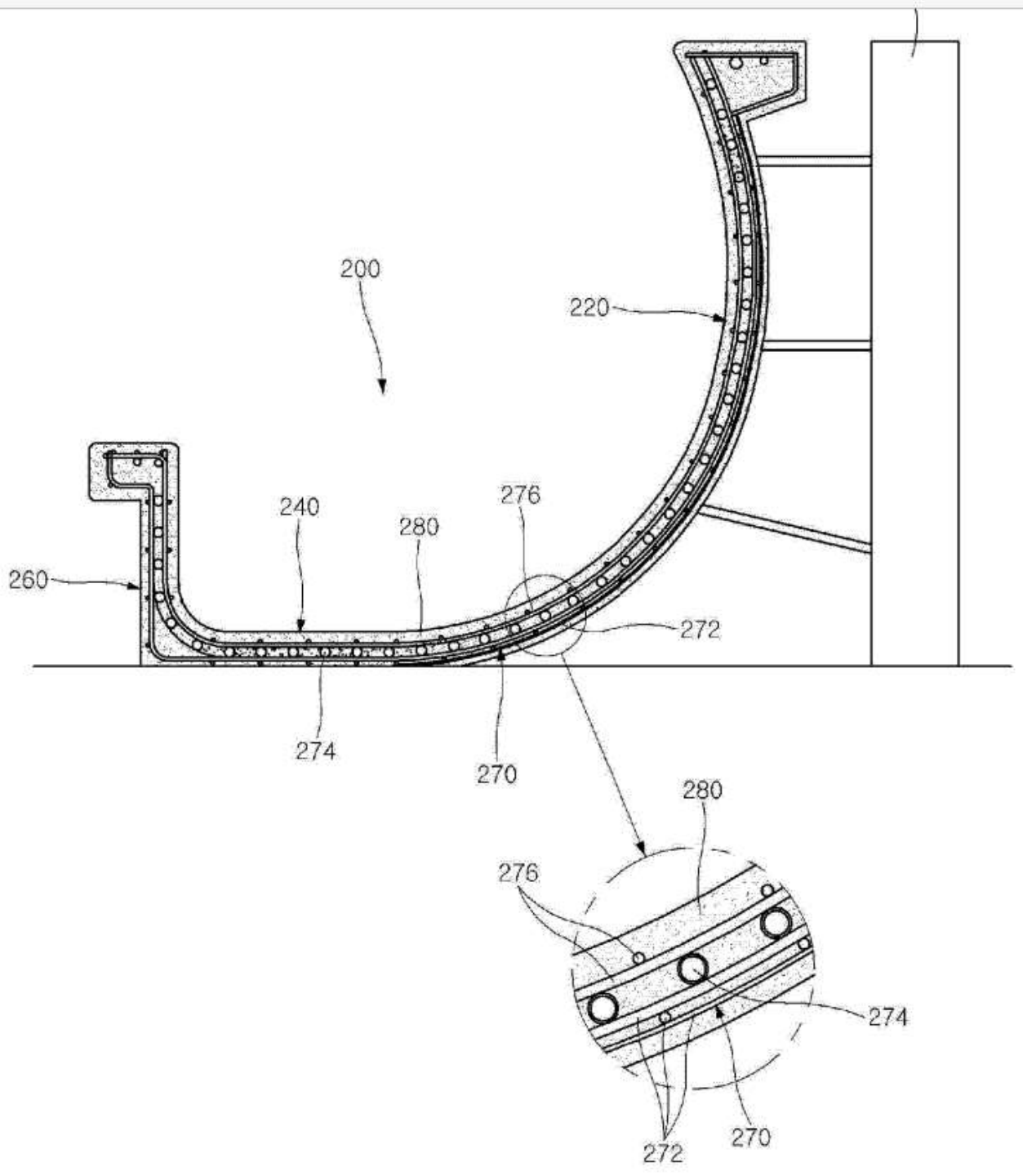
240
260
270
200


200
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240
280
276
260
272
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276
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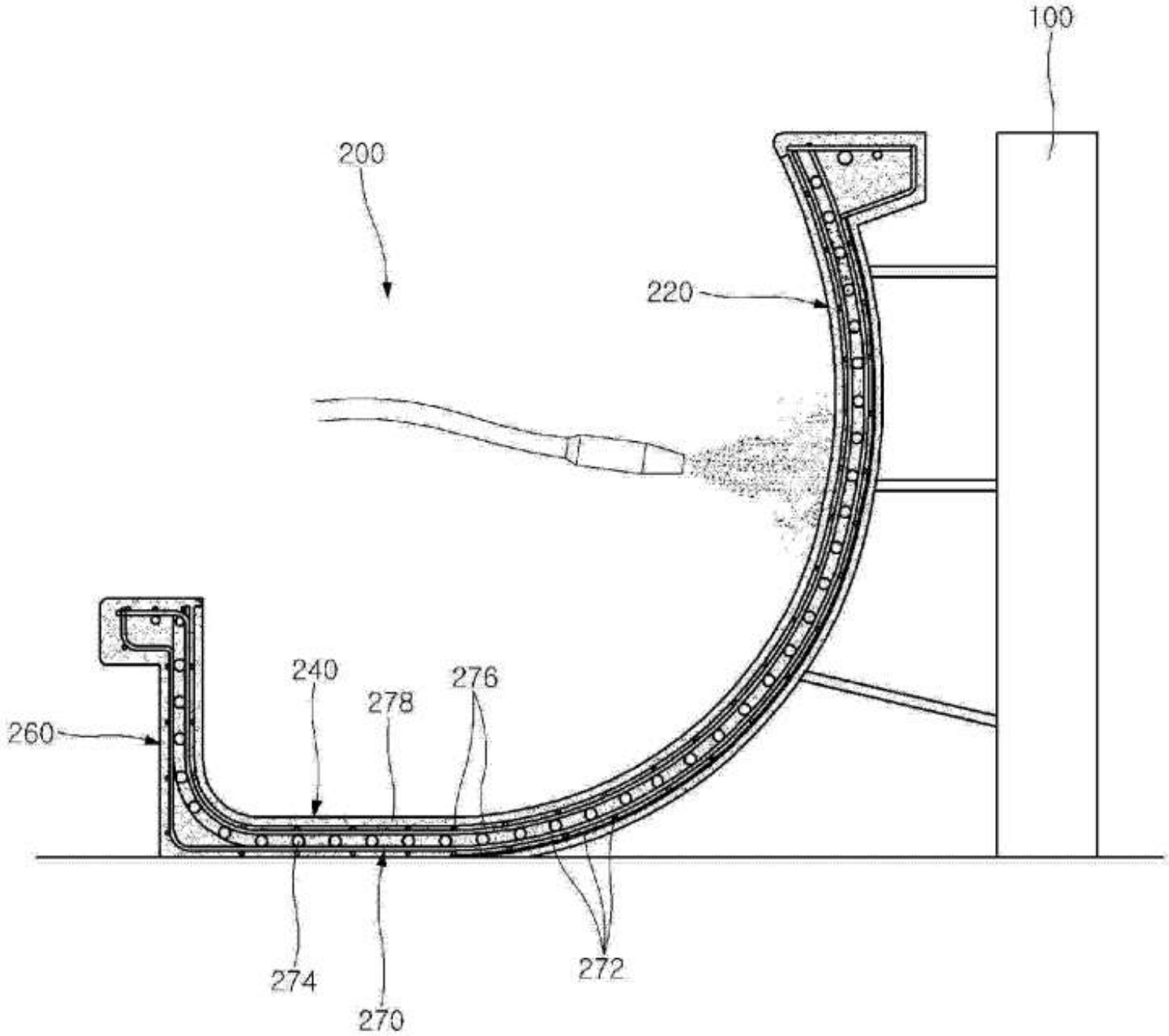
272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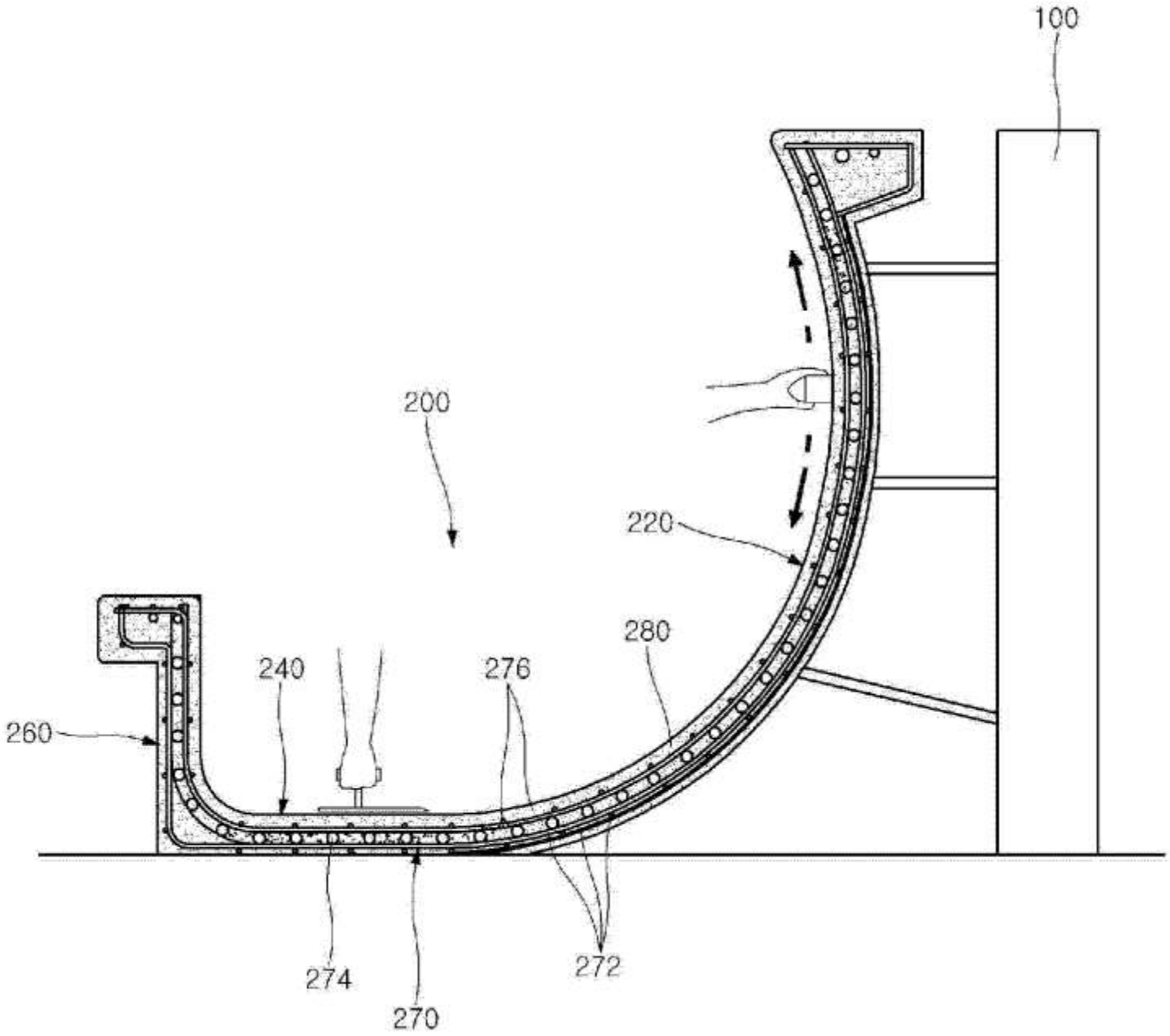
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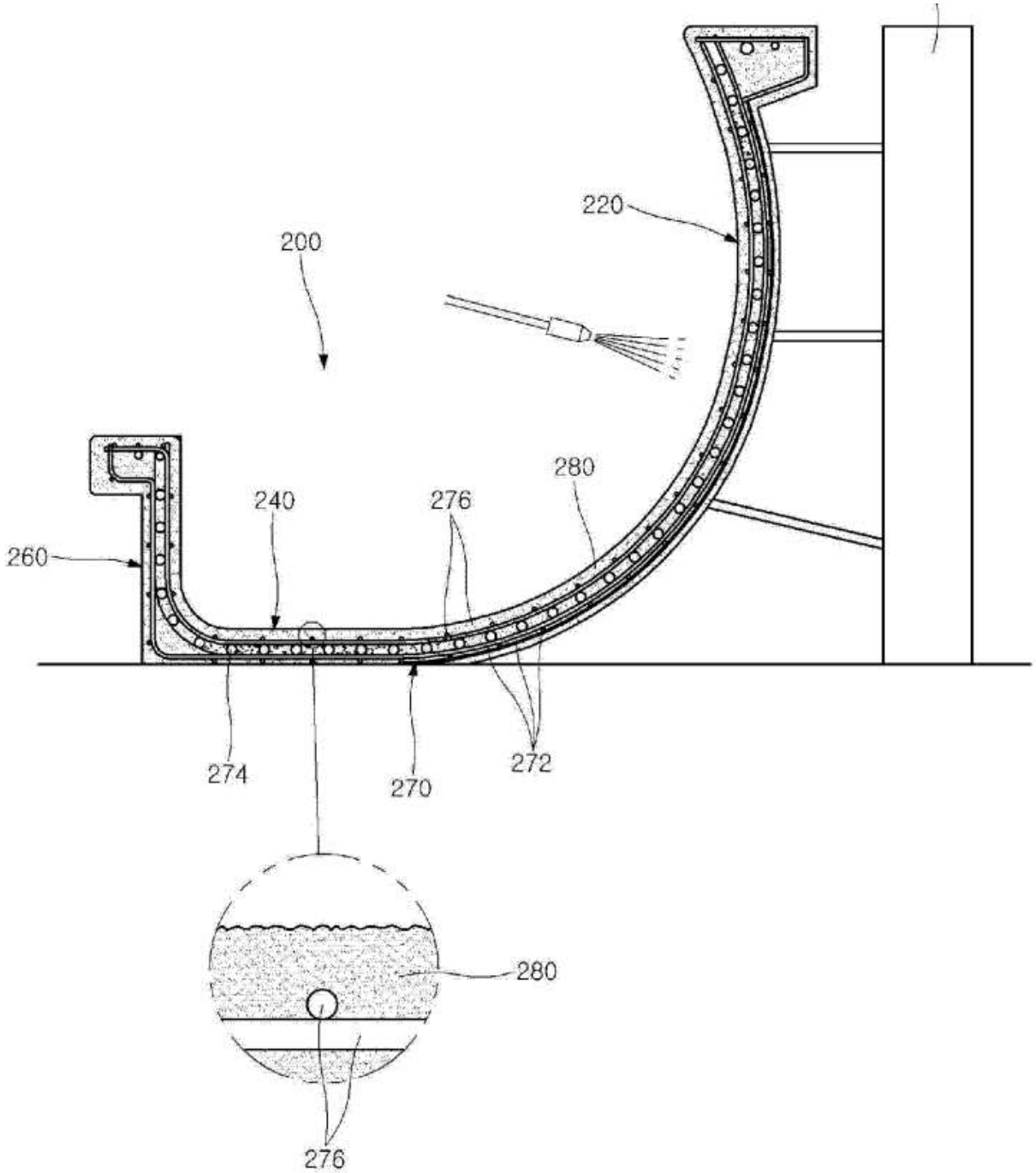
220
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260
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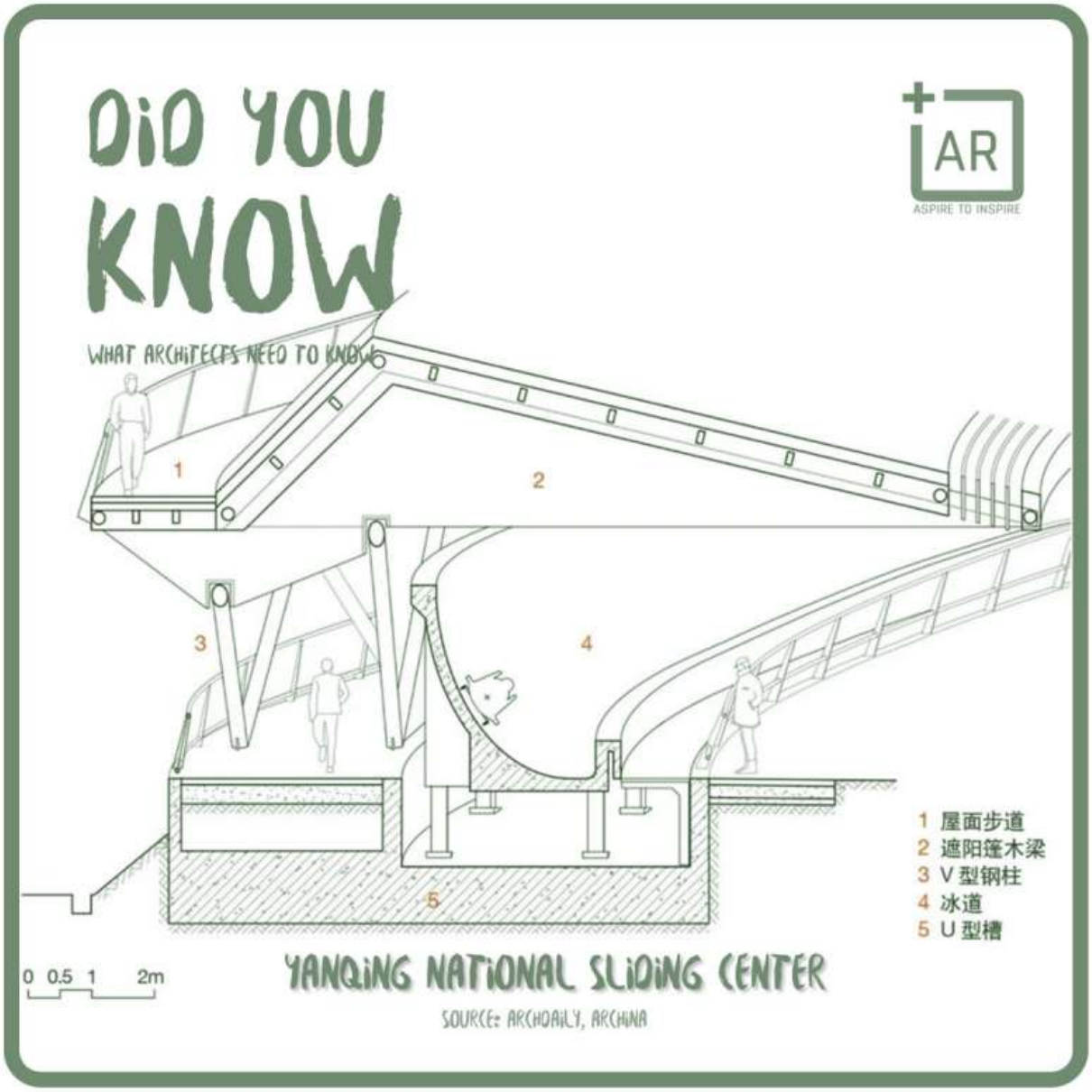
272
280
276

YANQING SLIDING TRACK SECTION

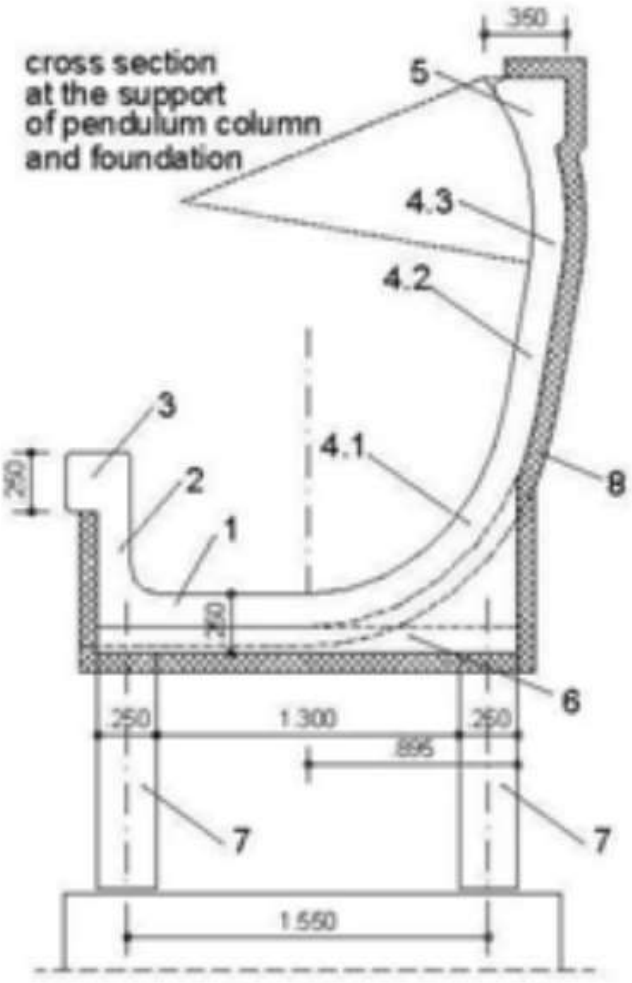


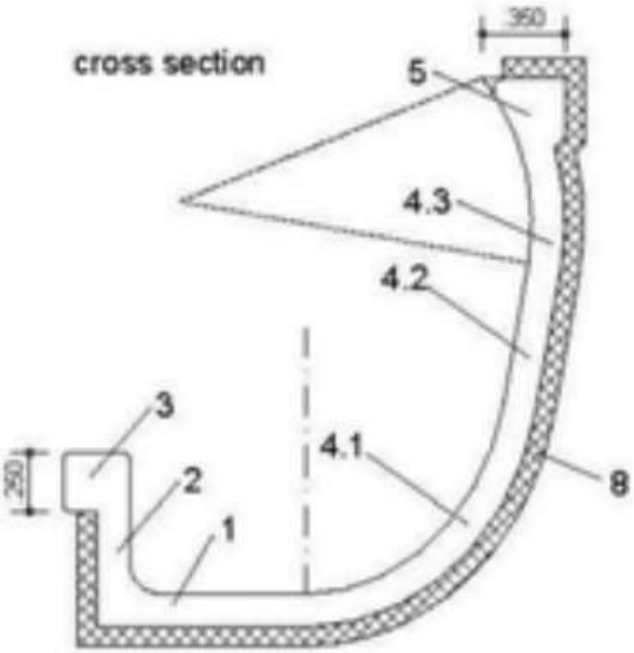

PyeongChang 2018 Winter Olympic Games
Mock-up Test for the Sliding Cer
3 - 6 June 2014, K

Fig. 3: Bench gun shooting shotcrete in high wall


欧力机械
P20
喷注浆一体泵
服务电话:400-187-0001

Fig. 5: Finishing radius cove of low wall with a custom-built tool



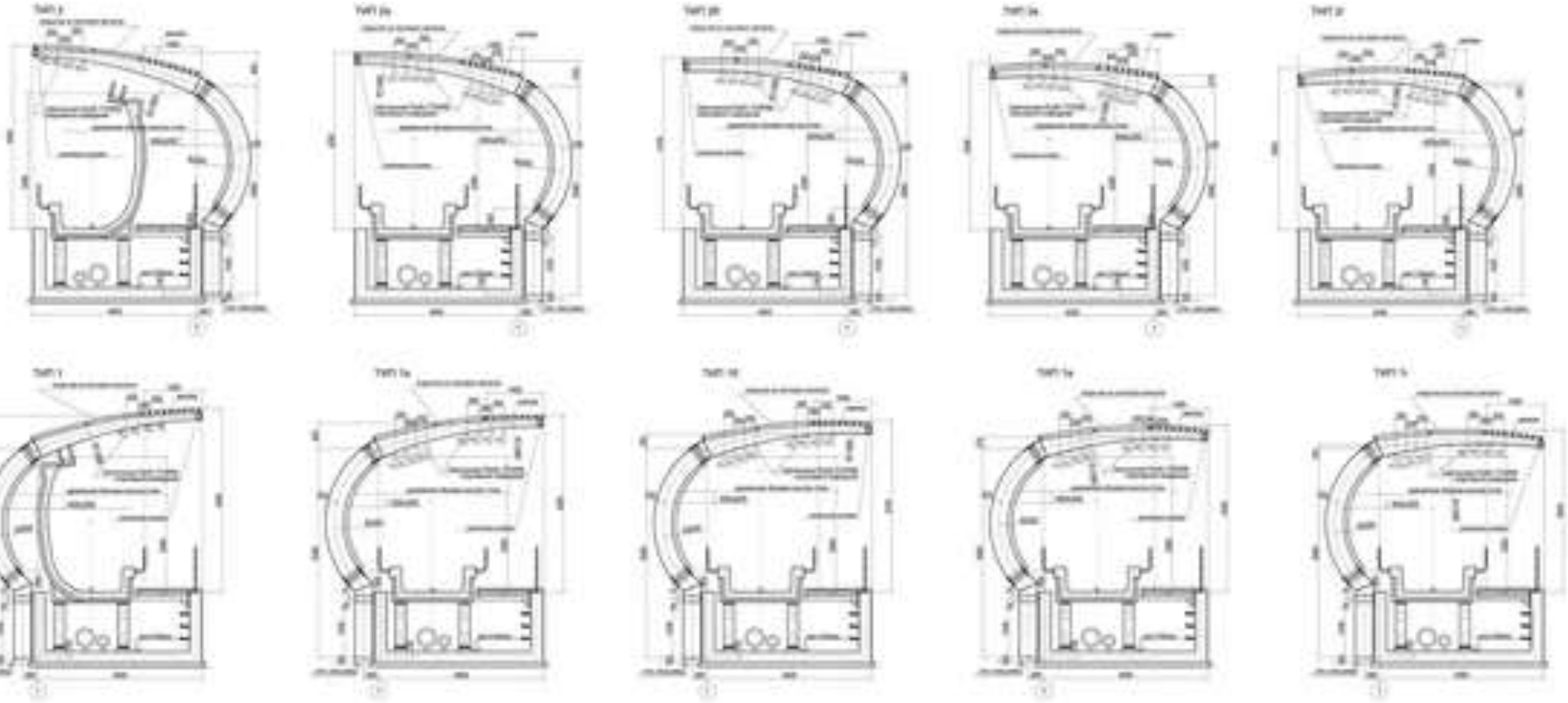


MATERIAL : EURO CODE 2/1

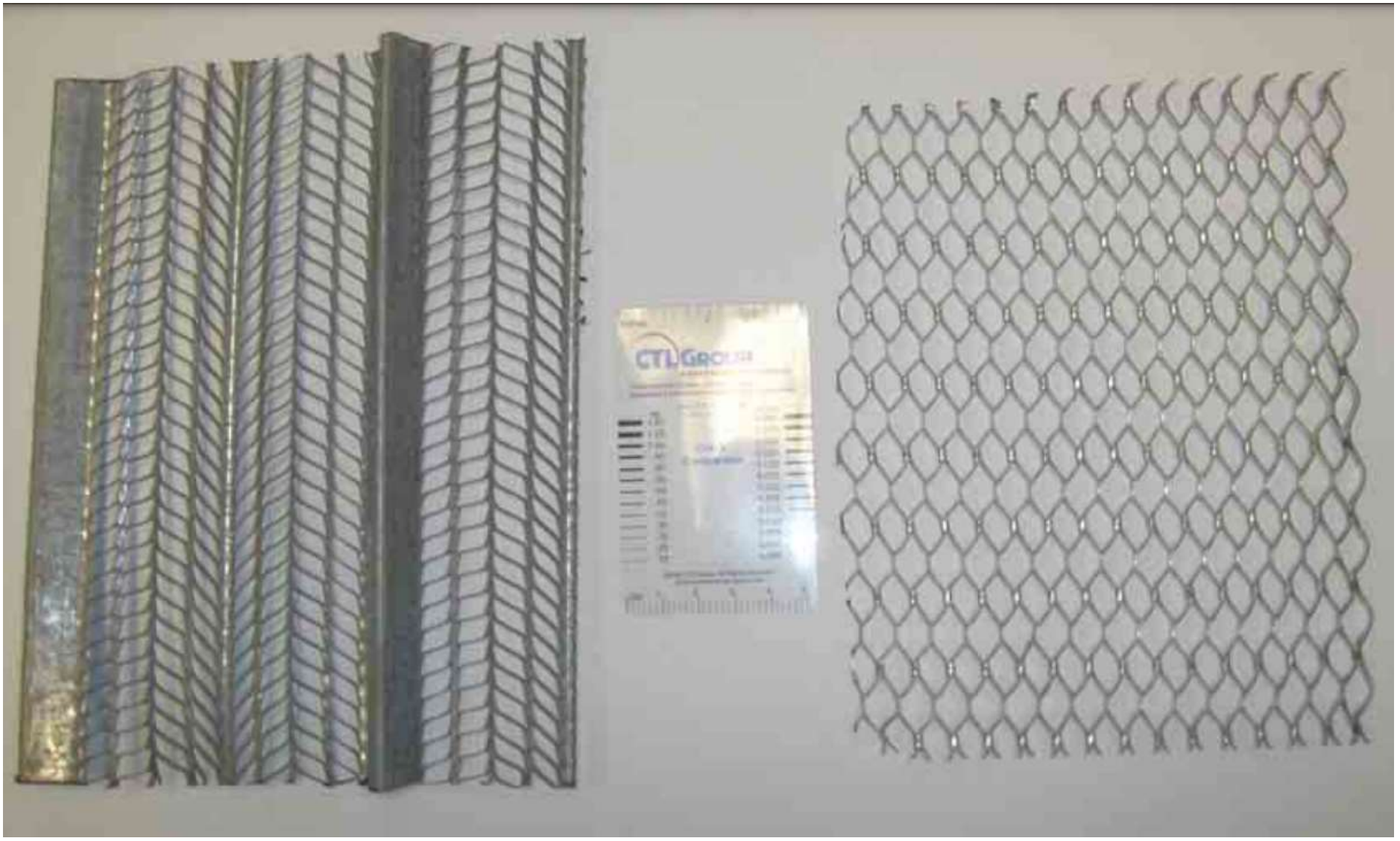
Concrete quality : C 30 / 37
Reinforcement steel : BSt 500

1 - ground slab
2 - band wall
3 - band head
4 - shell structure
4.1 - part of quarter ellipse
4.2 - straight segment
4.3 -.circular segment
5 - head beam
6 - main beam
7 - pendulum column or wall
8 - insulation

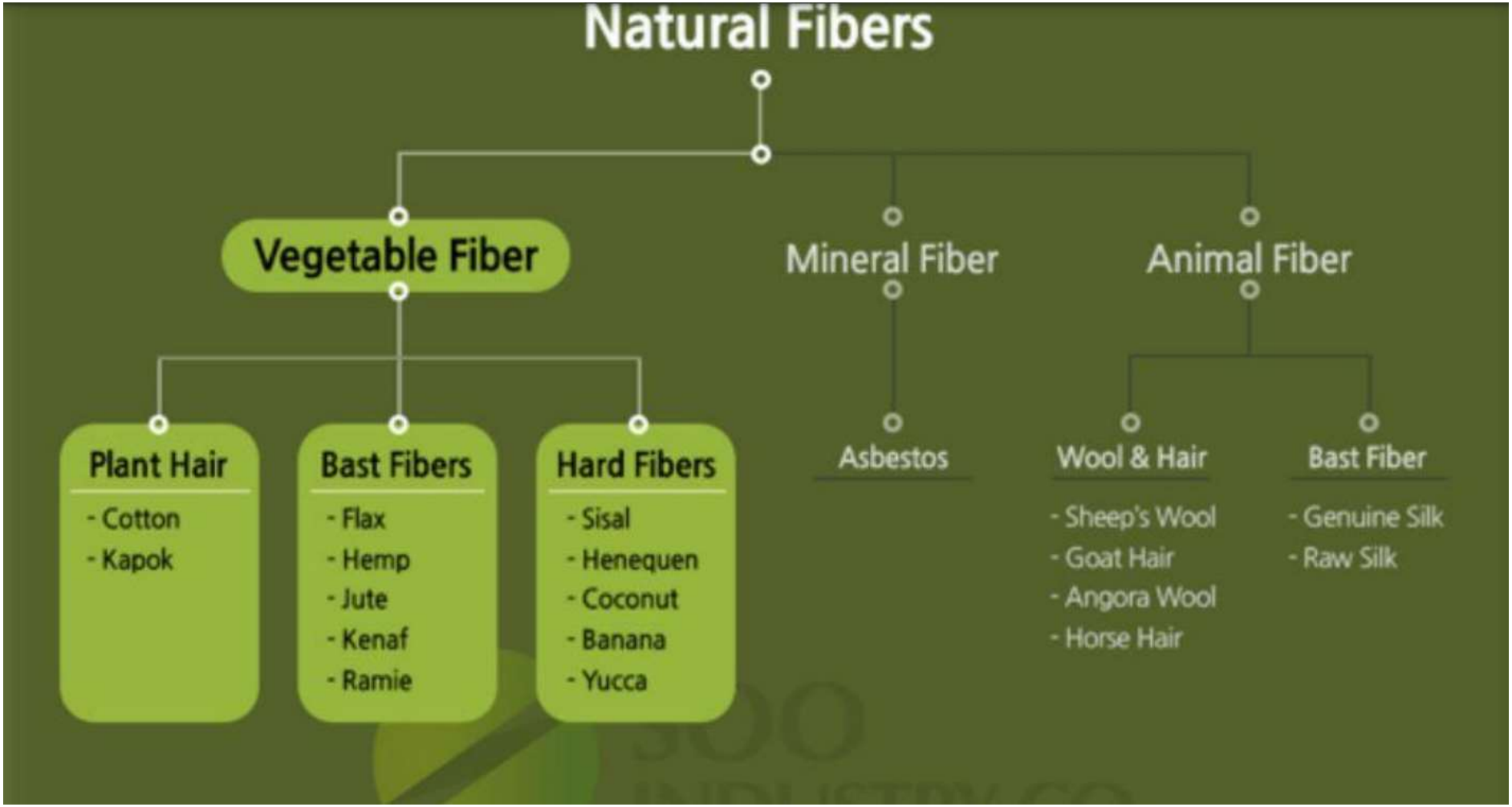
SOCHI RUSSIA SEZIONI DELLA PISTA



CASSERATURA IN CURVA



FIBRE NATURALI X SHOTCRETE



INTRODUZIONE ALLE FIBRE NATURALI X CLS

::Introduction of natural fibers

HIBISCUS CANNABINUS

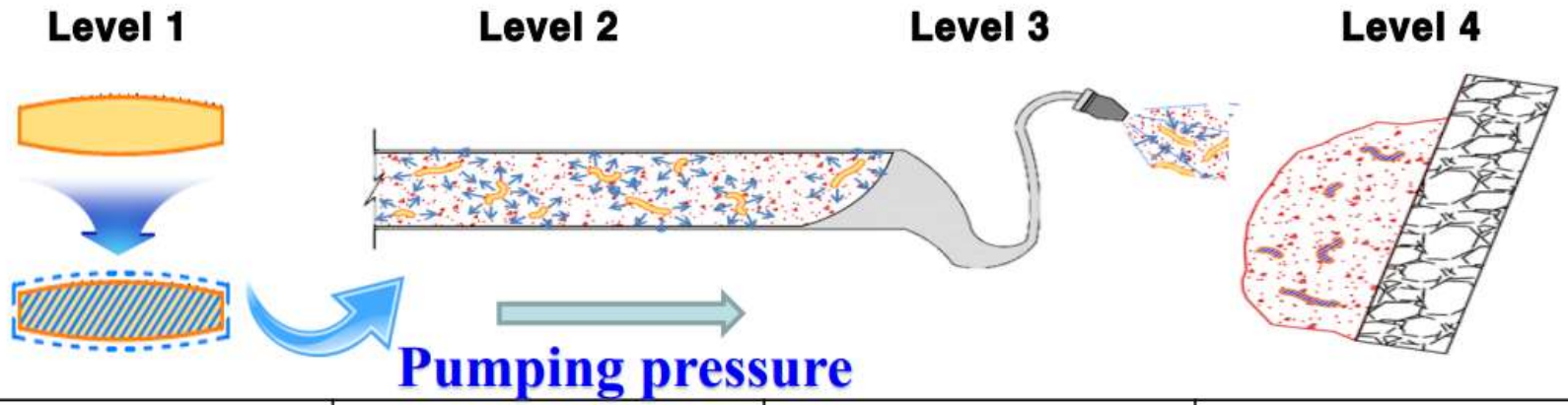
LINO

CANAPA

Natural Fiber in Concrete

CANADIAN GREENFIELD TECHNOLOGIES
NFORCE HEMP FIBRE

Action of Natural Fiber in Shotcrete



Absorb water	Squeezed by pressure	Absorb water by release	Internal curing
Natural fiber absorb water in mixing	The water is squeezed out by pressure	Natural fiber absorb water again by pressure release	Natural supply water and act as internal curing
Natural fiber in wet	Increased pumpability by increased water content in concrete	- Reduced rebound - Increase build-up thickness	Decreased plastic shrinakage

Application Benefits in Shotcrete

- ✓ Natural-friendly
- ✓ Easy to mix without additional equipment
- ✓ Save time with excellent adhesion in shotcrete
- ✓ Smoother finishing surface : less bowling or pooling effects
- ✓ Balanced drying and curing processes in any weather conditions
- ✓ Internal curing and resulted in a reduced cracking

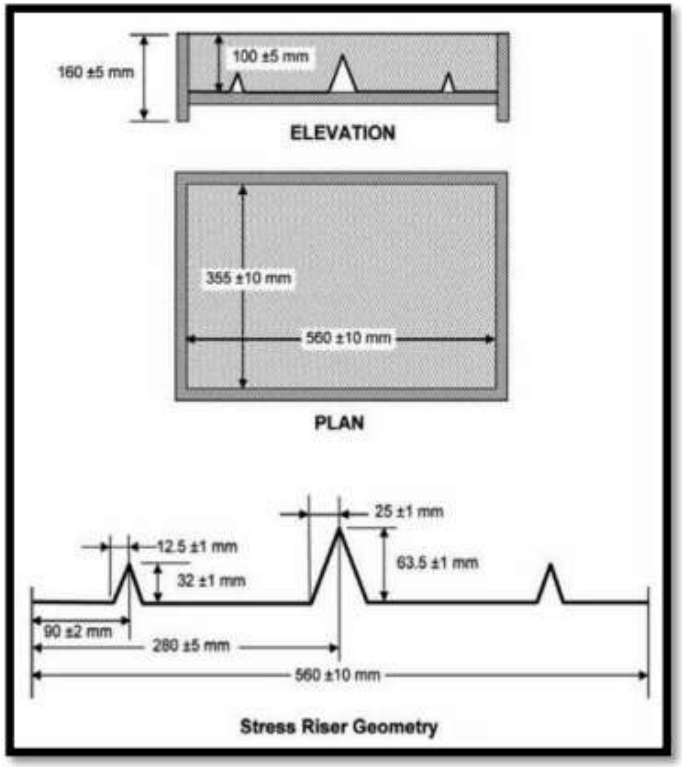
PLASTIC SHRINKAGE

Outline of experiment

- **Aggregates**
  - **Coarse : 10mm of maximum size** 380 kg/m3
  - **Fine : sea sand + crushed** 1099 kg/m3
- **Silica fume : 0, 7, 10% by cement weight**
- **Fibers**
  - **0.5, 1.0, 1.5% by cement weight**
  - **5, 10, 20 mm**

- **Mixtures**
  - **w/c = 0.4**
  - **s/A = 70%**
  - **cement content = 390kg/m^3**
  - **targeted slump = 70±20 mm**

Plastic Shrinkage Test (ASTM C 1579-06)



- Induce cracking in central
- Restrained in both sides

-wind speed : $4.7\,m/s$

-temperature : $36\,^{\circ}c$

-relative moisture: $30\pm10\%$

Plastic Shrinkage Test (ASTM C 1579-06)

- Measure crack width in 10mm space along crack
- Average the crack width
- Calculate CRR(Crack Reduction Ratio)

- $CRR = \left(1 - \frac{\text{average crack width of fiber-reinforced shotcrete}}{\text{average crack width of plain control shotcrete}}\right) \times 100$

Conclusion

- The average crack width increase as the amount of silica fume increase from 7% to 10%.
- The shorter fiber is better for plastic control.
- The optimum fiber length is 5 mm in term of plastic shrinkage control.
- The optimum fiber amount is 0.5% in 7% silica fume shotcrete mixture.
- CRR decrease as fiber length increase at 0.5% fiber and 7% silica fume shotcrete mixture.

GELO-DISGELO

CARATTERISTICHE

CONTENUTO ARIA IN BETON PRIMA E DOPO IL LANCIO

FATTORE DI SPAZIO

AREA SUPERFICIE SPECIFICA

CONCLUSIONI

IL LANCIO MODIFICA LE CARATTERISTICHE E LA RESISTENZA AL GELO DISGELO

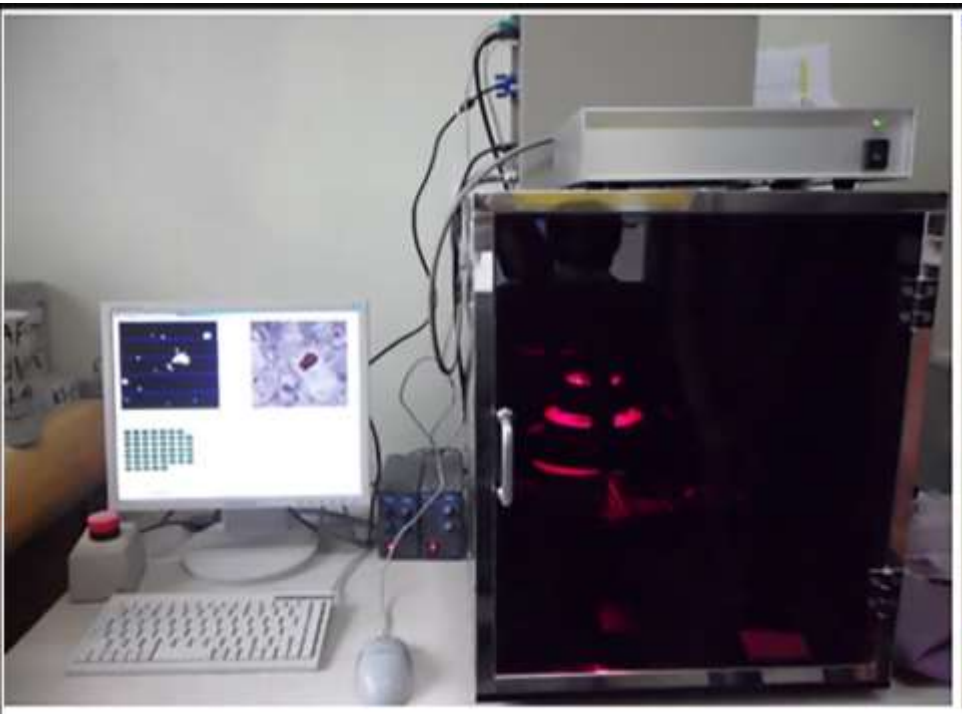
SHOTCRETE CARATTERISTICHE ARIA-VUOTI

AVA3000
GERMANN INSTRUMENT

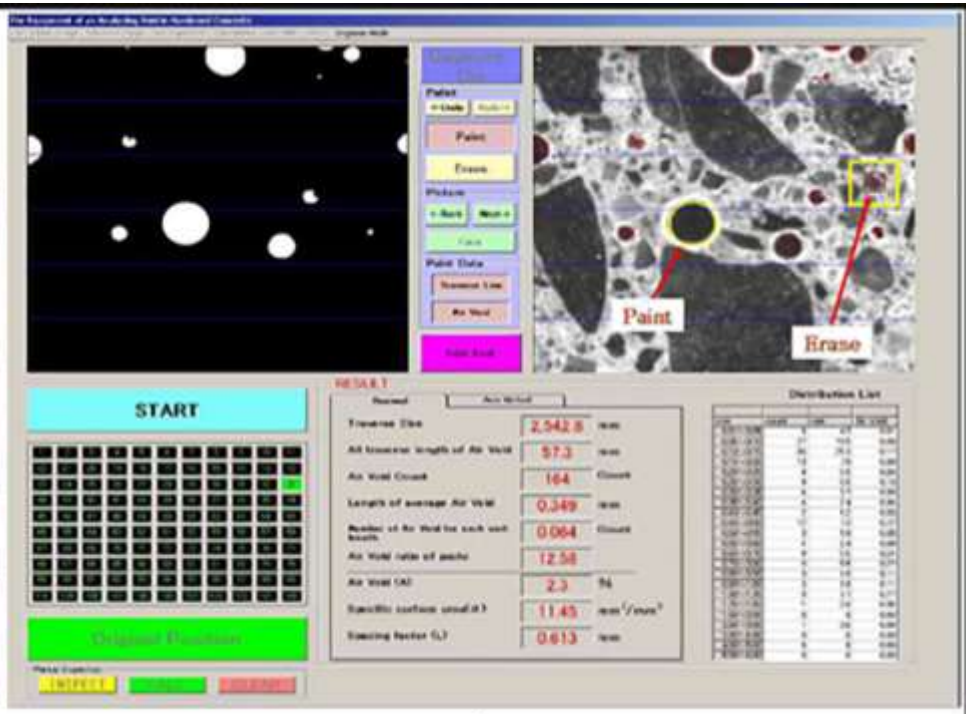
CAMPIONE

ESTRAZIONE BETON FRESCO X MISURA IMMEDIATA

VIDEO ANALISI DI ARIA/VUOTI DOPO PRESA



a



b

REFRIGERANTI NATURALI
ICE-CANAL
GHIACCIO – 12C SP. 5-6 CM

FLUIDI FRIGORIGENI

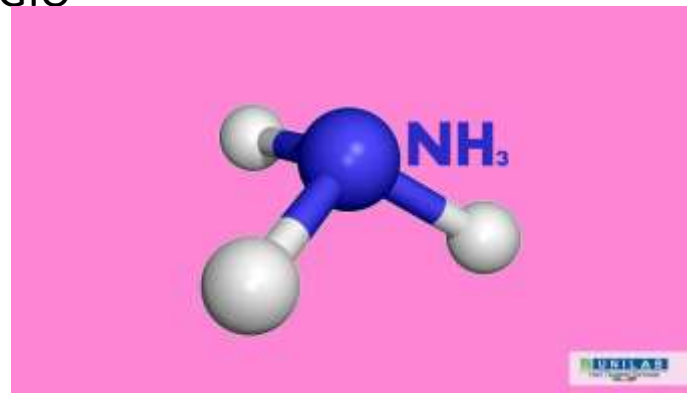
- GAS FLUORORATI AD EFFETTO SERRA
REGOLAMENTO UE N.517/2014 RECEPITO DPR 16 NOV. 2018 N.146 LEGGE F-GAS

- CFC, HCFC, HFC

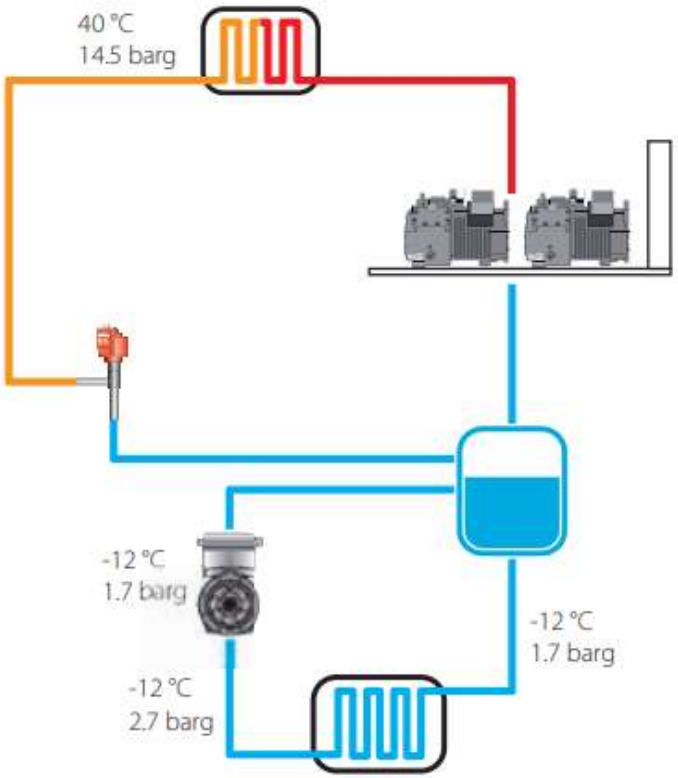
- A NULLO O DEBOLE EFFETTO SERRA

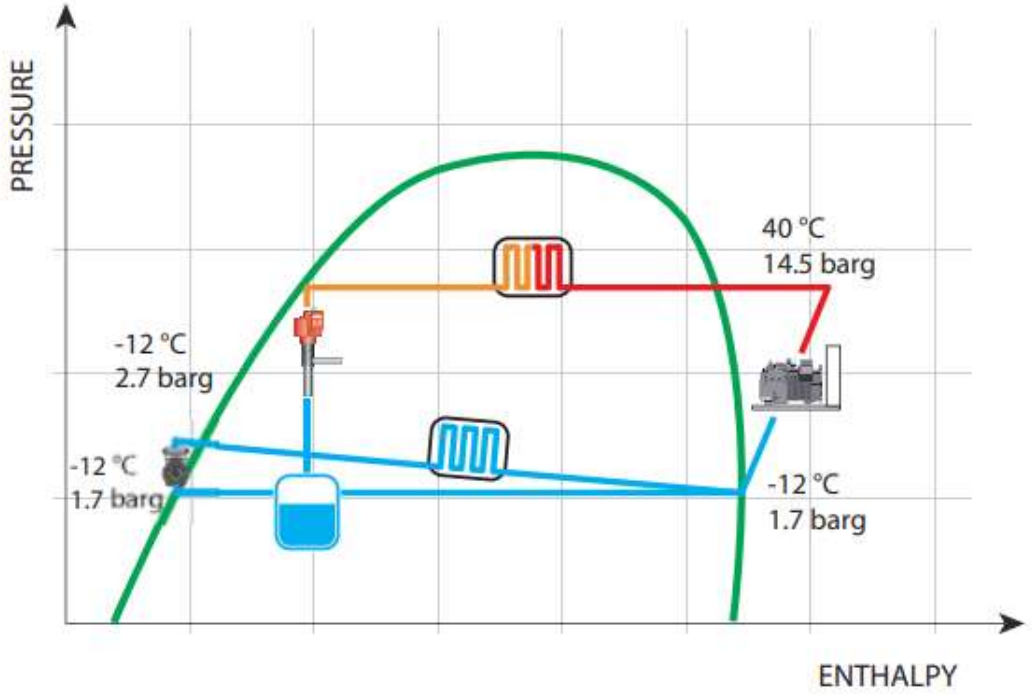
- CO2 PER GRANDI SUPERFICI PATTINAGGIO
- AMMONIACA PER BOBSLEIGH TRACK
- IDROCARBURI
- ACQUA

EN 13445:2021-XXX RECIPIENTI IN PRESSIONE
-



CICLO AMMONIACA



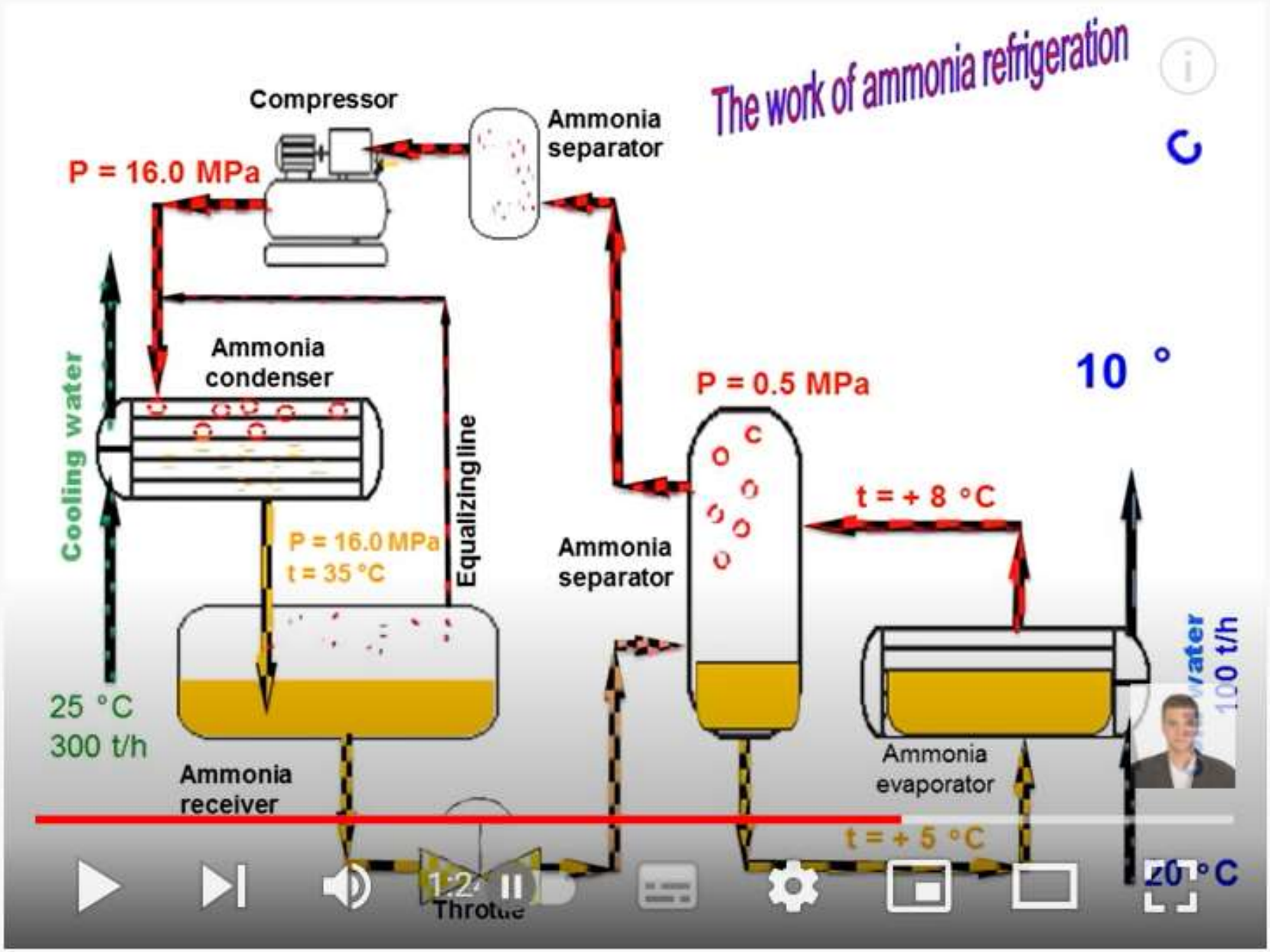


VANTAGGI AMMONIACA

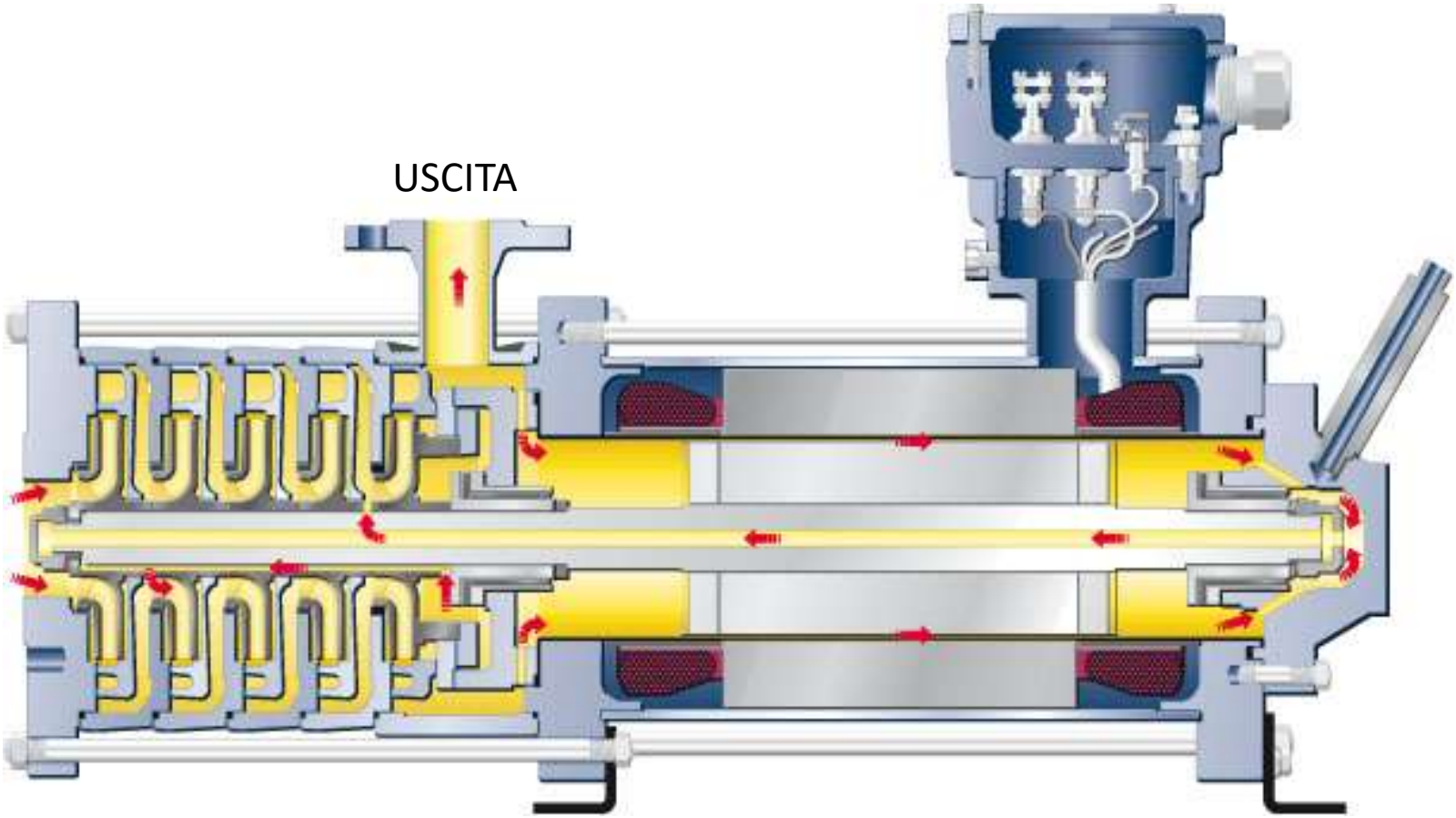
- COSTA POCO
- LEGGERA, EVAPORA
- CICLO MOLTO NOTO (1876)

SVANTAGGI

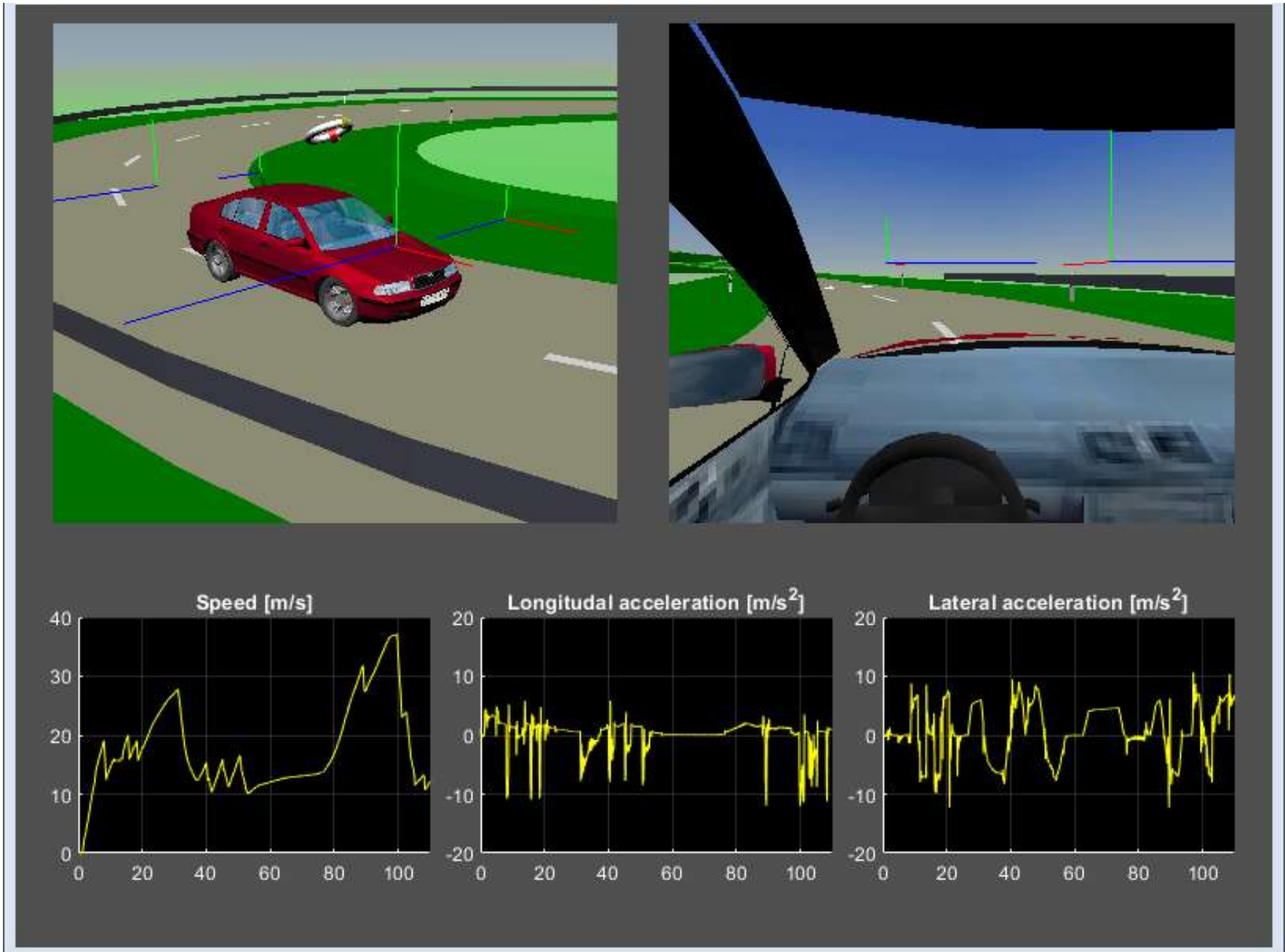
- CORROSIVA
- VELENOSA
- NO RAME, SI ACCIAIO E ALLUM.


The work of ammonia refrigeration
Compressor
Ammonia separator
P = 16.0 MPa
Ammonia condenser
Cooling water
Equalizing line
P = 16.0 MPa
t = 35 °C
P = 0.5 MPa
10 °
t = + 8 °C
Ammonia separator
25 °C
300 t/h
Ammonia receiver
Ammonia evaporator
t = + 5 °C
20 °C
100 t/h

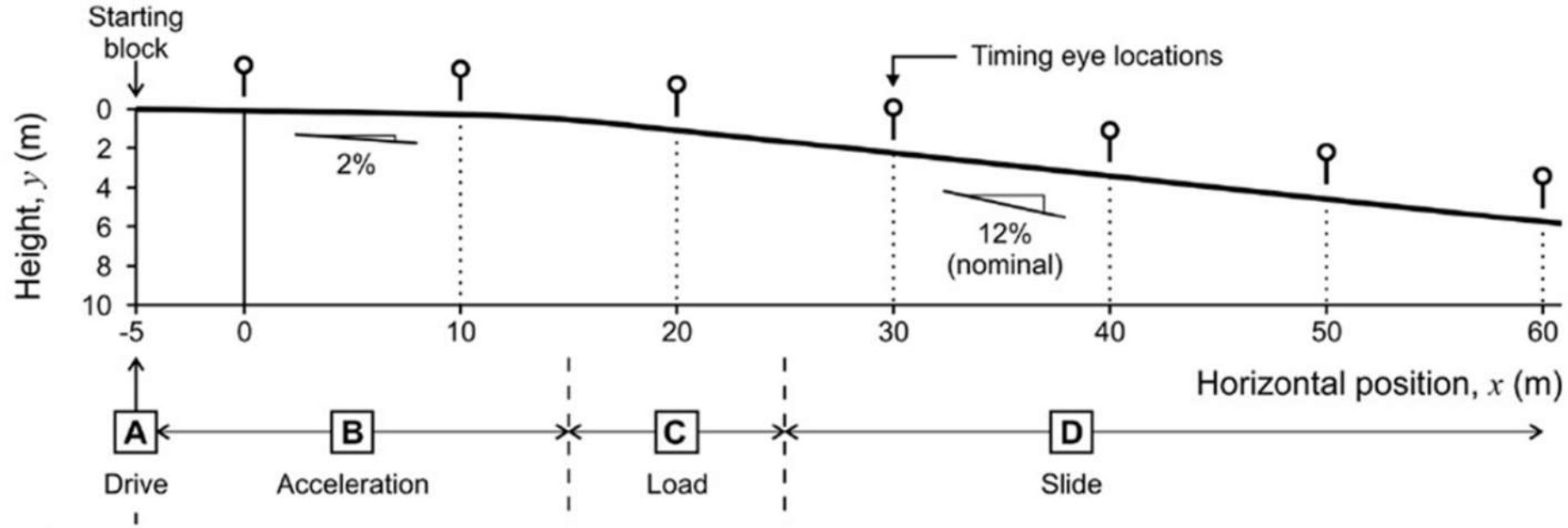
HERMETIC CANNED PUMP



SIMULINK MATHWORK



SKELETON FASE DI SPINTA



EFFETTO DEL CAMBIO PARAMETRI SULLA GARA

Table 1. Effects of parameter changes on run time (reference value is 51.149 s) for a simulated 4-man bobsleigh race on the Whistler Sliding Centre track.

Parameter	Reference value	New value	New run time (s)	Difference in time (s, and in %)
C_D	0.3	0.33 (+10%)	51.315	0.166 (0.32%)
A	0.4 m^2	0.44 (+10%)	51.315	0.166 (0.32%)
μ	0.008	0.0088 (+10%)	51.461	0.312 (0.61%)
m	630 kg	567 kg (−10%)	51.333	0.185 (0.36%)
v_0	9 m/s	8.1 m s^{-1} (−10%)	52.050	0.901 (1.76%)


OPPONESI ELEMENTO AD ELEMENTO
Auct. Oper. Inuent.
Aᵒˢ Zucchi Sculp.

DINAMICA APPROSSIMATA

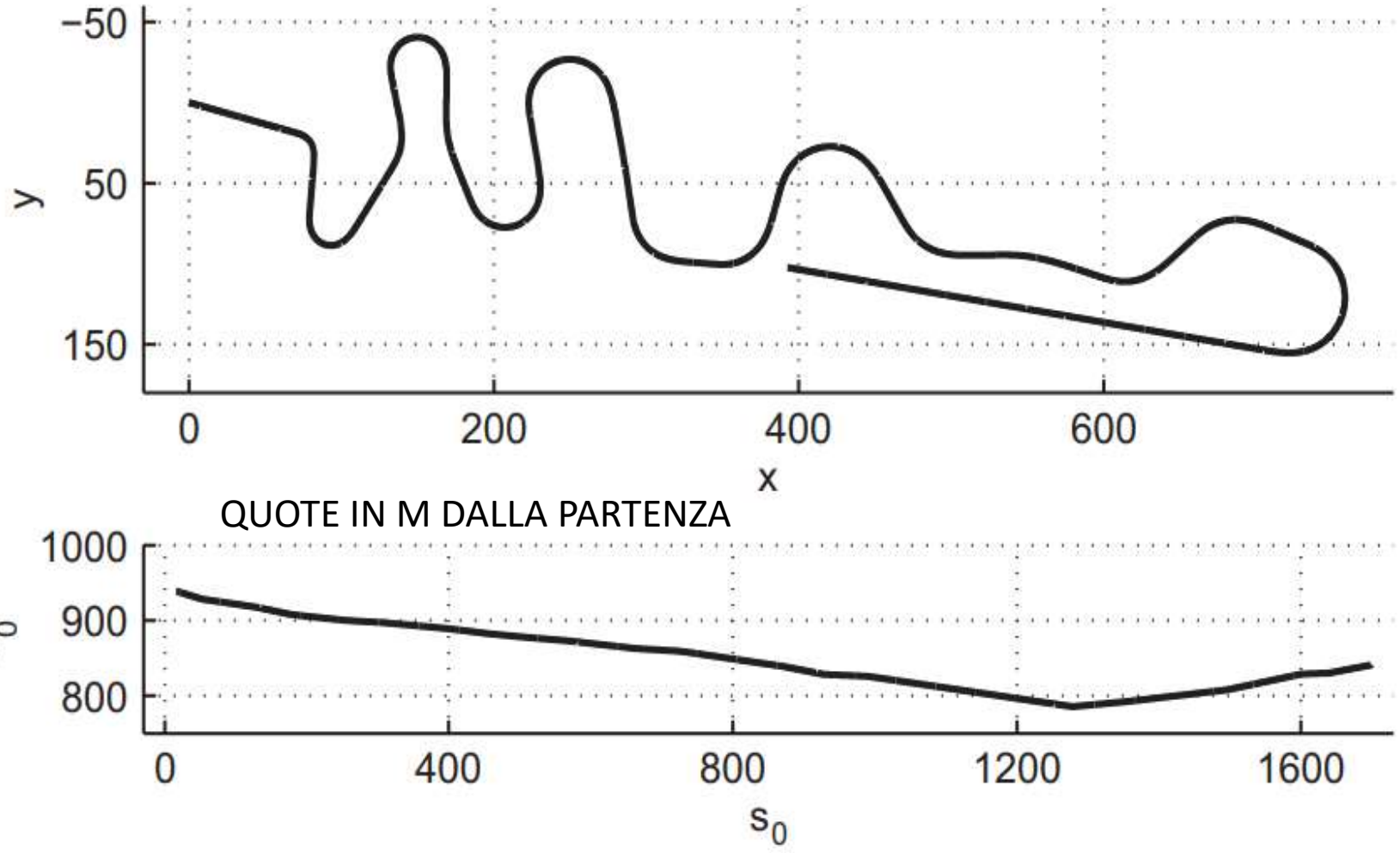
EQUAZIONE DEL MOTO (SECONDA LEGGE DI NEWTON F = MA)

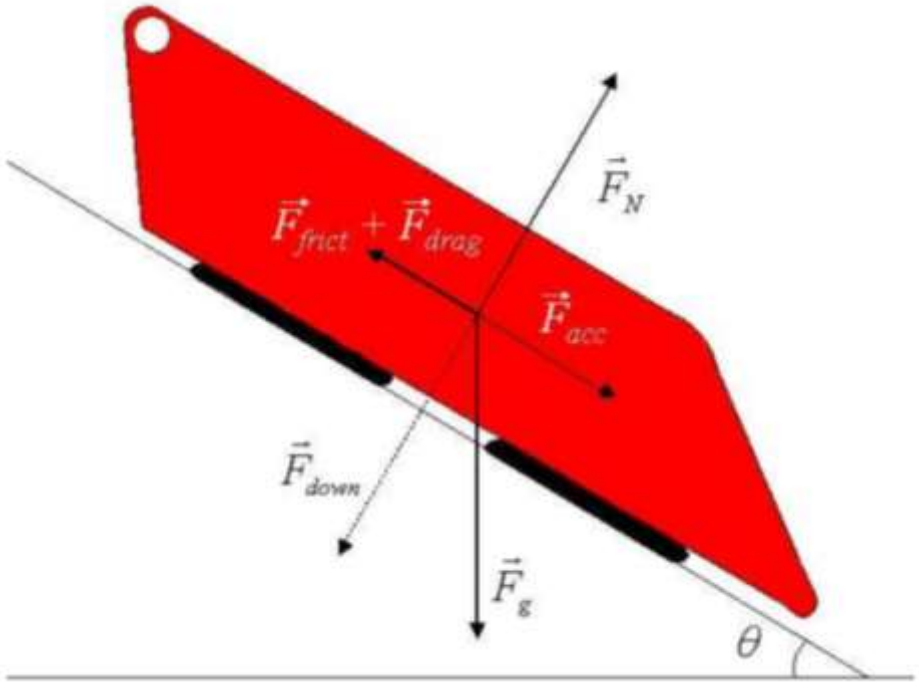
M A = F

MASSA X ACCELERAZIONE DEL MEZZO = FORZA AGENTE MENO FORZA ATTRITO
ATTENZIONE ALLA NON LINEARITA' DIPENDENTE DALLA VARIAZIONE DELLA PENDENZA DELLA PISTA, DALLA NON DEFINIZIONE DELLA TRAIETTORIA, ECC.

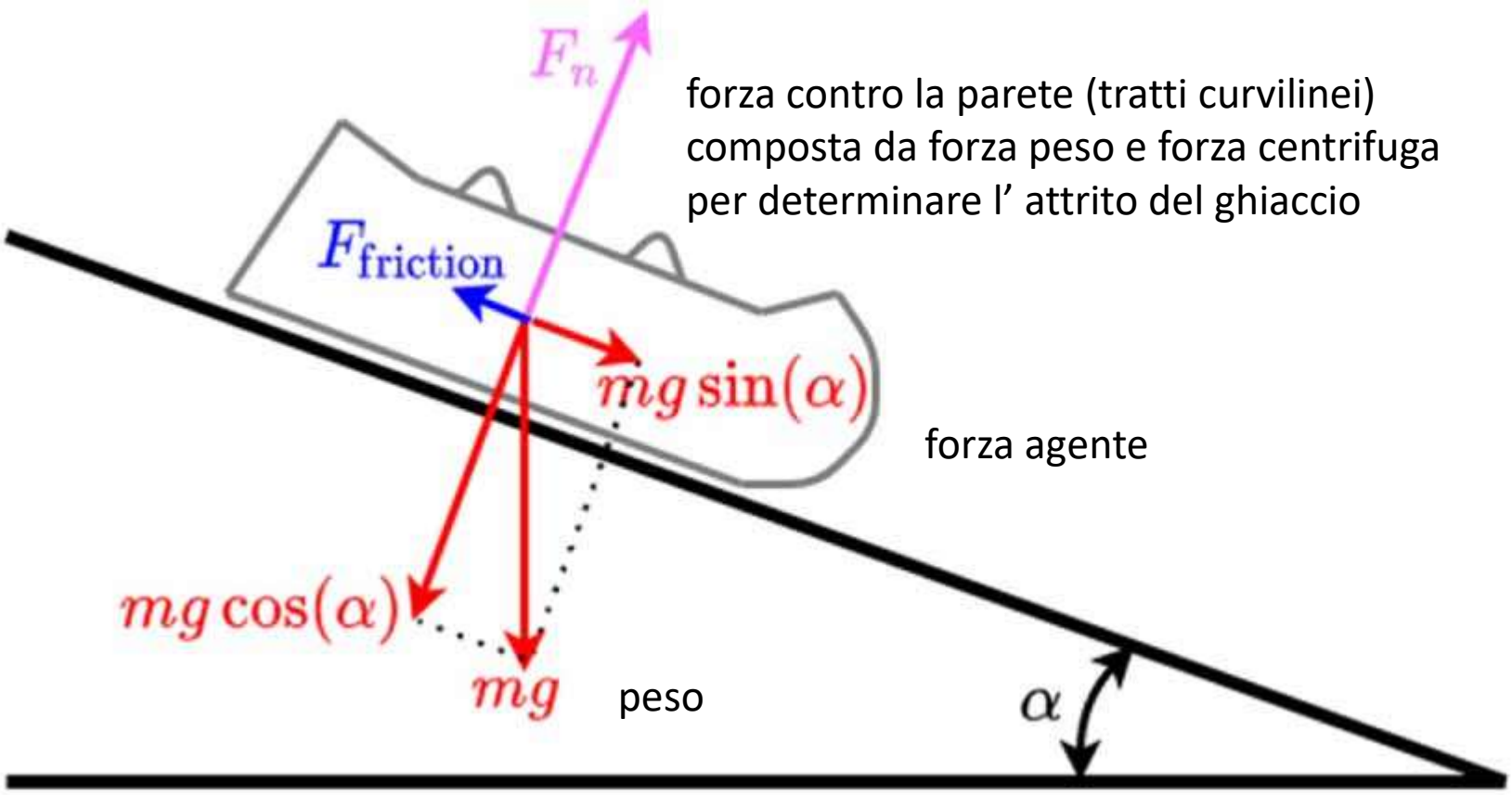
PROCEDURA
- SI DIVIDE IL TEMPO IN TANTI INTERVALI
- SI ESPRIME L' ACCELERAZIONE IN FORMA DISCRETA COME VARIAZIONE DI VELOCITA' DIVISO L' INTERVALLO E POI LA VELOCITA' COME VARIAZIONE DI SPOSTAMENTO DIVISO L' INTERVALLO
- SI RISOLVONO LE NON LINEARITA' IN MODO APPROSSIMATO
- SI OTTENGONO FORMULE RICORSIVE (IMPLICITE ESPLICITE) CHE DANNO LO SPOSTAMENTO IN FUNZIONE DEL TEMPO IN FORMA NUMERICA
- SI CONFROTANO I RISULTATI TRA LORO E CON DATI SPERIMENTALI (DISCESE)
-SI DISCUTE SULLA NATURA MATEMATICA DELLE SOLUZIONI OTTENUTE

BASELINE X Y IN M E QUOTE ALTIMETRICHE IN M DALLA PARTENZA




$\vec{F}_N$
$\vec{F}_{fnct} + \vec{F}_{drag}$
$\vec{F}_{acc}$
$\vec{F}_{down}$
$\vec{F}_g$
θ

DINAMICA DEL MOTO DI SLITTAMENTO



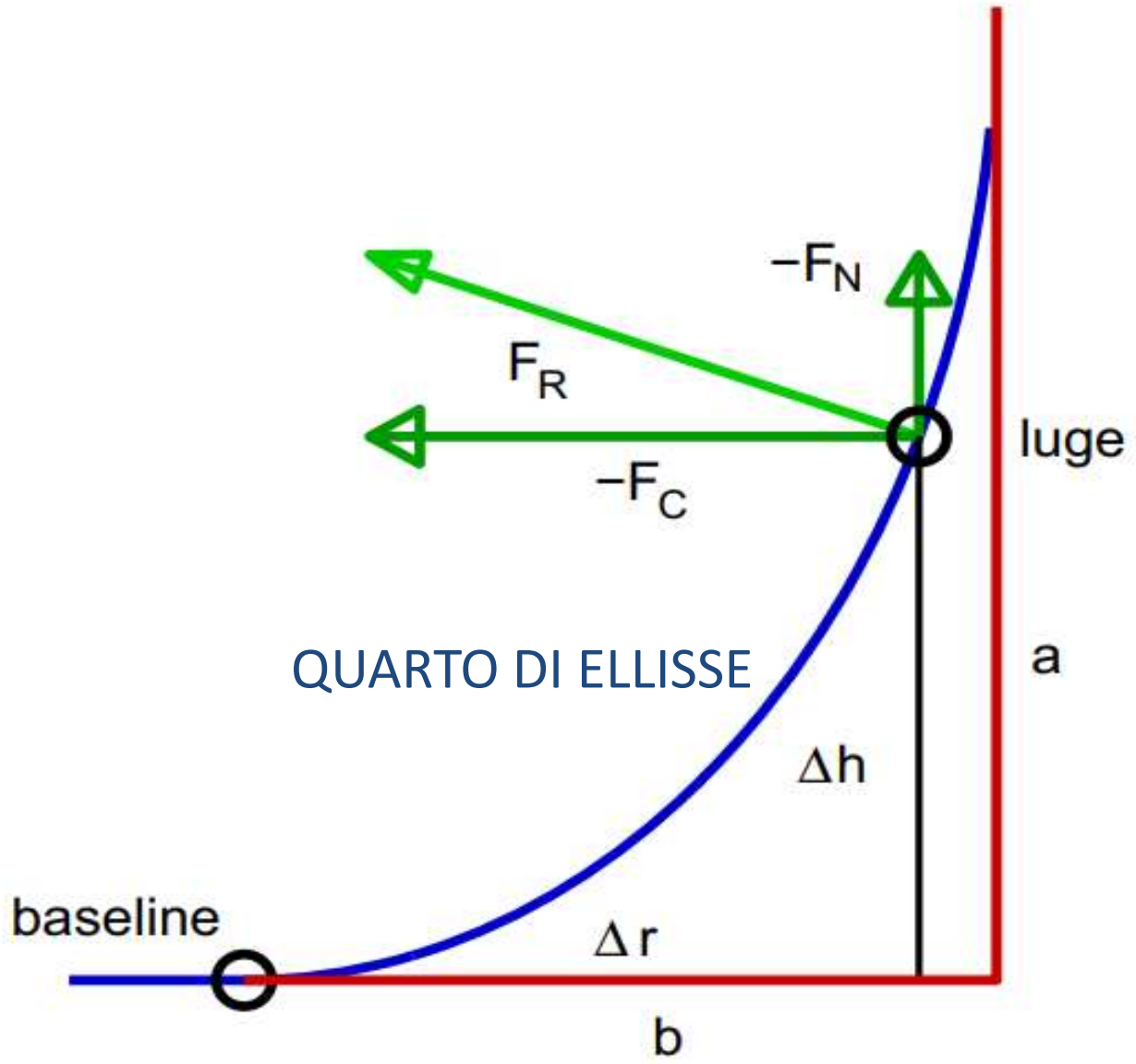
forza contro la parete (tratti curvilinei) composta da forza peso e forza centrifuga per determinare l' attrito del ghiaccio

forza agente

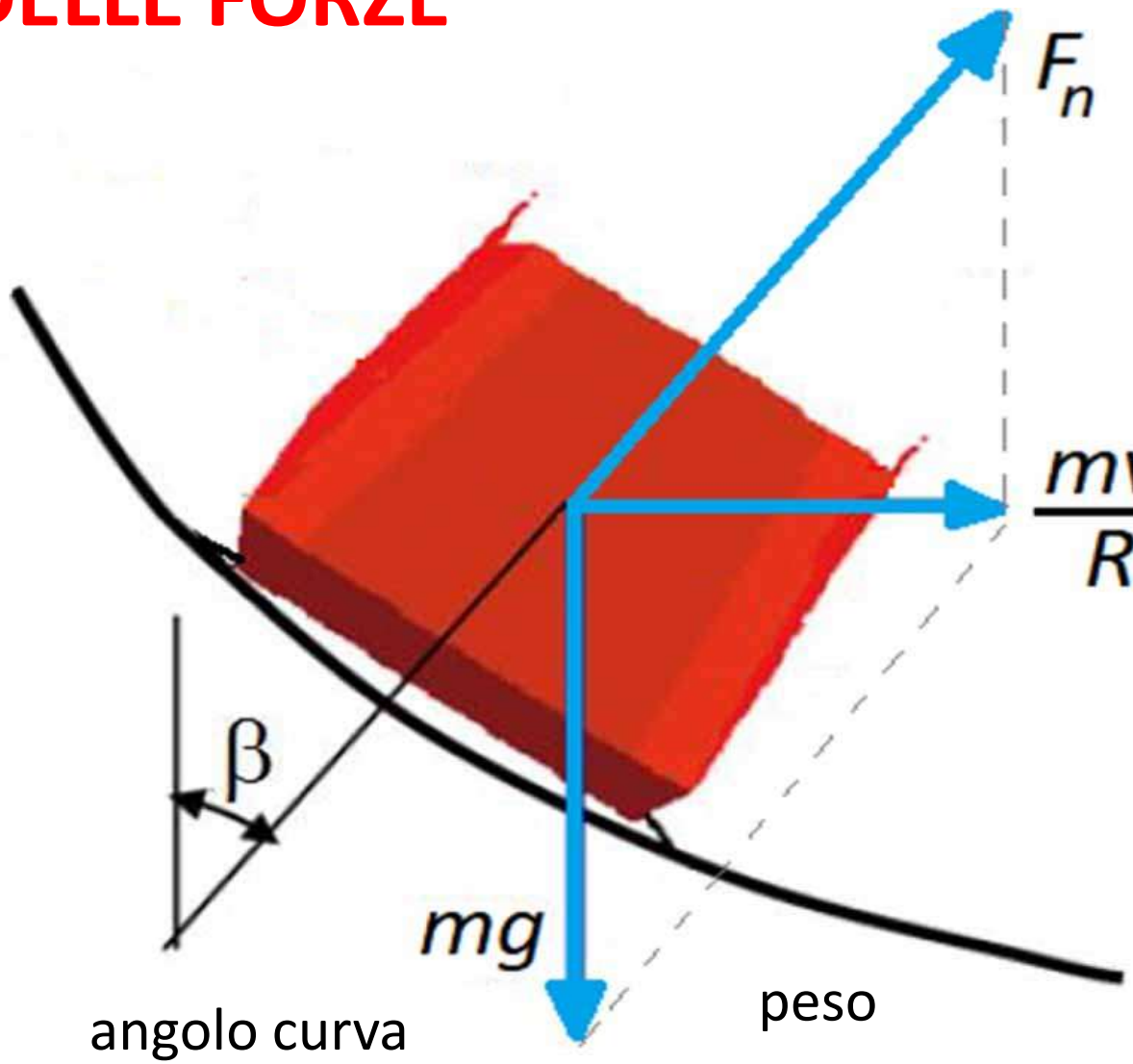
peso

mg	forza peso
α	pendenza variabile del track
mgsinα	forza agente del moto
Ffriction	forza di attrito (somma di attrito con ghiaccio e drag aerodinamico)
Fn	forza agente contro la parete (composizione di peso e azionecentrifuga)

ZONA TRANSIZIONE ELLISSE CON PARAMETRI a E b



RAPPRESENTAZIONE IN CURVA (SEZIONE) DELLE FORZE



Forza centrifuga.
Spinta laterale

DINAMICA APPROSSIMATA

IN CURVA

FORZA CENTRIFUGA Fc = M V2 / R

ACCELERAZIONE CENTRIFUGA Ac = V2 / R

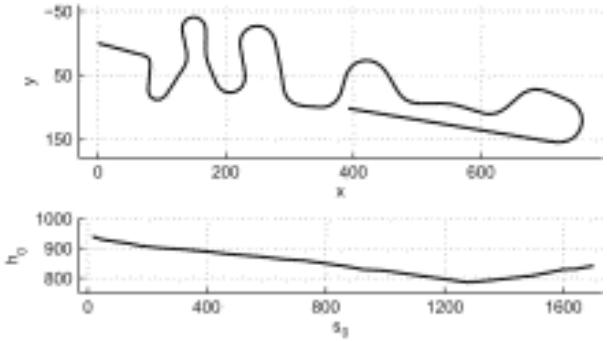
ESEMPIO CURVA R = 20 M V = 130 KM/H = 130 X 1000 / 360 = 36.1 M/S
Ac = 36.1 X 36.1 / 20 = 22.2 M/S2 = 32.58 / 9.81 = 3.3 G
G = 9.81 M/S2
QUINDI UNA FORZA DI SCHIACCIAMENTO CONTRO LA PARETE
PARI A 3.3 VOLTE IL PESO PROPRIO

SE LA CURVA E' COMPLETA 360°
CIRCONFERENZA 2 X 3.14 X 20 = 125.6M
TEMPO 125.6 / 36.1 = 3.47 S DURATA DELLA PRESSIONE

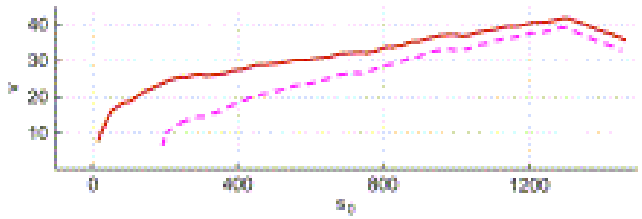
EQUAZIONE DELLA DINAMICA

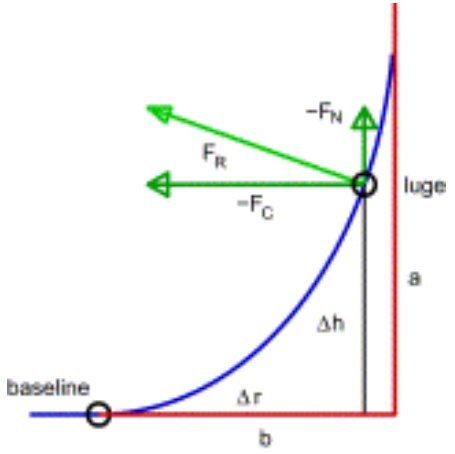
$$M\,a = Fw - Fd - Ff$$

M MASSA, a ACCELERAZIONE, Fw PESO, Fd DRAG ARIA, Ff ATTRITO GHIACCIO

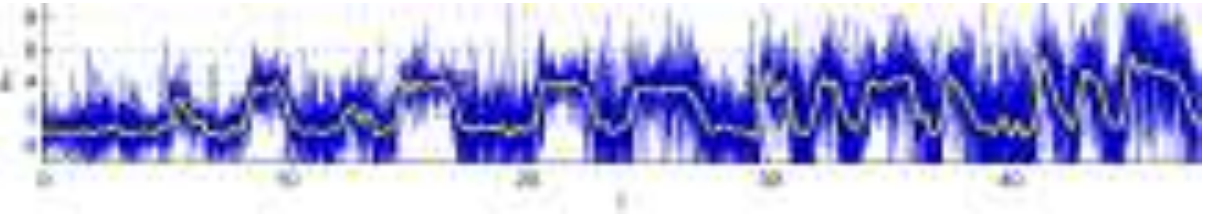


PLOT X-Y E ALTITUDINE

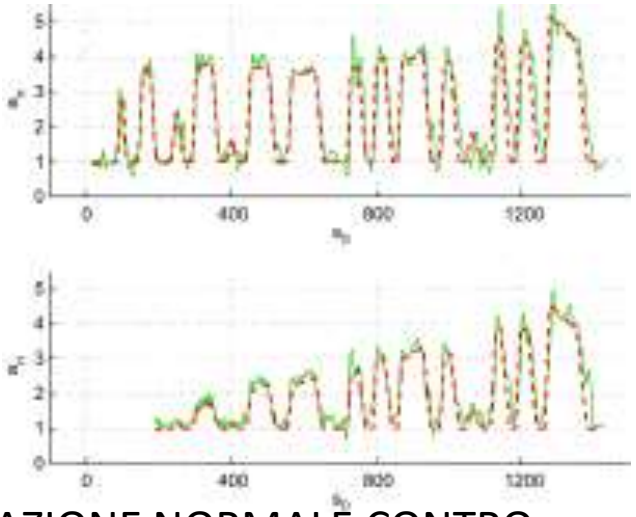




The 1d equation of motion for a point mass is formulated along the trajectory of the luge.
FW=mg
drag Fd =½ρ Cd A v2
surface reaction force Fr
friction Ff =μ FR . The luge is accelerated by the projection of the weight on the trajectory
FP =mg·sinα. In straights the surface reaction force is given by FR =FN with FN =mg·cosα.



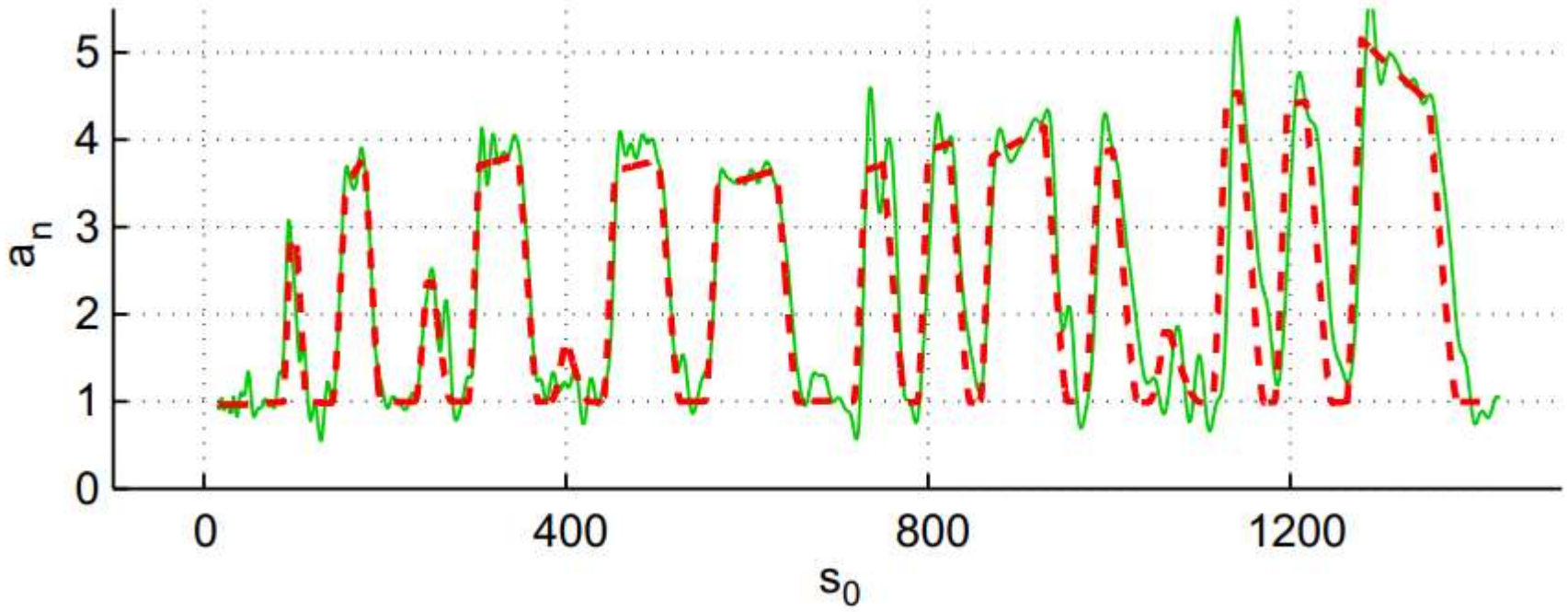
ACCELERAZIONE NORMALE CONTRO TEMPO



ACCELERAZIONE NORMALE CONTRO DISTANZA DA PARTENZA (DOPPIO-SINGOLO

ACCELERAZIONE NORMALE IN G

BASELINE:
TRATTO RETTILINEO, RACCORDO CLOTOIDE, CERCHIO, CLOTOIDE, RETTILINEO



DISTANZA DALLA PARTENZA IN M
LATO ASCENDENTE: RAGGIO CURVATURA IN DIMINUZIONE, ZONA TRANSIZIONE
LATO COSTANTE (CON VIBRAZIONI) RAGGIO COSTANTE
LATO DISCENDENTE:RAGGIO IN AUMENTO VERSO TRATTO RETTILINEO
CONFRONTO TRA DATI NUMERICI E SPERIMENTALI DA SENSORE

VALORI SPERIMENTALI O CONVENZIONALI PER LUGE

UN ATLETA 117 KG, DUE ATLETI 205.5 KG

ATTRITO SLITTAMENTO *ACCIAIO-GHIACCIO* **$FA = \eta\ FN$** FN FORZA NORMALE

LONGITUDINALE $\eta = 0.005$

ATTRITO TRAVERSALE $\eta = 0.010$ (MAGGIORE DI LONGITUDINALE)

ATTRITO ROTOLAMENTO ACCIAIO-ACCIAIO
$\eta = 0.0005$ (MINORE DI SCIVOLAMENTO)

DRAG ATTRITO AERODINAMICO **$FD = \frac{1}{2}\ \rho\ CD\ A\ V2$**

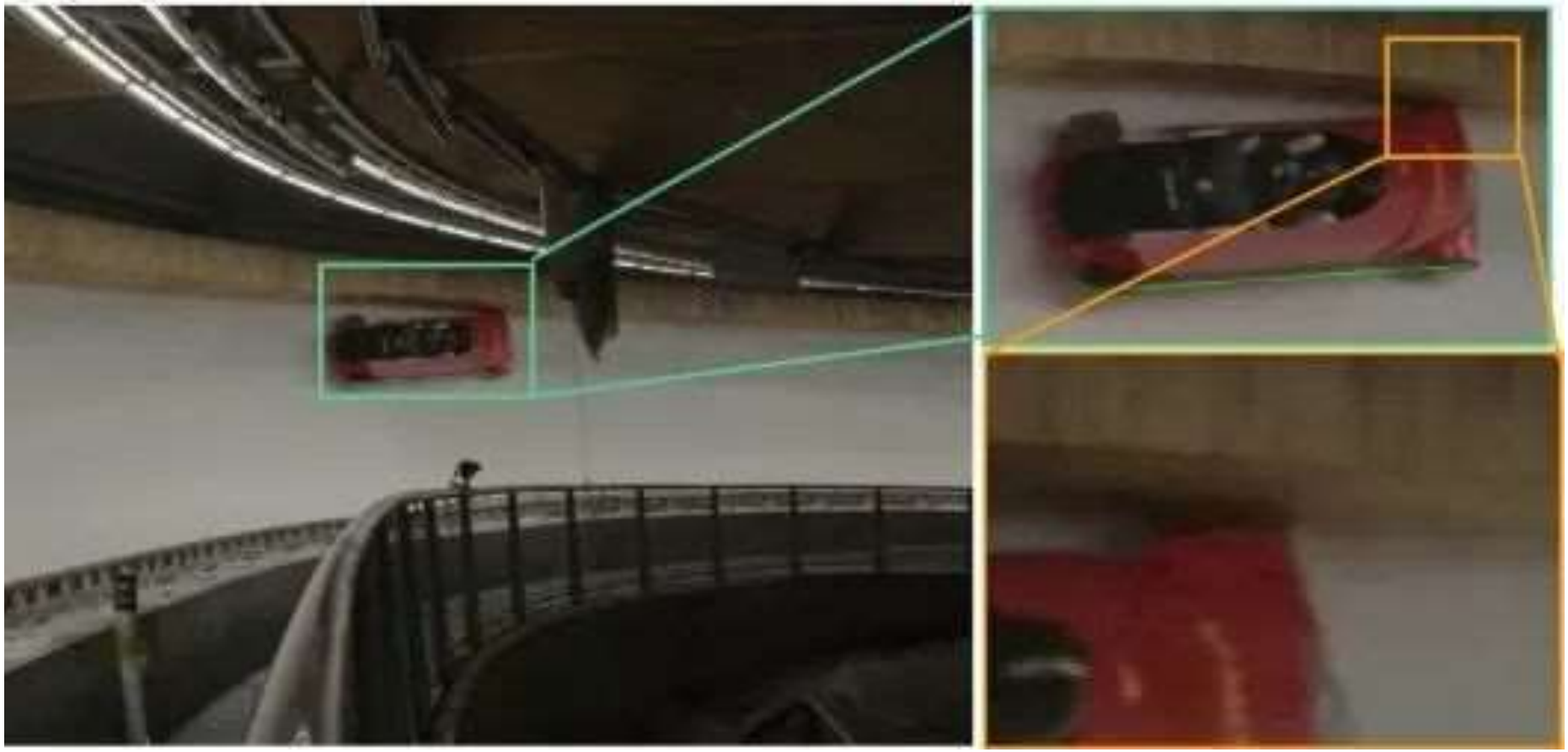
P DENSITA' DELL' ARIA DIPENDENTE DALLA QUOTA

CD COEFFICIENTE AERODINAMICO (CX)

A SUPERFICIE FRONTALE DI RIFERIMENTO

V VELOCITA' DEL MEZZO

DIPV MISURE CON VIDEOCAMERA

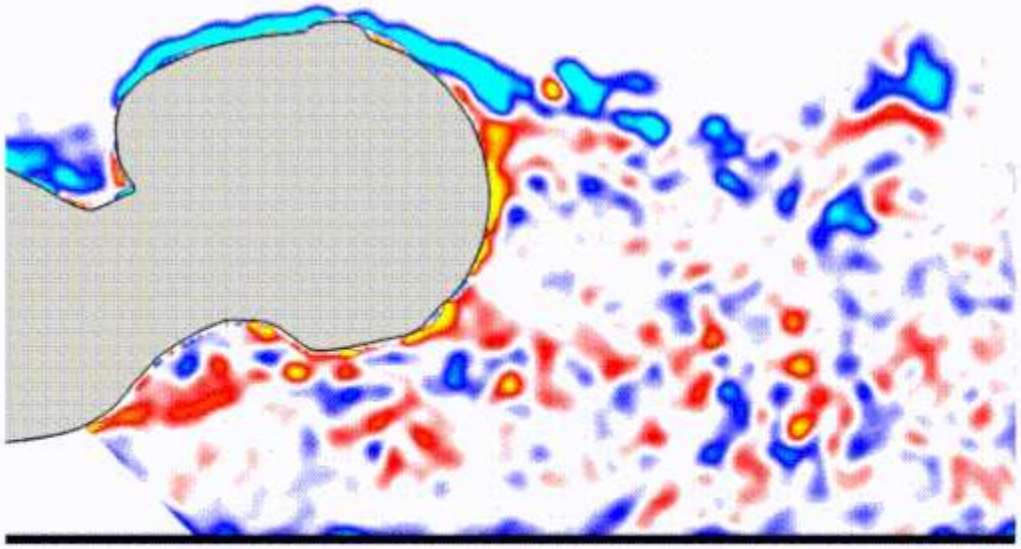


DIPV, VIDEO TECNICHE COMPOSTE DI MISURA DELLA POSIZIONE E DELLA VELOCITA’

AERODYNAMICS, PROF. BOHL, CLARKSON UNI

LASERLIGHT WIND TUNNEL WEI, NORTHWESTERN UNIV.

DPIV VIDEO MEASUREMENT BEHIND THE HELMET, AIR TURBOLENCE



SKELETON, PARTENZA NATHAM CRUMPTON,YANQING

ENSO EISKANAL ALTENBERG SAXONY

CENTRO DI PROVA ESTIVI CON MOTO DI ROTOLAMENTO

SPINTA ALLA PARTENZA COME RIFERIMENTO FONDAMENTALE DEI TEMPI DI PERCORRENZA


SEIZ
SWE

SIMULATORI FERRARI, BMW

BOBSLED SKELETON, LUGE

eSports?

MEDICINA-INGEGNERIA