

Paper on Air Fan Design & Selection (Analogous to Water Pump Selection)

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PhD Mechanical, Charisma University (Year 2020)

Assoc Prof (in MVAC teaching) Chu Hai Advance College of Education HK (2021-2022) PT

FCIBSE, FCIPHE, MASHRAE, MHKIE (BS), FHKICA, FIE.Aust (Mechanical), FIMechE

HK Govt EMSD REA,

HK Govt BD AS (Ventilation), RMWC Class 3 (MVAC)

HK Govt WSD QPs, RPC & AR,

HK Govt ITC HKAS HKICA Registered Carbon Auditor, HOKLAS Assessor

HK Govt DSD EME (Year 2000-2002)

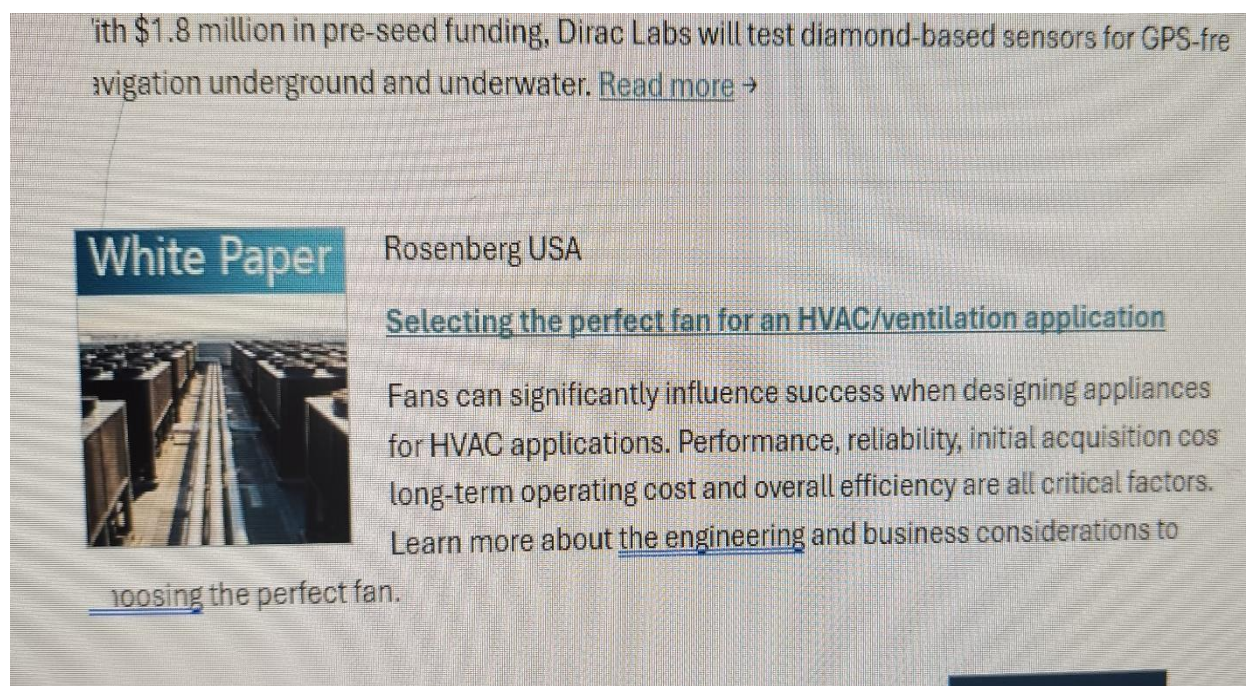
HK Polytechnic University, Lecturer in Building Services Dept (1995-1999) FT

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ABSTRACT/CONTENT

Arising from an extract on fan as below, this paper will go in depth to the design and selection of fan. Knowledge & principle are applicable to pump design & selection.



Different fan for different applications, propeller, centrifugal, inline ducted, or external. Ventilation air duct should use external belt linked centrifugal fan (fan motor outside air duct), not allow AC air to pass over fan motor, which is hot, may catch fire, smoke flow via air duct to everywhere.

Jet fan is suitable for carpark, fan sucked air from fan before and blow forward, continue to blow air to whole carpark. See below photo of jet fan. Compliments to Savwo Airflow to guide me to get these Jet Fan photos to let readers easily appreciate jet fans. Thank Google good search engine.



JET FAN ANIMATION-4K(AXIAL FAN)

YouTube · Engineering Master
2025年7月2日

查看全部 >

圖片



IJB Series - Induced Jet Fan
Kruger



JETFANS - AXIAL JET / TUR...
GTG Industries Sdn Bhd



High-Performance Jet Fans | ...
Marut Air



GELEC
GELEC



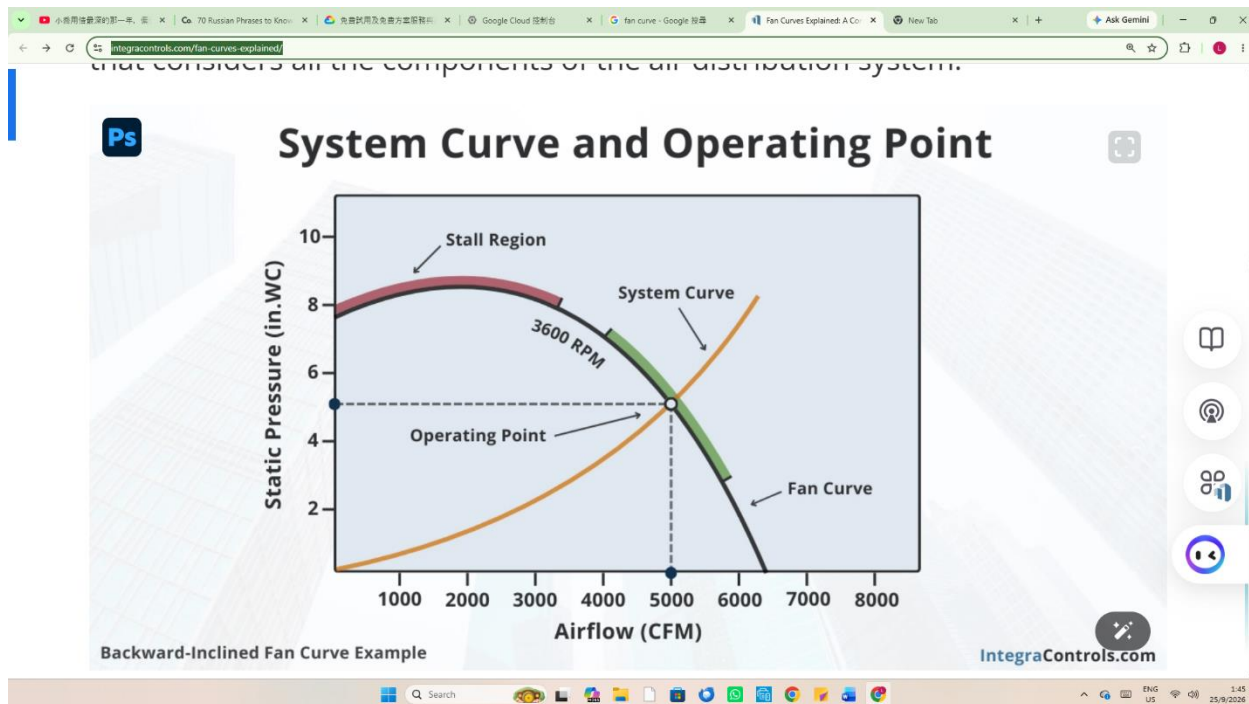
Axial Jet Fan Sistemleri - Cvs...
Cvsair



Kruger
Kruger

Propeller fan good for market, for cooling and ventilation inside market, also for use in toilet exhaust fan. For basement arcade, beside mVAC, need exhaust fan to create vacuum and suck in fresh air, and propellor fan to reinforce cooling, reduce MVAC energy. Select the right size and power of fan. Firstly, calculate the total static pressure of air flow in air duct, take the longest critical path, the highest air resistance, then determine the fan motor power from this pressure and the minimum air flowrate from CIBSE and ASHRAE for the occasion. Different air change per hour for different occasions. With ventilation flowrate and static pressure, can select the right size of fan from the fan curve catalogues provided by fan suppliers. Fan blade has forward and backward curve shape, different characteristics for different usage. Usually choose backward blade fan to limit fan energy at too high speed. Can all show in fan curves diagram for designers to select fan and know fan

power & efficiency, add 20% to fan BHP to get fan motor power rating. Underestimate the static pressure, select not correct fan power and flowrate to suit the purpose on the occasion can cause mal functioning or oversizing of fan.



Find the critical path of air duct to cover the longest friction to get the highest static pressure for the fan at different air flowrate, to form the system curve above. Find the frictional pressure ΔP by Darcy-Weisbach formula below. ΔP depends on length L of air duct, velocity V of air, diameter of air duct D , density of air. Substitute different V to get different Static Pressure at different air flowrate to form the system curve above. Obtain the fan curve from fan manufacturer to get the fan curve. The intersection of the fan curve and static pressure point is the operation point. Then know the fan speed is 3600 RPM, then order that fan from manufacturer. Also from other fan curves you can find the power and efficiency of the fan at the operation point. See the fan curves below.

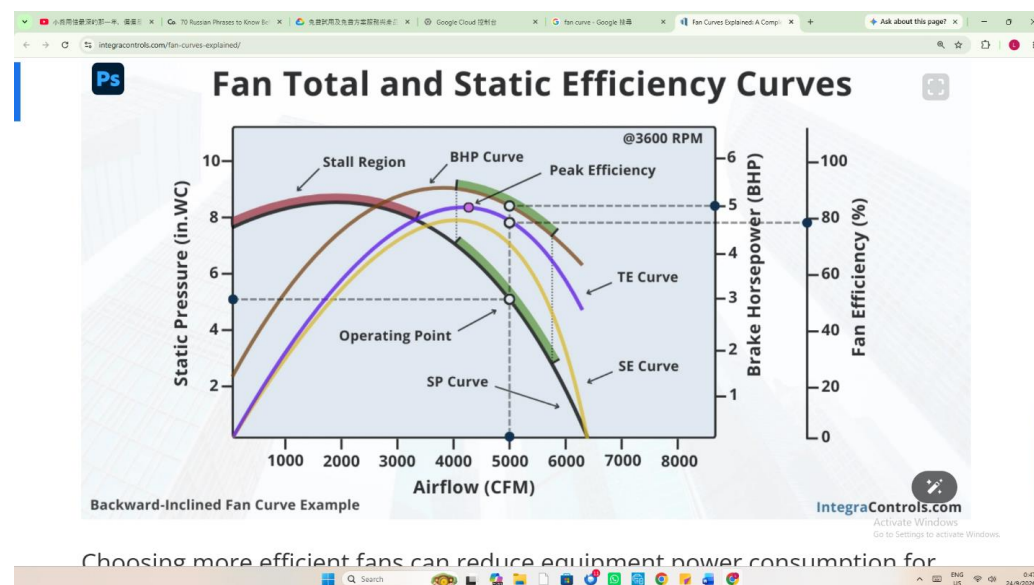
1. Correct Formula for Air Flow: Darcy-Weisbach

The [Darcy-Weisbach equation](#) is the universal, physics-based method used to calculate pressure drop due to friction in fluid systems, including gases like air. [Turn2Engineering +1](#)

$$\Delta P = f \cdot \left(\frac{L}{D} \right) \cdot \left(\frac{\rho \cdot V^2}{2} \right)$$

- **ΔP :** Pressure drop or friction resistance (Pascals, Pa)
- **f :** Darcy friction factor (dimensionless, found using the Moody chart or Colebrook equation)
- **L :** Length of the pipe or duct (m)
- **D :** Hydraulic diameter (m)
- **ρ :** Density of the air (kg/m^3 , which changes based on pressure and temperature)
- **V :** Air velocity (m/s) [hydrastore.co.uk +1](#)

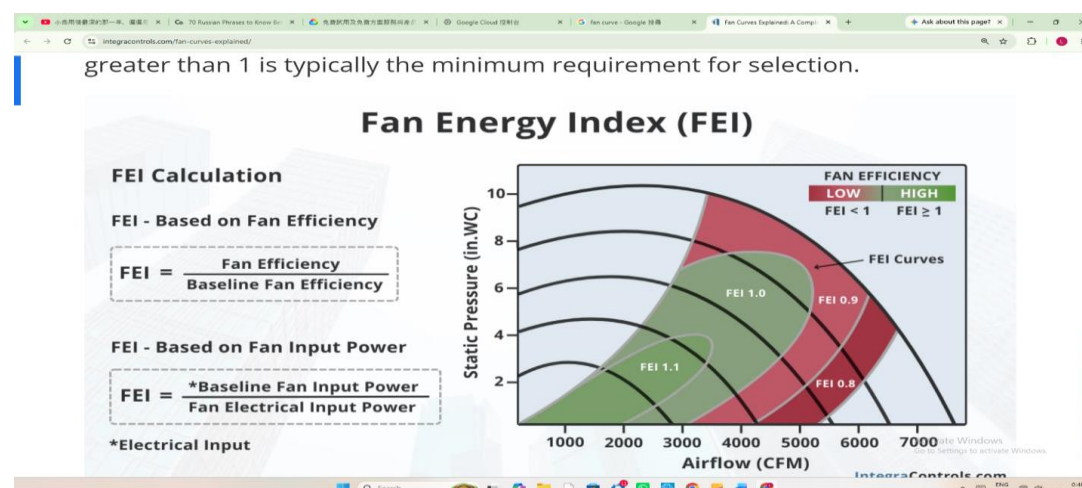
Row 2



From the particular fan u choose, look at the operation point RHS to find the Brake horse power (BHP brown curve)and efficiency (purple colour curve) of the fan. Then add 20% to BHP to find the motor power for the fan to cater for the required BHP.

Find water pump is same procedure for find air fan. Get pump curves from catalogues of pump manufacturer. For water pump, add the gravity head to the friction head as total static pressure as water is much heavier than air. Use the water density 1000 kg per cubic meter (1 gram per cc) to replace the air density 1 kg per cubic meter (for 1.3 kg per cubic meter). To be exact, need to add in the pressure drop losses when air flow through the air damper, diffuser, air filter for total air static pressure calculation. And fitment pressure losses when water flow through the valves, bend, Tee, reducer etc} for calculate the total water static pressure. Find these fitments pressure losses from ASHRAE, CIBSE, CIPHE manuals, handbooks. Not calculate right, find fan or pump not suitable, either too small power cannot cater for the pressure/flowrate required, or oversize the pump, fan. With Cap 610 Energy Efficiency Ordinance, need REA to check whether E&M installations are oversized. I am REA, often check new E&M installations via COCR and renovation via FOC to submit to EMSD. Failure to comply Cap 610 can delay owners letting out premises, owners lose rent. Rent can be very big amount if whole floor or whole building cannot let out.

How do fan catalogues curves are made by their manufacturers? They use the design formulae as below to formulate the Air flowrate curve, Static Pressure curve, power curve, Fan Efficiency curve in their fan catalogues. Compliments to Integra Control to provide the valuable formulae/curves and info to help me to prepare this paper. Thank Google good search engine.



integracontrols.com/fan-curves-explained/

CFM₂ = CFM₁ × $\left(\frac{RPM_2}{RPM_1}\right)$

Fan Law 2 - Static Pressure

SP₂ = SP₁ × $\left(\frac{RPM_2}{RPM_1}\right)^2$

Fan Law 3 - Brake Horsepower

BHP₂ = BHP₁ × $\left(\frac{RPM_2}{RPM_1}\right)^3$

OPERATING POINT 1			
RPM1	CFM1	SP1	BHP1
3600	5000	5	4.2

***If RPM decreases by 10% RPM₂ = 3240**

Applying Fan Laws

OPERATING POINT 2			
RPM2	CFM2	SP2	BHP2
3240 (-10%)	4500 (-10%)	4.05 (-19%)	3.06 (-27%)

IntegraControls.com

The multiple fan curves for the different RPM values provide information on the changes in airflow, static pressure, and brake horsepower characteristics, aiding in the selection of the mechanical equipment for different applications.

words, a 10% decrease in RPM will lead to a 19% drop in static pressure.

- **Fan Law 3:** Brake Horsepower (BHP) changes with the cube of RPM. This means a 10% decrease in RPM will lead to a 27% cut in horsepower.

Ps

Fan Laws

Fan Law 1 - Airflow

CFM₂ = CFM₁ × $\left(\frac{RPM_2}{RPM_1}\right)$

Fan Law 2 - Static Pressure

SP₂ = SP₁ × $\left(\frac{RPM_2}{RPM_1}\right)^2$

Fan Law 3 - Brake Horsepower

$\left(\frac{RPM_2}{RPM_1}\right)^3$

Fan Law Example

OPERATING POINT 1			
RPM1	CFM1	SP1	BHP1
3600	5000	5	4.2

***If RPM decreases by 10% RPM₂ = 3240**

Applying Fan Laws

OPERATING POINT 2			
RPM2	CFM2	SP2	BHP2
3240 (-10%)	4500 (-10%)	4.05 (-19%)	3.06 (-27%)

Need familiar with formula Hazen- Williams for water, Darcy-Weisbach to calculate the flow friction, and add the pressure drop across each fitment from professional institutions manuals/handbooks. Add gravity head for water flow calculation. Gravity pressure head can be neglected in air flow as air is light, but significant in water flow. Calculations are usually done by excel sheets which I have, fast and accurate. No more use manual calculations.



REFERENCES

1. CIBSE Guide B2 on ventilation
2. ANSI/ASHRAE 62.1, 62.2 on Ventilation & IAQ
3. CIPHE design guide, <https://www.ciphe.org.uk/members-and-shop/shop/design-guide/>
4. Beam Manual (New Building, NB) version 2 on IAQ
5. Integra Control :<https://integracontrols.com/fan-curves-explained/>
6. Savwo airflow
https://store.savwo.com/products/airflow-jetfanx?srsltid=AU7gw4XT-djiOg_7r02hCCLLbpHdqhpKYgJ4zygTfbxZaSOVB9sB7CJro

APPENDIX 1 : Qualifications of Ir Dr Assoc Prof KP Samuel Lip, (v8.8.2026)

Academic & professional qualifications

Proprietor & Founder of Lordray Engineering Co. Ltd. (www.lordray.com.hk)

Proprietor & Founder of SMA (Macau) Consultant & Construction Co. Ltd.

Proprietor & Founder of SMA (Australia) Consultant & Construction Co. Ltd.(progressing to register)

Proprietor & Founder of SMA (Germany) Consultant & Construction Co. Ltd. (progressing to register)

PhD Mech, PhD(Structure) student, HD&HC (Civil), MSc, PgD, BSc,

CEng (Construct), CPE, RPE, RCM, CBE,

FCABE, FCIBSE, FIMechE, FCIPHE, FHKICA,

FIE.Aust (E&M), MHKICM , MIET, MASHRAE, MIFireE,

MHKIE (BS, Elec, Fire, CAI).

Fire Services Experience

MSc Fire, PgD BS

MIFireE, MHKIE (Fire),

Thorn Security (HK) FS Company, Senior Engineer 2002-2006, Samuel did Airport new wing extension FS installations & commissioning.

Lordray did Airport new extension FS installations with Build King IEM company 2020 plus.

Lordray did miscellaneous FS hydraulic calculations for pml on FS upgrade eg at TST, Jordon bldgs and MTR louvre size calculation for subcon 2013

FSD Standard Safety Advisory Group 2005 Samuel nominated by HKIE (https://drive.google.com/file/d/1ns-g3ZmIy5p6GZJ-cg1rSniD_8kY1iTu/view?usp=sharing)

Lordray doing FS314, 501, 501A work since 2013

Lordray doing FS502, 572 work since 2013

Samuel as Guest speakers in giving FS talks to corporations and institutions



Assessor & Auditor REA Experience:

BSc Elec, PgD BS, MSc Fire, PhD Mech, HD&HC Civil

EMSD REA since 2010 Cap 610. Do Energy audit, FOC, COCR since 2010

FCABE (Panel Interviewer/Chairman), VTC E&M Assessor. HK Beam Society, Beamplus Technical Expert (2013) (Assessed New Bldg. Beamplus award applications), HOKLAS Assessor, Govt QSPs (Samuel & Lordray) Carbon Auditor, HKICA Reg. Carbon Auditor. Done 10 energy & carbon audits for Fugro, and ongoing with Fugro International Corporation at Tuen Mun & Kwai Fong.

Training & Education Experience:

BSc Elec, PgD BS, MSc Fire, PhD Mech, HD&HC Civil

RPE, MHKIE, HKIE Scheme A Engineering Supervisor (BS, Env) for Viewco, Telemax, Paul Y since 2018. HKIE only allow maximum 3 companies employers. Have to turn down others for seeking me as engineering supervisor.

Lordray's SMA is Govt OGCI0 Dept Reg. Training School, UK TQUK branch in HK (Training Courses are recognisable by CIBSE), Senior Curriculum Manager in EMHK (www.emhk.org) (2013-2023)

Lecturer (FT & PT) in HKU, PolyU, CityU & SCOPE, VTC IVEs (1995-2018) teaching students from High

Certificate level to Master degree level, then continue to teach in own SMA school to industrial peers and as Guest Speakers in giving various engineering disciplines talks to corporations and institutions

Building & Survey Experience:

PhD (structure) in progress, publishing construction papers

HD & HC in Civil Engineering

FCABE Chartered Building Engineer,

Member of Australia Institute of Building

Registered Construction Manager, MHKICM

BD RMWC Class 1 certify minor work completion certificate for subcon since 2020.

BD AS(Venti), BD RMWC3

Building Survey on Gratia College (Shek Kip Mei) for own Lordray project 2024,

Building Survey at TST1881 Hotel for Paul Y in 2018,

Elevator & lift experience:

BSc Elec, PhD Mech

MIAEE

EMSD Registered Lift Engineer Exam(written test passed in 2012). Assistant Manager in Chevalier Lift Company (2012-2013). EMSD Lift Legislative Branch, Contract EME (2001-02). HKHA Maintenance Dept, Lift Maintenance Branch (1979-81)



Electronic Security & Access Control Experience:

BSc Elec

MHKIE (Elec, CAI), MIET

HK Police Electronic Security Cat 3, & electronic security D licence,

Lordray did electronic security & access system, CCTV, audio visual, PA for a catholic church at Tai Po 2022

Thorn Security (HK) Tyco Group, Senior Engineer, done electronic security installations in CLP substations, MTR stations 2002-06

Plumb Drain Experience:

PgD BS, PhD Mech

FCIPHE, FCIBSE, FIE.Aust(E&M)

WSD QPs, RPC (AR),

RPE (BS) in site plumb drain FS pipes Interim Inspections & pipes hydraulic testing since 2013, notably for Paul Y Data Centre Bldg in airport

Nominated Tutor by WSD Registered Trainer EMHK to provide CPD training to LPs for WSD award (gold, silver, bronze) (2013-2023)

DSD Project Dept, Temporary EME(1999-2001)

Electrical & Building Services Experience

BSc Elec, PgD BS, PhD Mech

RPE, MHKIE(Electrical, BS),

REW(C0), MIET, FCIBSE, MASHRAE, FCIPHE, FIE.Aust (E&M)

EPD Registered Consultant for EV Chargers design & installation since 2020

WR2 work at Lohas Park estates 2021, Tuen Mun Supermarket 2022, which need REW(C0)

ICE, CxA work since since 2020

ICE & CxA, Beamplus T&C experience

BSc Elec, PgD BS, MSc Fire, PhD Mech

RPE, MHKIE(Electrical, BS), REW(C0), MIET, FCIBSE, MASHRAE, FCIPHE, FIE.Aust (E&M)

RCx Pro, CxA, ICE

Lordray is Nominated Consultant of Gammon since2025 & REC since 2020,

Tutor in EMHK teaching Beamplus classes to LPs (2013-2023)

CxA in Beamplus T&C compliance for Fugro at Long Ping estate 2023, Gammon at Cyber Port Extension 2025 and some subcons since 2020.



HK Beam Society Technical Expert 2013 in assessment of Beamplus award applications

MVAC experience

PhD Mechanical, Post Graduate Diploma (Building Services)

FCIBSE, MASHRAE, BD AS (Ventilation), PhD (Mechanical), FIMechE, FIE.Aust (E&M)

Sizing for AC duct for subcon at Kowloon Bay 2020

Investigation of chiller failure and cooling towers discolouration, did report for Build King IEM at Wanchai Sport Ground and Causeway Bay bldg 2020

Tutor on BD AS (Venti) exam preparation course, Data Centre MVAC, Psychiatric Chart usage, for own SMA Training school since 2020

Consultant employed by Chun Wo for toilet upgrading ventilation contract in airport 2020.

RPE (BS) to certify cooling towers operation satisfactory annually to comply with EMSD COPs at zero carbon centre at Kowloon Bay, and for subcons in HK everywhere since 2020

REA doing COCR and FOC for Chiller installations for subcons and Lap Kei MVAC HKEx listed company since 2020

Lifting & Hoisting experience

FIMechE, FIE.Aust (Mechanical), PhD Mechanical

Lordray did wheelchair and elderly bed mechanical certification for Jockey Club charity organisation 2024

Lordray did 25 heavy metal gates mechanical certification for CIC 2024.

Lordray did Tower crane mechanical certification at Gammon Construction site at Lohas Park 2021

Lordray did investigation and rectification report for entrance metal gate failure at an estate at So Guan Wat, Gold coast 2023.

Lordray did mechanical load test for luminaires mounting 2023

Appendix 2 : Asset

Lordray offices (3 self-owned properties in The Cloud, 111 Tung Chau Street, Tai Kok Tsui, HK) description video weblink

https://drive.google.com/file/d/1MMkDRsRpMOaBcdzEnpJU7-6pj_wKI6Eb/view?usp=share_link

Kindly refer to Appendices of this papers for more details of author Samuel and his Lordray Holding Group which author Samuel is Founder and Proprietor since 2013.