INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH
TECHNICAL VISIT TO PEAK TRAM ON 12/4/2014

IMechE-HKB delegation to visit Peak Tram [Edmund K.H. Leung]

General

Outside St. John's Building on Garden Road and The Peak Tower is always long queue for thousands of local residents and visitors of Hong Kong to ride the Peak Tram to and from the Victoria Peak every day. Notwithstanding being one of the world's oldest and most famous funicular railways in the world, it is a piece of interesting mechanical engineering establishment which is however rarely appreciated from the mechanical engineering perspective. Therefore, the technical visit to the Peak Tram organised by Institution of Mechanical Engineers Hong Kong Branch (IMechE-HKB) in the morning of 12th April, 2014 (Saturday) provided 20 privileged delegates to glance the engineering of this crown jewel of the tourism of the territory.

Vintage and Tradition

Peak Tramways Co., Ltd. first operated the Peak Tram on 30th May, 1888. Since then it has undergone five (5) generations of evolution as tabled below:-

Generation	Period	Feature(s)
First	1888 – 1926	Coal-fired steam-driven
Second	1926 – 1948	Electrified, 52 passengers
Third	1948 – 1959	62 passengers
Fourth	1959 – 1989	72 passengers
Fifth	1989 – present	120 passengers + 1 driver

The entire Peak Tram system was modernised to the current fifth generation in a three (3) month outage in 1989, when the Haulage Room and tramcar were retrofitted.

The glorious engineering past of the Peak Tram is exhibited in the Garden Road terminus (Lower Terminus), when the plants and equipment in the Haulage Room prior to the retrofit in 1989 is displayed. The Haulage Room manned an operator to control the drive and stop of the tramcar, with whom the driver on board communicated with bells in the tramcar. The drive displayed was the vintage 1926

model, and the power conversion principle from alternative current (a.c.) to direct current (d.c.) remains in use to date.


Metropolitan Vickers-made direct current generator operated until fourth generation [Edmund K.H. Leung]

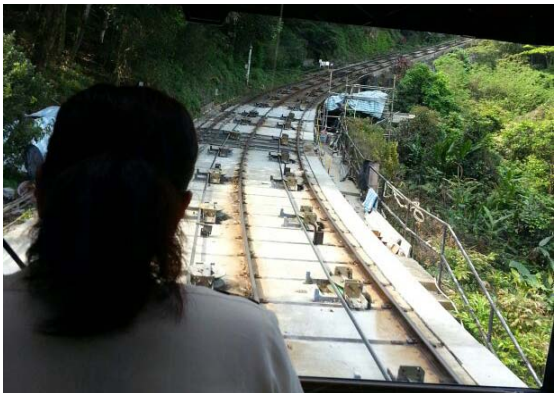
A section of the 1907 wooden tramcar was replicated. The first role was reserved for the Governor of Hong Kong and the copper-made sign plate attached on the seat back of the replica is the genuine piece made in 1888. Paper tickets were issued and validated by a puncher held in the conductor's hand and, of course being a Crown Colony at the time, the puncher was made in England.


Vintage ticket desk and conductor uniform displayed to illustrate Peak Tram history [Edmund K.H. Leung]

In commemoration of the 120th anniversary, on 30th May, 2008 the general public was offered a ride on the Peak Tram at the fare of 120 years ago, 30 cent Hong Kong, which proceeds were donated for charity. The public was much attracted and the queue for the special Peak Tram experience was endlessly long.

The terminus at Victoria Peak, The Peak Tower (Upper Terminus), has also undergone three (3) waves of major changes. It was first built in 1972 and re-developed in 1996. In 2006 it was extensively refurbished to the current contemporary form. Stepping into 2013, the Peak Tram celebrated its 125 years of service and record high passenger number of 6.2 million. With the continuous increase of passenger number is foreseen, the sixth generation of system upgrade is contemplated.

Infrastructure


Corner turn (harbour-side on the right) [W.H. Tsang]

Peak Tram is a double reversible funicular system. Two (2) tramcars run on a single track, with a cross-over (passing loop) mid-way along it. The tramcars are pulled uphill by Haulage Rope connected to a twin-drum in the Haulage Room beneath the Upper Terminus at the Peak Tower.

The track is 1,575 mm and 1,364 m in gauge and length respectively. The

largest gradient of the track is 27 degrees. Between the Upper and Lower Terminus at 296 m and 28 m above sea level respectively, there are nine (9) bridges and five (5) stops, namely Kennedy Road, MacDonnell Road, Magazine Gap Road, May Road and Parker Road. After 10:00 on weekends, these stops are by-passed in order to carry the large number of passengers between the terminuses.

Between May Road and Parker Road stops is a corner turn and passing loop for the tramcar pair to pass each other. One track is by the hill slope (hill-side) and another track is by the edge of the track route facing towards the famous Victoria Harbour (harbour-side). Next to Kennedy Road stop is a former tramcar garage where outside a fourth generation tramcar is parked permanently.

Hatch for lifting Haulage Room equipment to exit platform at Peak terminus [Benny C.Y. Sit]

Power-train and Drive

Haulage Room

The Haulage Room is beneath the platform of the Upper Terminus, well blended into behind the shops and merchants inside The Peak Tower. The heavy equipment is moved into and out of the Haulage Room through the hatch on the exit platform floor by the well-hidden hoist above the hatch.

Power-train

In spite of the power supply is a.c., the convention of driving of the Peak Tram with d.c. power in the form of motor-generator set, or "MG set", is retained to date. Power supplied from the main is 380 V a.c., which drives a 560 kV a.c. motor. The a.c. motor couples with a 545 kW d.c. generator to generate electricity to power a 510 kW d.c. motor. The motor shaft power turns a gearbox and, finally the output torque of the gearbox operates the Haulage Drum, pulling and releasing the tramcars in pair uphill and downhill respectively.

The "MG set" was an inheritance of the design in the past, when only d.c. motor could provide the level of controllability required. Nowadays a.c. motors are so advanced that the output variation quality is comparable with the conventional d.c. motors, whereas the frequent service of d.c. motors has become an issue for the Peak Tram. A

560 kV a.c. motor (blue; left) coupled with 545 kW d.c. generator (red; right) inside Haulage Room [Benny S.Y. Sit]

local shipyard with d.c. motor overhaul services is engaged to service its d.c. motor at two (2) year interval. Moreover, while d.c. motors are being phased out and no long commonly sold, to improve reliability, the Peak Tram has kept in stock additional d.c. motors proprietarily made by the Swiss original equipment manufacturer of the power-train system so that where replacement is required, it can complete in seven (7) hours.

The gearbox steps-down the speed from 1,600 r.p.m. at the d.c. motor to 25.5 r.p.m. for driving the Haulage Drum, and is lubricated once every quarter.

Benefited from the counter-weight principle of the tramcar, the "MG set" is not as energy-consuming as it may be perceived. Its power consumption is told lower than which of the air-conditioning chillier inside the Lower Terminus.

d.c. motor (blue, left), gearbox (red, middle), coupling (behind fence) and Hauling Drum (yellow far right) [W.H. Tsang]

Braking systems

Brake is applied on the braking flange on the Haulage Drum by either the Service Brake or Emergency Brake. The Service Brake stops the tramcar pair in 60 m whereas the Emergency Brake intervenes automatically if the tramcar speed exceeds 6 m/s to stop it in 20 m. The braking force is applied on the Haulage Drum by the spring load pressing the brake pads on the Haulage Drum flange. The brake is released by the hydraulic force acting against the spring load and, where the hydraulics fails the brake applies for the fail-safe operation. The springs are subject to regular testing to warrant full functionality.

On-board braking system installed on the tramcars applies when the tramcar is over-speed at 7.2 m/s. Braking is achieved by clamping the track and the system is tested annually, while the testing by the percentage of over-speed takes place on the straight sections of the track.

Hauling Ropes

Emergency Brake (top) and Service Brake (bottom) apply brake on the brake flange on Haulage Drum [Benny C.Y. Sit]

The single piece hauling rope is 1,540 m in length and 44 mm in diameter. Each tramcar has its dedicated rope, which is wound on the same twin Haulage Drum in opposite direction of each other. The hauling rope tension is monitored and, if the rope is too loose and touches the ground the entire system will stop for safety. Minor electric current is flown through the rope to observe the rope's integrity. Where the current is noted broken, the rope is likely to have failed and hence the system will stop.

With safety factor of four (4), the U.K.-made Hauling Rope is inspected weekly and examined the condition in every six (6) months, though low level of wear and tear has been observed. Though with six (6) years of design life, once every three (3) years the hauling rope in pair is replaced. The last replacement was on 14th March, 2014, which had taken five (5) days of 24 hour work. The new rope was first tied with the old rope in the Lower Terminus and then pulled to the Upper Terminus by the old rope. Once reaching the Haulage Room at the Peak, the old rope is removed from and the new rope was installed onto the Haulage Drum.

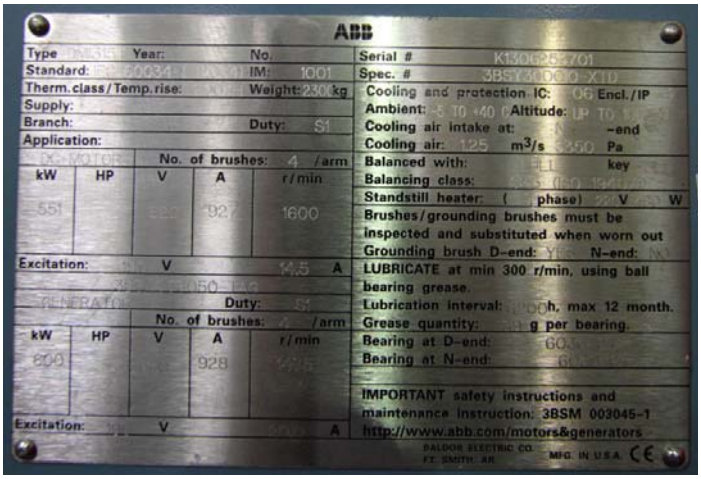


ABB-made d.c. motor rated power 551 kW (620 V and 927 A) at 1,600 r.p.m. for driving Haulage Drum [Benny C.Y. Sit]

The Hauling Rope for the "Green Car" is wound from the top of the Haulage Drum whereas the "White Car" from the bottom so that, when the Drum turns either clockwise or anti-clockwise one rope always acts in the opposite of another rope. The two (2) ropes leave the Haulage Room through the deflection sheaves to offset each other.

Tramcars

The German-built aluminium alloy-bodied "Green Car" and "White Car" of up to 30 tonnes travel at maximum speed of 6 m/s on straight run, whereas upon negotiating the corner turn between May Road and Parker Road the speed is reduced to 4 m/s. At one tramcar is turning the corner, the other tramcar is about at MacDonnell Road stop and is slowed down and, once the corner is passed the speed picks-up again.

Haulage Room beneath the Upper Terminus [Benny C.Y. Sit]

Power on the tramcars is provided by the on-board batteries, which are charged at the terminuses during passenger boarding. Where the output voltage is below 19 V the tramcar is put out-of-service.

The tramcars and the Drive Station are communicated wirelessly through an antenna installed on the ground along the track.

Operations

Track change

The Von Roll Transport System of Switzerland-made tramcars are in pair acting as counter-weight of each other. The tramcar which travels along the hill side of the dual track is identified "White Car" and the other "Green Car". They never run into each other because the wheel-sets are specially profiled to allow the "White Car" to travel on the hill-side passing loop and the "Green Car" on the sea-side. This is attained by the asymmetry of wheel profile on the same axle.

In normal trains, the wheels on the same axle are single-side flanged at the inner side to guide the wheel-set to stay on the rail gauge. In the Peak Tram, however, one side of the axle has dual flanged wheel and another side flat wheel. The former wheel guides the wheel-set with its dual flanges embracing the rail head to keep running on the designed track whereas the latter wheel on the same axle lets the former wheel to guide freely, enabling the tramcar to be steered at the track cross.

Deflection Sheaves offset the Hauling Ropes leaving the Haulage Room [Benny C.Y. Sit]

On the "White Car", the wheel on the hill-side is dual flanged which steers

the "White Car" to run on the hill-side of the passing loop. On the "Green Car", however, the arrangement is the opposite, that the dual flanged wheel is on harbour-side of the track, guiding the tramcar to use the harbour-side passing loop. As a result, two tramcars run on their dedicated side of the passing loop upon passing each other without the deployment of railroad switch.

Passing Loop, outside May Road stop (left hill-side for "White Tramcar") [W.H. Tsang]

Maintenance and man-power

24 and 32 engineering and operating staffs respectively work for the Peak Tram on two (2) shifts. Routine maintenance is carried out once every week at night. The trench at the Upper Terminus is utilised for the maintenance of the tramcars.

Control panel inside Drive Station locates at the Upper Terminus [Benny C.Y. Sit]

The operation of the Peak Tram is led by the Engineering & Operations Manager, whose under is an Engineer and then four (4) Operator stationing in the Drive Station. Although fully automated, a Driver is still deployed to monitor the conditions of the track and slope to warrant operation and passenger safety.

It is the statutory requirement for the Peak Tram to have a supervisor on duty to hold responsibility for the operation at the time of the Peak Tram is running. This supervisor is either the Manager or Engineer. The Operators are all trained and assessed internally and approved by the regulatory body, Electrical and Mechanical Services Department (EMSD) of the government. The Drivers are also subject to internal training and assessment.

Adjacent to The Peak Tower where the Peak terminus locates is 1 Lugard Road. The Grade III-listed building is the office of the Peak Tram, which is rented from the government through operating licence.

Drive Station

The Drive Station on the boarding platform of the Upper Terminus accommodates the Siemens-made SIMATIC S5 micro-processors-controlled haulage computer and communication computer. The Swiss-designed haulage system enables the operation to be fully automatic, while the Operator panel provides analogue display of the location of the tramcars along the track.

Law and Regulation


Peak Tram's office on 1 Luguard Road at the Peak [Benny C.Y. Sit]

The operations of the Peak Tram are governed by Hong Kong Ordinance Chapter 265 "Peak Tram Ordinance". By the Ordinance, the government grants the operation of the Peak Tram on a ten (10) year licence. Currently, however, the Peak Tram is operating on a two (2) year temporary licence, and negotiation with the government for the normal ten (10) year licence is underway. Peak Tram is also required to notify Transports Department (TD) and EMSD any service disruption so that sufficient TD may mobilise sufficient alternative transport means to divert the Peak Tram passengers.

Chapter 265A is Peak Tramways (Safety) Regulations. One key mandatory requirement is the employment of a surveyor to examine the braking and safety devices as well as the Hauling Rope. The Regulation also stipulates the employment of engineering superintendents responsible for the supervision of operation and maintenance is mandatory.


Exhibition of vintage powe-train (fourth generation) at the Lower Terminus [Benny C.Y. Sit]

Chapter 265B is Peak Tramways By-Laws. An interesting note is, though Hong Kong's sovereignty was handed-over to China in 1997, the colonial clauses of no

weapon carrying except Her Majesty's forces was not revised until 2012 (Cap. 265B by-law 25).

The Peak Tram complies with, "Code of Practice of Design, Manufacturing, Installation, Operation and Maintenance of Funicular Railway" published by EMSD in all aspects of peak tram operation. The Code of Practice (CoP) is the statutory publication principally based upon European Union and Swiss regulations on funicular railways, and subsequently has been reformed to "CoP of Design and Construction of Peak Tramways".

Future Development

With the ever increasing passenger number, the Peak Tram is actively planning to expand its capacity. The contemplated sixth generation of tramcar is over 50 tonnes in total weight with hauling rope of 55 mm diameter. The current "MG set" will be replaced with variable speed a.c. motor package. The increased payload will put extra pressure on the existing infrastructure, and consultant has been engaged to review and identify the areas to be strengthened.

Remarks

No question the Peak Tram is an ever-green icon and ambassador of Hong Kong to the world. Nevertheless, its mechanical engineering behind has delivered the outstanding performances of the only funicular railway in the territory in terms of safety, reliability and comfort. IMechE-HKB was grateful to be able to duly recognise and honour its accomplishments through this rare technical visit.

IMechE-HKB delegates were privileged to be offered Peak Tram Sky Pass for access to Sky Terrace 428 [Benny C.Y. Sit]

The organiser wishes to express the whole-hearted appreciated to Mr. Chiu-Fai Kwan, Engineering & Operations Manager of Peak Tramways Company, Limited and his colleagues for their generous hospitality.

The official Peak Tram websites are following:-

http://www.hshgroup.com/en/Property-Management-Portfolio/Country-Clubs-and-Services-Management/Peak-Tramways.aspx
http://www.thepeak.com.hk/en/5_5_1.asp

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Encl.
WHT

Photographs were taken by Mr. Edmund K.H. Leung, Mr. Benny C.Y. Sit and Mr. W.H. Tsang with permission to use.

IMechE Hong Kong Branch
Activity Sub-Committee
Local Technical Visit Group

TECHNICAL VISIT
THE PEAK TRAM

Institution of MECHANICAL ENGINEERS
Improving the world through engineering

Successful registration will be notified in due course

Date: 12 April, 2014.

Time: 0830 hrs. to 1130 hrs.

Since its commercial operation on 30th May, 1888, the Peak Tram is seen in postcards, movies and television series and ridden by millions of tourists from all corners of the world. The Peak Tram is always an icon and ambassador of Hong Kong. IMechE-HKB is privileged, for the first time ever, to go into the Peak Tram to learn about its engineering excellence in providing safe and comfort journey to passengers over a century.

The activity is free of charge. Places are limited to 14 and priority is given to IMechE members.

Registration and Enquiries

For registration, please visit IMechE and HKIE webpage:
http://nearyou.imeche.org/near-you/north-east-asia/hong-kong/events

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