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PHILIPPINES UNDERGROUND SPACE AND TUNNELS, PAST PRESENT AND POSSIBLE FUTURE

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Abstract: As the Philippines continues to grow and develop the demands of the growing country puts pressure on existing Infrastructure and services to provide much needed water supply, drainage, irrigation and transport to meet those increasing demands. There have been some significant tunnels and underground infrastructure built and this paper will outline the legacy and old networks and how the country is developing and expanding its underground facilities and infrastructure to meet that demand. Metro Manila, Metro Cebu and Metro Davao are some of the major urban areas that are looking at developing underground solutions to provide a balance to new metro lines and road networks to ease significant traffic congestion as well as meet urban growth demand from other sectors such as water, sewage, flood and power. A country with significant challenges in social, environmental and geohazards is continuing to grow rapidly with one of the quickest growing economies in Southeast Asia. This paper explores the past, present, and future of underground spaces and tunnels in the Philippines, examining their historical significance, current applications in transportation, utilities, and potential to be applied to future infrastructure development. As the country continues its economic ascent, the strategic use of underground spaces and tunnel options will be crucial in ensuring sustainable urban growth, ease of movement and resilient infrastructure development.

Keywords: Underground Space, Tunnels, Infrastructure, Rail, Road, Water, Transport, History, Philippines

1. INTRODUCTION

The Philippines, an archipelago of over 7,600 islands with a rich history shaped by its strategic location in Southeast Asia. From pre-colonial societies and Spanish colonization to American rule and eventual independence, the nation has undergone significant transformations. In recent decades, the Philippines has emerged as one of Asia's fastest-growing economies, driven by a booming services sector, remittances from overseas workers, and increasing foreign investments. Since the Duterte administration from 2016 to 2022 there has been a much-needed focus on improving much needed infrastructure in the Country across all sectors and this has been extended by the current Marcos administration. Much of this development is being partly funded and supported by Japanese International Cooperation Agency (JICA), Asian Development Bank (ADB), and Asia Infrastructure Investment Bank (AIIB). Many local developers and investment organizations are also helping to develop the much-needed infrastructure through PPP projects and the Government has a balance of investing in Government procured projects as well as private sector procured projects.

The country has a generally mountainous geography with around 65% of the country in hill terrain. Many of the growing urban areas lie on flood plains or flood prone areas and the country lies on the ring of fire around the Pacific so it experiences all the issues of a young tectonic country with frequent earthquakes, volcanic activity with numerous associated geohazards. It is also impacted by major cyclones and typhoons in the wet rainy season with associated risks from landslides, flash floods and general flooding on their major rivers.

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It is a socially conscious country aware of its roots, environment and rich history of its peoples and differing religions. It is well known for its fabulous beaches, marine environment and ecology which are some of the major draws for tourists to the country.

In recent years the country has seen significant growth with the per capita GDP currently at around USD4,350 in 2025 having rapidly grown from around USD1,053 in 2000 and expected to rise to around USD13,300 by 2050 as a 2 trillion economy.

With ever increasing wealth and a growing widespread urban congestion for a population of over 110M people there is demand to improve all the associated supporting infrastructure including transport, water supply, sewage, power. There are 6 recognized metropolitan urban areas in the Philippines with the 3 largest forming Metro Manila and the Greater Capital Region having expanded to over 20 million residents while Metro Cebu and Metro Davao have around 3.5M residents each. All these urban areas continue to expand, putting pressure on the existing infrastructure, transport and services. The situation is further compounded with the need to provide resilient and climate driven solutions but still maintain the environmental and social integrity of the country.

The legal context of the underground in the Philippines was defined by law in 2016 under RA10752, Sec 3&4 where the National Government Projects may acquire the strata below a private property below 50m without the need to provide any compensation and can occupy the subterranean areas for the purposes of the infrastructure project. The infrastructure types listed as subways, tunnels, underpasses, waterways, floodways or utility facilities. Its also applies to projects where a concessionaire or developer may undertake a project on behalf of the Government. The subterranean law is currently being reviewed, and this may be changed to raise the typical level to 40m depth and to allow shallower depths for key critical projects.

This paper only covers infrastructure related tunnels but there are a quite a few underground tunnels in some of the mining projects in the Philippines especially the underground gold mining operations in the North Luzon region in the Sierra Madre Mountains.

1.1. Geology of the Philippines

The Philippines is an archipelago of island formed by the subduction of the pacific oceanic plate below the Asian plate and comprises a series of uplifted and volcanic formed islands and landmasses. It is about 1,600km long by an average width of around 400km.

The region is characterized by lithologies and regional structure developed during Cretaceous-Tertiary period. During this period there was an extensive ultramafic intrusion tectonism, andesitic and dacitic volcanism and the sediments are diverse including sandstone, conglomerate, tuffs, siltstone, shale, reef limestone and coal. Diorite, quartzdiorite and andesitic stocks were intruded at various times. The oldest rocks found in the region are Cretaceous spilite, shale, greywacke and cherts. There are various trenches and subduction zones adjacent too and within the country that contribute to an actively seismic terrain with significant earthquakes that can be felt all over the country. Some areas are more seismically active than others. Volcanism due to the island arc nature of the country is widespread with many active volcanoes and some of the largest volcanic eruptions can and have occurred from volcanoes in the country. There are many young rocks formed in sedimentary basins that are generally weakly cemented while there are areas of very hard rock through intrusions on the island arcs and lava flows from the previous volcanic activities. In many places there are uplifted sedimentary rocks including limestones, shales, mudstones, sandstones etc.

Various geohazards can be found such as ground shaking, liquefaction of soils, landslides, tsunami and seiches and there are various dangers from rainfall driven landslides and debris flows over the mountainous areas and flooding in the wet season in low laying areas and major river floodplains.

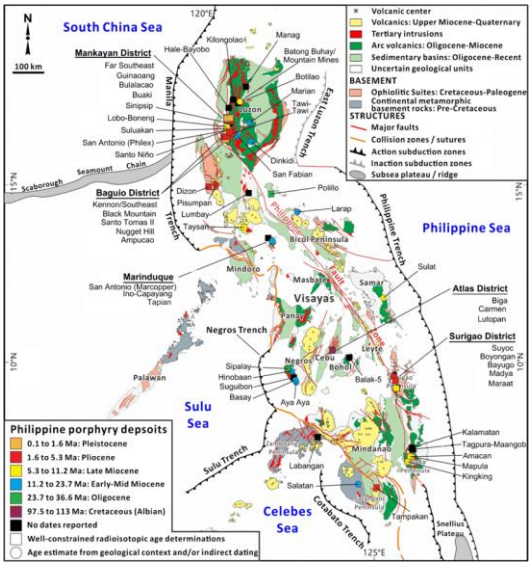

Figure 1 *– Geological and Tectonic Map of the Philippines. (source: JICA)*

In Metro Manila there are various deposits of weak sedimentary and volcanic rocks underlying the city at shallow depth. These deposits can be cut vertically down to 20 to 30 m depth relatively easily with minimal support to the surrounding rock faces that usually only need soil nail and shotcrete facings to control stability. There are few joints in the rock masses and they are generally massive although due to their weak nature there can be deep cracks and fissure that need to be considered. Groundwater can range from shallow to deep depending on whether there are nearby existing fluvial areas and where there may be deep well pumping for water supply. An example of the type of basement excavation that can be undertaken in Metro Manila are shown below:

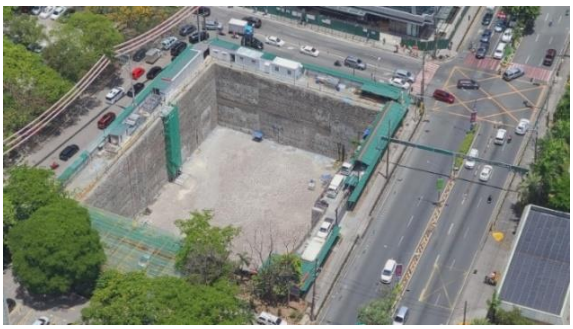

Figure 2 *– Deep Basement Excavation for a high rise building in Ortigas Metro Manila.*

1.2. Drivers for Tunnel and Underground Solutions

However, rapid urbanization and population growth have placed immense pressure on the country's infrastructure, leading to congestion, water shortages, and inadequate transportation systems. To address these challenges, the Philippines must expand and modernize its infrastructure, including the development of underground spaces and tunnels.

Historically, underground development in the country has been limited, with notable examples such as military tunnels from World War II and small-scale utility passages. However, recent projects like the Metro Manila Subway and underground water drainage systems signal a shift toward utilizing subsurface spaces to alleviate urban strain.

2. HISTORIC TUNNELS

2.1. Spanish Era Tunnels

The history of underground spaces and tunnels in the Philippines dates back to the Spanish colonial period (1565–1898), when the need for fortifications, water systems, and religious structures led to some of the country's earliest

subterranean constructions. Unlike modern infrastructure tunnels, these early underground passages were primarily built for military, religious, and utilitarian purposes.

One of the most notable underground structures from the Spanish era is the Fort Santiago Tunnels and Dungeons in Intramuros, Manila. Beneath the historic fortress, a network of tunnels and dungeons was constructed, serving as storage for supplies, secret escape routes, and prison cells. Philippine national hero Jose Rizal was incarcerated in those dungeons before his execution in 1896. These tunnels were further extended and strengthened during World War II when they were used by Japanese forces to imprison Filipino and American soldiers.

Figure 3 *– Old Map of Intramurous Fort Santiago and Inset Photo Dungeons (source: traveling-up.com)*

Many other Spanish Forts in the country had tunnels and underground chambers for military purposes. Such as at the old Spanish Fort in Puerto Princessa.

The Spanish also identified that the river and water supplies were becoming polluted even in the mid 1800's and this led to them developing some above ground aqueducts and some distribution tunnels that fed clean water from the Marikina River into the Manila City areas. Between 1878 and 1882 the Carriedo Water System Network was built and this incorporated various subterranean systems including an underground storage cavern (15 million gallons) and various brick lined tunnels to supply different parts of the city. The water supply system was named after Francisco Carriedo y Peredo, a Spanish philanthropist who funded Manila's first piped water network

Figure 4 – *Entrance to El Deposito (left) and the Main Storage Chamber (right) (source: facebook/tourism san juan)*

The Spanish also built underground structures for religious purposes. Some churches and cathedrals, such as San Agustin Church in Intramuros, have crypts and catacombs beneath them, serving as burial sites for Spanish clergy and elite colonizers. Many of these Spanish-era tunnels have deteriorated over time due to neglect, natural disasters, and urban development. However, some, like those in Fort Santiago, have been preserved as historical landmarks. These early underground structures reflect the ingenuity of colonial engineering and set a precedent for later tunnel construction in the Philippines, particularly in military and urban water management applications.

The Spanish colonial tunnels may not compare in scale to modern infrastructure projects, but they represent the Philippines' first steps in underground development—a legacy that continues to influence contemporary underground construction in the country.

While the Spanish built tunnels for civil defense and water supply, they also extended their reach into the mountainous regions and they were reported to have built some tunnels in Baguio to traverse ridges and steep terrain more easily for road construction. These are discussed later in the road tunnel section.

2.2. American and WWII Japanese Tunnels

The early 20th century saw significant underground construction in the Philippines, first under American colonial rule (1898–1946) and later during the Japanese occupation (1942–1945). These tunnels were primarily military in nature, serving as defensive fortifications, supply routes, and secret hideouts. Unlike the Spanish-era tunnels, which were limited in scope, the American and Japanese periods introduced more extensive underground networks, some of which still exist today as historical sites.

A well-known network was built on Corregidor Island that formed an island defense at the mouth of Manila Bay and was a strategic military stronghold during the war. The Malinta Tunnel network was expanded significantly by the Americans from 1932 to 1934 and had a 253m long main tunnel 7.3m wide by 5.5m high and then had 13 lateral branch tunnels on both sides and 49m long by 4.6m wide that served as a hospital during the second world war.

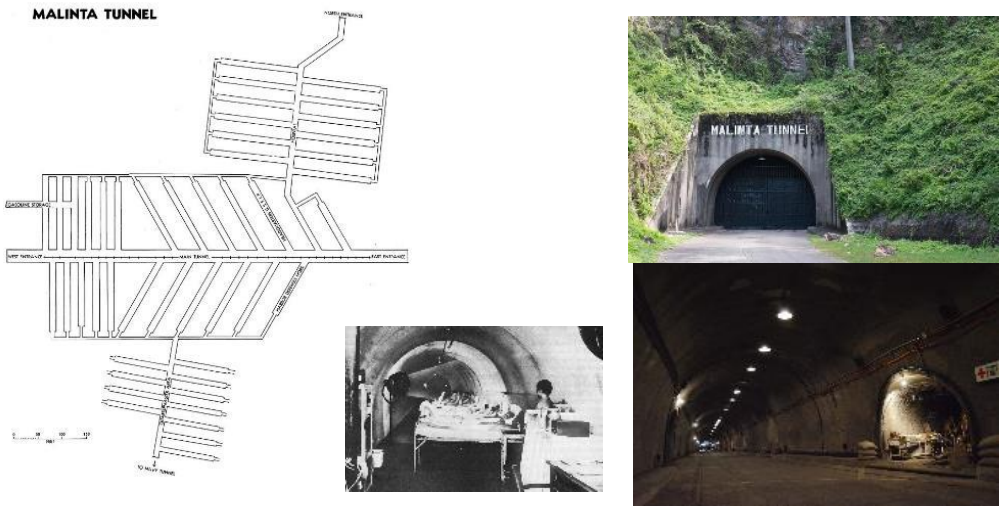

Figure 5 *– Malinta Tunnel Network, Portal and Underground Tunnels and Chambers.(source:uswarmemorial.org)*

The Americans also built an extensive network of tunnels and chambers in Fort Bonifacio in the 1910's ("Fort McKinely") in the middle of Manila. They built a network of over 2.2km of tunnel up to 30m deep up to 4m wide to service many of the buildings and facilities in the former camp. Some mapping of the network has been done and there have been recorded at least 32 chambers and a 6m wide deep well within the system. Many of it remains unmapped and unrecorded in the area.

During World War II, the Japanese Imperial Army expanded and constructed numerous tunnels across the Philippines, using forced labor (including Filipino and Allied POWs). These tunnels served as hideouts, supply depots, weapons and ammunition storage and detention facilities.

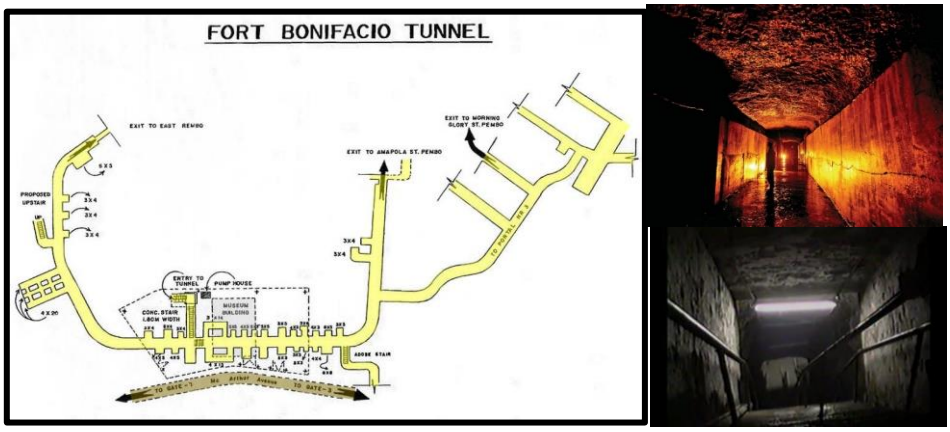

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Figure 6 *– Fort Bonifacio Tunnel Network and Tunnels / Shafts / Adits, (source:facebook/memoriesoldmanila)*

Many of these tunnels are now **historical landmarks**, serving as reminders of the Philippines' wartime past.

Some, like Malinta Tunnel, have been preserved for tourism, while others remain hidden or collapsed. The Japanese tunnels, in particular, are associated with brutal wartime atrocities, making them significant yet somber historical sites.

Figure 7 *– Typical Japanese Tunnels in Baguio and Davao, now Tourist attractions (source: thebaguiochannel.com & tracesofwar.com)*

These underground structures highlight the Philippines' strategic military importance in the 20th century and provided examples of how the ground in many areas could be relatively easily mined and excavated. By the end of the 1950's there was around 5.5km of old historic tunnels but there are likely to be many unrecorded or undocumented war and military tunnels around the country especially in strategic areas and at former engagements.

3. WATER TUNNELS

3.1. Early Years to 1990's

Even when the Spanish were occupying the Philippines the seasonal variations in the rainfall meant that there needed to be a reliable clean water supply to their forts and camps and in Manila this started with the Carreido Water Supply system that then was expanded into the Manila Metropolitan Water District water supply network by the Americans. By the 1930's it was obvious that water supply needed to be reliably provided to the growing city and various dams and water supply projects were initiated. The Wawa Dam at Montalban provided the initial aqueducts in pipes and later by 1939 the IPO Dam required the first 6.3km tunnel aqueduct to bring water from the newly constructed dam to Metro Manila area.

By the 1960's and 1970's the Philippine Government already knew that the water supply for drinking water as well as irrigation needed to be secured for the growing Metro Manila and Luzon plain areas and formed the National Irrigation Administration and the Manila Waterworks & Sewerage System to further manage and supply water to the city.

Two further water supply tunnels (1969 & 1992) both approximately 6.3km long were also built from IPO dam to supply expanding water works facilities. By the end of the 1990's there were around 33.1km of water tunnels.

3.2. 1990's to 2025

As the Philippines has expanded and in particular Metro Manila there has been an increased focus on providing water to the Metro Manila and the Greater Capital Region. Various schemes have been formulated and implemented to transfer catchment river water that would have flowed to the east and north back towards the capital. The Umiray Angat Transbasin Project was the first major aqueduct that brought water through a 13km 4.88m diameter hard rock TBM from rivers flow to the north and divert it to the southerly populated areas to the Angat and IPO dam systems. Recently there has been an investment in replacing and updating the water supply aqueducts to secure the water supply for the greater capital region. Angat Tunnel No 4 that was a hard rock double shield TBM was 6.3km long and 4.7m diameter with a design flow of 1600MLD and was completed 2019 and operational by 2020. Another subparallel Tunnel No 5 6.43km and 4m diameter was completed in 2024.

Figure 8 *– Angat AWTIP T5 Tunnel alignment and Photos. (source: Arup)*

In addition, projects like the Novaliches-Balara Aqueduct No 4 (NBAQ4) that comprised a 7.3km long, 3.74m diameter EPB TBM had a double articulated shield to provide a tight turning radius of 80m along the alignment to stay underneath existing public roads and land. This system provided a lower water take off from La Mesa dam and a more resilient tunnel scheme for possible future earthquakes.

Figure 9 *– NBAQ4 Tunnel alignment, geology cross section and EPB TBM (source: Novabala & Arup)*

The expansion of the water supply networks is continuing to be replaced and maintained and by 2025 there will be around 60km of dedicated water tunnels in the Philippines mostly in Luzon.

3.3. 2030 Onwards

There is no doubt that the Philippines needs to secure its water supply as the Metropolitan Waterworks and Sewerage System (MWSS) office struggles to supply around 20M households and businesses in the Calabarzon region and with the current phase of water tunnels as well as recognition of the existing aging aqueducts there is a need to upgrade, increase capacity and supply to the region. This is ongoing and there are more water supply tunnels underway and being planned. Climate change as well as seasonal changes in rainfall are impacting water security and over the next few decades there should be up to 105km of water tunnels projected to be built, mostly in Luzon but there are significant water demands in other Metropolitan Areas that tunnels may provide viable and secure supply options. Currently WAWA, Kaysakat, LTE, Kaliwa water supply projects will construct more tunnels in the near future. There are even plans for small / short tunnels to improve the low water take-offs from some of the dams to provide more resilient and supply options in the case of drought.

4. HYDROPOWER TUNNELS

4.1. Increasing Electricity Demand

The Philippines has suffered power shortages during the 1990's to the early 2000's and there has been steadily improving power supply and distribution but there is increasing demand in the country for power. The current trend is to promote more renewable energy and there are many hydropower projects in the Philippines. With its mountainous terrain there are many simple run-of-river and dam based hydroelectric schemes that have been built and planned over the last 2 decades. A few of those have been integrated with irrigation and power generation.

One of the longest tunnels in the Philippines is the Casecnan Hydro and Irrigation Project that transfers water across watersheds from the Cagayan River basin to the south to the Pantabangan Reservoir. This tunnel was formed by various techniques including drill and blast and by TBM and extends to around 26.6km for the main tunnel aqueduct / headrace tunnels and has around 2.5km of branch tunnels and adits to provide a network of about 29km in the system. It's a pressurized tunnel and produces about 150MW of power into the Philippine NGCP transmission grid.

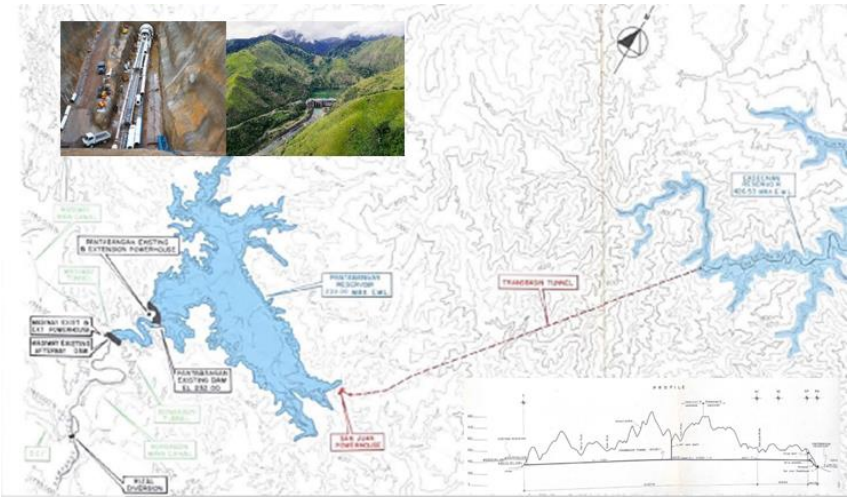

Figure 10– *Casecnan Hydro and Irrigation Project Layout, TBM and Cross-Section (source: cmcgruppo.com, & fphc.com)*

There are more than 70 existing hydropower projects in the Philippines and typically relatively small as run of river schemes that currently generate 1.2GW of electricity for the country. There is around 75km of existing hydropower tunnels forming supply and headrace sections both gravity and pressurized but reliable information on each of the plants has not been forthcoming and the known hydropower tunnels are likely to exceed 81km in the next few decades. The hydropower tunnels are found throughout the mountainous areas of the Philippines and in steep terrain areas prone to landsliding and flash floods. There is likely though to be competing aspects of water supply as well as uncertainty in seasonal fluctuations due to climate change that may impact sustained future growth of this area of tunnel development. Indeed, many existing facilities may be looking to optimize and expand and there could be further growth in the hydropower tunnels in the Philippines especially as dual-purpose tunnels.

5. ROAD TUNNELS

Some of the earliest infrastructure tunnels were in the mountainous areas of the country. The Spanish reportedly built some tunnels in Asin Benguet near Baguio in the 1700's that were refurbished in 1858 and then later by the Americans in the early 1900's. Tangadan 2 lane road tunnel (40m long) was built in 1934 by the Americans in Abra-Ilocos Sur to provide a better route for the regional road. Gessang and Patiking Tunnels were built in the 1920's to better connect local towns. Various other short tunnels are found in various parts of the country. An interesting solution is the Halsema Highway "Half Tunnel" in Zambales where an overhanging cliff has been undercut for around 150m to form the highway.

Figure 11 *– Asin Road Tunnels Benguet, Baguio (left), Tangadan Tunnel (middle), Gessang Tunnel (right) (source:Instagram.com/p/DGXfZp9yOXg & traveling-up.com & Lanz Michael Bautista)*

Figure 12 *– Patiking Tunnel, Dupag (left), Bontoc Single Lane Tunnel (middle), Halsema Highway "Half Tunnel" (right) (source: sean doctolero & spiritedthoughts.wordpress.com & rusa4.wordpress.com)*

There are some tunnels in Mindanao with a notable road tunnel at Malabang "Picong" Tunnel 2 lane road tunnel with walkways and central divider that was built by the Americans in the 1930's and is around 60m long. A more recent longer highway tunnel was the Kaybiang Tunnel completed in 2013 at 300m long was the longest drill and blast road tunnel in the Philippines until recently.

Figure 13 *– Picong Tunnel, Lanao del Sur, Mindanao (left), Kaybiang Tunnel (middle), Badiwan Viaduct Tunnel (rock protection shed) Marcos Highway (source:mindanaochronicles.com & outoftownblog.com & youtube.com/watch?v=gZR9Vx3AVPs)*

In several of the main highways in the mountains there has been at least 3 protection tunnels or sheds built to protect the road or highway against local landslides and rockfalls. 75m long (Dalton Pass Tunnel, built approx. 1995), 320m long (Marcos Highway, built 2001), 150m long (Kennon Road Tunnel, built 2024).

In the urban areas of the country there have been various cut and cover road tunnels to provide better traffic flow and interchange improvements. There are many in Metro Manila and a recent notable one in Cebu on the South Coastal Road. A notable cut and cover underpass road tunnel that is combined with the MRT3 railway was built in 2000 to provide better access to the Makati District of Manila and to allow traffic to freely navigate the major interchange. Various other underpasses and in the city suffer from flooding problems.

Figure 14 *– Cebu South Coast Road (left), EDSA Ayala Underpass Tunnel (right) (source: google maps & en.wikipedia.org/patrickroque01)*

Some of the new expressways that have been built over the last few years are also incorporating some tunnels.

In particular the Subic Freeport Expressway added another tunnel to the existing two-way tunnel built in 1990 and by 2020 the road had been widened and upgraded to a dual carriageway with the construction of another 108m long 12m wide by 9.6m high drill and blast tunnel.

Figure 15 *– Subic Freeport Expressway Tunnels (old 1996 and new 2020) (source sta clara international corporation)*

One of the recent ongoing highway tunnel projects is the current Davao City Bypass scheme that incorporates the Philippines longest highway tunnel. The Davao Bypass tunnels are approximately 2.3km long and dual carriageway with some cross passages and are due for completion in 2025.

Figure 16 *– Davao City Bypass Twin Tube Dual Carriageway (source: pna.gov.ph & mindanews.com/DPWH-XI)*

There are various planned and future highways proposed in some of the more mountainous areas of the country to solve traversing the hilly terrain and provide better infrastructure for the country.

6. RAIL TUNNELS

6.1. Early Years

Towards the end of the 19th century the Philippines had many 1000's of kilometers of railway but no operating tunnels. In 1913 there was a short 500m long 7.5m wide about 4m high rail tunnel constructed for a planned spur line to connect through to Baguio for Aringay. The tunnel was never used and the spur line abandoned by the First World War. Later it was used by the Japanese forces as an Army HQ center. It was renamed the Centennial Railway Tunnel in the last few years and is becoming a tourist attraction in the area.

Figure 17 *– "Centennial Railway Tunnel (Abandoned) (source: en.wikipedia.org/wiki/centennial_tunnel)*

6.2. Rail Tunnels Now and in the Future

The Philippines has started on a major campaign to regain the previous rail heritage that it had. Currently the country only has several hundred kilometers of railway in the Metro Manila and Calabarzon area. The Philippine Government with JICA funding are building the Metro Manila Subway Project (MMSP) with over 33.1km of underground railway with 15 underground stations with dual tunnel tubes with a typical metro rail diameter of around 7m and up to 25 tunnel boring machines to drive the tunnels between stations.

Figure 18 *– "MMSP alignment and Contracts with DOTr Transport Secretary Visiting CP101 Site, (source:pna.gov.ph/ articles/1220290)*

In addition the North South Commuter Rail (NSCR) Project has also a short section of tunnel planned to connect and allow interchange with the MMSP line. Some cut and cover sections of the NSCR can also be found near Clark Airport. MRT 7 a privately financed project by San Miguel also has some cut and cover section in Quezon City where the sensitivity of cultural heritage and a need to prevent future surface disturbance has led to several stations being placed underground as well as their connecting running tunnels. There have been plans for an underground metro line in Makati and this may also be resurrected in the future, to again, further improve connectivity in one of the main CBD areas of the capital.

There are also various other railways being planned and these will undoubtedly include some tunnel and underground solutions to allow the railways to navigate the hilly terrain or to hide the railways underneath the existing busy congested roads of the cities in the Philippines. Indeed, in Cebu there are tentative plans to consider building a Metro Line up to 67.5km long designated as the Urban Mass Rapid Transit (UMRT) in some JICA studies and is planned to be from southwest to northeast through the city. Much of the alignment could be placed underground, especially in the densely populated and land congested parts of the city. This project could significantly ease the overwhelming traffic congestion in the city.

7. OTHER TUNNELS AND UNDERGROUND SPACE

There are some interesting other types of tunnels and underground spaces in the Philippines. It is generally relatively easy to excavate in the Guadlupe formation rocks in Metro Manila and hence there are various deep

basements that could be integrated with underground Metro stations in the future. There are also various pedestrian underpasses in downtown parts of the city.

7.1. Pedestrian Underpasses

The Philippines has some pedestrian underpasses that cross busy highways and streets. In Makati Ayala have developed a series of eight underpasses that connect across the busy roads and provide a safe means of crossing and allow traffic to flow more freely. They have incorporated murals and advertising in the underpasses that are heavily used and serviced by escalators and lifts. Similarly in Quezon City for the Circle / Elliptical road to connect to the memorial. In Manila City the Lagusnilad pedestrian underpass connects Rizal park to the Manila City Hall and while it was built in the 1960's it has been recently upgraded and improved in the 2020's with the inclusion of better lighting along with murals and advertising to offset the electricity lighting costs.

Figure 19 *– Ayala Triangle Underpass Photos / Examples (source:morefunwithjuan.com)*

7.2. Underground Shopping

There is a small dedicated underground retail area at the famous Quaipo Church in Metro Manila. An underground underpass was constructed in the 1960's that incorporated various retail booths within the underpass. This underpass was the first pedestrian underpass and opened in 1964 and was reopened in 2014 after an extensive refurbishment. The underpass incorporates 6 entrances up to 200 retail booths.

8. COMPLETED TUNNELS UP TO 2025

A full catalogue of the past, present and possible future tunnels are outlined in **Appendix A** to this paper. These tunnels cover a wide range of types of tunnel to service a range of infrastructure sectors. By the end of 2025 there will be around 150km of tunnels in the Philippines and mostly built in the Calabarzon region to supply and provide underground infrastructure to Metro Manila.

For a metropolitan area of around 15 to 20M people the number of tunnels is surprisingly low and appears to be historically focused at water supply with many built in the 1960's to the 1990's to supply Metro Manila. Hydropower projects also contributed a large proportion of the tunnels up to 2025 with many of them servicing both irrigation and water supply as well as hydropower energy generation which is another significant demand for the growing metropolis.

It is clear that many of the old tunnels formed in the 1960's are needing to be refurbished / replaced and are getting to end of life. Indeed, the current driver for better transport options is delivering a significant amount of rail tunnels over the next decade.

Table 1 *– Tunnel Type and Length Constructed by 2025*

Tunnel Type	Length Constructed By 2025 (km)
Road	7.50
Rail	5.25
Water	53.71
Major Culvert	0.34
Underpass	1.24
Utility	0.00
Historic	5.49
Hydropower	77.63
Total Length (km)	**151.15**

9. FUTURE TUNNELING CHALLENGES AND OPPORTUNITIES

With the ever-increasing growth of the Philippine economy the countries cities will continue to grow and therefore underground solutions will be more attractive to provide solutions that meet public demands and expectations. The driver will be the demand for land and Right of Way issues and the inevitable need to minimize provide solutions that minimize impacts on the existing traffic in the urban areas.

Various railway lines will be extended and there will be further phases of expansion for the Metro Manila Subway and there are potential plans to develop inner circle lines to service Makati and BGC that would provide a easier circulation of people around the city. Some of the potential projects highlighted by DOTr, DPWH, MWSS, DOE, NEDA suggest that there will be over 130km of new tunnels to be built up to 2035. The majority of those tunnels will be in the rail and water sector to service the various major demands that the cities in the Philippines are encountering.

Table 2 *– Tunnel Type and Length to be Constructed 2025 to 2035*

Tunnel Type	Length Planned between 2025 to 2035 (km)
Road	13.00
Rail	67.60
Water	50.89
Hydropower	3.40
Total Length (km)	**134.89**

With the addition of the current tunnelling projects being constructed just now and in final stages of planning there will be over 280km of tunnels in the Philippines by the end of 2035.

Table 3 *– Tunnel Type and Length Constructed by 2035*

Tunnel Type	Length Constructed By 2035 (km)
Road	19.70
Rail	72.85
Water	104.60
Major Culvert	0.34
Underpass	1.24
Utility	0.00
Historic	5.49
Hydropower	81.03
Total Length (km)	**285.24**

As tunnels and underground solutions continue to be needed there will be likely demand to organize the underground spaces in the cities in the Philippines in a more coordinated manner with the need for urban planning and underground master plans developed to ensure that future generations can still provide options and solutions in the urban areas through tunnel options. As the Philippines has been growing the pre capita gross domestic product (GDP) has steadily risen up to 2000 where it was around

10. CONCLUSIONS

The Philippines is set for a significant development in tunnels and tunnelling in the country. Historically there are many legacy tunnels and underground spaces in the Philippines that are now being developed and used as tourist attractions. Essential infrastructure tunnels to provide water and hydropower have formed the main backbone of the tunnels in the Philippines in the 1960's to the early 2000's. While most of the tunnels are located in the Calabarzon region there will be many other underground solutions needed in the Philippines and other cities are likely to need underground solutions to service and provide infrastructure for their cities.

The growth of tunnelling is likely to continue in the future and the focus is already moving to transport orientated tunneling and underground solutions. The fast-increasing trend in GDP in the Philippines seems to be tracking the initial increase in tunnel projects and this is likely to continue in the near future. It may be that the trend is in line with affordability of the tunnel options as they are usually more expensive than surface or elevated projects. It seems that there is no choice now as the urban congestion has increased to a level demanding urban underground metro systems in many of the cities in the Philippines.

Table 4 *– Tunnel Length Constructed by Key Decades*

Year	Length of Tunnel Completed
1960	14.8 km
1980	24.8 km
2000	57.7 km
2020	122.5 km
2035	285.4 km

The population of the Philippines in 2020 was around 109M people with continued growth up to around 130M by 2040. As the population grows the urban population is growing faster as people migrate to the cities and major urban areas with cities like Metro Manila and Cebu expected to have increased traffic congestion as the populations expand. Metro rail as well as underground metro systems will be essential to meet that demand. Indeed, water supply, deep sewer networks, underground utility including cable tunnels and underground highways etc. will be needed to provide the Philippines with more livable cities.

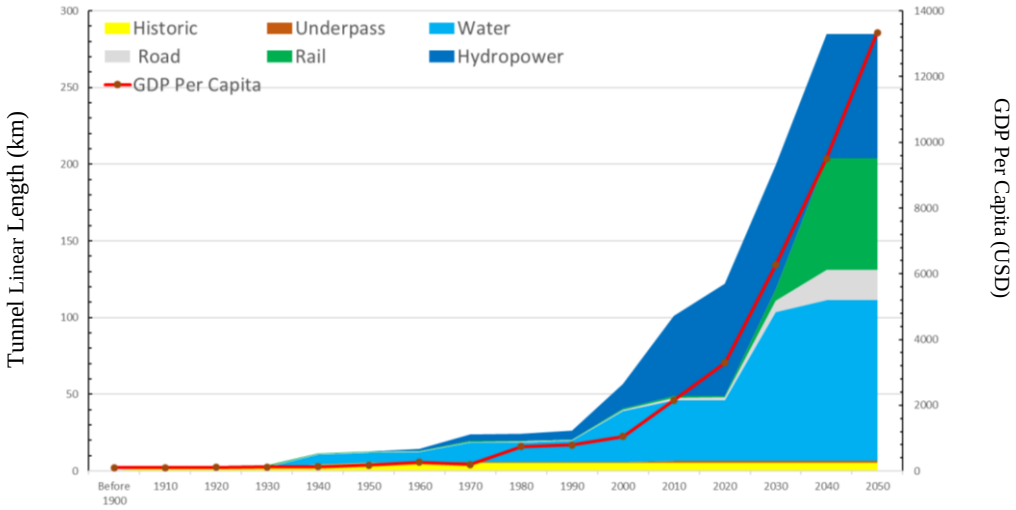

Figure 20 *– Total Length of Tunnels in the Philippines per Type and Per-Capita GDP Growth*

11. ACKNOWLEDGMENTS

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12. APPENDICES

Appendix A – Initial Catalogue of Known Tunnels and Underground Infrastructure in the Philippines

No	Project name / Tunnel name	Approx. Year of Completion	Type of Tunnel	Length (m) (km)
1	Asin Tunnels 1 & 2, Benguet, Baguio.	Built by POW's 1700/1800's refurbished 1850's	Road	95m and 158m Approx
2	Fort Santiago (Intramurous) Tunnels	Pre 1890's	Historic	> 300m of tunnels, not fully known
3	Puerto Princesa City Cuartel / WWII tunnels	1700s	Historic	100m Approx
4	El Desposito Network Underground Reservoir	1878-1882	Water	150m
5	Fort Bonifacio Tunnels	1910	Historic	> 2.24km Approx (many not recorded)

6	“Centennial” Railway Tunnel, Aringay, La Union	1913	Rail	0.5km Approx
7	Gessang & Patiking Tunnels, Dupag, Apayao	1920	Road	60m Approx
8	Malabang Tunnel, Lanao del Sur, Mindanao.	1930	Road	60m Approx
9	Malinta Tunnels, Fort Mills, Corregidor	1932	Historic	1.429km various tunnels and adits
10	Tangadan Tunnel, San Quintin, Ilocos Sur.	1934	Road	40m Approx
11	AWTIP Tunnel No 1	1939	Water	6.3km Approx
12	Ilagan Japanese Tunnel - Sto. Tomas, Ilagan City, Isabela	1942	Historic	40m Approx
13	Japanese Malagos Tunnel - Hillcrest Subdivision, Matina Balusong, Davao City	1942	Historic	300m Approx
14	Digos Tunnel	1942	Historic	150m Approx
15	Albay Town WWII Tunnels	1942	Historic	0.63km Approx
16	Wawa Dam WWII Japanese Tunnel, Rodriguez, Rizal.	1945	Historic	50m Approx
17	Baguio WWII Tunnels	1945	Historic	150m Approx
18	Amlan Mining Drainage Tunnel, Negros Oriental	1950	Major Culvert	340m Approx
19	Ambuklao Hydropower Plant / Dam, Bokod Benguet	1956	Hydropower	500m
20	Angono-Binangonan, Petroglyphs Tunnel	1960	Historic	100m Approx
21	Binga Hydropower Plant	1960	Hydropower	800m
22	Lagusnilad Vehicle Underpass, City of Manila	1960's	Underpass	240m Approx
23	Lagusnilad "Manila City Hall" Pedestrian Underpass, City of Manila	1960's	Underpass	60m Approx
24	Lacson Underpass, Quiapo, Manila.	1964	Underpass	0.15km Approx
25	Angat Dam Power Facilities, Norzagaray Bulacan 3No Tunnels	1967	Hydropower	1.8km, 607m, 597.5m
26	AWTIP Tunnel No 2	1969	Water	6.3km Approx
27	Bontoc Tunnel, Mountain Province.	1980	Road	30m approx
28	Half Tunnel Halsema Highway, Atok, Benguet.	1980	Road	150m approx
29	Magat Hydroelectric Power Plant / Dam, Ramon Isabella	1983	Hydropower	630m & 630m
30	Laiban Dam Tunnel, (Not used)	1984	Water	0.96km (twin tube 480m)
31	AWTIP Tunnel No 3	1992	Water	6.3km Approx
32	Dalton Pass Rockfall Protection Tunnel (Shed)	1995	Road	75m Approx
33	Makati Ayala Pedestrain Underpasses (8No.)	1995 to 2021	Underpass	0.4km Approx
34	Old Subic Expressway Tunnel	1996	Road	90m
35	EDSA Ayala Road Tunnel, Underpass Makati City	2000	Road	650m Approx
36	EDSA Ayala MRT3 Tunnel, Underpass Makati City	2000	Rail	650m Approx

37	EDSA Magallanes Tunnel - Underpass	2000	Underpass	45m Approx
38	Umiray-Angat Transbasin Project (UATP)	2000	Water	13.1km
39	Bakun AC 70 MW Hydropower Plant - HEDCOR Benguet and La Union	2000	Hydropower	10.45km
40	Badiwan Viaduct "Marcos Highway" Tunnel Shed	2001	Road	320m Approx
41	Casecnan Dam Tunnels	2002	Hydropower	Main 26.6km, total length of 29.066km of tunnels and adits
42	Villa Siga Hydropower Plant, Panay Island	2004	Hydropower	4.4km
43	C5 Underpass, Katipunan and Bonny Serrano Interchange Underpass	2007	Underpass	200m Approx
44	Quezon City Circle / Elliptical Pedestrian Underpass	2007	Underpass	60m Approx
45	26.25MW Sibulan A Hydroelectric Plant	2009	Hydropower	3km
46	Cebu South Coastal Road Tunnel Cut&Cover	2010	Road	610m
47	Malamig Tunnel, along Plaridel Bypass Road	2012	Underpass	25m Approx
48	Sipat-Dampol Tunnel along Plaridel Calumpit Road	2012	Underpass	30m Approx
49	Tambubong Tunnel along Plaridel Bypass Road	2012	Underpass	25m Approx
50	Kaybiang Tunnel, Ternate Cavite	2013	Road	300m Approx
51	14MW Sabangan Hydropower Plant - HEDCOR Benguet and La Union	2015	Hydropower	3km
52	8MW Catuiran Hydropower Project – Or Mindoro	2015	Hydropower	3.4km
53	Manolo Fortich 2 Hydropower Plant	2017	Hydropower	6km
54	60 MW run-of-river hydro project, Cordillera Hydro Electric Power Company's (COHECO)	2019	Hydropower	8km
55	Subic Freeport Expressway (SFEX) Tunnel	2020	Road	108m
56	AWTIP Tunnel No 4	2020	Water	6.3km Approx
57	SUMAG River Diversion Tunnel	2023	Water	0.6km
58	NBAQ4 Aquaduct - La Mesa Dam to Balara Water Treatment Works	2023	Water	7.2km
59	AWTIP Tunnel No 5	2024	Water	6.5km
60	Kennon Road Landslide Rockfall Tunnel (Shed)	2024	Road	150m Approx
61	MRT7 North Ave to Quezon Memorial and University Ave, Quezon City. Cut&Cover	Due 2025	Rail	4.1km
62	Siguil River 14.5MW Hydropower Plant, Maasim, Sarangahi	Due 2025	Hydropower	786m
63	25MW Lake Mainit Hydropower Project, Jabonga and Magdagooc, Agusan Del Norte	Due 2025	Hydropower	3km
64	225MW AGUS III Hydropower Plant	Due 2030	Hydropower	3km & 400m
65	Paranaque Spillway	Due 2035	Water	7.2km Approx

66	Upper Wawa Pumping Station Main Access Tunnel	Due 2025	Hydropower	1.016km
67	Davao City Bypass Construction Project	Due 2025	Road	2.3 km
68	North South Commuter Rail Phase 2 - Malolos - Clark Segment, Cut&Cover	Due 2026	Rail	2.2km
69	Kaysakat Raw Water Supply Tunnel	Due 2026	Water	6.09km
70	Kaliwa Dam Tunnel	Due 2027	Water	21.9km
71	LTE Raw Water Supply Aquaduct	Due 2028	Water	15km
72	North South Commuter Rail Contract 3B	Due 2030	Rail	4.7km
73	Angat Dam New Low Level Outlet Tunnel	Due 2030	Water	0.7km
74	Metro Manila Subway Project (MMSP)	Due 2030	Rail	33.1km
75	Proposed Dalton Pass Bypass Tunnels	Due 2031	Road	6.5km Approx

Note: Many tunnels and underground infrastructure are not well documented and in some cases the networks are more extensive than declared. The list does not include mining related tunnels of which there are quite a few in the Philippines. Please email (philtunnelsociety@gmail.com) if you have other information on other tunnels, lengths and type of construction to add to the Catalogue or to update the information provided in the above, thank you in advance.

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