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RECLAIM AS MUCH AS POSSIBLE AND NO TO UNPLANNED AND PIECEMEAL RECLAMATIONS

150 persons migrate to Hong Kong from China per day and one can work out that the Special Administrative Region needs a new town with a capacity house 0.4 million people per decade. The question is therefore: where to develop a settlement of this scale on a rolling 10-year programme (of which nothing of the sort exists in the official territorial planning statement *Hong Kong 2030)*?

There is no doubt that reclamation is generally the best strategy to accommodate a growing population in that it can bypass the complicated webs of local interests and development controls. The controversies arising from government determination to develop a small new town in the Northeastern New Territories testify to this consideration.

If Victoria Harbour and the Country Parks and their fringing Green Belts are treated as untouchable for urban development, then the government has the choice of making existing development denser, opening up agricultural lots in the New Territories and reclamation outside Victoria Harbour. The last option is not only the easiest but can also be the most innovative. That is because it can provide opportunities for imaginative ecological planning efforts for a huge new development area (which need not be in one piece and can be in the form of a series of man-made islands) with its own CBD, port, reservoirs and industries that satisfy the long term economic and recreational needs for the next 50 to 60 years (Lai 2011). The plan horizon must transcend the electoral terms of government so that the matter ceases to be politicized by short term interests. The scale must be able to accommodate another 6 to 7 million people to provide the steady stream of land supply needed. That is the only way to correct present expectation about property prices. Details are merely engineering. For instance, there should no lack of fill materials as the government has been shipping unused fill materials to China, at a cost.

However, scale economies, along with ecological and urban design concerns, call for a large and comprehensively designed scenario capable of further growth rather than minuscule, make-shift, piecemeal, and thoughtless “options” that are on plans manifested by drawing straight lines across natural coves. Options in government consultative documents (Hong Kong Special Administrative Region 2012) like C11 (Sandy Bay – Telegraph Bay in the past), D7 (Tai Ham Harbour), and C131 (the beautiful rocky coast of Devil's Peak (now confusingly called Pau Toi[1] Shan) in Junk Bay (now called Tseung Kwan O) in the government's recent proposal are even worse, as they are not even straight, but create bulges in existing artificial or natural coasts.

C11 and C131 are the most disastrous in terms of the overall urban imaging of Victoria Harbour, as they would very likely mess up further the settings to the western and eastern maritime approaches to the harbour. The backdrop of C11 is Mount Davis-Kennedy Town Gap-High West, while that for C131 is Devil's Peak. Both "options," given current land economic logic, would mean the piling up of residential blocks that break the ridge lines and hardly add any scenic or cultural value to existing visual settings. C131 ignores the past decision of the government's engineers to abandon a coastal road from Lee Yue Mun to Tseung Kwan O New Town to save the rocky coast. D7 is also a bad idea, as the disused quarry site is large enough for recreational or non-residential purposes: Shek O and Tai Tam Road (especially the section along the narrow top of the main dam of Tai Tam Tuk Reservoir) would not be able to cope with another Red Hill-type residential development without widening or tunneling work, which would likely destroy the WWII pillboxes and bunkers at Tai Tam Gap as well as irredeemably blight one of the few landscapes penetrated by roads that still are fringed by relatively unengineered natural slopes.

What Hong Kong needs is the planning and development of manmade offshore islands of significant scale with their own CBD and functional areas rather than ad-hoc reclamations added to existing coastal lines. This strategy can integrate with ecological compensatory endeavours and cope with long term development.

Hong Kong Island and the land mass across the Victoria Harbour have already been over-saturated with urban development through reclamations and hill terracing. Also, the carefully planned options of Metroplan have been stopped by the *Protection of the Harbour Ordinance.* The alternative, therefore, must be a major new urban area away from any existing shoreline intelligently sited to minimize adverse effects on both summer and winter monsoon tide and current flows, whilst equally minimally impacting the already severely compromised natural outlines of the islands from Tung Lung to the Sokos, and protecting the undamaged beauties of the waters to the east. Shall we call it Utopia?

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[1] "Pau Toi" literally means "batteries". Hills like Mount Davis have remains of batteries and so this name for Devil's Peak is not ideal, bearing in mind also that the Chinese name of Fortress Hill Road, North Point, is also called "Pau Toi Shan" because there was once a battery there too.

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Surveying & Built Environment

A Note on British Blockhouses in Hong Kong

Rob Weir*

ABSTRACT

Hitherto unreported in the literature, a line of blockhouses[1], which is best remembered as the "Anderson Line" after its brain child Major General Charles Anderson, were built along Kowloon Range in the early part of the last century, which might well be the predecessor of the Gin Drinker's Line (Kwong 2012, this issue), now surveyed (Lai, Tan, Davies, and et al 2009, Lai, Tan, Ching and Davies 2011, last issue).

This technical note, as part of a large project[2], provides in this context some background information on construction in colonial Hong Kong of the first, c.1911 line of 30 blockhouses, their design details, the weaponry they were defended by and their actual positions.

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[1] Blockhouses were defined in Section 17, Blockhouses, Field Defences, Pt 1, *Manual of Military Engineering,* page 107, in the *Manual of Military Engineering* of 1894 seen by the author at the Royal Engineers Museum, Chatham, as being:

> "Blockhouses are defensible guard-houses or barracks, having framed or stockaded walls and roofs formed of timber, or iron rails, with earth on top. Being easily destroyed by artillery, they are chiefly suited to mountain warfare in wooded country, where it is not always easy to bring artillery to bear upon them; and where the artillery itself is of inferior power." (School of Military Engineering 1894, p. 107)

[2] Editors' note: The author is an Australian who lived and worked in Hong Kong for 15 years. Now retired and living in Melbourne he has been researching the locations of batteries, shelters, pillboxes, and blockhouses in Hong Kong for more than 20 years and in communication with Tim Ko and Y K Tan on matters relating to these matters. He visits Hong Kong on a regular basis for site visits and archival research. He became interested in HK military history as a result of finding many unexplained ruins during hill walks, and discovering there were few sources of information easily available.

BACKGROUND

From the beginning of British control of Hong Kong, defence of the port Victoria Harbour was a high priority. Initially, this was primarily by fixed gun batteries against naval attacks, but as more territory was obtained, and movement on land became easier, consideration had also to be given to land based attacks. This finally became reality with the Japanese invasion from China on 8 December 1941.

The Treaty of Nanking, which ceded Hong Kong to Britain, only covered Hong Kong Island itself and the small islands immediately off the island shore (Green, Little Green, Kellett, Tweed, Round, Apleichau). The Island, although relatively small (roughly 72 square kilometres) has a high land mass running east-west across its length, with several passes, locally called "gaps", allowing easier access north – south. This resulted in initial growth being concentrated along the relatively flat area of the northern coastline of its excellent harbour. The rest of the Island remained inhabited only in small local villages and boat harbours. Transport in these areas was by boat, or by foot along village paths. This difficulty in movement had the advantage of deterring potential enemies from landing in the less populated areas.

At a distance of 1.6 km from the rapidly developing town of Victoria (initially Sheung Wan), was the southern tip of the Kowloon Peninsula with an Imperial Chinese fort at Tsimshatsui built after 1842 . This promontory, although difficult to appreciate today, was hilly and populated with only a few small villages. Its position and the presence of a fortified Chinese garrison presented a threat to the town and harbour. Following the Second Opium War with the Manchu Chinese, The Treaty of Tientsin ceded the promontory of Kowloon and Stonecutters Island to Britain in 1860 to become a new part of the Crown Colony of Hong Kong. The northern boundary of this piece of land ran along what became called Boundary Street. Shortly after, gun batteries were built by British engineers on both sides of the Peninsula to enhance the defence of Victoria Harbour. For a while the ruggedness of the terrain to the north beyond the northern boundary of Kowloon was considered enough to deter even small scale attacks.

By the beginning of the 1880s, Hong Kong had developed into a major international trading centre and hub of British influence in Asia, as well as becoming an important Royal Navy station for her China Station, which could be used for support, or persuasion. Authorities in Britain and Hong Kong, still worried that Western rivals, particularly Russia and France, would use their forces in the area to disrupt the port and facilities by naval gunfire, now began to seriously consider defending against small raiding parties, landed either on the southern beaches of Hong Kong Island or the mainland to the north of Kowloon. The first defensive plans were for Redoubts, manned by infantry, to be built on various heights with the purpose of defending the nearby passes and paths, limiting any expansion of the landing until reserves could be sent to the area. This plan was cancelled in 1894, largely because the Redoubts were often above the fog line[3] and placed where poor visibility prevails for several months of the year because of low cloud, and the musketry of the period had too short a range to perform the task.

In 1894, a revised Defence Plan introduced the use of Blockhouses[4]. These were to be built below the fog line, and used as advanced posts for scouts and signallers, also forming the nucleus of a strong second line as forces built up. Thirteen were planned, nine on Hong Kong Island from the west through south to south east, and four in a line across the Kowloon Peninsula, from approximately Ma Tau Wai on the east to Yau Ma Tei on the west.

The defence plan proposed that the type of stone blockhouse in contemporary British army field engineering manuals be constructed[5]. It further suggests they should be built as far as the foundations and walls in peacetime and, if possible, be completed before hostilities commence. The leasing from Imperial China of the "New Territories" in 1898, a landmass which went north well beyond the Kowloon Range to reach the Shenzhen River, rendered the planned blockhouses to the south of Boundary Street no longer meaningful and that land mass itself, especially the commanding heights along Kowloon Range, needed to be defended.

Yet, though the "blockhouses" had disappeared from the Island portion of the 1897 Defence Plan, they were still included as "will be constructed" in the Kowloon in the 1900 plan. The 1901 plan, revised to include the recently gained New Territories (1898), moved the defence line well north and did not show any Kowloon blockhouse. There is no other evidence at present to indicate any of these were ever built.

The 1901 plan then considered, and planned, the defence of Hong Kong against two possible forms of attack by:

(a) a European power, or by Japan and
(b) a Chinese army from Canton.

To defend the Island, it planned for holding the central ridge and gaps with small forces against initial landings expected to be made on the southern beaches, reinforcing them as necessary with mobile reserves. To defend the mainland against landings, or a Chinese army marching from Canton,

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[3] The expression "Fog Line" is used in the Introduction to the Defence Plans and describes the percentage of days of the year, by month and total, where the 'fog' on the Island is down to 800 - 1000ft, and 1000 - 2000ft.

[4] Editor's note: See http://rapidttp.co.za/milhist/research.html for an image of a typical Boer War 'Rice' pattern blockhouse. The General Staff, War Office, *Manual of Military Engineering,* London: Harrison & Co/Her Majesty's Stationery Office, 1905, has extensive and full depictions of Rice blockhouses, p.112 passim and discussion of these in military engineering circles can be traced back to the 1870s and before – see for example WW Knollys (1873), *Hand-book of field fortification, intended for the guidance of officers preparing for promotion, and especially adapted to the requirements of beginners,* Philadelphia: G. Gebbie, pp.39-46

[5] Plate 49 and Para. 161, Section 17, Blockhouses, Field Defences, Pt 1, *Manual of Military Engineering,* pages 106 – 107. (School of Military Engineering 1894, pp. 106-107) Seen by the author at the Royal Engineers Museum, Chatham.

it proposed holding a line along the Kowloon Range north of the ceded Kowloon Peninsula, using infantry detachments and mobile artillery to defend the passes over those hills. This plan remained unchanged until 1910.

THE 1911 DECISION TO BUILD

A review of the situation in 1911 still considered any attack on the Island likely to come through naval bombardment, naval attacks into Victoria Harbour, or landed raiding parties. The attacks on the mainland would probably come from either a Chinese Army or a raiding force of one of the European powers, Japan still being part of the Anglo-Japanese Alliance until 1921. Defence against either would be along the Kowloon Range, "but this has been much strengthened by a series of Blockhouses". Thirty blockhouses were built along the ridges, numbered from 1 at Devils Peak in the east, to 30 at Lai Chi Kok Pass (Tai Po Road) in the west, divided into five sub-sections. Their object was to be a base for infantry carrying out observation duties and patrols, protect the guns of the movable (mobile) artillery, and afford protection to places of importance e.g. the railway tunnel at Beacon Hill. (CAB 11/58)[6].

THE LOCATIONS OF THE 30 BLOCKHOUSES

Subject to subsequent confirmatory ground survey, most of the blockhouse ruins can be identified on 1963 aerial photos locations of 30 were plotted in **Figure 1**.[7] It can be seen that their general alignment was close to that of the pillboxes (PBs) of the Gin Drinker's Line though even the highest PBs were seldom found as close to or on ridge lines.

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[6] CAB 11/57 and CAB 11/58 are large boxes containing bound copies of the Hong Kong Defence Plan for various years from about 1894 to 1920 found in the National Archives, Kew.

[7] Editor's note: the only BHs the locations of which have not yet been identified from aerial photos are those of BH 2, 4, 14, 27, 28 and 30. Those clearly identified were marked precisely in Figure 1. Courtesy: Mr. Ken S.T. Ching and Mr. Y. K. Tan.

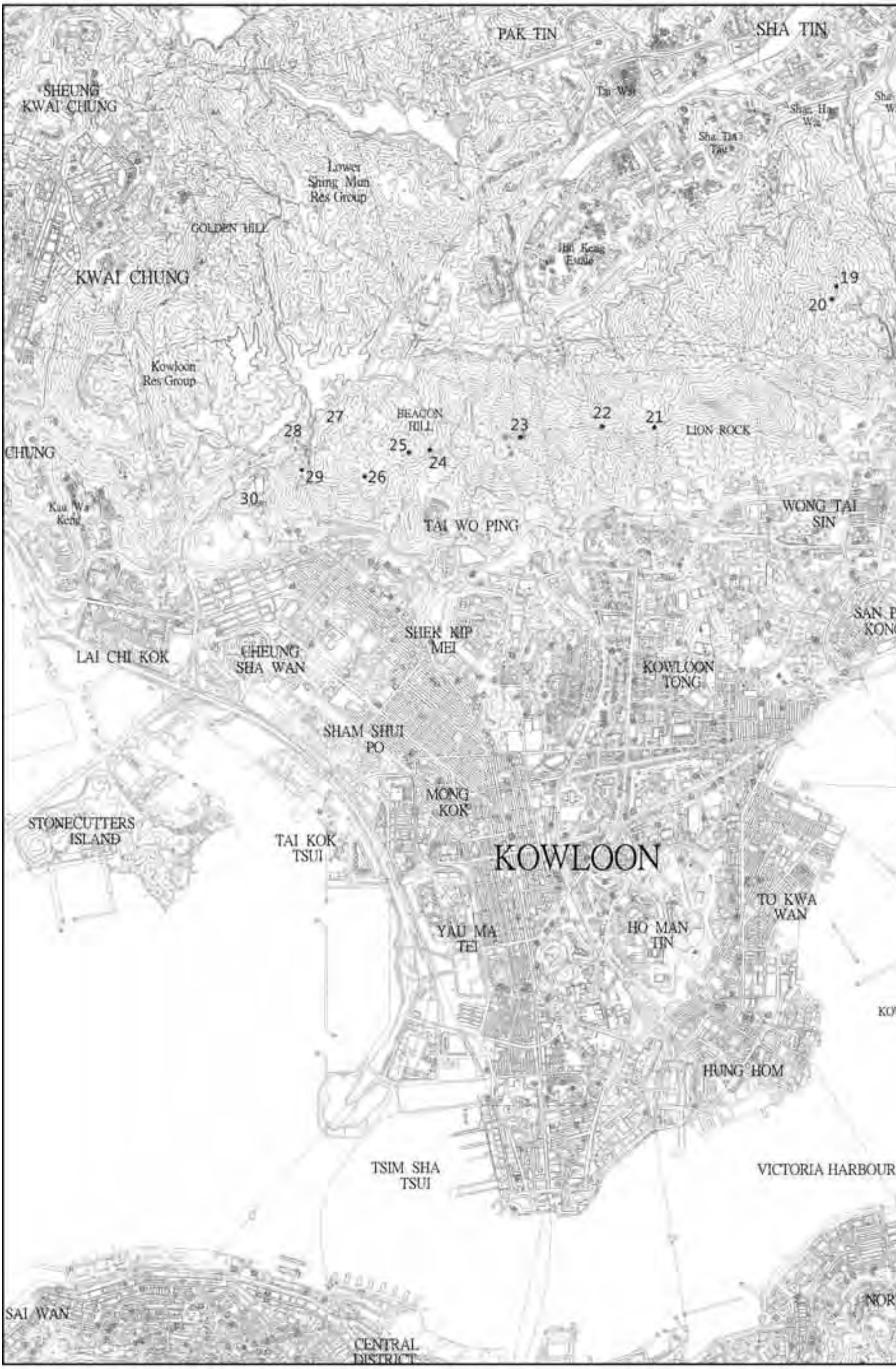

Figure 1: The location of Briti

ish blockhouses in Hong Kong

The blockhouse plan for Hong Kong is likely to have been of a 'Circular "Rice" Blockhouse, Stone Filled Shields Earth Filled Caisson'.[8] This was the standard British Army Blockhouse at the time. Developed in South Africa by Major Rice of the Royal Engineers, it was built in huge numbers there during the South African War at the beginning of the 20th Century. Its big advantages were that it was prefabricated and could be delivered and constructed quickly and easily, and was relatively cheap. It consisted of two walls of corrugated iron, separated by stones, with ready cut loophole positions, a single closable entrance, a wooden roof, and was surrounded by a trench, one side of which was revetted in stone. An outer wire entanglement was placed some 20 yards away. The roof was for weatherproofing only, it was not bulletproof. **Figure 2**, based on a drawing in the Royal Engineers Museum at Chatham, shows the general design of the blockhouse.

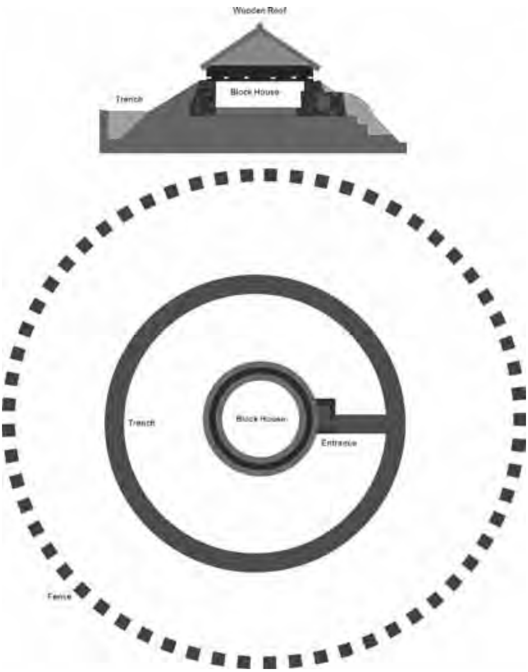

Figure 2: Design of a British blockhouse

[8] The author does not claim to have enough evidence to say the Hong Kong ones were definitely of the Rice type, but they were the standard type at the time, and the few remains show distinct similarities: the diameter of the footprint is the same (about 20ft/6m), there is much uniform shingle (foreign to the area) in the immediate vicinity, and there are circular stone walls fronted by the remains of ditches (BH 22 at Railway Pass is a particularly good example). The only known picture of Hong Kong blockhouses (BH 24, 25 and 26), at the Hong Kong Public Record Office, is inconclusive.
At the Scottish Regiments Museum in the UK the author tried to get the original of that photo, but they could not find it in their records.

The only Hong Kong Public Record Office photo of any blockhouses is one which I believe shows BHs 24, 25 and 26 at Eagle's Nest.[9] **Figure 3** shows a site photo of the ruins of BH 22 in Kowloon Pass.[10] **Figure 4** shows an artist's impression of a Hong Kong BH.[11] On aerial photos, such circular blockhouses appear like red blood cells and can be easily mistaken for Chinese graves. As far as the author reckons, the only remains still in existence are BHs 19 and 20 near Crown Point, 22 at Railway Pass, and possibly 26 at Eagles Nest.[12] BHs 5 to 9 on the top of Tai Sheung Tork did exist at the time of his last visit. They may since have been lost to quarrying above Anderson Road. He has also looked in most places where BHs might have survived, but except for the first three, no evidence of a BH was found. Most areas are as heavily overgrown as the PB sites.

Figure 3: A site photo of Blockhouse 22 today

Figure 4: Artist impression of a Hong Kong blockhouse

[9] There is also a file from – from the author's memory – KCR to the Military on payment of land rental for a BH on KCR property, from around 1926. It had no specific detail, so he made no note of it.

[10] Courtesy: Mr. Y. K. Tan

[11] Courtesy: Dr. Ho-yin Lee.

[12] Editor's note: remnants of BH 24, 25 (both on Eagle's Nest) and 29 (Piper's Hill) can still be found.

The strategic situation remained little changed for some time. With China distracted by internal conflict and European Powers' resources directed towards the First World War, the pressure on Hong Kong was removed. With those conflicts settled, it was time to re-evaluate Britain's strategic position in Asia.

In the period 1920 to 1922, the Hong Kong situation was reviewed at length, with the priority now being on dealing with a Chinese attack across the New Territories. It was considered that, where previously an attack would have been on a small scale, the improvement in organisation and tactics within the Chinese Army could see Hong Kong facing a force 50,000 strong and, with the rail line between Canton and Hankow soon to be completed, a further 30,000 men could be available within a further two months. Also in 1922, Britain, the USA and Japan signed the Washington Treaty that guaranteed among its articles, in return for other concessions, that Hong Kong would not become more heavily fortified. Whilst this was primarily intended to cover naval forces and coastal artillery, it was applied as a 'status quo' for all defences.

Faced with a Chinese force of that size, it was unlikely that Hong Kong could be defended for any great length of time with its existing garrison (5 Infantry Battalions plus Artillery and Engineers). There were many advantages in defending a line near the border (called the Blue Line in defence plans), but its length, and the length of the coastline to be defended behind it made it impracticable. Pending any increase in the size of the garrison, the main line of defence would be across the narrowest part of the Peninsula between Tide Cove and Gin Drinkers Bay (Red Line), with a subsidiary line (Brown Line) between Tide Cove and Hebe Haven to prevent raids by small parties under cover of darkness. Whilst the position of the Red Line would not prevent long-range artillery fire from hitting parts of the Island, it was the only line that could be economically held for a considerable time by the existing garrison.

There were three lines of Chinese attack considered by the defence planners[13]; the coast road along the shores of Tolo Harbour and Tide Cove from Taipo, a track over Lead Mine Pass towards Smuggler's Ridge and Golden Hill, or another track further west over the comparatively high pass on the west side of the Tai-Mo-Shan Ridge towards the coast, thence towards Golden Hill. As long as the Royal Navy had command of the sea, the use on any scale of either the Coast Road on the East or an attack on Golden Hill from the west would be a somewhat precarious operation for the enemy. The most likely attack was considered to be in the centre of the line, in the vicinity of Smugglers' Ridge. Delaying tactics would be employed forward of the line for as long as possible, to gain time for local reinforcements to arrive. It was

[13] The various lines of attack come from WO 32/5303 *Defence of Hong Kong against Chinese Forces 1920-22,* in the form of an 'Appreciation from GOC to War Office', and subsequent correspondence. This document also has the earliest seen copy of the map showing the Blue, Brown and Red lines.

envisaged that Hong Kong would have to rely on itself for two months. There was no longer any reference to the Blockhouses.

Considering the requirements for the line, a reserve, and forces on the Island, a total of 8 Infantry Battalions were considered necessary for the defence of Hong Kong. (WO 32/5303)

A further assessment in 1926 concluded that Hong Kong could not be defended without an Air Force, and in any case the Mainland could not be defended with the forces available. The whole defence should be based on retreat to, and defence of the Island until reinforcements arrived, probably in 8 weeks, or if necessary destroying everything of value before being overrun. In the face of a determined enemy, even if the reinforcements arrived, they would probably find the existing naval, military and commercial facilities of the Colony so crippled, if not actually ruined, as to make HK of little further strategic value for a considerable period[14].

In 1931, Japan seized Manchuria and the three north-eastern "three provinces" of the Republic of China, and the next year set up a puppet government. The following years brought continuing military conflict between Japan and China. This aroused British concern that Japan may soon become the biggest threat to Hong Kong, either by land through China, or amphibious landings on suitable beaches of the territory. This culminated in the plans made in 1934/35 to defend the Mainland along the line basically chosen in 1922, but strengthened by the construction of concrete pillboxes along its length from Gin Drinkers' Bay in the west to Hang Hau in the east, (the Inner Line or Gin Drinkers Line), a distance of approximately 18 Km. There would also be a small force forward near the Hong Kong border with China for demolitions and delaying, and prepared machine gun positions on some forward beaches. Because of its length, and the limited strength of the garrison available, it was envisaged that it would at best protect Hong Kong long enough for arrival of overseas reinforcements.

DISCUSSION

A fuller discussion of how these very different strategic perceptions related to the earlier defence line and its blockhouses awaits further historical inquiry. Had these already been abandoned and allowed to fall into ruin by, say, 1926? If they still existed, how were their positions related to the planning for the GDL? This sort of analysis is needed so that the relationship between the 1911-line, the Red Line of post-1922 and the subsequent GDL has been as fully explored as it can be. A total of 30 large blockhouses built and the normal inertia of military practice mean it is unlikely that there was no connection at all.

[14] CO 129/198/12.

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The author is in debt to the comments of two anonymous referees. Figure 1 was produced by Mr. Ken Ching, chartered land surveyor, and Mr, Y. K, Tan based on a draft prepared by the author. Figures 2 and 3 were courtesy of Mr. Y. K. Tan. Figure 4 was produced by Dr. Ho-yin Lee.

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Reconstructing The Early History of the Gin Drinker's Line from Archival Sources

Chi Man Kwong*

ABSTRACT

This article uses newly discovered archival sources from the National Archives of the United Kingdom and the National Institute for Defense Studies of Japan to outline the decision-making, layout and construction of the Gin Drinker's Line. It suggests that the idea of building a defensive line across the Kowloon Ridge appeared as early as in the 1910s, and that the Line predated the defensive line built on the British Isles during the invasion crisis in 1940 (the "Stop Lines"). The archival sources help us to locate the exact dates of the beginning and the end of the construction of the Line, and understand the reasons for the decision to build and to abandon it.

KEY WORDS

Military structure, Hong Kong, Gin Drinker's Line, Second World War, Pillbox, Defence

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INTRODUCTION[1]

The Gin Drinker's Line[2] has recently attracted much scholarly attention as it is one of the most elaborate military structures ever built in Hong Kong; its dramatic fall on 9 December 1941 contributed significantly to the fall of the Colony to the Imperial Japanese Army. Recent studies by Lawrence Lai and others have offered us new insights into the structure of the Line and the battle that caused its fall.[3] Previously, however, we knew comparatively little about the history of the Line, except from sporadic archaeological evidence. With newly discovered archival sources from the National Archives of the United Kingdom and the National Institute for Defense Studies of Japan, this article attempts to reconstruct the early history of the Line, including the emergence of the concept of a Kowloon defence line during the early 20th century, the events leading to the construction of the Line, the planning and layout of the Line, as well as its building process. The reasons for and the events leading to the eventual cancellation of the project will also be discussed.

Studies of the military history of Hong Kong usually focus on the Second World War. Works by Tony Banham, Oliver Lindsay, and Nathan Greenfield have exhaustively studied the Japanese invasion of Hong Kong in December 1941.[4] Recently, work done by Lawrence Lai and others provided fresh insights into the landmark battles during the campaign, such as that at the Shing Mun Redoubt and Wong Ngai Chung Gap.[5] These works provide the invaluable historical context of the military heritage of Hong Kong, allowing us to have a better of the history and significance of the particular heritage sites. Such understanding is of utmost importance in preservation

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[1] The author would like to extend his gratitude to Prof. Lawrence Lai, Mr. Rusty Tsoi Yiu Lun, Mr. Dennis Cheung Tsun Lam and Mr. Anthony Wong for their contribution to this paper. The author would also like to thank the Advanced Institute for Contemporary China Studies of Hong Kong Baptist University to provide resources for the research.

[2] The word "Drinkers" in the name of the "Gin Drinkers' Line" usually appeared in plural form in official documents.

[3] Lai LWC (2009), The Gin Drinker's Line: Reconstruction of a British Colonial Defence Line in Hong Kong Using Aerial Photo Information, *Property Management,* 27:1, 16-41; Lai LWC, Davies SNG, Ching KST, Wong CTC (2011), Decoding the Enigma of the Fall of the Shing Mun Redoubt Using Line of Sight Analysis, *Surveying and Built Environment,* 21:2, 21-42; Lowry B, The Gin Drinker's Line: Its Place in the History of Twentieth Century Fortification, *Surveying and Built Environment,* 21:2, 58-68; Lai LWC, Tan YK, Ching KST, Davies SNG (2011), Location of Pillboxes and Other Structures of the Gin Drinker's Line Based on Aerial Photo Evidence, *Surveying & Build Environment,* 21:2, 69-70; Tan YK (2011), Pillbox above Shing Mun Road, *Surveying and Built Environment,* 21:2, 71-77.

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[5] Recent articles such as "Pillbox 3 did not open fire!," Mapping the Arcs of Fire of Pillboxes at Jardine's Lookout and Wong Nai Chung Gap, *Surveying and Built Environment,* 21:2, 43-57 and Lai LWC (2001), The Battle of Hong Kong 1941: a Note on the Literature and the Effectiveness of the Defense, *Journal of the Hong Kong Branch of the Royal Asiatic Society,* 39, 115-136 are excellent examples.

efforts. This article, by filling an important gap of the history of the Gin Drinkers' Line, namely the history of its planning and construction, contributes not only to existing literature but also the preservation effort.

British archival materials about the Gin Drinker's Line mainly come from the meeting minutes, reports and proposals of the organisations responsible for the defence policy of Hong Kong during the Colonial Period (1841-1997), such as the Committee of Imperial Defence (CID), Chiefs of Staff Committee (COS), Joint Planning Committee (JPC), as well as the War Office (WO). *The Hong Kong Defence Scheme* of 1936 drafted by the Hong Kong garrison was also consulted. Japanese military engineers had compiled The *Study of the Main Defence Position on the Kowloon Peninsula* after the fall of Hong Kong in January 1942. The report provides much insight as to the Japanese view of the Line and enables us to understand the layout and construction process of the Line by cross-referencing with British sources.

FROM CONCEPTS TO REALITY, 1910-1935

The question of defending the Kowloon Peninsula against attack from the mainland was raised soon after the British had leased the New Territories from the Qing in 1898. Major General William Gascoigne, the commander of the Hong Kong garrison, highlighted the importance of the Kowloon Ridge, situated between the Kowloon Peninsula and the New Territories, in the defence of the Colony in 1901:

> This chain of hills runs for two-thirds of the way due west and east, and then sharply recurves for the remaining distance to the south. The western and eastern flanks rest on the sea, and it thus forms a barrier wall affording many facilities for defence, and represents to Kowloon in miniature degree much what the Himalayan range does to India.[6]

Gascoigne estimated that the most likely enemy would be France, Russia, or Japan, who might seize the Kowloon Ridge as a strategic height before challenging the defence of the Hong Kong Island.[7]

As most of the British officers at Hong Kong had served in India, the analogy was instantly understood, hence the importance attached to the Kowloon Ridge. The first proponent of a landward defence line on the Ridge was Major General Charles Anderson, the garrison commander from 1910 to 1913. When drafting the *Defence Scheme of 1910*, he pointed out that the Ridge might provide an easily-defensible position for the invader to observe the harbour and cover it with artillery fire.[8] Thus, in the *Defence Scheme* he included a plan to construct

6 "Hong Kong Defence Scheme, Revised to June 1901," CAB 11/57, p. 14.
7 CAB 11/57, 33.
8 "Hong Kong Defence Scheme, Revised to June 1910," CAB 11/57, p. 24.

a series of temporary redoubts at the beginning of any hostilities with France and Russia along a 15-km front stretching from near Devil's Peak to Lai Chi Kok Pass, with Chiu Lan Chu, Grasscutters Pass, Beacon Hill Pass and Kowloon Reservoir in between. This should be the official basis for the mainland defence line which Anderson formally proposed to the War Office to construct in May 1911.[9]

Anderson's idea was not considered until he argued that the rapidly-modernising Chinese army might be able to threaten the safety of Hong Kong in early 1912. In particular, he mentioned the effectiveness of the Cantonese New Army (*xinjun*), which had participated in the Revolution.[10] Paradoxically, the formation of a republic in China raised rather than eased British concern for the security of Hong Kong. Although the Overseas Defence Committee acknowledged the need to build an "infantry defence line," it did not specify its scale or budget. After that, the War Office sanctioned Anderson to build redoubts armed with heavy guns along the Kowloon Ridge.[11] However, the First World War broke out before any actual work had been done.

During the First World War, a smaller defence line was built across the Kowloon Peninsula near modern-day Ho Man Tin and Yau Ma Tei. "Caponiers" (the term used in official documents) were also built near major batteries such as the Lyemun Battery, Devil's Peak and Mount Davis.[12] Although actual maps have yet to be found, it was noted that the line consisted of trenches and pillboxes built with plywood and corrugated metal, protected with barbed wire. Nonetheless, as the Hong Kong Government started to develop the nearby area, the garrison reported some of the recent building works had already overlapped with the defence line.[13] In January 1915, the Commanding Officer of the Royal Engineers at Hong Kong suggested that the British might have to defend a new position along the Kowloon Ridge as the result of urban expansion.[14]

After the First World War, the question of Hong Kong defence resurfaced as Japan was seen as a potential foe. Hong Kong was seen as an important base in the Royal Navy's plan against Japan (the *War Memorandum (Eastern)*) as it was closest to mainland Japan among the British colonies in Asia. From Hong Kong, the Royal Navy could disrupt the trade between Japan and

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[9] See paper by Weir in this issue, which reports that a total of 30 were built.

[10] "General Officer Commanding the Troops, South China, to War Office," 14/3/1912, CAB 38/22/38, p. 7.

[11] "D.M.O. (Director of Military Operations) and D.F.W. (Director of Fortification Works) signed," 3-9/1/1913, WO 32/5316.

[12] "Hong Kong – Storm-proof Defence and Land Fronts," 14/1/1915, WO 32/5316; see also Lai LWC, Ho DCW, and Leung HF (2003), Survey of the Devil's Peak Redoubt and Gough Battery, *Journal of the Hong Kong Branch of the Royal Asiatic Society,* 42, 101-137. It is noted by Lai et al. that the caponier at Devil's Peak was built in 1914.

[13] "Hong Kong – Storm-proof Defence and Land Fronts," 14/1/1915, WO 32/5316.

[14] "Hong Kong – Defences on the Land Fronts: Summary of Proposals Affecting the Defence of Kowloon," 14/1/1915, WO 32/5316.

the rest of the world, and then lure the Japanese Navy to fight a decisive battle against the main body of the Royal Navy.[15] Weihaiwei, another British possession in North China till October 1930, was not seen as a usable base. Soon after its acquisition in 1901, the Admiralty had already warned that it was "strategically too isolated" and thus the port was not fortified. As T. G. Otte mentioned, the Naval Staff had suggested in 1921 that it would not be possible to retain Weihaiwei during an Anglo-Japanese War.[16] Thus, Hong Kong was the most advanced naval base in a war against Japan. To prevent Hong Kong from being captured by the Japanese before the British main fleet had reached it, it was deemed necessary to provide adequate defence for the Colony. However, efforts to augment Hong Kong defence were marred by the Washington Treaty signed in 1921, which had forbidden Hong Kong to construct or upgrade coastal defence artillery and naval bases.[17] It was in this context that numerous studies on the defensibility of Hong Kong were conducted.

In 1925, the Governor of Hong Kong Sir Reginald Stubbs, with the Army and Navy commanders at Hong Kong, submitted a report on Hong Kong defence arguing that Kowloon and the New Territories should be given up in face of an enemy attack.[18] Apparently, the Committee of Imperial Defence in London was not satisfied, as the Joint Planning Committee was instructed to submit another report in December 1927. The JPC consisted of the personnel from the Army General Staff, the Department of Naval Plans, and the Directorate of Operations and Intelligence of the Air Ministry. The report anticipated that after landing at Starling Inlet, the Japanese would advance along the Kowloon-Canton Railway towards the Kowloon Peninsula. To resist such attack, the JPC put forward two plans with different scales. A "full scale" plan required a garrison of 10 battalions, with the main area of resistance at Tai Mo Shan. A more practical "reduced scale" plan involved a garrison of 8 battalions, and the mission of the garrison would be as follows:

> To provide sufficient force to ensure an adequate bridgehead being maintained on the mainland; this will entail the retention of the line Tide Cove-Gin Drinker's Bay;
>
> To prevent any actual Japanese landing as long as possible, and to impose on any force which

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15 Bell C (1996), 'Our Most Exposed Outpost': Hong Kong and British Far Eastern Strategy, *Journal of Military History,* 60:1, 66.

16 Otte TG, 'Wee-ah-wee'?: Britain at Weihaiwei, 1898-1930, in Kennedy G (2003), *British Naval Strategy East of Suez, 1900-2000,* London, Routledge, 10-18, 26.

17 For the full text of the treaty limiting coastal defence of Hong Kong, see "Conference on the Limitation of Armament, Washington: Treaty Between the United States of America, the British Empire, France, Italy, and Japan, Signed at Washington, February 6, 1922." http://www.ibiblio.org/pha/prewar/1922/nav_lim.html

18 "Defence Against Overseas Attack," 17/2/1926, CO 129/498.

> succeeds in gaining a footing the maximum of delay before they can attack the bridgehead;
>
> To provide a mobile reserve available to resist attempts to land elsewhere at points which would turn the main bridgehead position and cut off the forces delaying the landing about Starling Inlet;
>
> To secure Hong Kong Island against a direct attack.[19]

The assumption behind the above arrangement and objectives was that the main fleet of the Royal Navy would be able to reach Hong Kong in 44 days after commencement of hostilities.[20] It was also estimated that the invading Japanese army could only reach Hong Kong from Taiwan or Japan 10 days after the war started. Thus, the so-called "Tide Cove-Gin Drinker's Bay Line" was not meant to be held permanently, but to delay the fall of Hong Kong for 34 days with other land, naval and air support.

Throughout the 1927 report, there was no mention of the previous proposals about the Kowloon Line or even the line actually built during the First World War. It seems that the JPC had approached the question afresh. Although the report of 1927 brought no immediate change, it had set the objectives for the garrison and put forward the idea that the line between Tide Cove and Gin Drinker's Bay could be the main area of resistance, thus laying the conceptual foundation for the Gin Drinker's Line.

In June 1930, the JPC submitted another report on Hong Kong defence. Although it was still assumed that reinforcement could arrive in 44 days, additional factors were introduced. For example, it was noted by the Committee that the Japanese would be able to land two infantry divisions in Starling Inlet or on mainland China. Referring to the lessons from the Russo-Japanese War and the First World War, the report suggested that one should not count on terrain to delay the "unusually mobile" Japanese.[21] To meet a landward attack, the report suggested establishing a three-layer defence in the New Territories. The first line stretched from Starling Inlet to Shum Chun (Shenzhen) and the second would be "a line of 16,000 yards near Tai Mo Shan".[22] The JPC did not specify the location of the so-called "Tao-mo-shan Hill Line," except pointing out that the Line consisted of an open right flank of 3,000 yards and a left flank protected by a river. The JPC, who had not been to Hong Kong, might have judged the location near modern day Sheung Tsuen as a possible "area of resistance," with its flanks being Tolo Harbour and the Kam Tin River. According to the JPC's plan, these two lines were "delaying lines". The third line would be the Tide

[19] "Defence of Hong Kong: Report of Joint Planning Sub-Committee," 10/12/1927, COS 117, 18.
[20] COS 117, 7-8.
[21] "Defence of Hong Kong: Report of the Joint Planning Sub-Committee," 31/5/1930, COS 233JP, 19.
[22] COS 233JP, 20.

Cove-Gin Drinker's Bay line of 8,800 yards, which was seen as the most important:

> The Tide Cove-Gin Drinker's Bay line is a strong defensive position. The only approaches by road both on the east and west run on the edge of the sea and the main approaches, those on the east, are exposed for some thousands of yards to fire of machine guns and light artillery south of Tide Cove. Any frontal attacks on the position must be made over country impassable except to the most mobile infantry and down slopes exposed to the fire of all arms from the main position. A considerable portion of the front is protected by the precipitous gorge of the Shing Mun River, which, if swept with machine gun fire, is capable of stopping any attack southwards from Needle Hill…
>
> If, therefore, this line were strongly wired and good machine gun emplacements were prepared it should be possible for the line to be held by three battalions, with an increased establishment of machine guns…[23]

At the end of the report, the JPC recommended to investigate "the most rapid method of constructing concrete machine gun emplacements."[24] This report was the first firm proposal for a permanent defensive line from Tide Cove to Gin Drinker's Bay. The report also envisaged a smaller garrison of 6 battalions, implying that more fortification could help reduce the permanent garrison of Hong Kong.

As the British government was unwilling to increase military spending due to the Great Depression, the above discussion did not lead to immediate action. However, as the international situation in Europe and Asia deteriorated rapidly from 1931, the problem of Hong Kong defence resurfaced yet again. The JPC was ordered by the Committee of Imperial Defence to submit the report, *Hong Kong: Plans for Defence, Relief or Recapture*, in July 1934. In the report, the JPC again urged the construction of a defensive line on Kowloon Ridge:

> If the main position is wired throughout its length and provided with concrete pillboxes, its capacity for defence can be greatly increased and it is by no means improbable that, with a small expenditure of money, the main line of defence with both flanks resting on the sea could be adequately defended by a comparatively small garrison.[25]

The JPC also noted that "large concrete

[23] COS 233JP, 20.
[24] COS 233JP, 47.
[25] "Hong Kong – Plans for Defence, Relief or Recapture, Report of the Joint Planning Committee," 30/7/1934, COS 344, 9.

reservoirs and conduits are being constructed in the neighbourhood of Hong Kong in connection with the Shing Mun Valley water supply scheme, and lend themselves for incorporation in the defensive line."[26] In the report, the cost-effectiveness of the line became the main argument for its construction. In fact, as discussed below, the willingness of the British decision-makers to replace manpower with fortifications was the main reason for its construction.

In March 1935, Major General Frederick Barron, the Inspector of Fixed Defences of the War Office, was sent to Hong Kong to inspect the proposed site of the Line.[27] When Barron arrived at Hong Kong, he noted that "platoon localities in two sectors have already been dug during the winter months, using military labour." [28] After inspection, Barron recommended the War Office to sanction the project. Six months later, the Chief of Imperial General Staff (CIGS) General Sir Archibald Montgomery-Massingberd submitted a report to the Defence Requirement Committee to secure a budget of £3,861,000 for the improvement of Hong Kong defences. The Line was surprisingly cheap compared to other installations. For example, an additional 9.2-inch gun cost £186,000, a new barracks for an infantry battalion £362,500, and the annual upkeep of an Indian infantry battalion was £78,000. However, the construction of the Gin Drinker's Line cost only £168,000. Thus, it was hardly surprising that the War Office welcomed the project.

DESIGN AND LAYOUT FROM THE DOCUMENTS

Overall Planning

The design of the Gin Drinker's Line was done by the Hong Kong garrison led by Major General Arthur Bartholomew. Although the actual proposal sent by Bartholomew to the War Office has yet to be found, General Frederick Barron submitted a review of Bartholomew's proposal, which contains much detail about the design and layout of the Gin Drinker's Line. According to Barron's Report, the defence of the Leased Territory contained three phases:

1. Prevention of a landing within its boundaries
2. Development of delaying action from either the frontier or the point of landing back to the final defensive position covering the vital areas
3. The defence of the final defensive position[29]

As it was impossible to defend all

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[26] Ibid., 9.
[27] "Mock Battle at Hong Kong," 20/3/1935, *The Straits Times;* "10,000 Men in Secret Battle," 9/4/1935, *The Straits Times;* "British Defences in Far East," 18/4/1935, The Straits Times.
[28] WO 106/111, 19.
[29] "Report on the Defences of Hong Kong," 4/1935, WO 106/111, 16.

beaches, both Barron and Bartholomew argued that the land forces of the defenders should focus on delaying the enemy rather than stopping them from landing, which should be entrusted to the coastal batteries, the RN, and the RAF. Before the Japanese forces could reach Kowloon, they first had to overcome the Gin Drinker's Line, or the "final defensive position" as the report called.

According to Barron, the Line stretched "from Junk Bay on the right, via Razor Hill and Buffalo Hill to Tide Cove, and thence along the Shing Mun River to Smugglers' Ridge and Gin Drinker's Bay."[30] Barron divided this line into four "Sectors" as in the following (**Figure 1**):

Sector 1: The Right, from approximately Junk Bay to One Rise More, covering the right flank against an enemy landing in Port Shelter

Sector 2: The Right Centre, stretching westwards to the head of Tide Cove, and covering any attempt of the enemy to outflank the Centre and Left Sectors by transferring troops to the south side of Tide Cove

Sector 3: The Left Centre, covering the Taipo Road and Shing Mun Valleys

Sector 4: The Left, covering the Castle Peak Road and Golden Hill[31]

Thus, the Gin Drinker's Line as

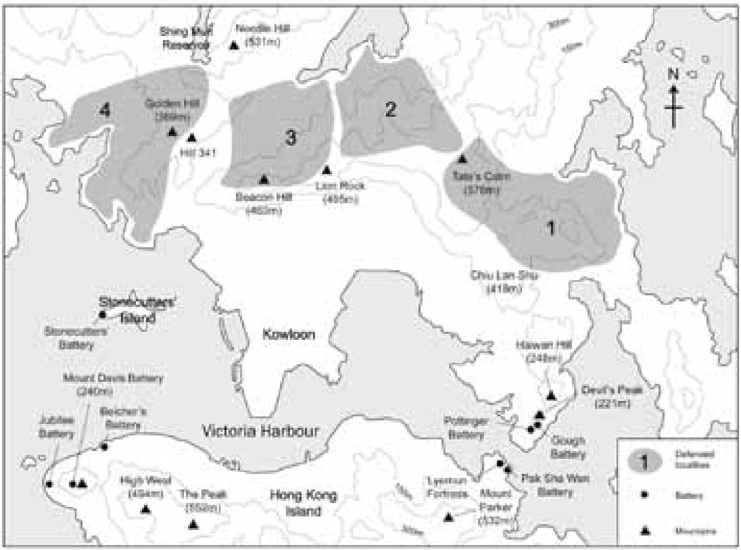

Figure 1: General defence sectors of the Gin Drinker's Line

[30] WO 106/111, 17.
[31] WO 106/111, 17-18.

envisaged was not a continuous line *per se*; it consisted of four stand-alone "defended localities" each manned by more or less a battalion and supported by artillery. The idea of "defended localities" emerged during the First World War. To prevent penetration by the enemy, defenders usually deployed in depth rather than in line. Positions were held not by separate lines of defence but by a series of interlocking and mutually-supporting positions spread across a specific area. The term "defended localities" first appeared in the *Manual of Field Works* of 1925 to describe a group of mutually-supporting positions forming one large defended area.[32] Such localities would be clustered around a dominant position or on terrain that prevented further advance by the enemy.

From **Figure 1**, one can see that each Sector is itself a locality around a group of mountains and together they form a large defensive "belt". The JPC estimated in 1930 (see above) that the Japanese would approach the Line from mainly two sides: from the north through Shatin or from the west along the Frontier and Castle Peak Roads. Those attacking from the north would be blocked by Sectors 2 and 3, while those from the west would be fended off by Sector 4. Barron suggested that "three of these sectors must be strongly held, but so long as there are fixed seaward defences covering Port Shelter by day and night, the Right Sector can be left comparatively weak."[33] Thus, Barron approved the design of the Line based on the assumption that its right flank at Sai Kung would be covered by the proposed coastal guns at Junk Bay. However, no actual work had been carried out, and the whole idea of defending Kowloon and the New Territories was dropped altogether in 1938.

The term "Inner Line" was only adopted officially in February 1937, after the *Defence Scheme of 1936* was adopted.[34] Concurrently, the Hong Kong-mainland border was designated as the Outer Line, and the area between the Outer and Inner lines was known as the Intermediate Position, and was also divided into four sectors. After that, although the specific time and order for the change has yet to be found, the pillboxes of the Line were numbered in groups, with the first digits of 1, 2, 3, and 4 denoting the number of "defended localities" of the Line.[35] It was proposed by General Bartholomew that the garrison of the line should not be "less than four battalions," of which three

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[32] *Manual of Field Works (All Arms) 1921 (Provisional),* London: HM Stationary Office, 1925, pp.82-83 and 86. It is important to note that the *Manual* specifies that "Each defence post within a locality must afford support to its neighbours, and be connected up by communication trenches on flanks and rear."

[33] WO 106/111, 18.

[34] "Extract from D. O. Letter d/-13.2.37 from Col. Harrison, Hong Kong," 13/2/1937, WO 106/2363.

[35] It seems that the 1, 2, 3, 4 numbering system was introduced only after some of the pillboxes were built, as the surviving early reports used a different 2-digit system which started with "5". See "Work Completed on Gin Drinker's Line," circa 1936, WO 106/2363; "Report of the Director of Public Works for the Year 1937," Annual Report 1937, 55; also see Lai LWC, Davies SNG, Ching KST, Wong CTC (2011), Decoding the Enigma of the Fall of the Shing Mun Redoubt Using Line of Sight Analysis, 23.

would be in the line and one in reserve, supported by 12 3.7-inch mountain guns and 8 6-inch howitzers.

Barron also highlighted the possible danger of the Line being infiltrated at night, as he noted that the ground on which the Line rested was very broken and valleys were all covered with thick vegetation. Thus, whilst he not only proposed to build a network of pillboxes, Barron also recommended the Line to have a "strong garrison of infantry by night or under adverse weather conditions."[36]

The Construction Process and Layout
As mentioned, soon after the JPC had submitted their report in July 1934, the Hong Kong garrison had already started preliminary work on the Line. Although sources are scarce and far apart, it is still possible to reconstruct the construction process by examining existing documents. An undated note titled *Work Completed on Gin Drinker's Line* suggested that the first pillbox of the Line, known as No. 55, was completed on 20 December 1935. The second pillbox, No. 57, was finished on 4 March 1936. The two pillboxes were probably experimental in nature, as will be discussed below. In June 1936, five more pillboxes were completed, all were found on the Left Sector, designated as Nos. 56, 58, 60, 64, and 66.[37]

In the *Report of the Director of Public Works for the Year 1937,* the Public Works Office mentioned that it had built three pillboxes (Nos. 53, 54, 65) and "tunnels" when discussing its work along the Shing Mun Valley.[38] It is possible that they were pillboxes of the Shing Mun Redoubt, but solid documentary evidence has yet to be found.

The *Progress Report of Landward Defence* submitted to the War Office in April 1938 was the most detailed report on the construction process of the Gin Drinker's Line. It noted that although only 20 pillboxes were built by 1937, the pace accelerated from the second half of the year, probably after the outbreak of the Sino-Japanese War. By April 1938, there were 38 completed pillboxes, with another 33 85% finished and 19 half-finished. Meanwhile, nine splinter-proof headquarters were finished or almost finished, with two more half-finished. Three observation posts (OP), located at Shing Mun Redoubt, Smugglers' Ridge and Crown Point, were all finished. By then, barbed wire and apron fences were already erected at the Shing Mun Redoubt and some of the sectors.[39]

Since General Bartholomew's proposal has yet to be found, the total number of pillboxes proposed for the Gin Drinkers' Line remains a mystery. Thus, we are unable to discern how far the line was completed. However, Japanese sources and recent research allow us to discover the actual layout

[36] WO 106/111, 18.
[37] "Work Completed on Gin Drinker's Line," circa 1936, WO 106/2363.
[38] "Report of the Director of Public Works for the Year 1937," Annual Report 1937, 55.
[39] "Landward Defence," 4/1938, WO 106/2363.

of the Line and the types of pillboxes. From these sources, one can even trace the transformation of British pillbox design between 1935 and 1938. Japanese military engineers mentioned 94 "pillboxes (*tochika* in Japanese)" in *The Study of the Main Defence Position on the Kowloon Peninsula* (those with designations "A" and "B" were counted as one pillbox). HQ, Ops and bunkers are treated separately in the Japanese report, as only those with a British-assigned number (i.e. "PB 419") were treated as a *tochika*. However, the *Progress Report* of the War Office in 1938 mentioned only 90 pillboxes, 11 headquarters, and 3 observation posts. Of the pillboxes found by the Japanese, 27 were found in the Right Sector, 23 in the Centre-Right, 16 in Centre-Left, and 28 in the Left Sector. Using aerial photographs and on-spot inspections, Lawrence Lai et al. found 93 pillboxes, with 20 other structures including the OPs and so on.[40]

The Japanese did not find the layout of the Line well-designed, as although many pillboxes had wide firing arcs, vertical firing arcs were always blocked by terrain. The spacing between each pillbox was about 500-1,000 meters. If one of the pillboxes had been captured, the attacker would be able to find more blind spots of the pillboxes nearby.[41] In addition, some of the pillboxes were unable to blend with the surrounding environment and became more conspicuous because of their half-hearted camouflage.[42] The Japanese also noted that the concrete used by the British was of a superior quality to that used in Japan. As the Line was half-finished, it is impossible to know whether these defects would have been rectified had the British not suspended the project in 1938.

It was possible that the Gin Drinker's Line was seen as an experiment for the British to test and refine their pillbox design. The *Study of the Main Defence Position* revealed that most of the pillboxes of the Gin Drinker's Line were of a standard design with only a few distinctive exceptions. Compared with the *Work Completed on Gin Drinker's Line* report, the number and location of these distinctive pillboxes matched, showing that the first few pillboxes of the Line were very likely of experimental nature. The first pillbox, No. 55, was possibly PB 414 found by the Japanese on the Left Sector. Of the around 90 pillboxes of the Line, only PB 414 had five embrasures and two separate chambers within the concrete body (**Figure 2**).

[40] Lai LWC, Tan YK, Ching KST, Davies SNG (2011), 69.

[41] While this might be the cause of the rapid fall of the Shing Mun Redoubt during the Battle of Hong Kong in December 1941, further investigation as to whether the Japanese had such knowledge before the battle and acted accordingly is needed.

[42] "Kyūryū hantō okeru honbōgyo jinchi chōsa hōkoku *(The Study of the Main Defence Position on the Kowloon Peninsula*)," 1/1942, Shina-Dai Tōasen-Nanshi 90, Archives of the National Institute for Defense Studies of Japan.

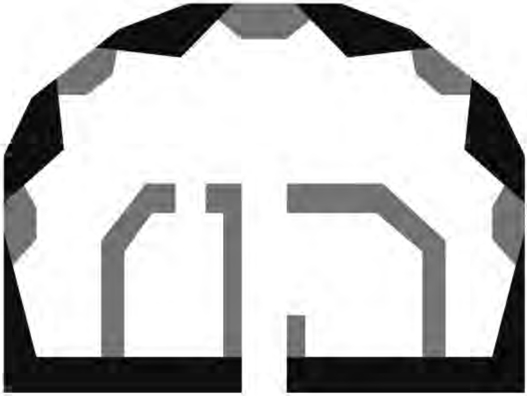

Figure 2: Simplified layout of PB 414 as drawn by the Japanese military engineers

Another distinctive pillbox was PB 419, which was also found on the Left sector. It was equally likely that PB 419 was No. 57 mentioned by *Work Completed on Gin Drinker's Line*. According to the Japanese and recent research by Y. K. Tan, PB 419 had three embrasures and a central corridor dividing the pillbox in the middle (**Figure 3**).[43]

Figure 3: Simplified layout of PB 419 as drawn by the Japanese military engineers

[43] Tan Y K, Pillbox above Shing Mun Road, in *Surveying and Built Environment,* Vol. 21, No. 2, (Dec. 2011), 71-77.

Except PB 414 and 419, the layout of other pillboxes closely resembled the design stipulated in the *Manual of Field Engineering* of the Royal Engineers (RE), issued in 1936[44]. Most of them had a width of 5.5-6m and a length of 2.5-4m and had two embrasures, such as those found at the Shing Mun Redoubt. Lawrence Lai et al. had conducted detailed research on these more standardised pillboxes,[45] with the only difference being the absence of the concrete wall within the pillboxes. As the previous RE Manual was issued in 1925, the two pillboxes illustrated above were probably "experimental pieces". Currently, there is only circumstantial evidence to prove that they were the first British pillboxes built across the British Empire during the Interwar Period, but they certainly predated the pillboxes built on the British Isles in 1940.[46] Further research is required to discern the ways in which the Hong Kong pillboxes did or did not influence the design of their counterparts at home, or were linked to late WW1 designs, or designs being used in contemporary British India.

The Changing Purpose of the Line

The planned use of the Line changed over time. In the *Defence Scheme* of 1936, General Bartholomew saw the Line as the final position of the mainland garrison:

> In the event of the enemy achieving considerable successes north and west or east of the "Inner Line" – by sheer weight of numbers or by the synchronization of his thrusts – it is the Fortress Commander's intention to delay the enemy from every direction and finally to fight the issue out to a finish in the "Inner Line"
>
> …even the smallest of foremost defended localities must fight out to the last man and the last round...troops (will be) fighting their way back steadily to the "line of the Passes," where the final issue will be fought out to a finish.[47]

Throughout the *Defence Scheme*, Bartholomew made no provision for the withdrawal of troops from the mainland to Hong Kong Island. The Kowloon garrison was expected to be destroyed in the attempt to impose maximum delay on the advancing enemy in order to prevent the capture of the Island. As he had deployed three out of four battalions of the garrison to Kowloon, Bartholomew was seemingly confident that the Line would enable the garrison to resist until reinforcement arrived. Nonetheless, sources suggested that he was less sanguine about the possibility of holding Hong Kong with the existing garrison. When he was replaced by Major General Arthur Grasett in 1938, he urged the War Office to deploy at least eight battalions in order to allow

[44] War Office, *Manual of Field Engineering,* 2 vols., London: HMSO, 1933-36. Vol. 1, All Arms; Vol.2, Royal Engineers, the design is in vol.2.

[45] Lai LWC (2009), 16-41.

[46] Lowry B, The Gin Drinker's Line: Its Place in the History of Twentieth Century Fortification, 61-62.

[47] *Hong Kong Defence Scheme* (1936), Hong Kong Public Records Office, 343.01 HON, 58-59, 63.

the garrison to fulfil its mission.[48] In retrospect, Bartholomew's arrangement in the *Defence Scheme* of 1936 was a rather desperate attempt to maximize the use of the Line.

The idea that the garrison should be destroyed with the Line was soon challenged. In the *Far Eastern Appreciation* drafted by the JPC in 1937, it was decided that Britain would not deploy more infantry to Hong Kong as the international situation deteriorated.[49] Without an adequate garrison, it was impossible to hold the Gin Drinker's Line for long:

> The Japanese may well have as much as a division with which to attack the Gin Drinker's Line and are not likely to anticipate much delay in capturing it, whether they use their superior numbers in a frontal attack or to turn the flanks by landing in rear of the position…[50]

Thus, the JPC suggested that the Line should be used only as a "delaying line", and the garrison should withdraw to the Island once the Japanese had breached part of it.[51] The role of Hong Kong would be changed from an advanced base into an "outpost" that should be held as long as possible.[52] As will be discussed below, the adoption of this view by the COS and CID soon led to the suspension of the project in 1938.

THE DECISION TO SUSPEND THE PROJECT

The Gin Drinker's Line project was suspended in July 1938 as the result of the rethinking of Hong Kong's role in British strategy in Asia in face of the impossibility of sending more troops to Hong Kong under deteriorating circumstances in Europe and the Mediterranean as the *Far Eastern Appreciation* of 1937 illustrated. In March 1938, the Overseas and Home Defence Committee submitted a report to the Chief of Staff Committee on the refortification of Hong Kong. The report suggested three plans of refortification, including a comprehensive plan costing £23,326,000. Although the Royal Navy insisted that Hong Kong should be extensively fortified, the Army and the Air Force were much less enthusiastic, as they believed that the Japanese would be able to destroy the naval base with long-range artillery and aircraft even if the Gin Drinker's Line was held. During a meeting on 4 April 1938, General John Gort, the new CIGS, suggested that

> …the best solution…would be to base our defensive plans on a retirement to the island. The Gin-drinkers Line should be only held lightly, and the garrison would retire back, destroying the base facilities on the mainland... [it is] not only impossible but

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48 Greenhous B (1997) *"C" Force to Hong Kong: a Canadian Catastrophe, 1941-1945,* Toronto; Buffalo, NY, Dundurn Press, 8.
49 "Far East Appreciation, 1937," 5/1937, COS 579, 31.
50 COS 579, 57.
51 COS 579, 60.
52 COS 579, 31.

> also valueless to try to hold the Gin-drinkers Line to the end, since in any case the naval base would be subjected to shelling from the land and heavy aerial bombing.[53]

As the navy insisted, the COS still recommended finishing the work in progress along the Line. However, the Army and the Air Force submitted reports to the CID in May, arguing that the Line could no longer serve the strategic purpose of protecting the Hong Kong naval base. The Army suggested that:

> …the Line (is) very long for any probable garrison; it has no depth; it can be outflanked by landings in its rear from the sea; it permits the enemy to be within artillery range of all the vulnerable areas; and it has the large and excitable masses of Chinese immediately in its rear at Kowloon…Once battle is seriously joined, the longer this line is held the greater the chances of a breakthrough and the greater the chaos and suffering of the civilian population in the rear. To hold on too long is to risk a serious defeat whilst doing little to prevent the destruction of the base facilities in the rear by artillery fire and air attack.[54]

Both the Army and the Air Force argued that the only feasible mission for the Hong Kong garrison during a Japanese invasion was to deny the use of the Victoria Harbour to the enemy by holding Hong Kong Island. The Gin Drinker's Line would be irrelevant in the new defence arrangement except to serve the purpose of delaying the advancing Japanese Army.

As the Army and the Air Force had made their position clear, the Royal Navy finally gave in. The memorandum *Policy for the Defence of Hong Kong* submitted by the COS in July 1938 suggested that the garrison would only conduct a delaying action on the mainland and then withdraw to the Island. As for the use of the Gin Drinker's Line, the memorandum suggested:

> We consider that the general defence for the Colony in such a contingency should be to delay the enemy from the frontier to the Gin Drinker's Line, mainly by demolitions, and subsequently to make a temporary stand on the Gin Drinker's Line itself. Resistance on this line, however, would not have to be continued long enough to endanger the chances of the infantry garrison retiring to the Island or to cause heavy causalities to the civilian population of Kowloon by the enemy's land bombardment.[55]

At that point, no new works were

[53] "Chiefs of Staff 234th Meeting," COS/234 Mtg, 9.
[54] "The Policy for the Defence of Hong Kong," 16/5/1938, COS 725, 5.
[55] "The Policy for the Defence of Hong Kong," 15/7/1938, COS 740, 7.

authorised on the Line but the half-built pillboxes were allowed to be completed[56], and all the coastal batteries on the mainland were withdrawn to the new emplacements on the south shore of Hong Kong Island, such as Pottinger Battery's relocation to Bokhara Battery at Cape D'Aguilar. At that time, the decision to use the Line only for delaying action was seen as top secret. When General Grasett was appointed as the garrison commander, he was specifically warned by the War Office not to disclose the decision to others, including the Governor.[57]

CONCLUSION

This article gives insight into the early history of the Gin Drinkers' Line. It helps us to better understand its planning, construction process, and the historical context that led to its emergence. It shows the changing purpose of the Line, from protecting Kowloon from possible Chinese aggression, to protecting an advanced base in a possible Anglo-Japanese War, to delaying the Japanese attack on Hong Kong Island. Contrary to previous assumptions, the Gin Drinker's Line was the product of long deliberation going back before the 1920s. As early as 1911 the idea of building a permanent defence line along the Kowloon Ridge had emerged. During the First World War, a smaller line was actually built across the Kowloon Peninsula, but was quickly swallowed up by urban sprawl. Rather than a response to a rising Japanese threat during the 1930s, the decision to augment Hong Kong's defences was to maintain the Colony as an offensive base against Japan, which was seen as a potential enemy soon after the First World War. From 1927, Kowloon Ridge was seen as the main defensive position, although the proposal to build a concrete defence line appeared only in 1930. It took five more years for London to sanction the project, and during the construction process the purpose of the line changed from holding the Kowloon Peninsula to merely imposing delay on the invaders. As the international situation prevented the British from deploying enough troops to man the line and it was deemed impossible to retain Hong Kong as a naval base in face of Japanese attack before the British fleet could reach Hong Kong, the project was finally suspended for good in July 1938. However, the decision to abandon the Line as a main position was kept secret, and consequently the Line was widely seen by many, including the Japanese, as a formidable defensive position by 1941.

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[56] Documents on the exact date of the completion of the Line (in its incomplete form) have yet to be found.

[57] Vincent C (1981) *No Reason Why: the Canadian Hong Kong Tragedy: an Examination,* Ontario, Canada's Wings, 8.

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Surveying & Built Environment

Good Property Valuation in Emerging Real Estate Markets? Evidence from Ghana

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ABSTRACT

Traditional valuation methods were designed with developed real estate markets in mind. Within that paradigm, the Cost Approach to property valuation is the method of last resort for surveyors, the exception rather than the rule. However, in countries such as Ghana where cultural practices, special relationships and administrative bottlenecks constitute structural impediments to the use of more 'progressive' valuation methods, surveyors rely on the Cost Approach (with some modifications) as the method of choice.

KEY WORDS

Valuation, Cost Method, Ghana, sub-Saharan Africa, Property Market

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INTRODUCTION

The size of the housing sector in Ghana, one of Africa's most urbanised countries, is growing. In 1970, the housing sector was made up of only 941,639 houses. Now, with increased population and demand, there are over 2,000,000 houses in Ghana (Ghana Statistical Service, 1970; 2005). Similarly, the quality of the houses has improved over time. In 1874, Accra, the capital city, was perceived as a city made up of thatched houses and crooked streets (Grant and Yankson, 2003, p.66), today that city has gated communities with villas (Grant, 2009).

The changing nature of the housing sector warrants a reflection on how Ghanaian professionals assess property values. The literature on real estate markets in sub-Saharan Africa, where Ghana is located, has largely ignored property valuation (see, for example, Ebohon et al., 2002). A small number of studies have examined valuation practices (e.g., Amidu and Aluko, 2007; Aluko, 2007; Babawale and Ajayi, 2011; Otegbulu and Babawale, 2011). However, most of them focus on factors that influence the opinion of valuers. Also, almost all of them are about the situation in Nigeria. To date, research on valuation methods in other countries in sub-Saharan Africa remains thin. So, analysing valuation in Ghana is important for expanding the knowledge base of valuation methods in sub-Saharan Africa.

Valuation in Ghana is influenced by the United Kingdom, which colonised the country from July 1874 to March 1957 (Ministry of Education, 1991, p.99). During that period there were some surveyors, who were deemed 'licensed' by virtue of consistently working according to the standards laid down in legislation such as the Gold Coast Technical Instructions of 1921 (Ofori-Boadi, 2006). According to Emmanuel Mohenu, Director of Surveying and Mapping Division of the Lands Commission of Ghana (now called the New Lands Commission), surveying in Ghana started about 100 years ago when Brigadier-General Sir Frederick Gordon Guggisberg, K.C.M.G., D.S.O., R.E. (1869-1930)[1] was the Governor of the Gold Coast (as Ghana was then called) (Zaney, 2009). Although there were surveyors with various specialisations, the dominant group was the land surveyors (LISAG, 2011). On 28th February 1969, over a decade after independence (which was obtained on 6th of March, 1957), the Ghana Institution of Surveyors, the professional body that tries to regulate professional valuation in Ghana, was established (Ghana Institution of Surveyors, 2011).

There are already some studies of valuation in Ghana that seek to describe the role of valuers (see, for example, Mends, 2006 and Ayittey et al., 2006) and how they are trained (Obeng-Odoom and Ameyaw, 2010; Obeng-Odoom and Ameyaw, 2011), so this paper extends that literature. It examines valuation methods, identifies their peculiarities in the context where they are used and highlights how valuers adapt the methods to the prevailing

[1] Editor's note: Guggisberg was Governor from 1919 to 1928. More importantly, He was himself an army surveyor and had been Director of Surveys of the Gold Coast 1905 to 1908. From 1910 to 1914, he was in the same post in Nigeria. In 1911 he wrote *The Handbook of the Southern Nigeria Survey.*

circumstances. It also draws attention to the continuing contradictions in the methods and suggests ways of overcoming them. The paper shows that, unlike in more developed real estate markets where the Market Comparison Approach is normally used for the valuation of real property, it is the Cost Method that is the dominant approach in Ghana. It traces this feature to the complex land tenure system and the pervasive problem of asymmetric information in the land sector mediated by weak land sector agencies.

The rest of the paper is divided into three parts. The first provides an institutional background and describes the land tenure system in Ghana. The next discusses valuation practice in Ghana, focusing particularly on the Cost Approach. Then, finally, the paper highlights some of the deficits in the Cost Method used and suggests some possible remedies.

INSTITUTIONAL BACKGROUND: LAND TENURE AND REGISTRATION

The land tenure system in Ghana is complex. In relatively developed real estate markets, such as Hong Kong's, the land tenure system is usually made up of registered freehold and leasehold interests (see Lai, 2005; Lai and Lorne, 2006). The system in Ghana is rather different. There is a dual system of land tenure, one customary, the other state based. Only 22 per cent of land is owned by the state, either alone (20 per cent) or jointly with communities (2 per cent). Most of the state land was obtained through compulsory acquisition for public use. The rest of the land is held under the customary land tenure system which constitutes 78 per cent of all land in Ghana (Kasanga, 2003). It is the more indigenous of the two systems and hence the source of the allodial interest, which is the highest title to land in Ghana.

The allodial and freehold interests are similar. However, unlike the latter, which is usually held by individuals in more developed economies, the allodial or paramount interest is vested in traditional land owning institutions (chiefs or priests), families, and clans (Woodman, 1996; Ministry of Lands and Forestry, 1999). So, unlike in countries such as Hong Kong where land tenure is mainly a relationship between state and individual and between individuals (Lai, 2005, p.18), in Ghana the community is central in land tenure relationships.

Two key features of customary land tenure are pertinent to this paper. First, the allodial interest in different parts of Ghana, the lesser interests deriving from them and their incidents differ according to local customs and practices. Second customary land tenure in Ghana is usually unregistered, consistent with the unwritten nature of customary land law: customary interests in land know no writing (Abdulai, 2006; 2010). However, since 1843, the state has taken the position that some writing or documentation is crucial to ensure clarity in land management and provide the ingredients for private ownership of land. Realising that aspiration would facilitate the valuation of landed property. It is known that an effective land administration system, characterised by ample information about landed property transactions such as the names of the parties involved in the transactions, the amount of consideration, the geographical location of the lot and its value create the conditions for socio-economic development (Lai, 2005; Lai and Lorne, 2006; Lai, 2010). So, the form and outcome of land administration in Ghana may be different from the situation in more developed real estate markets such as Hong Kong's, but the intent and objectives are similar.

In 1895, the state passed the Land Registry Ordinance, and, in 1962, repealed and replaced it with the Land Registry Act, which stipulated voluntary registration of any *instrument* in land (Alhassan and Manuh, 2005). The late 1980s and 1990s witnessed three significant changes in land management in Ghana. First, the state passed the Land Title Registration Law in 1986 to replace deed registration[2]. Second, it introduced a National Land Policy in 1999. Third, it launched the Land Administration Project (LAP) in 2003 (see Ministry of Lands and Forestry, 1999; Karikari, 2006; LAP, 2009). These reforms were aimed *inter alia* to improve the recording of transactions in land.

Under the Land Title Registration Law, 1986, all interests in land in areas declared as registration districts should be registered. To facilitate this process, the Government of Ghana has established eight land registries in regional capitals, such as Accra, Kumasi, and Cape Coast (Dauda, 2010). The Land Title Registry of Ghana claims that it strives to 'register all transactions relating to land in declared districts as enshrined in the provisions of the Land Title Registration Law, 1986, PNDCL. 152; develop, keep and provide readily accurate information on interests in land to the public; [and] provide security of tenure to land' (Land Title Registry of Ghana, 2007, p.2).

The institutional arrangement of title registration in Ghana, namely the *Torrens System,* is one of the most effective in the world. Under a Torrens System, registered land has state guarantee and is indefeasible. That is, registered land is conclusive evidence of ownership. It is one area where Ghana does better than many economies whose real estate markets are relatively well developed. In Hong Kong, for example, deeds, not interests, continue to be registered (Lai, 2010, p.665). Generally, under a system of deed registry, there is no strict requirement to enclose or append maps when applying for registration. Contrast that with the current Ghanaian system which makes the enclosure of maps and plans *conditio sine qua non* for any persons who wish to register their interests (Agbosu, 1990, pp.122-124).

According to the Land Title Registry of Ghana (2007, pp.4-5), the longest time it takes to provide service to the public is four weeks and its staff members are 'friendly' and 'courteous'. The documents it requires to do its job include indenture, proof of oath, parcel plans and, of course, the application forms. These documents are a vital source of information for valuers. The

[2] Title registration is different from deed registration. It requires compulsory registration and serves as a framework for the registration of *interests* in land rather than instruments. Furthermore, unlike deed registration, it is believed to provide the basis for a more secure backing by the state, what is called the 'indefeasibility principle'.

registry has an interest to ensure that the value of the interest in land which is to be registered is accurate, because its fee schedule is dependent on the value of land. Table 1 gives a breakdown of registration fees and corresponding land values.

Land Value (¢)*	Registration Fees for first time applicants (¢)
40 million	222,000
Above 50 million	290,000
100 million	425,000
150 million	590,000
Above 150 million	622,000
200 million	755,333
250 million	922,000
300 million	1,089,000
400 million	1,422,000
500 million	1,756,000
600 million	2,089,000
700 million	2,422,000

Table 1: Land valued in the millions and corresponding registration fees, 2007

Source: Land Title Registry, Ghana, 2007, pp. 8-9

*Cedi (¢) is the national currency of Ghana in the 'old' denomination. The 'new Ghana cedis' is written as GH¢. 'Old', as a descriptor, is used because the Bank of Ghana has recently redenominated the currency. The relationship between the old and new denomination approximates ¢ 1,000,000 = GH¢100 = $ 0.7 (see Bawumiah, 2010, pp.150-160 for more detailed discussion about the redenomination of the Ghanaian currency).

These sources of data notwithstanding, information about land in Ghana is sparse. One reason for this state of affairs is that only few transactions in land are registered. Even in Accra, the capital city, between the 1981 and 2001, only 11,382 transactions were registered (Abusah, 2004, p.44), although there were over 55,000 land transactions around this time. In 2008, Obeng-Dapaah (2008), a former Minster of Lands and Forestry, announced that, in Ghana as a whole, only 11,460 documents had been registered since 2005 (Obeng-Dapaah, 2008). What about getting data from other land sector agencies? Apart from other long bureaucracy valuers would have to go though to obtain information from the land sector agencies[3] (LSAs) in Ghana, Anim-Odame and his colleagues (2009) reveal that the LSAs

[3] In Ghana, these agencies are collectively called 'New Lands Commission', which excludes the Office of the Administrator of Stool Lands (OASL).

have limited amount of information about property transactions in Ghana. One reason is that the land registries are few, compared with the population of the country (about 25 million people).

Also locating the registries in only regional capitals, although there are over 350 urban areas in Ghana (Owusu, 2005) creates problems of accessibility for the majority of the urban population. The Chief Registrar of Land has noted several other reasons. The fees are deemed too expensive by most people, especially when they have to pay registration fees in addition to stamp duty. Also, the institutional capacity of the supporting land sector agencies is weak. Hence, the preparation of basic cadastral plans can take as long as 12 months. Also a majority of people do not understand the need for so much paper work (Sittie, 2006). Further, there is some evidence (Aryeetey et al., 2007, pp. 50-51) that, contrary to claims by the Title Registry that it deals with cases in a fair and expeditious manner, there are delays, red tapeism and corruption plaguing the registry. Finally, even when information in the land registry is available to valuers, questions of how recent the data are may arise, as in how to use information registered in 1986, 1996, or even 2006 for a valuation in 2011.

In principle, the problem of lack of data may be ameliorated by using information from the processes of compulsory acquisition of landed property. In Ghana, the state often acquires the allodial interest through compulsory acquisition under the State Lands Act 1962 (Act 125), Administration of Lands Act 1962 (Act 123), Statutory Way Leaves Act 1963 (Act 182), or the current (1992) Constitution (Abdulai, 2010). Between 1850 and 2004, the state executed 1,336 instruments to compulsorily acquire land. It did so in all the ten regions of Ghana. The regions with the greatest share of compulsorily acquired lands were Greater Accra (34.1 per cent), Western (26.7 per cent), Ashanti (13.3 per cent) and Brong Ahafo (10.1 per cent) (Larbi et al, 2004, pp.121-122). According to article 271 of the Constitution of Ghana, fair and adequate compensation must be provided promptly for any land that is compulsorily acquired. The principle of land law as established in *Nii Kpope Tsuru v Attorney General* and *Nii Amotia v Ghana Telecom* is that the requirement to make the payment of compensation condition precedent for compulsory acquisition has no retrospective effect. In earlier constitutions, the state had to pay compensation but it could do so after acquiring the land.

So, the requirement to pay compensation whether pre- or post compulsory acquisition has long been established in Ghanaian land law. Evidently, that opens up an avenue to obtain information for valuation purposes. In valuation parlance, the usual basis of compensation is the *deprival value* concept or the notion that compensation is equivalent to how much it would cost to reinstate expropriated persons to the condition in which they were prior to losing their land (Johnson et al., 2000). Assuming the subject land was useful for farming, estimating compensation on this basis requires accounting for crops lost as well as incidental costs such as the cost of relocation. Often, contestations of the adequacy and fairness of compensation in land courts lead to judicial pronouncements, which serve as a guide to valuers in future valuation exercises.

Does judicial guidance help valuers in Ghana to ascertain value? Land cases abound in the Ghanaian courts. As of 2003, there were 15,000 land cases pending before the courts in Accra (World Bank, 2003), 9,214 cases pending before the courts in Kumasi (Crook, 2004), 74 land cases pending before the courts in Bolgatanga, Tamale and Wa (Abdulai, 2010), and 40 cases in Cape Coast (Cashiers' Office, 2010). Overall, there were an estimated 60,000 land cases in Ghana in 2003 (Kasanga, 2003) as against 11,556 land cases in 1999 and 14,964 cases in 2002 (Kotey, 2004). It implies that, between 1999 and 2003, there was a 419[4] per cent increase in the number of land cases in Ghana. More recent evidence suggests that the spate of land conflicts has increased. In Cape Coast, for example, the number of cases pending in the High court as of 2008 was 114 (Cashiers' Office, 2010), being an increase of more than 100 per cent over 2003 levels. These figures exclude over 770 land disputes that arose between 2003 and 2010, which were resolved through alternative dispute resolution (Land Administration Project, 2010).

However, most of the cases are about the wrongful alienation of interests in land by family members and the multiple granting of land by chiefs (see, for example, Woodman, 1996; Kludze, 1998; Crook, 2004). Questions of compensation are major issues in Ghanaian society because, often, the Government of Ghana does not discharge its responsibility of compensating expropriated people (Brobbey, 1990; Gough and Yankson, 2003; Kasanga, 2003). In the Central region of Ghana, for example, the state has paid only 20.4 per cent of the compensation due landowners of the 692 parcels of land it has compulsorily acquired (Larbi, 2008). Although expropriated people complain about the adequacy of compensation, they do not usually seek redress in the courts of law (Crook et al., 2007, p.46). Street protests and agitation are the more common approaches to pressure governments for compensation and restitution (see, for example, Committee for Joint Action, 2010). In the few instances where issues of compulsory acquisition have been tested in the law courts (e.g., *Nii Tetteh Opremreh II v Attorney General & Anor* and *Amontia v MD, Ghana Telecom Co.*), the issues have been about whether the state is putting the land it has purportedly acquired to the use for which it acquired the land (see Larbi, 2008 for details).

There are notable cases where the Land Valuation Division of the New Lands Commission, the constitutionally mandated unit to assess how much compensation the state must pay for compulsory acquisition, has assessed compensation. In principle, such exercises should ease the problem of limited information that values in Ghana face, as it can provide information about land valuers. A case in point was when the Land Valuation Board – as it was then called – had to estimate compensation for land owners

[4] Ghanaian and Nigerian readers may be inclined to see a connection between section 419 of the Criminal Code of Nigeria and this figure. No such connection exists between the percentage increase and the criminal code.

who had given up their land for the Boankra Inland Port Project[5]. However, in such cases, the Land Valuation Division usually adopts a severely limited concept of compensation. It typically uses the *Crop Enumeration Method* to assess compensation for farmers from whom land is taken by the state. The method entails counting how many crops are destroyed (enumeration) and multiplies the total number by the value of the crops, as assessed by the Ministry of Food and Agriculture. The method fails to compensate for any other inconvenience, as stipulated in the State Lands Act, Act 125. Where the Land Valuation Division considers the land value, it makes reference to only the market value and ignores the cost of disturbance in its assessment (see Larbi, 2008). Therefore, court cases of the value estimates from the state valuer do not provide much help to valuers. In any case, valuers find it difficult to use parcels of state land as comparables because, as with customary interests in land, they are governed by multiple laws, an estimated 26 – excluding about 56 subsidiary legislations - as of 1999 (See details in MLF, 1999, PP. 20-25).

It is within this difficult context that valuers have to execute their duty of carrying out valuations of real property in Ghana. How they negotiate these complexities, which methods they use, and what adjustments they make warrant careful analysis.

VALUATION IN GHANA

The Department of Land Economy based at Kwame Nkrumah University of Science and Technology, the Department of Real Estate and Land Management, University for Development Studies, and the Department of Estate Management at Kumasi Polytechnic are the leading academic centres for the training of valuers in Ghana. Both centres train students in all five traditional methods of valuation, namely Market Comparison, Investment, Residual, Profit, and Cost. Of these methods, the Cost approach is widely regarded as the least accurate. The experienced valuers who authored the famous *Modern Methods of Valuation* note that the '[Cost Method] is limited in terms of providing a valuation…' (Johnson et al., 2000, p.18). When should the Cost Method be used? According to the authors, only when all the other methods are inapplicable:

> Within the wide range of properties which exist there are some which are designed and used for a special purpose to meet specific requirements and which are outside the general range of commercial and residential properties. Typical examples are churches, town halls, schools, police stations and other similar properties which perform non-profitable community functions…..such properties are rarely sold and, when they are, they generally need to be replaced by alternative premises which have to be newly built since alternatives

[5] The project, in which this author was involved as an observer, entailed a plan to develop large parcels of land in the Ejisu Juaben district of the Ashanti region of Ghana.

rarely exist (Johnson et al., 2000, p.18).

Other textbooks on principles of valuation regard the Cost Approach as 'a method of last resort' or 'a poor best' (Scarrett, 2008, p.167). Consistent with this philosophy, the training of valuers entails studying all the other methods of valuation, namely especially the Market, Investment, Profit and Residual approaches. However, in practice, the Cost Method is the most widely used in Ghana. The results of a discussion with some valuers in the leading valuation firms in Ghana reveals that, when valuing residential, investment, and industrial properties, they use the Cost Approach most of the time (see **Table 2**).

Valuation Firm	Approximate share of Cost Method Valuation
KOA Consult, Accra	80%
Quaynor Consultancy Services, Tema	90%
A.K.Baffoe and Co, Kumasi	85%
Asenta Properties, Kumasi	90%
Valuation and Development Services, Accra	90%

Table 2: How frequently the leading valuation firms in Ghana use the Cost Method

Source: Interviews with surveyors who work or have worked in these firms

These results confirm the findings of earlier studies (e.g., Obeng-Odoom and Ameyaw, 2010; Obeng-Odoom and Ameyaw, 2011). The Cost Approach is used on a variety of occasions, including when valuers are called upon to value for sale, and insurance.

Note, however, that it is not in all cases that the Cost Method is used. Three exceptions are particularly noteworthy. First, in valuation for rental purposes[6] the Market Approach is usually used. In such cases, the asking price of a property can be obtained from landlords or the Rent Control Department. Rental levels in Ghana are considered high by most people, especially when juxtaposed with their incomes. The rent in Accra could be around US$100 – US$1,000 per month, depending on the type of house, location, building finishes and the relationship between the landlord and the tenant (Global Property Guide, 2009). In some extreme cases, in the so-called prime areas, Richard Grant's (2009) survey shows that self-contained rental units were priced between $1,400 and $2,500 per month in 2005 or, as Mireku (2010) notes, between $2,500 and $5,000 per month more recently.

Farm valuation constitutes the second exception. In such cases, it is the Investment Method which is used,

[6] Individuals seeking to rent single rooms do not usually obtain valuation opinions. However, institutions (e.g., the Volta River Authority) which seek rental accommodation for their members of staff or office space typically seek the opinion of valuers.

usually by private valuers. The method works by capitalising the income from the farm at a particular yield over a period of time. So, in a palm plantation, for example, the annual income from the palm fruits and the annual market value of the trees would be estimated by drawing on market information collected from the Ministry of Food and Agriculture or directly from food markets. With a suitable yield, the total annual income from the farm would be capitalised for the term of the farm to arrive at its market value.

Finally, the Market Approach – not Cost Approach - is usually used in the valuation of properties in newly developed estates, such as those in Hydraform Estates, Regimmanuel Estates, Coastal Estates and Ayensu River Estates in the Accra-Tema area. Houses from these companies may sell between $30,000 and over $300,000 depending, *inter alia*, on location, finishes, number of rooms, and size (see Karley, 2009 and Grant, 2009 for more detailed discussion). In this scenario, valuers obtain relevant information from the estate developers about market values of the units which they have developed. A related scenario is when valuers are called upon to assess the value of properties which are sold by quasi state departments such as the Tema Development Corporation (TDC) and the Social Security and National Insurance Trust (SSNIT). As with estate housing, it is fairly straightforward to ascertain the market value of such properties by consulting with the real estate departments of TDC and SSNIT.

If there is so much information about these properties, why is the use of the Cost Approach so pervasive in Ghana? Most landed properties in Ghana do not have the features of those just described. Most are built incrementally by individuals, rather than by estate developers (Tipple et al., 1997; Tipple and Korboe, 1998; Tipple, 1999; Tipple and Speak, 2009). According to the Bank of Ghana (2007), members of the Ghana Real Estate Developers Association (GREDA) have constructed an estimated 10,954 houses, constituting less than 1 per cent of the housing stock in Ghana. Thus, it is only in a few cases that the flow of market information is unimpeded.

In the majority of cases, there is severe information asymmetry. Limited information is characteristic of land markets everywhere, of course. It arises *inter alia* because every parcel of land is different by reason of location and most property transactions do not neatly fit any one property sub-market (Johnson et al., 2000, pp.1-11). However, apart from these commonplace features of land and property markets, there are other factors that are peculiar to Ghana. One is the prevalence of cultural norms. Transactions in land and property are often shrouded in secrecy. Some people equate the sale of houses with being indebted, the rationale behind the forced sale of houses. Therefore, to avoid being labelled 'financially bankrupt', those who sell their houses do so 'undercover', leading to a situation where most land transactions are not formally recorded (Antwi and Adams, 2003). In a recent survey on how people buy or build houses in Ghana, Grant (2009, p.83) notes:

> ..these are sensitive questions in any housing environment, and particularly so in Ghana because of cultural norms. Twenty-five percent of respondents …did not

> provide answers to the questions, and one-third of respondents were nonresponsive to the same questions. Non respondents also included two heads of households who credited the Grace of God ….and a Foreign Aunty as a source of funds but would not elaborate.

There are other reasons for the dearth of information about property transactions, such as tax avoidance. That is, some people buy or sell (for an analysis, see, for example, Sinai, 1998; Antwi and Adams, 2003; Abdulai and Ndekugri, 2007; Karley, 2009), but do not usually report those transactions. Not all non-reporting can be attributed to cultural practices or an attempt to avoid tax. Some people do want to record their transactions in landed property but may be discouraged from doing so because of administrative delays, arising, from under resourced planning offices (Gough and Yankson, 2003), red tapeism (see Gambrah, 2002, pp.24-27), and corruption in the land sector agencies (Centre for Democracy and Development, 2000; Mensah et. al., 2003), among others. A rather different type of reason for the severe dearth of information in Ghana is that some traditional houses (e.g., family houses or *abusua fie*) are rarely exchanged in the market because they have sentimental, rather than market, value (see, for example, Korboe and Tipple, 1995, p.271).

There is some limited market information, but it is tainted by special and cultural relationships between buyers and sellers (see Korboe and Tipple, 1995). Not all cases of information asymmetry are structural. Others are self-imposed. For instance, although unlicensed real estate agents are knowledgeable about land transactions because they facilitate transactions in land; most valuers do not consult them because they feel the agents are untrained in formal valuation methods (Obeng-Odoom, 2011). In turn, valuers find it extremely difficult to use the Market Comparison Method to estimate value.

Using the Investment method of valuation is equally difficult. The inflationary nature of the Ghanaian economy (see Asafu-Adjaye, 2008 for a discussion of the causes) poses problems for the assumption that the full rental value of an interest would remain stable. This problem raises doubts about the feasibility of the all-risks-yield which is used in the Investment Method of Valuation. However, in practice, increasing the yield to account for inflation has often led to ridiculously low capital values. In theory, a real value approach could be adopted to account for inflation (Crosby, 2007), however, other problems, such as special relationships among market actors make it difficult to determine what really is the market and ascertain the nature of outgoings. So, the same factors that hinder the application of the Market Comparison approach plague the Investment Method too.

Turning to the Profit Method, similar concerns apply. Although it does not come up against the problem of information asymmetry in the property market, the unrecorded nature of the Ghanaian economy brings new sets of problems. Many restaurants operate 'off the books' and 'without books'. It is estimated that between 51 (Ghana Statistical Service, 2008) and 80 (International Labour Organisation, 2009, p.12) per cent of economic activities in Ghana take place in the informal sector of the economy. Typically, small scale enterprises in the informal sector do not keep sufficient records. For example, in a survey of estate agents who work informally, Obeng-Odoom (2011) found that, although agents keep some records on their clients, this information is limited to names and other basic contact details. A study of public expenditure in 1993 concluded that 'government ministries, departments and agencies saw their role as spenders not keepers of accounting data' (cited in Centre for Policy Analysis, 2005, p.7). Therefore, although the Profits Method could be used in theory in the valuation of public restaurants and guesthouses, for example, the lack of adequate data is a major hindrance to its use in practice. The situation is similar in the private sector. A recent review of accounting and auditing practices in the private sector in Ghana (World Bank, 2004, p.1) concluded thus:

> [t]here is inadequate adherence to auditing standards and professional ethics. Apart from the banking sector practice, monitoring and enforcement mechanisms are ineffective. These factors, as well as poor quality accounting education and training, have contributed to weaknesses of the financial reporting and auditing regime.

These structural problems frequently discourage the effective use of the Profit Method.

Residual valuation is hardly undertaken in Ghana, mainly because large scale regeneration is not currently a feature of urban development in Ghana. The closest to urban gentrification is forced evictions in cities. However, people who are evicted do not usually receive compensation from the state, as they are squatters and have no legal interest in land (Grant, 2009; Afenah, 2010). We return to this issue later.

These problems, which rule out the use of other valuation methods, make the Cost Method of valuation the most popular. In addition, the practical training of surveyors reproduces the *status quo*. A recent survey of probationers of the Ghana Institution of Surveyors by Obeng-Odoom and Ameyaw (2011) revealed that, although surveying students are trained in all the traditional methods of valuation in the universities and polytechnics, probationers are given 'practical training' mainly in cost valuation. In a situation like this, surveyors may even become unyielding to change when some of the problems which hinder the application of other methods are minimal or do not exist. Thus, deep rooted problems in the property market and a process of professional socialisation informed by that social context combine to make the Cost Method of valuation *the* method of choice for Ghanaian surveyors. How that method is used in practice warrants careful study.

APPLYING THE COST METHOD OF VALUATION IN GHANA

'Value' means different things to different people. However, in valuation parlance, 'value' typically means market value or value in *exchange*. Cost is hardly a proxy for market value because it connotes value in *production* (Johnson et al., 2000, p.2-5). Therefore, of the five traditional methods of valuation, the Market Comparison Approach is the most accurate; Cost Approach the least accurate. In turn, surveyors in developed economies typically rely on the Market Comparison more often than other methods of valuation. In Hong Kong, for example, market based traditional econometric models and, more recently, artificial neural networks are the most common approaches used by practitioners and property researchers (Yip and Lee, 2008).

The situation is rather different in Ghana. Valuers-in-training normally are schooled in using the Cost Method of valuation (Obeng-Odoom and Ameyaw, 2011). Therefore, the majority of reports prepared for the qualifying examination for professional membership of the Ghana Institution of Surveyors draw on that approach (Ezaah, 2007). Apart from rating valuation which, according to section 96 (9) of the Local Government Act, 462, valuers are obliged to use the Cost Method, in all other cases, such as estimating value for the purpose of sale, forced sale, insurance, and mortgage, valuers are at liberty to choose any other valuation method. However, valuers in Ghana adopt the Cost Approach for almost all valuation tasks.

This situation stands in stark contrast with the situation in Australia, a country from which Ghana has benefitted considerably - in terms of valuation[7]. In Australia, there is an overwhelming reliance on direct market approaches to valuation and a positive correlation between academic qualifications and valuation methodology. That is, as valuers advance in *academic qualifications*, there is a high tendency to abandon simple market approaches to sophisticated market approaches such as discounted cash flow methods. Also, as valuers advance in *experience*, more simple market approaches are replaced with discounted cash flow techniques (Boyd, 1995). None of these is the case in Ghana where the Cost Method of valuation is the dominant method, regardless of education or experience.

In Ghana, the Cost Method 'is king'. Sometimes referred to as the Contractor's Test, it is based on the philosophy that the informed purchaser would pay no more than the cost of producing a substitute property with the same satisfaction as the property which is the subject of valuation (Johnson et al., 2000). When using this method, typically Ghanaian valuers go through three stages. First, they estimate the gross replacement cost. Next, they ascertain depreciation. Then, they assess the value of the subject land, which is given by two simple equations:

GRC – D =
NRC ....Equation 1

NRC + LV =
PV ....Equation 2

Where:
GRC is Gross Replacement Value;
D is Depreciation;
NRC is Net Replacement Value;
LV is Land Value; and

[7] For example, it was the Australian valuer, John Francis Murray who was commissioned by the UN in 1958 to advise the Ghanaian government on the problems of using the number of rooms and windows as a basis for rating, and on what alternatives were available. The current system of rating in Ghana is based on Murray's ideas (see a detailed history in Adem and Kwarteng, 2007, pp.40-41).

PV is Property Value

The procedure looks neat and simple but, in practice , it is a labyrinthine process, involving several twists and turns.

Assessing GRC and Depreciation

First they estimate the gross replacement cost (GRC), which is the cost of producing a substitute property as new or functionally similar to the subject property (See Scarrett, 2008, pp.162-163 for other ways of estimating cost). Rating information about buildings may be helpful in this sense. However, in Ghana, that information is dated because local authorities – for want of adequate resources – do not produce valuation lists on a regular basis (see Mensah, 2005). So, in practice, such costs would typically be obtained from bills of quantities (BOQs), which are prepared by quantity surveyors who consider current labour and building materials costs and the cost of building techniques. More diligent valuers usually take their cost figures from BOQs that have undergone tendering because such BOQs are deemed to be slightly reflective of the 'real' market value.

Second, they estimate accrued depreciation to reflect physical defects, functional and economic obsolescence (for a discussion, see Albritton, 1982; Mansfield and Pinder, 2008; Hackman and Scott, 2008). Surveyors often grapple with how to estimate one figure for all the aspects of depreciation. Gyamfi-Yeboah and Ayittey (2006, pp. 8-9) propose a 'decomposition approach' to the problem by estimating the individual contribution of each component of depreciation in the first instance to provide a basis for estimating a combined depreciation rate, which takes into account the weight of each component. However, in practice, such 'academic' approaches are hardly used. The valuers use their 'experience'; a colloquial way of saying that they judge how much is required to restore the property to its new state. A more structured way of estimating depreciation is to make reference to the operational percentage chart – a figure which shows how much each part of a building contributes to the total cost – and estimate how much depreciation should be ascribed to the various parts of the subject building. This estimate of depreciation is deducted from GRC to arrive at net replacement cost (NRC).

Estimating Land Value and PV

In theory at this stage in using the Cost Approach, land value should be estimated typically by the Market Comparison approach. That is, comparable land values would need to be found for the subject property, assuming it is vacant and put to its highest and best use. The comparables must come from the same neighbourhood or class of neighbourhood, if there is limited information in the subject neighbourhood. Valuers usually obtain this information particularly from three sources, namely reference to land registries, reference to judicial cases about compensation, and reference to past valuations by fellow valuers. However, as we have seen, the land registries, judicial guidance and information from cases of compensation provide limited information.

So, in practice, Aryittey et al. (2006) report that valuers in Ghana usually consult one another for information about comparable properties and supplement it with information from conveyancing documents, if it is readily available. Then, they either simply use the capital value of the comparable land without adjustments or they decapitalise the land value of the comparable property to its annual equivalent using an 'appropriate rate of interest'. The resulting figure is recapitalised for the term of the subject land. The resulting figure is deemed the land value.

To obtain PV, the land value is added to NRC as described in Equation 2. Then, even though cost is used as proxy for value, they adopt the general assumptions underpinning market value, namely that:

a) There is a willing seller;
b) Prior to the date of valuation, there had been a reasonable period for the proper marketing of the interest, for the agreement of price and terms, and for completion of the sale;
c) That the state of the market, level of values and other factors, as on an earlier assumed date of exchange of contracts, were the same as on the date of valuation;
d) That the property will be freely exposed to the open market and that no account will be taken of any price that might be paid by a purchaser with a special interest;
e) Both parties to the transaction had acted knowledgeably, prudently and without compulsion (For a discussion, see Johnson et al., 2000, pp. 404-405 for discussion).

These assumptions are strange, given that the valuers have to guess what happens in the real estate markets, leading to questionable judgments, such as the choice of capitalisation rates (Ezaah, 2007). Mends (2006, p.10) has even suggested that the opinion of valuers in Ghana is not reliable. Consequently, there is a general perception that valuers are 'magicians' or 'value inventors' in Ghana (Ayittey et al., 2006).

Nevertheless, given that valuation is an art; not a science, it may be argued that most aspects of the process of estimating value in Ghana are justified. The valuers have tried to adapt the normative theory underpinning the Cost Method of valuation to the extremely difficult circumstances in which they find themselves. These tensions and contradictions do not mean that there is no information at all in the real estate market in Ghana such that only the Cost Method of valuation can be used. Indeed, as suggested in **Table 1**, there are some cases where there is sufficient market information to allow valuers to use other methods of valuation, such as the Market and the Investment Approaches. Rather, the pervasive problem of asymmetric information implies that, unlike in developed economies with relatively developed real estate markets, the Cost Approach is the norm in Ghana, while other approaches constitute exceptions.

Given that little or no litigation is reported in the popular press, professional meetings, academic lectures or conferences about legal or professional challenges to the use of the method, it may be inferred that the valuers have been successful. Also, it seems that, generally, clients are satisfied with the work of most valuers in Ghana (Obeng-Odoom and Ameyaw, 2010; Obeng-Odoom and Ameyaw, 2011). Of course caution is needed in interpreting the opinions of clients because they take into account quite a different set of factors, such as customer care and how smartly valuers are dressed, in judging quality of valuation. Also, there are many reasons for not contesting valuations made on cost basis in the law courts, such as high legal fees. However, given that, even within the profession, there seem to be no dissenting voices, it may be taken that there is a consensus that, given the prevailing circumstances in Ghana, using the Cost Method is justifiable.

What is questionable is the failure to account for the environment, especially the presence of injurious materials in buildings. This neglect is important, particularly because the use of asbestos is pervasive in the building industry in Ghana. Evidently, another adjustment to the Cost Method is required.

'GREENING' THE COST METHOD

Slate or asbestos roofing sheet is the third most widely used building materials in all urban and rural localities in Ghana. In urban housing, asbestos material constitutes 23.5 per cent, but in rural housing it is only 3.9 per cent. In big cities such as Accra, the majority of houses (52 per cent) are roofed with asbestos material (UN-HABITAT, 2004, p.4).

Asbestos has negative effects on health. Its fibres can cause lung cancer, mesothelioma and asbestosis, pleural plaques, thickening and effusions. These fibres also cause laryngeal and other types of cancer. Globally, it is estimated that 90,000 asbestos-related diseases occur every year (WHO, 2006). Ghana has no national statistics on cancer cases because there is no population based cancer registry in the country (Ghana News Agency [GNA], 2010). As such, it is difficult to know the number of cancer cases in Ghana, let alone ascertain how many cases are caused by asbestos. However, a recent study of 3,659 cases suggests that the lung is number 14 out of 22 sites for cancer in Ghana (Wiredu and Armah, 2006, p.3). This evidence does not prove that asbestos-induced cancer is pervasive in Ghana. Smoking, for example, may be another contribution to lung cancer in the cases reported.

However, research by Owusu-Dabo and his team (2009) shows that the prevalence of smoking among the Ghanaian population is low. Also a study that compared the prevalence rate of smoking among urban civil servants in Accra in 2006 to 1976 showed considerable decline from 32 per cent in men and 5.9 per cent in women in 1976 to 6.1 per cent in men and 0.3 per cent in women in 2006. Therefore, it is arguable that asbestos is fairly a significant contributor to lung cancer in Ghana.

Despite being evidently hazardous, valuers in Ghana have not adjusted their version of the Cost Method to account for its presence. This inattention could be blamed on the negligence of valuers. However, it can be argued, more fundamentally, that the failure to account for health hazard exposes the inability of markets to always provide for human need (see Rosewarne, 2002 and Goodman and Rosewarne, 2011 for a discussion of the inherent problems with markets and the environment). Valuation is the art of interpreting the market based on the premise that the market is the best medium to reveal value (Babckock, 1932, p.7). Therefore, valuation is not attentive to ‘values’ that markets do not reveal. In turn, issues such as health hazards that are not directly revealed by market forces tend to be ignored when valuers use the Cost Method of valuation.

However, all is not lost, there is room for valuers to account for the environmental concerns in valuation. The question, of course, is how to do it. There are three options that may be considered by valuers in Ghana. The first option derives from the Market Comparison Method. Valuers may use a direct comparison approach by which they can draw information about value from comparable properties which have exchanged hands in the market. Here too, restricted information is likely to impede successful application.

A second option is a variant of the Cost Approach. It entails determining the quantum and duration of the ‘damage’ from asbestos. In terms of the former, valuers could estimate the multiplier effects of asbestos poisoning, such as a loss in productivity and ascertain the effects of such a loss on earnings. In turn, the valuers could ascertain economic losses to immediate and extended family. This ‘social cost’ could then become a separate deduction from GRC after accounting for depreciation. A more straightforward method would be to estimate how much it would cost to replace, not repair, the whole asbestos part of the building. So, in this scenario, it would be necessary to estimate the land value and GRC of the subject property on the assumption that there is no injurious material. Next, the extent to which the market value of the property is affected and reduced by the presence of injurious materials is ascertained. Then, the latter estimate is deducted from the value of the subject property assuming that it does not have any injurious materials. A possible limitation is that it would be laborious to apply. Alternatively, the cost of treating lung cancer could be obtained from medical practitioners, the Ghana Health Service or the Ghana Medical Association and deducted from GRC.

These more straightforward methods have their problems too. They fail to recognise that the effect of asbestos may go beyond the individual to the society as a whole. Also, there is an implicit assumption that these ‘social costs’ would be just one off payments. However, a one off payment is unlikely to be reflective of the damage caused by asbestos. Therefore, the valuer could estimate the annual equivalent of the impact of asbestos and capitalise it for the rest of the tenure of the subject property and deduct it from GRC. That, evidently, is more straightforward than using a principle of ‘willingness to accept’ to calculate the cost of a shadow project (see Potts, 2002, p.168-169).

However, it is uncertain what would be the relationship between this ‘cost of treating cancer’ and the estimate of the reduction in market value identified in the Market Approach. Therefore, it is doubtful whether the valuation made with such deductions for cost of treatment would truly reflect the market value of the property with injurious materials. The valuation made with the deduction based on the ‘cost to replace’ would more likely represent the market value of properties with injurious materials, although that is premised on the runaway assumption that such market information is available.

A related matter to the issue of greening the Cost Method is what happens to more environmentally friendly housing. Should they be valued higher for having green elements? It is a difficult question because people may not always want to pay more for environmentally friendly buildings. However, the health benefits of 'green buildings'[8] and the economic benefits from better health to the individual and the society as a whole would suggest that valuers could start thinking of ways of accounting for 'indirect market value', knowing that the market value is not always indicative of or propitious for a healthy society. There is a need for a more effective measure of value that considers environmental hazards. Pedro Belli and his team (2001, pp.62-71) propose several approaches in which environmental effects could be measured. The limitation with these methods is that valuers are likely to find these methods complicated and laborious. Probably the solution to this methodological quagmire is to seek answers from a state that is willing to regulate the building industry and weed out the use of injurious materials.

CONCLUSION

Severe information asymmetry arising from special relationships and cultural practices as well as administrative and institutional bottlenecks, as well as the customary land tenure system, which is dominant in Ghana, have forced surveyors in Ghana to rely on the Cost Method of valuation as the first, rather than last, resort. In turn, they have developed, adapted and 'perfected' the method to suit their local and peculiar circumstances in estimating market value.

In *Platform Home Loans Ltd v Oyston Shipways Ltd,* Jacob J famously stated that 'valuation is an art and not a science, but it is not astrology' (cited in Johnson et. al. 2000, p.vi). So, although most of the practices of valuers in Ghana deviate from the normative principles of valuation, the Ghanaian model is worthy of study by valuers in other economies in sub-Saharan Africa that work in similar real estate markets. Greater amounts of quality information can enhance value estimates. The architects of the model need to collaborate with rather than antagonise unlicensed agents. Also, the model is in need of revision because it fails to account for the use of injurious materials, such as asbestos, which are used in building most of the properties they value. How such adjustment should be made and which other amendments could be considered, such as the choice of a capitalisation rate and the process of estimating land value, warrant further research. Meanwhile the productive force of the state can be used to regulate the kind of materials that are used for building. Whether the Ghanaian state has that capacity is a story for another time.

[8] According to the U.S. Environmental Protection Authority (2010), 'Green, or sustainable, building is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition'.

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Surveying & Built Environment

Modelling Gaseous Emissions from Energy Consumption during Building Life Cycle

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ABSTRACT

It is well known that building and construction contribute a large part of emissions to the environment, and it is estimated that worldwide, the buildings and constructions sector is the second largest global carbon dioxide (CO_2) emitter after industry, representing approximately 33% of the global total. Therefore, improving sustainability performance through mitigating emissions in construction has become a pressing issue. This paper divides any building's life cycle into seven elements: i) manufacture of building materials; ii) transportation of building materials; iii) construction; iv) operational life; v) maintenance and repair; vi) demolition; and vii) disposal of construction waste. We define eight types of gaseous emission during a building's life cycle: CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and particulates. The paper analyzes the sources of gaseous emissions and presents a model for calculating the gaseous emissions during a building life cycle with particular reference to Hong Kong. The model helps evaluate the impact of building projects on air quality, from which strategies can be devised to reduce its environmental impact during a Building Life Cycle. A preliminary review of a case study of the construction stage is also discussed to show an application of the developed model.

KEY WORDS

construction, building life cycle, gaseous emission, Hong Kong

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INTRODUCTION

Gaseous emissions are generally defined as any substances emitted into the atmosphere by human and natural activities that can cause any current or future environmental problems. These include acidification and eutrophication, air quality degradation, global warming/climate change, damage and soiling of buildings and other structures, stratospheric ozone depletion, and human and ecosystem exposure to hazardous substances (European Environmental Agency, 2007). Atmospheric emission sources can be categorized into many types, such as power plants, factories, domestic households, offices and public buildings, cars and other vehicles, and there can be millions of distinct emitters in each type.

The building and construction sector has been identified as the second largest global CO_2 emitter after industry, representing approximately 33% of the global total quantity (Ürge-Vorsatz and Novikova, 2008). Therefore, improving the sustainability performance through mitigating emissions in construction can contribute significantly to emission reduction and has become a pressing issue.

Research has been conducted to analyse the CO_2 emission of buildings. Zhang conducted a life cycle assessment study on the reduction of CO_2 emissions of buildings (Zhang, 2002) and established an evaluation model to calculate a CO_2 emission index in a building's life cycle. Guggemos conducted research on the environmental impact of on-site construction processes, focusing on structural frames and introduced a model to calculate quantities of energy use and gaseous emissions during the construction process (Guggemos, 2003). The Architectural Institute of Japan-Life Cycle Assessment (LCA) method, Residential LCA Method and Building LCA Calculating Method were developed in Japan, in 1996 and 1997 respectively, for assessing the energy demand and emissions of given buildings. In Europe, EcoEffect and Eco-Quantum methods for assessing environmental effects during the life cycle of a building were developed in 1998 (Zhang, 2002). Other work concerning building emissions includes several major assessments of available green building methods, such as the Building Research Establishment Environmental Assessment Method (BREEAM) in Britain, the Leadership in Energy and Environmental Design (LEED) in the United States, and the Hong Kong Building Environmental Assessment Method (HKBEAM) in Hong Kong. BREEAM is a tool for surveyors and engineers to evaluate the life-cycle costs of a building. However, the system mainly focuses on the ecological and global effects of construction activities, such as the quantity of carbon dioxide emitted. There is less emphasis on issues like management and construction methods. HKBEAM is a classification system in which buildings are divided into four categories according to their environmental-friendliness. Finally LEED is a software tool used to measure the environmental performance of a building site on an operational level; that is, on-site technical information concerning daily environmental performance. A criticism of LEED is that it is concerned mainly with the technical aspect of environmental performance with very little emphasis on the management side.

Based on the above, it appears that there is lack of a detailed holistic approach for examining all aspects of gaseous emissions of a construction project across a Building Life Cycle. Therefore, the aim of this paper is to build a model for calculating gaseous emissions from energy consumption during a Building Life Cycle. The model can help evaluate the impact of implementing building projects on air quality. From this evaluation strategies can be devised to reduce the total Building Life Cycle environmental impact.

MAIN ELEMENTS DURING A BUILDING LIFE CYCLE

Buildings go through many periods during their useful life. From the initial conception to final recycling, re-use or demolition of a building, a whole range of processes must be taken into account when assessing a Building Life Cycle (Cole and Kernan, 1996). An assessment of the environmental impact of any building has become a major research discipline, with the aim of providing more complete information about the relationship between a building and the environment. Nevertheless, life cycle thinking is required for any proper and thorough assessment of the environmental effects of a building. According to the United States Environmental Protection Agency (EPA), the product life cycle is divided into three major phases: i) cradle to entry gate phase; ii) entry gate to exit gate phase; and iii) exit gate to grave phase. A building is also regarded as a product, and its life cycle is from materials acquisition to waste disposal (United States Environmental Protection Agency, 2006). In this paper, the cradle to entry gate phase of a building refers to the process of manufacturing and transporting building materials before they actually reach the construction site. The entry gate to exit gate phase refers to the processes of construction. The exit gate to grave phase refers to all the processes involved in building operation, maintenance and repair works, and then in the post-operational period, demolition and disposal of waste. Accordingly, there are seven main elements in the life cycle of a building, as shown in Figure 1.

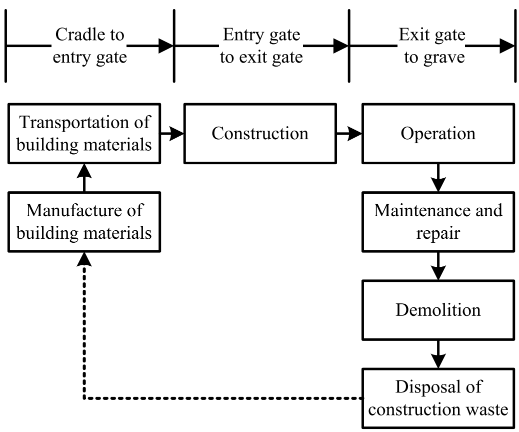

Figure 1: Seven main elements during building life cycle

CLASSIFICATION OF GASEOUS EMISSIONS DURING THE BUILDING LIFE CYCLE

There are various classifications of gaseous emissions from buildings. According to the Hong Kong Environmental Protection Department (Environmental Protection Department, 2009), the emission inventory consists of five major gaseous pollutants, namely: sulphur dioxide (SO_2), nitrogen oxides (NO_X), respirable suspended particulates (RSP or PM_{10}), volatile organic compounds (VOC) and carbon monoxide (CO). Under the Clean Air Act (United States Environmental Protection Agency, 2006), the US EPA establishes air quality standards to protect public health and the environment. The US EPA has set the national air quality standards for six common gaseous pollutants (also called the criteria pollutants): NO_2 (nitrogen dioxide), O_3 (ozone), SO_2, PM, CO, and Pb (lead). The United Nations Framework Convention on Climate Change considers CO_2, CH_4 (methane), N_2O (nitrous oxide), PFCs (perfluorocarbons), HFCs (hydrofluorocarbons), SF_6 (sulphur hexafluoride) as direct greenhouse gases, and SO_2, NO_X, CO, NMVOC (non-methane volatile organic compounds) as indirect greenhouse gases (United Nations Framework Convention on Climate Change, 2004; United States Environmental Protection Agency, 2006). O_3 is not directly emitted, but is formed when NOX and VOCs react in the presence of sunlight (Colorado Department of Public Health and Environment, 2007). In general, the total quantities of PFCs, HFCs and SF_6 produced by energy consumption are much less than the other three direct greenhouse gases. For example, in 2007, the total weight of CO_2 emitted in Hong Kong was 40,000 kilotons while the number of PFCs, HFCs and SF_6 added up to only 0.590 kilotons (Environmental Protection Department, 2009). The quantity of Pb emission is also small compared to SO_2. In Hong Kong, for example, the national lead emission in 2002 is 1,663 kilotons, while the quantity of SO_2 is as large as 14,581.911 kilotons (Census and Statistics Department, 2008). Based on the above understanding, the typical gaseous emissions during the Building Life Cycle include CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and particulates (as shown in **Table 1**). These emissions exist across all periods of the Building Life Cycle (Zhang et al., 2012).

Gaseous emissions	Sources of gaseous emissions during building life cycle						
	Manufacturing of building materials	Transportation of building materials	Construction	Operation	Maintenance and repair	Demolition	Disposal of construction waste
CO_2 CH_4 N_2O SO_2 CO NO_X	Fuel combustion activities and electricity use.	Fuel combustion activities of mobile sources.	Equipment fuel combustion activities and electricity use.	Fuel combustion and electricity use.	Fuel combustion activities and electricity use.	Fuel combustion and electricity use.	(1) Transportation fuel combustion; (2) Waste biochemistry change; (3) Waste incineration.
VOC	(1) Fuel combustion activities and electricity use; (2) Calcinations evaporation process; (3) Material surface coating volatilization.	Fuel combustion activities of mobile sources.	(1) Equipment fuel combustion activities and electricity use; (2) Using paint, other surface coating and ordinary solvents.		(1) Calcinations, evaporation process; (2) Material surface coating volatilization; (3) Using paint, other surface coating and ordinary solvents; (4) Fuel combustion activities and electricity use.		Transportation fuel combustion.
Particulates	Diesel combustion and electricity use.	Diesel combustion.	Diesel combustion.	Diesel combustion and electricity use.	(1) Diesel combustion and electricity use; (2) Construction dust.	(1) Diesel combustion; (2) Construction dust.	Diesel combustion.

Table 1: Sources of gaseous emissions during building life cycle (United Nations Framework Convention on Climate Change, 2004; United States Environmental Protection Agency, 2006)

Major gaseous emissions of the manufacture of building material element

Gaseous emissions caused by using energy during the process of manufacturing construction materials are mainly the result of stationery sources. These include fuel combustion and electricity use for various appliances and plant. The major construction materials are cement, aggregate, sand, steel, aluminium, glass, and timber (Zhang, 2002).

Major gaseous emissions during the transportation of building material

Gaseous emissions from using energy during construction material transportation are mainly the results of the direct (internal combustion engines) or indirect (electric motors) combustion of fuel by delivery, moving and hoisting vehicles. For example a tower crane is normally one of the most significant and common sources in moving building material and is driven by powerful electric motors consuming up to 65KW.

Major gaseous emissions during construction

Gaseous emissions from energy use during construction are mainly the result of the direct or indirect fuel consumption of fixed and mobile construction equipment from major plant like tower cranes to individual operator power tools. Construction is normally the most important stage during the life cycle process, as poor construction can lead to poor operation and high maintenance cost, and may even shorten the total life cycle.

Major gaseous emissions during operation

Gaseous emissions from energy use during building operation are mainly the results of direct and indirect fossil fuel consumption for air-conditioning, lighting, cooking, washing, and operating various electrical equipment like pumps, elevator motors, office or home fitout, etc. This depends on how the end-users use facilities and equipment.

Major gaseous emissions during maintenance and repair

Gaseous emissions from energy use to undertake maintenance and repair works are partly the result of materials manufacturing and transportation for maintenance and repair projects, and partly the result of changes to energy use caused by maintenance and repair work in concurrent building operation.

Major gaseous emissions during demolition

Gaseous emissions from energy use during building demolition are mainly the result of fuel requirements for demolition works. During this phase there is also the significant risk of high PM emission.

Major gaseous emissions during disposal of construction waste

Gaseous emissions from energy use in treating and recycling for demolition waste are mainly caused by fuel consumption for transport of waste and subsequent handling. Proper treatment and recycling of demolition waste can, other things equal, result in reducing social costs by extending the limited space for landfills or discover new areas for landfills for the disposal in the long term.

MODELLING GASEOUS EMISSIONS DURING THE BUILDING LIFE CYCLE

According to Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change, 2006), the basic formula for the estimation of emissions from a single pollution source is in Equation (1).

$$Emissions = AD \times EF \qquad (1)$$

where *AD* is the activity quantity; and *EF* the coefficient which quantifies the emissions or emission removals per unit of activity.

Different equipment for measuring the quantity of the gaseous emissions produced will require calibration at least every six months, or according to local standards if these are more frequent, to ensure accurate data is collected for any calculation.

Manufacture of building materials
In building materials manufacture, if the quantity data of each material used in a building is provided, then by using the emission factor, emissions can be calculated through Equation (2).

$$Emission_{1i} = \sum Q_j \times EF_{ij} \qquad (2)$$

where i *(* $i = 1, ..., 8$ *)* is a particular type of emission, such as CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and particulates generated by the production of each material; j *(* $j = 1, ..., 7$ *)* is a particular type of material used, such as cement, steel, aluminium, glass, sand and timber; Q_j is the sum of energy for producing any material j (kg/kWh); EF_{ij} is the emission factor of any emission i generated by producing a unit of material j (kg/kWh); $Emissions_{ij}$ is therefore the total quantity of emission i in material manufacture (g), and "1" denotes the material manufacture element. The quantity of each type of material is calculated in kg.

Transportation of building materials
In transporting building materials, the following four types of transport are considered: road transport, railway transport, aviation transport, and sea transport. If the distance data and fuel data are provided, transportation emissions can be calculated through Equation (3).

$$Emission_{2i} = D \times FR \times EF_{ij} \qquad (3)$$

where i ($i = 1, ..., 8$) is one of the emissions, such as CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and particulates; $Emissions_{ij}$ is the quantity of emission i in transportation (g); D the total transport distance (km); FR the fuel consumption rate of the means of transport (kWh/km); $D \times FR$ the amount of fuel combusted (litre or kWh); and EF_{ij} the emission factor of emission i generated from fuel j type of combustion (kg/kWh). The fuel consumption data is calculated by fuel type, by conveyance category and by transport mode.

Construction
In building construction, emissions are mainly generated by using electric power and burning fuel. The data for electricity and fuel used in this period are needed to calculate emissions by using Equation (2) and replacing j ($j = 1, ..., n$) as one of the fuel types and Q_j as the amount of the fuel j burned or electricity used (kWh).

Operation

Direct emissions

Most energy using devices for operating buildings are boilers, burners, turbines, heaters, furnaces, ovens, dryers, internal combustion engines (e.g. emergency electricity generator), lift motors, and any other equipment or machinery.

Indirect emissions

Indirect emissions during building operation are generated by the energy used for providing required essential services to the building, for example water, electricity, gas, telecommunications, sewerage. These are usually supervised by government and provided either by major public utilities or government departments. For example in Hong Kong the Water Supplies Department and Drainage Services Department respectively provide freshwater and waste water treatment.

The indirect emissions due to the use of electricity for processing fresh water by Water Supplies Department or sewerage by Drainage Services Department can be assessed as follows:

$$EF = Consumption\ of\ per\ unit_z \times Territory\text{-}wide\ default\ value$$

where z can be fresh water or sewerage consumption

To sum up, direct and indirect emissions in building operation period can be calculated through Equation (2) and replacing $j\ (j = 1, \ldots, n)$ as the one type of fuel or electricity and Q_j as the amount of fuel burned or electricity used (kWh).

Maintenance and repair

There are two methods to calculate these emissions. A precise calculation method can be used when the maintenance and repair work of building has been completed and the detailed data are available. The emissions can thus be calculated exactly. On the other hand, when the building construction has been finished, it will take several years before any maintenance and repair work is needed. Therefore, a forecasting calculation method can be used to forecast emissions during this period.

(a) Method for precise calculation

The precise calculation method is applicable to a situation when all building maintenance and repair works have already been done and the building is to be demolished. Thus the total consumed energy data can be collected. The emissions calculation can be conducted using Equation (2) and replacing *j* as one type of fuel and *Q* as the amount of *j* burned or electricity use (kWh).

(b) Method for forecasting

The forecasting calculation method is applicable to a situation when no building maintenance and repair works have been done and actual energy consumption data cannot be collected. In this case emission quantities can be estimated as approximately 1.5% of the emission data generated during construction period (Zhang, 2002).

i) Thus during daily use of a building all emissions resulting from failures, small defects, small-scale damage, and all emissions resulting from necessary maintenance and repair work per year can be calculated through Equation (4).

$$Emissions_{5i}' = (\text{the total emission } i \text{ of the building during the construction phase}) \times 1.5\% \qquad (4)$$

ii) After the use of building for a period of time (assuming a standard period of 15 years), emissions resulting from the large-scale update of building including full inside and outside decoration, can be calculated through Equation (5).

$$Emissions_{5i}'' = (emission\ i\ of\ fitting\text{-}out\ works\ outside\ the\ building + household\ renovation) \times 100\% \quad (5)$$

Therefore, emission quantity for building maintenance and repair will be the sum of emissions due to the two aspects above and can be calculated through Equation (6).

$$Emissions_{5i} = Emissions_{5i}' + Emissions_{5i}'' \quad (6)$$

Demolition period
Similar to the analysis in the previous part, there is a precise and a forecasting calculation method to calculate emissions resulting from building demolition.

(a) Method for precise calculation
Precise calculation method is applicable when the building has been demolished, thus the total consumed energy data can be collected. The calculation method shown in Equation (2) but replacing j as one type of fuel and Q_j as the amount of fuel j consumed by various kinds of devices or electricity use (kWh).

(b) Method for forecasting calculation
The forecasting calculation method is applicable when the building has not been demolished and the energy consumption data is unknown. The emission quantity can be estimated by using the total building floor area and units for floor removal data. The calculation can be conducted by using Equation (7).

$$Emission_{6i} = the\ total\ building\ floor\ area \times emission\ units\ for\ floor\ removal \quad (7)$$

Disposal of construction waste
Emissions generated for waste disposal are due mainly to transportation, which will induce fuel combustion and dust abatement measures. The emission can be calculated through Equation (8).

$$Emission_{7i} = D \times FR \times EF_{ij} \quad (8)$$

where i $(i = 1, \ldots, 8)$ is one of the emissions, such as CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and particulates; $Emission_{7i}$ the quantity of emission i in this period (g); D the total transport distance (km); FR the fuel rate of conveyance (kWh/km); D x FR the amount of fuel burned (kWh); and EF_{ij} the emission factor of emission i generated by fuel j combustion (kg/kWh).

Calculation model for total gaseous emissions during building life cycle
Based on the analysis above, the total amount of eight gaseous emissions during construction project life cycle can be calculated through Equation (9).

$$Emissions = \sum_{k}^{7} \sum_{i}^{8} Emissions_{ki} \quad (9)$$

where k $(k = 1, \ldots, 7)$ is a specific element of the building life cycle, including manufacturing of building materials, building materials transportation, construction, operation, maintenance and repair works, demolition, waste disposal; i $(i = 1, \ldots, 8)$ for each of the emissions, such as CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and particulates; and $Emissions_{ki}$ the amount of gaseous emission i during period k.

APPLICATIONS OF A CASE STUDY

The building is One Peking Road located in Hong Kong, which is a thirty-story building of 43,210 m^2. Its foundation type is reinforced concrete with raft foundation and H piles, and the structural frame is reinforced concrete construction. The building lifespan is assumed to be 50 years. Its major body materials include concrete, cement, steel, aluminium and sand, which are shown in **Table 2**.

Material	Country of origin	Distance from site (km)		Quantity (tonne)
		Land	Sea	
Concrete	HK	30.0	0.0	73,635,840 kg
Cement	China	250.0	150.0	1,628,543 kg
Steel	China	250.0	150.0	7,169,568 kg
Aluminium	USA	5463.4	18753.3	47,075 kg
Sand	China	250.0	150.0	3,888,622 kg

Table 2: Major body materials list of the reinforced concrete building in the construction stage for the case study (United Nations Framework Convention on Climate Change, 2004; United States Environmental Protection Agency, 2006)

To show how to apply the developed model to this actual project, data is collected during the construction stage as an example. Quantities of each material used is measured and summarised in Table 2. The major material used for this project is concrete, which is about 73.6 million kg. Emission factors of each material can be found from the literature and is summarised in **Table 3**. Emissions for each material used for the construction stage in the case study can then be calculated based on Equation (2) [by multiplying the quantities of materials used (from Table 2) and emission factors for each material (from **Table 3**)]. **Table 4** summarises the emissions for each building material in the construction stage of the case study. From that, the total emissions of the construction stage for each material can be shown in Table 5. Based on the estimation from the developed model, it has about 7.8 billion kilograms emission of CO_2 from concrete, 1.6 billion kilograms emission of CO_2 from the cement, 9.1 billion kilograms emission of CO_2 from the steel, 0.38 billion kilograms emission of CO_2 from the aluminium and 30 million kilograms emission of CO_2 from the sand in the construction stage for the case study. Therefore, the total emission from the construction stage is about 19 billion kilograms emission of CO_2. Although steel is not the major material used for the case study, the emissions produced from the steel contribute the major component for the case study. As the case study mainly uses plain concrete structure, this figure is about the norm for a typical concrete structure project. If the project mainly uses steel concrete composite structure, the norm figure will be much higher.

Material	CO_2	CH_4	N_2O	SO_2	CO	NO_X	NMVOC	Particulates
Concrete	106			0.14	0.02	0.02	0.01	0.05
Cement	994	0.05	2.1	2.4	1.10	4.13	0.05	0.6
Steel	1242	0.12		0.09	21.1	5.1	0.02	2.03
Aluminium	8000		2.15	14.2	135	4	1	
Sand	6.9					0.016		0.98

Table 3: Emission factors of manufacturing building materials (g/kg) (European Environmental Agency, 2007)

	CO_2	CH_4	N_2O	SO_2	CO	NO_X	NMVOC	Particulates
Concrete	7,805,399,040	0	0	10,309,018	1,472,717	1,472,717	736,358	3,681,792
Cement	1,618,771,973	81,427	3,419,941	3,908,504	1,791,398	6,725,884	81,427	977,126
Steel	8,904,603,456	860,348	0	645,261	151,277,885	36,564,797	143,391	14,554,223
Aluminium	376,607,616	0	101,213	668,479	6,355,254	188,304	47,076	0
Sand	26,831,492	0	0	0	0	62,218	0	3,810,850

Table 4: Emissions of each building material in the construction stage for the case study

	Emissions
Concrete	7,823,071,642
Cement	1,635,757,679
Steel	9,108,649,361
Aluminium	383,967,941
Sand	30,704,560
Total	18,982,151,182

Table 5: Emissions of building materials in the construction stage for the case study

The present case study is not able to show the accuracy of the developed model as there are insufficient resources and it is at this funding level of preliminary research too costly and complicated to measure the actual gaseous emissions from each building material. However, it should be noted that the developed model aims to estimate the gaseous emissions for projects and to provide understanding on their emission levels. In a way, the proposed model can be considered as one possible method to rectify resource insufficiency. Because most companies often have insufficient resources, technology, labour and time to measure the emissions, the developed model can be a useful tool to understand the emissions of any project. From that, companies can aim for a target gaseous emission level to reduce gaseous pollution and to improve the environment.

CONCLUSION

This paper suggested classifying a building life cycle into seven elements, namely manufacture for building materials, transportation of building materials, construction, operation, maintenance and repair, demolition, and waste disposal. The study considered eight kinds of gaseous emissions during the Building Life Cycle, which are CO_2, CH_4, N_2O, SO_2, CO, NO_X, NMVOC and PM (particulates). The paper presented an analysis of the sources of gaseous emissions during each element of the Building Life Cycle. It introduced a model for calculating gaseous emissions throughout the Building Life Cycle. The application of the model for calculating gaseous emissions needs energy consumption data and the emission factor of each kind of energy. A preliminary case study in the construction stage was discussed to show the application of the developed model. In future research, the detailed data of gaseous emissions generated for each element of the Building Life Cycle will be analysed. These data can then be used to identify the most environmentally polluting materials or structures. Such results will enable effective strategies for gaseous emission reduction to be selected and adequate solutions to major polluting materials or structures to be adopted.

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Surveying & Built Environment

Direct Geo-referencing and Orthophoto Correlation with Demarcation District Sheets

Conrad H. W. Tang* and H. D. Zhang**

ABSTRACT

This paper introduces two methods of deriving horizontal coordinates from a Demarcation District Sheet. The first method performs geo-referencing using long-lasting prominent features on a Demarcation District Sheet directly. The second method performs geo-referencing against the 1963 orthophoto images, and this method is recommended and expected to have a wide application in the land boundary industry.

KEY WORDS

Demarcation District Sheets, geo-referencing, orthophoto, land Boundary Record

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INTRODUCTION

The Demarcation District (DD) Survey was a comprehensive boundary survey which covered the New Territories between 1899 and 1905. A DD Sheet, under the deeds registration system, is a registered plan with a boundary clause stating that the lot boundaries were "particularly delineated".

There is no spatial coordinate framework on a DD Sheet. The geodetic control information of the DD Survey has been unavailable in recent decades. Thus, the exact positioning accuracy of DD Sheets cannot be checked directly. In a plane-table survey done in the period of 1900's, the survey plan could possibly claim a good accuracy up to 1 mm. It means that the surveyed features are drawn accurately on the plan which is within 1 mm on the plan to the 'true' position. Accumulated professional experience and research results on using DD sheets indicate that field bunds in a good accuracy DD sheet should have achieved the 1 mm accuracy within a standard deviation (Zhang & Tang, 2012).

Much that has been published on the DD Sheet, (Leung et al, 2008) confirms its nature as the product of a land occupation survey. This theme is followed in this paper. The reliability of the inherent graphical accuracy of DD Sheet is analysed. And, it is suggested that the agricultural occupation pattern should be used to reasonably represent the DD images.

DIRECT GEO-REFERENCING DD SHEET WITH FIELD SURVEYING COORDINATES

Direct geo-referencing means that the coordinates' control information is applied directly onto the selected features of the un-coordinated plan image. The basic principle is to find out the coordinates of some significant landmarks on the DD Sheet providing that a feature that existed in 1905 can still be seen as the same intact land boundary feature today. The geo-referencing function of a Geographic Information System (ArcGIS 9.2 is used in this project) applies the current coordinates of the selected features to the corresponding features on DD Sheet. In theory, given the scale and the north direction, one control point (define x and y coordinate) is sufficient to determine 4 parameters in a horizontal datum. However, after the DD Sheet scanning, the scale and direction information need to be defined again. So, at least two control points are needed to perform DD Sheet geo-referencing. Different numbers of control points and different transformation algorithms will give different results. This paper gives examples using a subject area in the Kam Tin Demarcation District Sheet (DD 109) as shown in **Figure 1**.

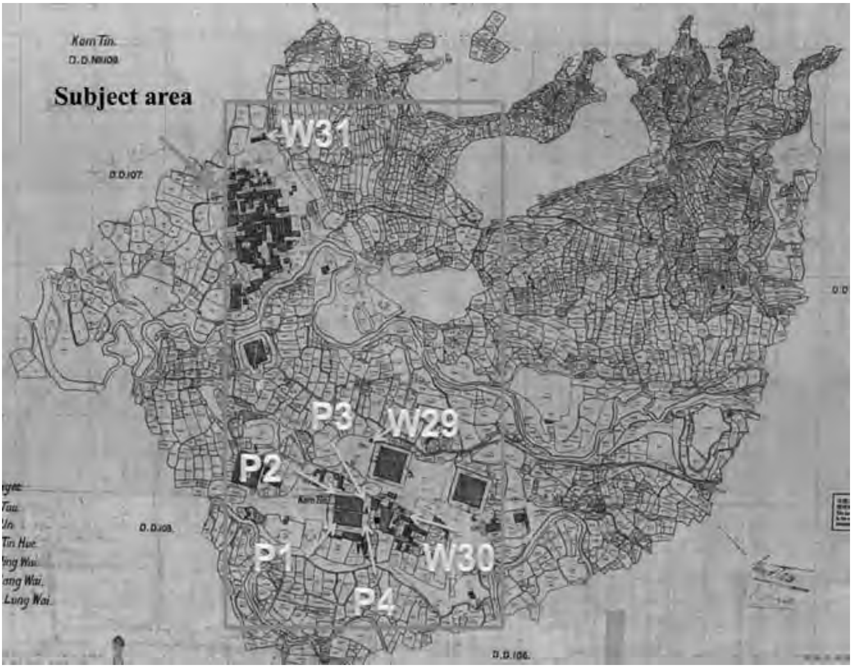


Figure 1: Direct geo-referencing of a subject area and featured points

On the subject area, the four corners of Kat Hing Wai and three old wells are used as geo-referencing points (**Figure 1**). Current positions and corresponding DD Sheet images are shown as **Figure 2**. Wells were drawn on the 1:3960 DD Sheet using a circle symbol with a dot in the centre. The current centre of the well was surveyed with the 1980 horizontal coordinates using the Kinematic GPS service provided by the Survey and Mapping Office. The KGPS survey was checked in-situ against urban survey marks with conforming accuracy within a couple of centimetres.

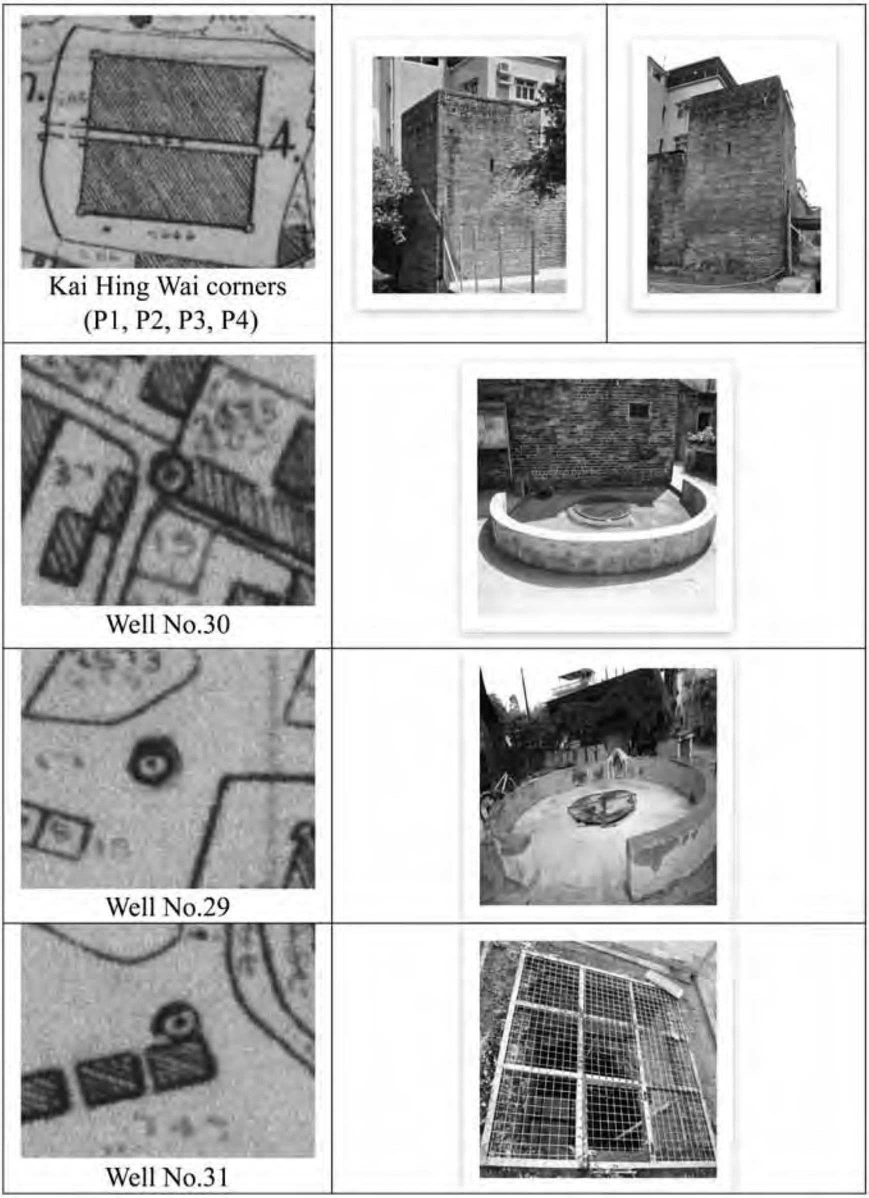


Figure 2: Long-lasting stable features on the DD Sheet and on the ground today

Applying a minimum of two control points to perform a direct similarity transformation and three control points to perform a direct affine transformation, the DD Sheet can be differently geo-referenced. In addition, by applying all the seven long-lasting stable features as the geo-referencing control points, the final geo-referencing result can also be tested. The testing points' positioning accuracy of those three differently georeferenced DD Sheets are listed in **Figure 3**.

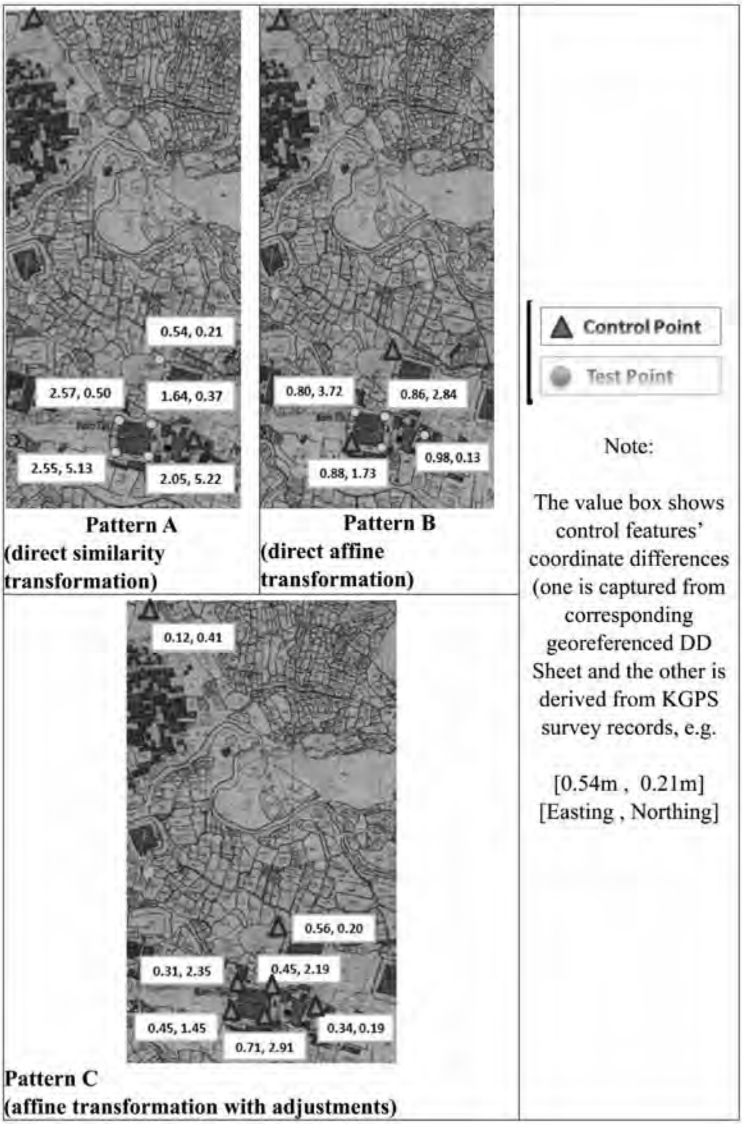


Figure 3: Three tested examples of the georeferenced DD Sheet

The results show that an affine transformation with a high degree of freedom of control points can achieve a better result than a similarity transformation in direct DD Sheet georeferencing ('Pattern A' & 'Pattern C'). However, such positional accuracy is far from sufficient to cope with the current centimetre-level positioning accuracy requirement for land development. If the DD Sheet's function as a lease plan is interpreted solely on its graphic presentation, an average error at about 4 metres is likely to be what we get (Zhang & Tang, 2012). After all, it reflects a good internal accuracy of the 1:3960 DD Sheet such that 1 millimetre of error on the map represents 4 metres on ground.

The main shortcoming of this direct georeferencing method is in the case of a lack of long-lasting (between 1905 and nowadays) stable features. So, only if several long-lasting stable features are evenly distributed in the subject area, can this direct georeferencing method be useful.

INDIRECT COORDINATE FIXING – ORTHOPHOTO CORRELATION

A correlation using the detailed survey plan and the DD Sheet has been the traditional method for obtaining land parcel coordinates. With the availability of large scale survey sheets, the New Territories Administration has made good efforts at correlating the DD Sheet. It allowed small modifications to the DD Sheet according to then-existing features.

> (a) Any line which follows the same general shape as the original may be accepted if the average dimensions of the lot do not vary from the original by more than +/- 2% or +/- 5' (whichever is the greater) and if the area when compared with the original is within the limits laid down by Instruction No. 20.
>
> (b) Reorientation of a lot by rotation depends on its situation. Isolated lots may be rotated until the best fit is obtained, but when in groups, each and every lot must be considered. (Empson, 1969)

The current boundary layers of the Cadastral Information System of the HKSAR Government are very much inherited from survey plan and DD Sheet correlation work in the 1980s for which the product "Green Key" was produced with correlation rules that affirmed long-time peaceful occupation.

> 3. The overriding consideration is that the original DD boundaries were in fact Lines following ground features. Whilst their planimetric positions may not be reliable, their "occupation-dependent" nature must hold true. It therefore follows that details shown on the current survey sheet which appear to be features surviving over the years and resembling the DD boundaries, must be adopted for correlation to be put into effect. (Leung, 1987)

Correlation invariably produces slightly amended and improved versions of the land boundary record as compared to the original lease plan. The updated boundary record is needed by the government for daily administration as well as by society as a whole for land development. The catch in our leasehold system is that one party cannot 'change' the lease plan without agreement (Tang, 2010). The correlated land boundary record has thus a dubious status.

1963 Aerial Photos
Hunting Surveys planned and implemented the aerial survey in the 1960's for which large scale maps were produced, 1:600 for urban and 1:1200 for rural areas. Compared with earlier sequence aerial photos (e.g. 1920s, 1940s), this aerial survey covers the whole territory of Hong Kong[1]. The set of photos taken in 1963 to 1964 gives a good record of the then agricultural land use in the New Territories. With the Wild A7 analogue plotter, control points were determined at good horizontal (Eastings 0.24 feet and Northings 0.27 feet over 170 points) and vertical (Elevation 0.27 feet over 208 points) accuracies (Dawe, 1969).

Generally speaking, due to the tilt of aerial photos and terrain relief, aerial photos should not be measured directly. A scale-correct orthophoto can be generated based on a stereo pair of aerial photos. In this paper, the operation was done under the Leica Photogrammetry Suite (version 9.2). **Figure 4** shows the procedures of doing this.

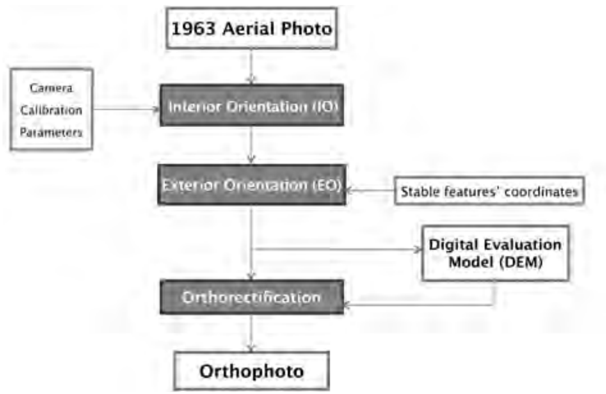


Figure 4: Flowchart for orthophoto generation

[1] Editor's note: The 1963 and 1964 photos, taken by R C Huntings, were generally taken at low altitudes (generally from 2700 to 3900 feet or more) and are squared in shape. The 1924, 1945, 1949 and 1956 RAF aerial photographs are essential for the identification of the *existence of* and general if not also precise delineation of such key referent features as reclamation limits, graves, houses, farmland, footpaths, highways and stream courses, which more often than not looked, if they remained, very different in 1963 or 1964. The 1945 photos cover the entire territory of Hong Kong though they were taken at high (20000 feet) altitude. The 1949 photos were middle altitude (8000 feet) and show very clear ground features though those available at Lands Department do not cover some areas in the New Territories. The 1956 photos were taken from a high altitude (16700 feet) but they are of good resolution. These earlier photos, where available for an area, must be taken into consideration where geographical, land use and development changes are critical issue for that area. For action for adverse possession against the government, photos earlier than 1963 were essential as evidence. All these photos were taken at a time there was little air pollution and the hills in Hong Kong generally more grassy and with less tree and bush cover than today.

The internal orientation parameters are unavailable. With the knowledge of the camera RC8 Aviogon 152.4mm lens (Dawe, 1969), we used approximate values for the internal orientation and it worked well (internal accuracy at about 7 microns). We performed exterior orientation using currently identifiable features with survey-accurate coordinates. These features include wells, wall corners, bridges, graves and sharp path junctions. The subject agricultural area terrain in this paper is flat. An auto-generated DEM for orthorectification is considered sufficient. The orthophoto image used in this paper had a tested horizontal accuracy of 0.3 metre (Tang & Guan, 2010).

Correlation of DD Sheet onto the Orthophoto of 1963

Correlation in a GIS environment is done using the geo-referencing function. Based on the DD Sheet images, the field bunds were traced to form polylines. Similarity transformation and affine transformation were used. In correlation examples here the affine transformation was adopted because the Northing and Easting grid lengths of the adopted DD Sheet (DD 106) image were found to vary slightly.

Four blocks of lots were identified with areas 100m x 100m, 200m x 200m, 300m x 300m and 400m x 400m. Each block was tested with different combinations of control points. In **Figure 5**, showing the test on 100m x 100m, 22 nodes were selected and 3 of them (No.3, 15 and 19) were assigned with higher weights. The mean of the misclosures is 2.0 metres and standard deviation at 1.6 metres. **Figure 6** gave the result using other 3 control points. The mean is still 2.0 metres.

In **Figure 7 and 8**, for the testing area of 200m x 200m, the two means are 2.3 metres and 1.9 metres. In **Figure 9 and 10**, for the testing area of 300m x 300m, the two means are 1.8 metres and 2.1 metres. In **Figure 11 and 12**, for the testing area of 400m x 400m, the two means are 2.0 metres and 2.1 metres.

From these tested samples, we could say only that the subject 1:3960 DD Sheet can be correlated to the agricultural occupation in 1963 with a mean accuracy of 2 metres. Of course, all lot boundaries can be read under the 1980 horizontal coordinates. The significance of this exercise is that not only can a surveyor produce a technically accurate land parcel boundary based on DD Sheets and orthophotos, but most importantly an assessment of accuracy can also be provided.

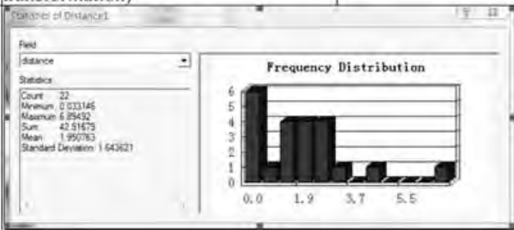
22 field bund junctions

Geo-referencing with 3 controls (affine transformation)

FID	Shape *	distance
0	Polyline	2.22953
1	Polyline	0.717816
2	Polyline	1.34573
3	Polyline	0.151618
4	Polyline	2.03922
5	Polyline	1.32749
6	Polyline	3.03444
7	Polyline	3.01537
8	Polyline	3.05105
10	Polyline	0.159346
12	Polyline	1.36145
13	Polyline	0.503078
14	Polyline	0.033146
15	Polyline	0.074117
16	Polyline	2.37222
17	Polyline	1.34609
18	Polyline	2.58156
19	Polyline	0.43217
20	Polyline	6.89492
21	Polyline	4.69878

Misclosures in metres

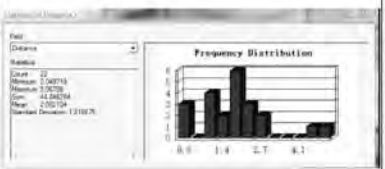
Misclosure vectors shown with point numbers



Statistics of the misclosures

Figure 5: Geo-referencing of DD Sheet on orthophoto in an area of 100m x 100m

3 control points



Statistics of the misclosures

FID	Shape *	Distance
0	Polyline	1.91367
1	Polyline	1.20483
2	Polyline	2.05745
3	Polyline	1.99895
4	Polyline	1.37642
5	Polyline	1.27515
6	Polyline	1.28634
7	Polyline	0.545719
8	Polyline	2.43707
9	Polyline	2.60844
10	Polyline	4.58463
11	Polyline	2.02245
12	Polyline	5.06708
13	Polyline	2.3159
14	Polyline	1.33254
15	Polyline	1.38333
16	Polyline	1.92247
17	Polyline	1.67213
18	Polyline	3.07097
19	Polyline	2.1979
20	Polyline	0.074117
21	Polyline	0.111668

Misclosures (m)

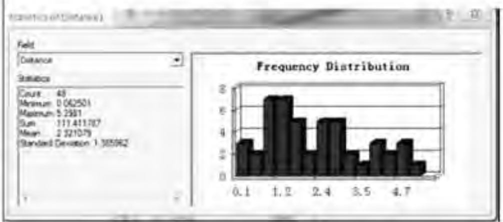
Figure 6: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 100m x 100m

48 field bund junctions

Geo-referencing with 3 controls (affine transformation)

Misclosures in metres

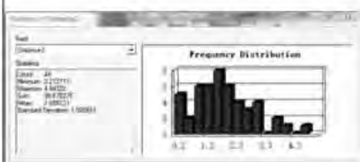
Misclosure vectors shown with point numbers



Statistics of the misclosures

Figure 7: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 200m x 200m

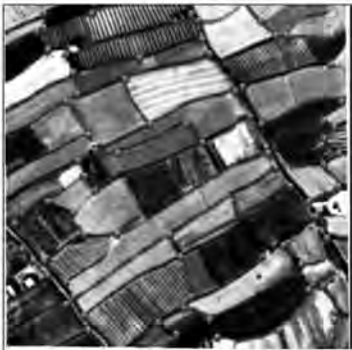
3 control points



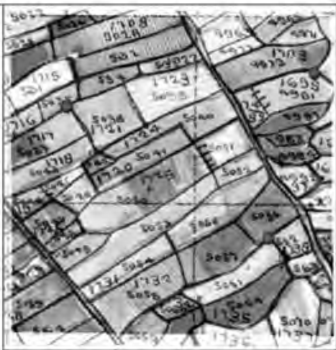
Statistics of the misclosures

Misclosures (m)

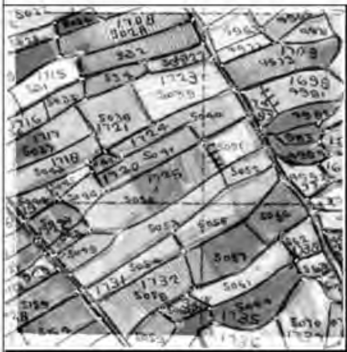
Figure 8: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 200m x 200m



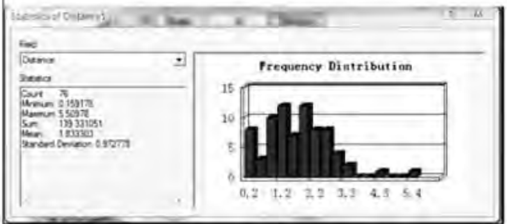
76 field bund junctions



Geo-referencing with 3 controls (affine transformation)

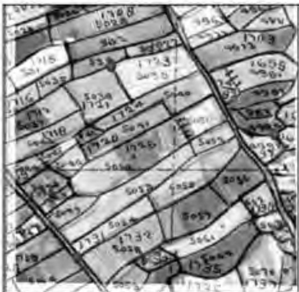


Misclosure vectors shown with point numbers

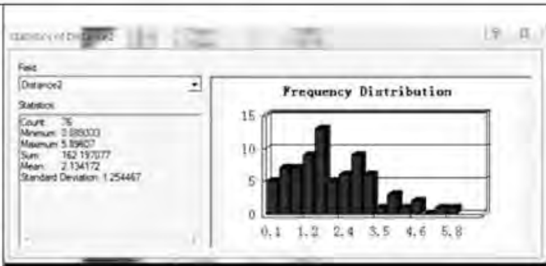


Statistics of the misclosures

Figure 9: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 300m x 300m

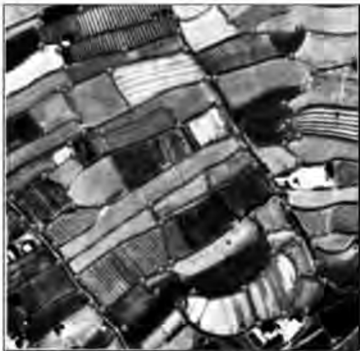


3 control points

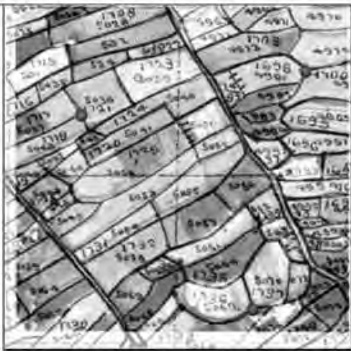


Statistics of the misclosures

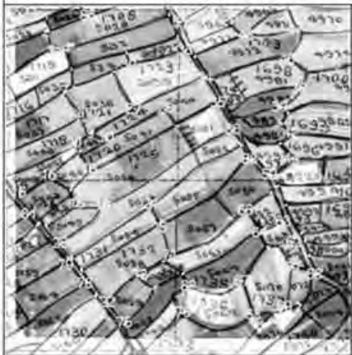
Figure 10: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 300m x 300m



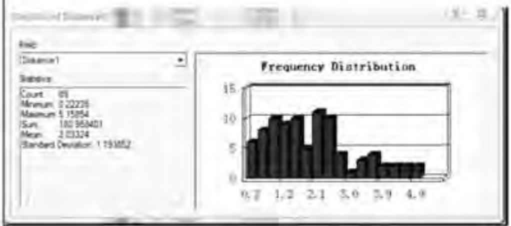
89 field bund junctions



Geo-referencing with 3 controls (affine transformation)



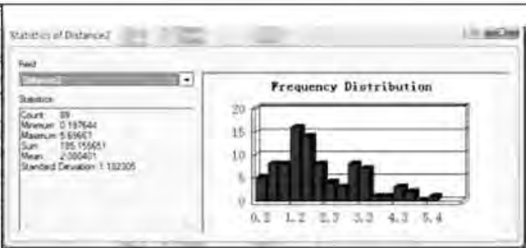
Misclosure vectors shown with point numbers



Statistics of the misclosures

Figure 11: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 400m x 400m

3 control points



Statistics of the misclosures

Figure 12: Geo-referencing of DD Sheet on 1963 orthophoto in an area of 400m x 400m

CONCLUSION

In this paper, two methods (direct georeferencing and orthophoto correlation) are applied to derive horizontal coordinates from DD Sheets. **Table 1** lists the merits and demerits of these two methods in this paper.

	Direct Georeferencing	Orthophoto Correlation
Implication	Interpret coordinate information 'directly' from DD	Interpret coordinate information through 1963 photos
Control Points' Coordinate Source	Field-surveying (cm level)	Captured from generated orthophoto (sub-meter level)
Number of available Control Points	Insufficient (long-lasting common features between 1905 and nowadays)	Sufficient (long-lasting common features between 1905 and 1960s)

Table 1: Comparisons between two applied methods

The "direct" method relies on several long-lasting (1905 ~ nowadays) stable features as the control points. Those features' coordinates can be surveyed at a centimeter level and can be directly applied for georeferencing. This useful method is however limited by the availability of surviving control points.

The "indirect" method relies on several long-lasting (1905 ~ 1963) stable features. From the 1960s aerial photos, the agricultural occupation patterns were maintained largely as in the 1905 NT. Based on those widely distributed common features, the DD Sheet can be correlated onto the orthophoto, besides, an assessment of the correlation accuracy can be provided.

We surveyors understand that the DD Sheet was a good survey record depicting agricultural occupations in the 1900s. As it is limited by the scale used at the time of survey, surveyors need to use other technological means to accurately delineate lot boundaries. Orthophoto images are certainly a very helpful means. The orthophoto model used in this paper used 11 accurate and permanent features. Other village areas may not have similar conditions. The Survey and Mapping Office works on the full coverage of orthophoto images to Hong Kong. Should this product be available to industry, surveyors can easily delineate boundaries with reasons and accuracy attached.

ACKNOWLEDGMENTS

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Surveying & Built Environment

Kadoorie Hill and Footnote 43 in Cheung's (1975) "Roofs or Stars" Regarding Evidence for Pre-Mature Redevelopment under Rent Control

Lawrence W C Lai

Ronald H. Coase always urges economists to look at the real world and avoid producing theories based on armchair speculation. Few have followed his advice though Steven Cheung is an exemplary exception. Cheung's studies on share cropping (Cheung 1968), the market for bee pollination of apple flowers (Cheung 1973), and rent control (Cheung 1975) are well known in the field of institutional economics as cases in point.

Cheung's (1975) analytical study on pre-war rent control on housing under the *Rents Ordinance* of 1921 predicted that one of the effects would be premature reconstruction, i.e., redevelopment, to by-pass the rent control legislation. However brilliant was the theory, a major problem with testing it was the difficulty in isolating the effect of rent control from such other factors that favoured redevelopment such as growth in effective demand and new buildings' regulations.

Accordingly Cheung could not find any empirical evidence and admitted, "The only available information on tenement reconstruction during the existence of the Rents Ordinance is contained in the legislative proceedings. However persuasive, the evidence does not conclusively demonstrate that many reconstructions were indeed premature. Regardless of the reported age at which an existing tenement was pulled down, much more information is needed to confirm that the demolition was premature." (Cheung 1975: p.15) Cheung then went on to produce statements made by officials in the Legislative Council about eviction of tenants under rent control. "The reconstruction craze apparently continued, for on February 28, 1924, a Bill was again introduced to check the trend. The Attorney-General stated explicitly that "some landlords used [reconstruction] for the sake of the increased rent they can obtain from the new house. . ."." (Cheung 1975: p.17)

Footnote 43 in Cheung's (1975) work states, "In a forthcoming book which investigates various rent controls in Hong Kong (Cheung, in progress), detailed evidence will be presented to confirm that premature reconstructions occurred in some tenements protected by the Landlord and Tenant Ordinance during the postwar period." (Cheung 1975: p.15) That book has not yet appeared. Cheung's (1979) paper on housing reconstruction in post-war Hong Kong examines, among other things, 185 Land Tribunal cases heard from 1969 to 1972 in relation to s.11 (A) of the *Landlord and Tenant Ordinance.*

In that later paper the focus shifts from reconstruction as a means used by the landlord to circumvent any rent cap to:

> (a) the landlord's drive to reconstruct to minimise loss due to the introduction in 1962 of plot ratio control in the Buildings Ordinance, which reduced the permitted floor area; and
>
> (b) overcoming tenants who were holding out when landowners find it more profitable to redevelop

In this latter regard s.11 (A), introduced in 1968 to allow private negotiation between landlord and tenant, was found useful in preventing premature redevelopment by overcoming the holding out problem.

Cheung's (1974) theory of price control covers all types of regulation of the market and thus one should appreciate that his (1979) case study demonstrates well the predictive power of his theory. Nonetheless, evidence remains wanting of pre-mature redevelopment intended only to by-pass rent control itself rather than any other form of control, yet that was nonetheless not a response to growing demand.

In the light of this, we can turn to a University of Hong Kong dissertation by Lu (2007) on architectural conservation in Kadoorie Hill, developed and owned substantially by Hongkong Engineering & Construction Company Ltd., controlled by the famous Kadoorie family. This does provide real life, post-war evidence in support of Cheung's (1975) theory of pre-mature redevelopment due to rent control.

Lu's (2007) dissertation recorded that the 1980 annual report of this company stated,

> "as prewar properties are not subject to the control of Landlord and Tenant (Consolidation) (Amendment) Ordinance 1980, the renewal rentals of the Company's pre-war properties have been brought up to realistic levels as have other properties upon vacation by tenant...*it has been decided not to proceed with the demolition and re-development of six of the Company's small pre-war houses in Kadoorie Avenue*...Instead, complete renovation of some of the houses is under active consideration." (Lu, p.39 of the e-thesis)

This is the public statement of a landlord in relation to rent control. This piece of information supports Cheung's (1975) theory. One year earlier, the company had expressed worries about the adverse effects of a proposed amendment to the rent control law on rentals of tenancy agreements due in 1980/1981 and contemplated redevelopment. (Lu, p.39 of the e-thesis) The 1980 amendment lifted rent control on the pre-war buildings and this saved the *post-war* premises from demolition. The company had demolished the pre-war houses at no. 16 and no. 18 Braga Circuit in the 1970s and rebuilt blocks of flats on the sites for leasing. Note that the first Outline Zoning Plan which covers Kadoorie Hill, under which there could be little gain in GFA by redevelopment, was not introduced till 1985. Thus, the reported company decision was made in the absence of any economic restrictions on redevelopment due to law. It is company policy to renovate whenever a tenant vacates his house or flat.

It took 32 years for the key issue in a frequently cited economic theory announced in 1975 to be vividly demonstrated.

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Surveying & Built Environment

Definitions of Land Use Terms in Statutory Town Plans

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Properly interpreting the meaning of land uses in a statutory zoning plan in Hong Kong is not always an easy professional task (Lai, Ho and Leung 2010). This technical note provides basic facts regarding the dates of three administrative definitions produced by the Town Planning Board. To the extent that at least one of the versions can be browsed on the government's website and most of (but not the latest) the versions can be inspected by the public at the Planning Department at the time of this note's writing and because the Court of Appeal in Civil Appeal No.231 of 2011 (the Hero Case) made reference to such definitions, we shall regard them as *published* planning documents *relevant* to the interpretation of land uses in statutory town plans.

Unlike those under the British planning system, but like those under the New South Wales planning system, statutory town plans in Hong Kong are "zoning plans". That is, land uses have been grouped under various "zones".

Land uses that are: (a) always permitted in all zones, (b) "always permitted" in a specific zone, and (c) "may be permitted" in a specific zone are itemized and listed in the "Notes" of a statutory plan, which may be an Outline Zoning Plan (OZP) or a Development Permission Area Plan (DPA Plan).

There is no statutory definition of each of the land use items within a specific statutory plan or, generally, under the Town Planning Ordinance or Town Planning Regulations. The Town Planning Board has, however, administratively issued definitions of land uses from time to time.

The three types of definitions are: (A) those that deal with those areas without a history of an Interim Development Permission Area or Development Permission Area Plan [these mainly cover the areas (including new towns) with OZPs prior to the 1990 amendment to the Town Planning Ordinance]; (B) those that deal with those areas with a history of an Interim Development Permission Area or Development Permission Area Plan; and (C) those that deal with all areas. The titles and dates of these three distinct groups of definitions are shown in the chart (**Figure 1**) below.

Type (A) was originally called "Definitions of Terms used in Statutory Plans," but has been called "Definitions of Terms Used in Statutory Plans (for Areas not Previously Covered by Interim Development Permission Area Plans or Development Permission Area Plans)" since July 2000.

Type (B) was originally called "Definitions of Terms for Interim Development Permission Area Plans/ Development Permission Area Plans," but has called "Definitions of Terms Used for Rural Outline Zoning Plan (for Areas Previously Covered by Interim Development Permission Area Plans or Development Permission Area Plans) and Development Permission Area Plans" since July 2000.

Type (C) was introduced on 28 February 2003 and is called "Revised Definitions of Terms/Broad Use Terms used in Statutory Plans."

A version of each of the three types was revealed on the government website on 16 May 2003.

As far as the author is aware, the last updates of these three types of definitions were on 6 January 2005, 6 January 2005, and 27 September 2010, for Types A, B, and C, respectively. These latest versions can be inspected in the public enquiry office of Planning Department with permission of the Town Planning Board secretariat. The file reference for the 27 September 2010 version of Type C is M:/PSOTA200707/ PEC Operation C'lists as at 27.9.2010. doc. It is bilingual and has 45 pages. Type C definition of a "shrine" was referred to in the decision on the Hero Case.

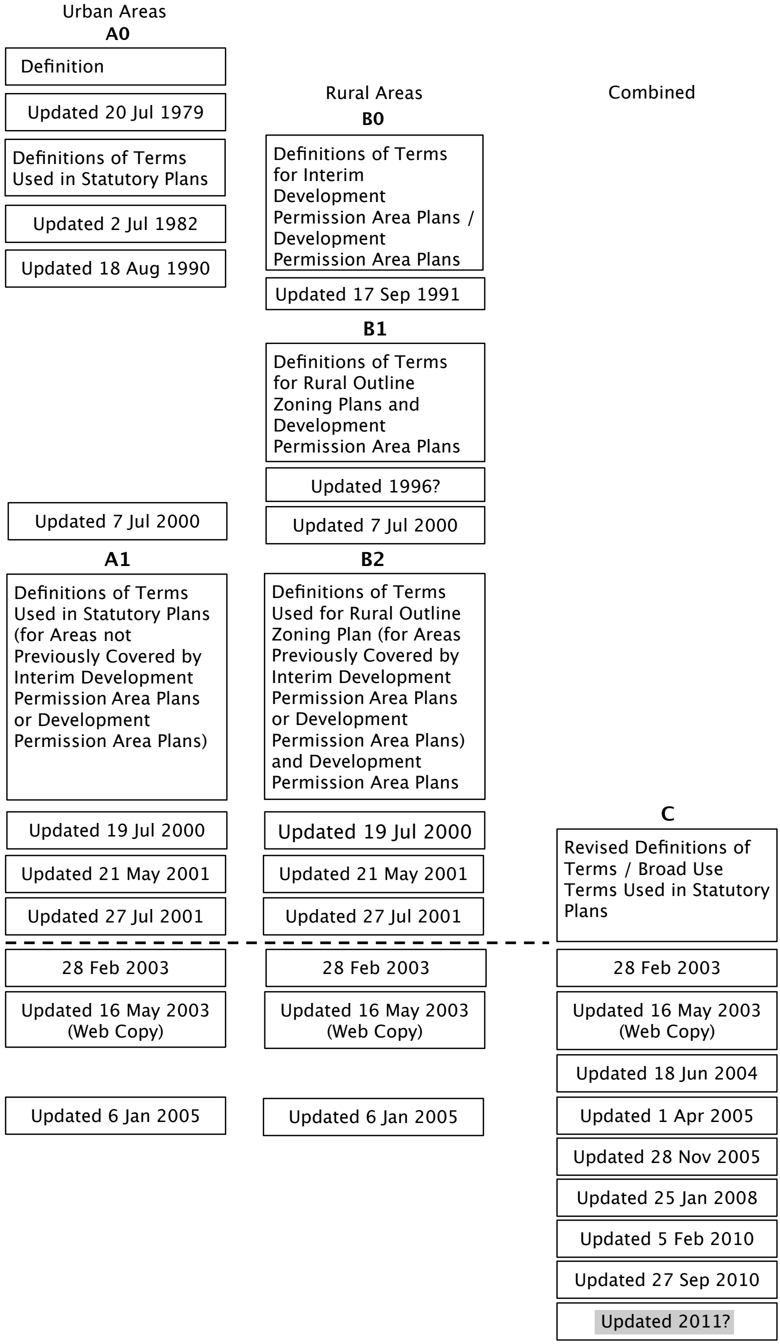

Figure 1: Three types of administrative definitions of terms used in statutory town plans

REFERENCES

Lai L W C, Ho D C W and Leung H F (2010), *Change in Use of Land: a Practical Guide to Development in Hong Kong,* 2nd ed. Hong Kong, Hong Kong University Press.