A Review of Ex-Mining Land Reclamation as Construction Project Activities: Focusing in City of Ipoh

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Abstract

A large demand of housing and land development in Malaysia since the last two decades has resulted in the reduction of suitable and proper spot for housing development. This kind of land can now only be found in the area far away from the cities. However, most people choose to be near or not too far from the cities. This has led to the development of the less desirable area such as ex-mining land.A study of completed and ongoing development in the above mentioned areas reveal that there are less than adequate guidelines, laws or policies to ensure development in these areas are given proper attention in term of safety and environmental provisions. This paper discussed several issues regarding to the construction of housing and development in the difficult and less desirable areas.As land is getting scarce due to rapid development, an abandoned ex-mining area hasbecome valuable lands for developments.

Keywords: Ex-Mining Land, Ground Subsidence, Land Slides, Green Approach

1.0 Introduction

According to Xia (2006) since the Brundtland Commission first put forward the concept of sustainable development; all industries have been seeking ways to perform in a more sustainable manner. The extraction of minerals from ground can have a number of impacts, topographical, eco-toxicological and socio-economic, from operation to closure. To achieve sustainability, Hilson and Murck (2000) recommended that the industry should pursue ‘‘the combination of enhanced socioeconomic growth and development, and improved environmental protection and pollution control’’. Mine land reclamation constitutes an integral component part of mine sustainability, which is, as Morrey (1999) explains, to achieve ‘‘physical stability, waste management and acceptable land use’’, and as added by Kahn et al. (2001) to improve resilience, productivity, biodiversity of the land. The amelioration sometimes is both technically and economically difficult; therefore, the realistic objectives of land reclamation may differ significantly from the ideal goal of site rehabilitation. However, in the context of long-term land sustainability, reclamation may provide the potential for ecological adjustment or for practical reuse of mined land (Xia, 2006). According to Gao et al, (1998) mining is a temporary use of land and mine land reclamation is clearly justified from the perspective of sustainable development. Thus, it has become important part of the sustainable development strategy in many countries. Mining land reclamation as a part of sustainable development and is known by local government as a good achievement for land use. Construction projects as a part of land development also known as one of the social economical mileages for contributing in gross domestic product (GDP) of Malaysia. At the earlier stage, those problems facing by Local Authority about land use constraint has been solved. At present, the developments and construction projects still proceed. However, there are lots of issues surrounding the development in ex-mining area. While developments are growing rapidly, some buildings are facing settlement and in certain cases those building that are affected have been no longer to accommodate their building. Therefore, this paper will review the common problems in ex-mining land development, causes and some suggestion for green method of reclamation to enable the mining area to performed as good as a normal land but yet still environmental friendly.

2.0 Problem Associated with Ex-Mining Land

Krebs et al (2009) stated that with care, surface-mining operations can be conducted so as to yield reclaimed land topographically suitable for residential development. But much of this land will consist of filled landin the form of deep deposits of mining spoil produced by the mining operation. Such fills are almost always deeper than 20 feet and commonly extend to depths of100 feet or more. Even when carefully placed with compaction, such fills continue to settle under their own weight for many years.Zipper et al (2009) also suggested a critical factor affecting suitability of reclaimed mines for building construction is surface stability. As filled lands, virtually all reclaimed mines will be subject to some settlement, or consolidation, over time**.** From several past research conducted by Tan (1988); krebs et al (2009); Zipper et al (2009) determine that the construction on ex-mining land will resulted a soil settlement. Tan (2006) and Tan et al (2005) added that the formation of Karstic geology as refer in figure 1, both surface and subsurface, is the dominant influence. Thus, subsidence and sinkhole formation is frequent. The common mining heritage and inheritance of mining deposits also contribute to landslide occurrences and problematic soils for the geotechnical engineer to contend with in both areas.

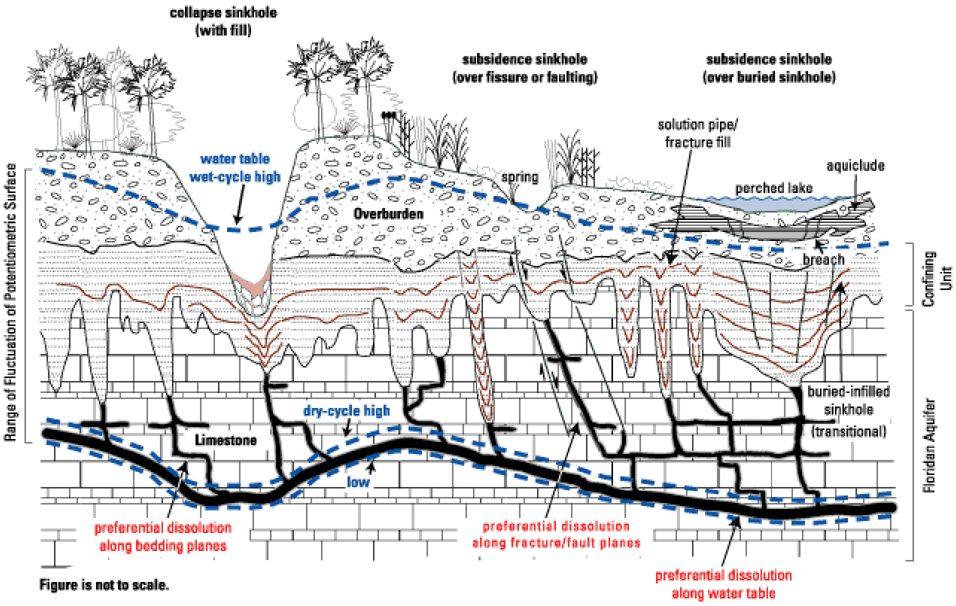

Figure 1: Karstic Feature. Source USGS (2014)

The Star reported on 31st January 2001, there are 14 sinking houses at Bandar Pengkalan Indah caused by ground settlement as the properties were on former mining land. The Star also reported on 4th February 2005 there are sinkhole measuring 3 meter by 2 meter appeared beside the road near the ground-floor unit at Sungai Pari Tower Flats, Ipoh. Beside that on 8th January 2006 NST reported at the Taman Pusing Indah, Ipoh had experienced a land slide which damage six houses. Former MenteriBesar Perak, Datuk Seri TajolRosli Said *'The project has always been a problem case. It is located in an unstable soil….on Ex-mining land.* On26th October 2009 a sinkhole appeared at SekolahMenengahIdris Shah, Gopeng, the news was reported on 27th October 2009 in Utusan Malaysia. Malay Mail online reported that on 16thDisember 2013 Ipoh was shocked due to the appearing of sinkhole at the Ipoh Airport. 1st March 2014 NST reported a sinkhole appeared at KampungPengkalan Gate Tambahan 2, Ipoh and subsequently The Star Online reported another ½ meter sinkhole appeared at BuntongTigaTambahan on 29 August 2014. On the other hand, the resident of GerbangMeru Indah, Ipoh was staggered on the landslide that hit on 5 December 2014 the report was published in The Star Online. This is an on-going problem and will continue to be so as long as buildings are constructed over improperly reclaimed land.The rapid rate of urbanization of the Kinta Valley has greatly increased the size of the built-up areas. Many urban areas have expanded to the ex-mining land which has numerous ponds. It is estimated that the urban population will double itself every 10 to 15 years (Yong, et al 1985) and ex-mining ponds in the way of urban expansion will be reclaimed and utilized for the construction of industrial and residential centers.

2.1 Sinkhole

Tan (2006) suggested that sinkhole formation or emergence is much more sudden and catastrophic. Numerous incidents of the sudden formation of sinkholes in the Ipoh areas have been reported, often affecting houses, roads, railways and other structures. Sinkhole development is related to the underlying highly irregular or pinnacled limestone bedrock with its associated subsurface troughs and trenches, the collapsed soil zone described above, cavities in the limestone bedrock, subsurface erosion of mine tailings, and lowering of the groundwater table sometimes caused by dewatering and excavation activities during mining and construction. Typical examples of sinkhole occurrences in the Ipoh area have been documented by Shu (1982, 1986). These incidents are thought to be related to the dewatering of deep, open-cast mines, although attempts at correlation havebeen inconclusive. Many of these sinkholes are small with diameters of several metres, vertical sides and variable depths.. Chow (2005) explained that the formation of sinkhole in Ipoh is related to its geologic condition as its was developed on limestone bedrock overlain by mostly sandy mine tailings, were such as to have higher potential for the formation of sinkhole. Figure 2 shows the houses is totally damage by the sinkhole.

Figure 2: A sinkholes caused a five-meter deep crack developing inside a wooden house in Ipoh. Image copyright, The Star Online (2014).

2.2Ground Subsidence/Settlement

There are broadly term used for ground settlement for example soil consolidation, soil settlement, soil subsidence and etc. Even though the terms are different but it shares the same definition as desribe by Tan (2006) that the subsidence or land settlement are common engineering geologic problems in the Ipoh areas due to widespread limestone bedrock, a history of mining and deposits of mine tailings. Several ground conditions give rise to land subsidence, including the widespread occurrence of soft mining slimes in the ex-mining areas upon which housing projects and roads are built. This type of land subsidence is due to consolidation of the underlying slime/soft clay upon loading, and proceeds at a gradual or slow rate. Although it causes severe damage to houses and infrastructure, often leading to their demolition. It is not as dangerous as sudden collapse due to the collapse of cavities in limestone. Gue (1999) suggested that the formation of subsidence in Ipoh areas are often associated with the occurrence of soft mining slime in ex-mining area upon which housing and roadwork projects. This is due to the consolidation of the underlying slime/clay upon loading and proceeding at a gradual or slow rate. This problem of differential settlements as stated by Krebs & Zipper (2009) may be reduced if the reclaimed ground is allowed to undergo self-consolidation which may take a few years. A second solution as recommended by Krebs & Zipper (2009) is to install vertical and horizontal drain to extract the water within the slime to hasten the consolidation process. Unfortunately, most housing developers do not undertake such procedure, and they often construct houses almost immediately after reclaiming the ex-mining land. Houses or building constructed over such ground and without any piled foundation often suffer cracks in the ceiling, walls and floor. However, as most of the ex-mining ponds have karsticlimestone bedrock, some of the slime may be trapped within the troughs of the karstic bedrock, leading to differential settlement of the overlying soil (Tan, 1986a). This problem is commonly observed in houses where the foundation is not on piles, but rather on footing, and cracks are often observed on the floors, walls, and ceilings (Krebs & Zipper, 2009). Figure 3 shows that of the houses id affected by the ground subsidence.

Figure 3: Twelve houses in Kampung Tersusun Buntong, Ipohwere damaged when the foundation of their houses started sinking. Image copyright Bernama (2014)

2.3Landslides

Tan (2006) stated that Landslides are a common problem in the Ipoh areas. This areas landslides are associated with mining and ex-mining ground which are highly susceptible to landslides due, in part, to the loose sands and soft slimes/clays in the mine tailings areas. The method of mining using gravel pumps with hydraulic jets and its various associated artificial landforms (tailings bunds, mining ponds, etc.) also increase the potential for landslides. Figure 4 shows that that the landsilde that hits Gerbang Meru Indah in Ipoh.

Figure 4: A Landslide hits GerbangMeru Indah in Ipoh. Image Copyright, Manimaran(2014).

3.0 Conventional Reclamation Technique

Due to rapid lateral expansion of the urban centers in Kinta Valleys, many residential, industrial, infrastructure and recreational developments have taken place on ex-mining land. However, developers usually carried out reclamation on an ad-hoc basis, with the major concern given to the profitability of the projects. The techniques include:

3.1 Lowering of Water Table and Emplacement of Fill Material

Tan (1986) stated this method of reclamation is widely practice by developers of housing estate or industrial parks in Malaysia. Reclamation is often carried out on an ad-hoc basis without any prior investigation. The water in the pond is loweredand fill material, usually tailing sand nearby dumps is pushed in from one end of the pond. The soft slurry at the bottom of the pond is not removed and some slurry slime would seep into the void of the fill material and other, on the pond between are consolidated. It is almost impossible to predict the total time needed for the development of a competent, consolidated ground as classical methods for determination of consolidation deal with small strain settlement.

3.2 Displacement Method

Ting & Wong (1990) stated that the Soft slurry slime was displaced by pushing in sand fill in a prescribed direction. A layer of geo-membrane is laid over the entire pond surface and sunk by laying sand bags or dipping fill material over it. The slurry slime is then displaced as more fill material dropped on to the surface of the geo-membrane. When the slurry slime is displaced, a mud wave will develop in front of the sand fill. This mud wave will increase the right of the fill material to displace the slurry slime. After displacing the slurry slime to one end of the pond, the slime is excavated. Fill material is then pushed in from one end of the pond. The Displacement method stated by Chow (1998) has the disadvantage of incomplete displacement whereby some of the slurry slim is trapped within troughs of the karstic limestone bedrock. This results in the creation of localized ‘soft’ spots in the reclaimed ground.

3.3 Containment Method

Yee (1990) stated that this methodrequires the removal of the topmost 500mm layer of the soft material (slurry slime). The initial layer of fill material has to be placed carefully so as not to exceed the bearing strength of the underlying slime. Geo-membrane is often used as separation and reinforcement layer. Fill material is placed by sand pumping and conveyer belt system in uniform layers with depth not exceeding the bearing capacity of the underlying slime. The underlying slime is allowed to consolidate, whereby resulting in an increase in the shear and bearing strength. When a stable condition is attained, side tipping can be used to speed up the works. Often, vertical drains are installed to speed up the consolidation of the slime. The Containment Method does not displace the slurry slime in the pond. Instead, the slime is contained within the pond and is compressed in-situ. This method has advantages of requiring lesser fill material for the backfilling of the pond. The problem of this method that confirmed by Chow (1998) is that the laying of the geomembrane over the very soft material at the pond bottom which has very low shear strength is difficult to execute. The sandfilling process has to be carried out in uniforms layers with depths not exceeding the bearing capacity. Such sandfilling requirements are difficult to achieve.

4.0 New Green Reclamation Technique

With so much of unsolved problems regarding to the conventional method of land reclamation, a new reclamation method, which is economically competitive, technologically feasible and will not contribute to any environmental problems, was developed. As suggested by Ashraf et al (2012) it is based on flocculation of slurry slime with Natural Organic Polymer (NOP) or Poly Vinyl Acetate (PVAC), mixed with residual soil and usage of the flocculated slurry slime as part of the fill material. Test carried out by the Chow (1998) showed that the slurry slime flocculated with NOP or PVAC have higher engineering strenght and better settlements chracteristics (i.e. less settlement and a shorter time to achieve complete settlement). He also explained that NOP orPVAC-flocculated slurry slime admixed with residual soilor tailing sand distinctly have better physical (i,e. Higherincreasing solid concentrations, higher rate of decrease inthe voids ratio and moisture content) and higher engineeringstrengths (i,e. higher shear strength and higher bearingstrength). The flocculated slurry slime is mixed with eitherresidual granitic or schistose soil, depending on theiravailability, or with tailing sand, often found in the tailingdumps in the vicinity of the ponds. The admixed material isthen emplaced in the pond as part of the fill material.In this proposed method, a holding pond is excavatedbeside the pond ear marked for reclamation. An ideal sitefor the location of the holding pond is on slightly higherground.Material excavated from the holding pond is used forthe construction of bunds resulting in a higher holding-pondcapacity. Alternatively, the excavated material can be usedas a source of admixing material.Slurry and very soft slime from the bottom of thepond designated for reclamation is pumped out usingsubmersible suction pumps until the layer of soft slime isreached. Mixing is best achieved by passing the slurry andthe flocculating reagents along a 20-50 m long sluice boxfitted with transverse riffles. The flocculated slurry is thenallowed to settle in the holding pond, and the clear supernatantis allowed to be drained off into a nearby pond, orinto the drainage system.The still wet flocculated slurry is then admixed, preferablywith granitic soil or schistose soil.The admixedmaterial is then pushed back into the designated pond inlayers of about 500-mm thickness, taking steps to ensurethat the initial layer of admixed material does not cause ashear failure in the underlying soft slime.Following this, fill material comprising either tailingsand or residual soil is emplaced over the admixed material. This method of reclamation does not involve thedumping of slurry slime into another pond, as it forms partof the admixture. As such, there will not be environmentalproblems (Chow 1998; Ashraf et al 2012).

5.0 Conclusion

A large number of ex-mining lands near to urban centers had been reclaimed in the last decade for the construction of residential houses and factories. From time to time, case had been reported in the press where houses or factories built over reclaimed ground had problems involving cracks on the walls, ceiling and floor (Chow, 2005; Tan 1988; Krebs et al 2009; Zipper et al 2009). These problems are largely due to differential ground settlement resulting from consolidation of trapped slime lenses as well as the sinkhole and landslide that always be a majorconcernto residents of Ipoh. The causes of the problems are due to the reclamation method as stated by (Chow 1998: Chow 2005; Tan 1986; Tan 2006). Ashraf et al (2012) stated that in Malaysia, the most common method of reclamationpractised by developers of housing estates and industrialparks is lowering of water level and emplacement offill material method. This method results in a number oftechnical problems, amongst which is that slurry slimeportions are entrapped in the voids of the fill material andwithin the troughs of the karstic limestone bedrock. Also,it is almost impossible to predict the total time required toachieve a competent and consolidated ground. Two other conventional methods of reclamation currently practisedare the displacement and the containment methods butboth also have a number of shortcomings. He also added that the proposed flocculation and admixing method is technically feasible,economically competitive andenvironmentally friendly. Itis recommended that the slurry slime has to be pumped outfrom a pond, flocculated with NOP or PVAC, and then, theflocculated slurry slime is admixed with residual graniticor schistose soil, or as a last resort, with tailing sand. Theadmixed materials are then put back into the pond as part of the fill materials.Investigations on the physical, geotechnical and geochemicalcharacteristics of the flocculated slurry showthat the material has favourable engineering propertieswhich make it suitable to be used for land reclamation. Theflocculated slurry is rather weathering resistant. The absenceof acidic leachate generation due to redox reactionsfrom the flocculated slurry also rules out the possibility ofacid generation and excessive leaching of the material. Inaddition, the material is rather stable in its redox characteristics. However, further studies that focus on field monitoringare still required as there may be unexpected long-termenvironmental consequences arising from the massive use of flocculated slurry in reclaimed sites. Time-dependentreactions, such as redox processes and mineral dissolutionkinetics under field conditions, and the possibility of catalysisby indigenous microorganisms, must be monitored.Ultimately, life-cycle assessment approach will be neededto identify the best solution for the admixing of flocculatedslurry with residual soil in Malaysia.

6.0 References

Ashraf et.al (2012).A New Fill Material Technology for Ex-Mining Land Reclamation and Construction Purposes, Fresenius Environmental BulletinVol 21-No 5a.2012.PP 1334-1343.

Chow, W.S. (1998). Studies of slurry slime in mined-out ponds Kinta Valley, Peninsular Malaysia for Purpose of Reclamation, PhD Thesis, Geology Department, Universiti Malaya.

Chow W.S. (2005) Geological Inputs in Civil Works-Problem and Issues; Geological & Geotechnical Consideration in Civil Works.

Gao, L., Miao, Z., Bai, Z., Zhou, X., Zhao, J., Zhu, Y. (1998) A case study of ecological restoration at the Xiaoyi Bauxite mine, Shanxi province, China: In: Ecological Engineering 11, 221–229.

Gue, S.S. (1999) Foundations in limestone areas of peninsular Malaysia: In: Civil and Environmental Engineering Conference (C&EEC) New Frontiers & Challenges, 8th -12th November, 1999, Bangkok, Thailand.

Hilson, G., Murck, B. (2000) Sustainable development in the mining industry: Clarifying the corporate perspective: In: Resources Policy 26, 227–238.

Kahn, R.J., Franceschi, D., Curi, A., Vale, E. (2001) Economic and financial aspects of mine closure: In: Natural Resources Forum 25, 265–274.

Krebs R.D. and Zipper, C.E. (2009) Foundation for Housing on Reclaimed Mines Land, Civil and Engineering Department and Crop and Soil Environmental Sciences, Virginia Tech.

Morrey, D. (1999) Integrated planning for environmental management during mining operations and mine closure: In: Minerals and Energy 14 (4), 12–20.

Malay Mail Online (2013) Published at www.malaymailonline.com on 16th December 2013, assessed on 12th July 2015

New Strait Time (2006) Newspaper Published on 8th January 2006, NST Publication.

New Strait Time (2014) Newspaper Published on 1st March 2014, NST Publication.

Shu, Y.K. (1982) A sinkhole occurrence in Kg BaruBtMerah, Menglembu, Ipoh: In: Geological Survey Malaysia, Report E(F)1/1982.

Shu, Y.K. (1986) Investigations on Land Subsidence and Sinkhole occurrence in the Klang Valley and Kinta Valley in Peninsular Malaysia: In: Proc. LANDPLAN II conf., Kuala Lumpur.

Tan, B.K. (1986) Geological and Geotechnical Problems of Urban Centres in Malaysia: In Proceedings of LANDPLAN II Symposium, Kuala Lumpur, April 1984, Association of Geoscientists for International Development, Kuala Lumpur, 10-14. http://www.iaeg.info/iaeg2006/PAPERS/IAEG_264.PDF.

Tan, B.K. (1988) Engineering geology of the Ipoh area, Perak: Final Report, Research Project No. 7/86, Sept. 1988, Univ. Kebangsaan Malaysia, 74 pp. (in Malay).

Ting W.H., & Wong T.F., (1990) Building on Reclaimed Mining Land. Proceedings of 10th Southeast Asian Geotechnical Conference, 16-20 April 1990, Taipeh.

The Star (2001) Newspaper Published on 31st January 2001. Star Publication.

The Star (2005) Newspaper Published on 4th February 2005, Star Publication

The Star Online (2014) Published on 29th August 2014 at www.thestaronline.com, assessed on 12th July 2015

The Star Online (2014) Published on 5th December 2014 at www.thestaronline.com, assessed on 12th July 2015

Tan S.M and Simon (2005) Karstic Features of Kuala Lumpur Limestone: Geotechnical Engineering Technical Division.Underpinning Method, Acessed on 8th May 2010, downloaded from www.wikipedia.com.

Tan, B.K. (2006) Urban Geology of Kuala Lumpur and Ipoh, Malaysia, Univ. Kebangsaan Malaysia.: In: The Geological Society of London.

Utusan Malaysia (2009) Newspaper Published on 27th October 2009, Utusan Malaysian Publication.

Xia Cao, 2006. Regulating mine land reclamation in developing countries: The case of China, Land Use Policy 24 (2007) 472–483, download from www.sciencedirect.com on 28thDisember 2009.

Yong, R.N. et al. (1985). Characterizations Studies of the Singapore Clay Slurry Slime, Geotechnical Engineering Vol 16, 1985. PP 139 – 166.

Yee, K. (1990). The uses of Geotextile In Reclmation of Ex-Mining Land for Housing and Development and Other Purposes, Paper Presented in the Seminar on Land Affected by Mining – Utilisation, Planning, Investigation and Reclamation on 12 November 1990, in Mines Research Institute, Ipoh.

Zipper, C. and Winter, S. (2009) Stabilizing Reclaimed Mines to Support Buildings and Development, Department of Crop and Soil Environmental Sciences, Virginia Tech and Schnabel Engineering Associates, Blacksburg, Virginia.