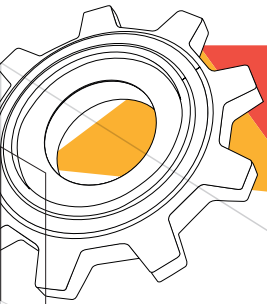




Ministry of Works



GUIDELINES FOR CONSTRUCTION ON PEAT AND ORGANIC SOILS IN MALAYSIA





GUIDELINES FOR CONSTRUCTION ON PEAT AND ORGANIC SOILS IN MALAYSIA

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FOREWORD

Peat occurs over about 25,000 square km in Malaysia corresponding to about 8% of the country's land area. Malaysia despite being a relatively small country area has, on a country basis, the 9th largest peat area in the world. About 69 % of Malaysia's peat area is in Sarawak. Significant parts of major towns like Sibul and Kuching are founded over peat.

Construction on peat is always more problematic than on soft clay with greater difficulties in access, earthworks and settlements. Over the last 25 years the industry has made appreciable advances in methods of construction over peat.

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This document contains maps that show the locations of peat, classification systems, information on methods of testing, methodology for obtaining parameters, design and construction. Case histories reflective of good practice are included. This document is however not a code or a set of specifications. Engineering judgement must be applied to determine whether the methods and techniques contained in the document are applicable.

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TABLE OF CONTENT

FOREWORD	II
ACKNOWLEDGEMENTS	III
LIST OF FIGURES	VIII
LIST OF TABLES	XIII
LIST OF SYMBOLS AND ABBREVIATIONS	XIV
CHAPTER 1: FORMATION AND DISTRIBUTION OF PEAT LANDS	1
1.1 Introduction	1
1.2 Formation of Peat	2
1.3 Distribution of Peatland in Malaysia	7
1.3.1 Peninsular Malaysia	11
1.3.2 Sabah	16
1.3.3 Sarawak	16
1.4 Limitations	21
CHAPTER 2: PEAT CLASSIFICATION SCHEME	22
2.1 Peat Classification	22
CHAPTER 3: SOIL INVESTIGATION AND PEAT TESTING	29
3.1 Introduction	29
3.2 Desk Study	30
3.2.1 Literature Survey and Data Collection	30
3.2.2 Topographical Map Study	30
3.2.3 Remote Sensing	30
3.3 Site Reconnaissance	31
3.4 Field Tests	32
3.4.1 Geophysical Survey	32
3.4.2 Visual Inspection	32
3.4.3 Deep Boring	34
3.4.4 Mackintosh/ JKR Probe	34
3.4.5 Vane Shear Test	35
3.4.6 Static Cone Penetration (CPT/CPT μ)	35
3.4.7 T Bar and Ball Penetrometers	36
3.4.8 Full Scale Loading Test	37

3.5	Sampling of Peat	37
3.5.1	Peat Sampler	37
3.5.2	Tube Samplers	38
3.5.3	Block Samples	39
3.5.4	Other Sampling Techniques	39
3.5.5	Securing Natural Moisture Content	40
3.6	Laboratory Tests	41
3.6.1	Mineral Composition	42
3.6.2	Natural Moisture Content	42
3.6.3	Density	42
3.6.4	Atterberg Limit	43
3.6.5	Specific Gravity	43
3.6.6	Organic Content	44
3.6.7	Fiber Content	45
3.6.8	Chemical Tests	45
3.6.9	Permeability	46
3.6.10	Consolidation	46
3.6.11	Shear Strength Test	49
CHAPTER 4: METHODOLOGY AND CRITERIA FOR DESIGN		53
4.1	Introduction	53
4.2	Methods for Stability and Settlement Analysis	53
4.2.1	Stability analysis	53
4.2.2	Settlement	55
4.3	Design Criteria	55
4.3.1	Embankment Factor of safety	55
4.3.2	Settlement	56
4.4	Earth Filling to Form a Platform for Development	57
4.5	Other Important Considerations	58
4.5.1	Effects of agriculture	58
4.5.2	Embankment toe drain	60
4.6	An example of stability and settlement analyses of an embankment	61
4.7	Prefabricated vertical drains	65
CHAPTER 5: DESIGN PARAMETERS FROM BASIC PROPERTIES		67
5.1	Introduction	67

5.2	Basic Peat Properties that are correlated to design parameters	67
5.3	Correlations with Parameters for Estimating Settlement	67
5.4	Correlations with Strength Parameters	73
5.4.1	Effective stress parameters	73
5.4.2	Total Stress Parameters	75
5.5	Slow rate of embankment construction	77
CHAPTER 6: CASE HISTORIES OF CONSTRUCTION ON PEAT		79
6.1	Introduction	79
6.2	Coverage	79
6.3	Lessons from history	80
6.4	Earth Fills	82
6.4.1	General	82
6.4.2	Method of fill placement	83
6.4.3	What if there are localized areas where surface drainage cannot be achieved	89
6.5	Construction of Embankment on Deep Peat in Balingian, Sarawak	90
6.5.1	Sub-surface conditions and filling	90
6.5.2	Measured performance and back analysis	91
6.6	Stage Construction of a High Embankment on Thin Peat and Soft Clay in Pagoh, Johor	95
6.7	Stage Construction of a High Geotextile Reinforced Embankment in Sylhet, Bangladesh	99
6.8	Excavation of Peat and Replacement With Sand or Suitable Soil	103
6.8.1	Methods	103
6.8.2	Excavation and replacement for North South Highway between Machap and Simpang Renggam Johor	104
6.8.3	Excavation of peat without dewatering for the Sungei Bidut Road, Sibul, Sarawak	109
6.8.4	Excavation of peat without dewatering for Jalan Nang Sang / Teku Link Road, Sibul, Sarawak	114
6.9	Case studies on construction over soft peaty ground in Malaysia using bamboo grid frame – Geotextile Method	117
6.9.1	General	117
6.9.2	Principles	117
6.9.3	Construction Method	118

6.9.4 Advantages of Deploying Bamboo Grid Frame-Geotextile System on Soft & Deep Peat	120
6.10 Pile Embankments	121
6.11 Summary	121
SUMMARY	123
REFERENCES	124

LIST OF FIGURES

Figure 1 - 1. Peat swamps formation (Leete, 2006)	3
Figure 1 - 2. Typical cross section and longitudinal sections of a basin peat (Yogeswaran, 1995)	4
Figure 1 - 3. Vertical profile of a basin peat dome (Esterle <i>et al.</i> , 1991)	5
Figure 1 - 4. Geological development of a riverine depositional model (Chen <i>et al.</i> , 1989)	6
Figure 1 - 5. General Distribution of Quaternary Deposits including Peat and Soft Soils in Peninsular Malaysia (modified after Geological Map of Peninsular Malaysia, 9 th . Edition, Minerals and Geoscience Department Malaysia, 2014)	7
Figure 1 - 6. General Distribution of Quaternary Deposits including Peat and Soft Soils in Sabah and Sarawak (modified after Geological Map of Sarawak and Sabah, 5 th Edition, Geological Survey of Malaysia, 1992)	8
Figure 1 - 7. Highly – developed inland peat dome (Wetlands International, 2010).	9
Figure 1 - 8. Major Peat Soil Areas in Peninsular Malaysia (Wetlands International, 2010)	10
Figure 1 - 9. Distribution of Peat Soil Areas of Sabah (Wetlands International, 2010)	10
Figure 1 - 10. Major peatland areas in Sarawak (Wetlands International, 2010)	11
Figure 1 - 11. Peat soil areas in Johor (Wetlands International, 2010).	12
Figure 1 - 12. Peatlands in Pahang (Wetlands International, 2010)	12
Figure 1 - 13. Major Peatlands in Selangor (Wetlands International, 2010)	13
Figure 1 - 14. Major Peatlands in Perak (Wetlands International, 2010)	13
Figure 1 - 15. Major Peatlands in Terengganu (Wetlands International, 2010)	14
Figure 1 - 16. Major Peatlands in Kelantan (Wetlands International, 2010)	14
Figure 1 - 17. Major Peatlands in Negeri Sembilan (Wetlands International, 2010)	15
Figure 1 - 18. Peatlands in Federal Territory (Wetlands International, 2010)	15
Figure 1 - 19. Distribution and status of peat swamp forest in Sibul and Mukah Division (Wetlands International, 2010)	17
Figure 1 - 20. Distribution and status of peat swamp forest in Sri Aman dan Betong Division (Wetlands International, 2010)	18
Figure 1 - 21. Distribution and status of peat swamp forest in Miri Division	18
Figure 1 - 22. Distribution and status of peat swamp forest in Samarahan Division (Wetlands International, 2010)	19
Figure 1 - 23. Distribution and status of peat swamp forest in Sarikei Division (Wetlands International, 2010)	19
Figure 1 - 24. Distribution and status of peat swamp forest in Bintulu Division (Wetlands International, 2010)	20
Figure 1 - 25. Distribution and status of peat swamp forest in Limbang Division (Wetlands International, 2010)	20
Figure 1 - 26. Distribution and status of peat swamp forest in Kuching Division (Wetlands International, 2010)	21
Figure 3 - 1. Peat Decomposition Identification In-Situ	33
Figure 3 - 2. Full Flow Penetrometers – T Bar and Ball Penetrometers (Boylan <i>et al.</i> , 2011)	37
Figure 3 - 3. Peat Sampler	38

Figure 3 - 4. (a) Sherbrooke Sampler in Use (b) Waxed Sample (Boylan <i>et al.</i> , 2011)	40
Figure 3 - 5. UPM Peat Sampler (Duraismy <i>et al.</i> , 2009)	40
Figure 3 - 6. A Muffle Furnace	44
Figure 3 - 7. Set up of Hydraulic Conductivity Test for Peat (ASTM D4511-00, 2006)	46
Figure 3 - 8. Schematic diagram of Oedometer Cell	48
Figure 3 - 9. Schematic diagram of Rowe Consolidation cell	48
Figure 3 - 10. (a) Shear Box; (b) Triaxial Apparatus	49
Figure 4 - 1. Method for stability analysis	54
Figure 4 - 2. Settlement at Moantuatua Swamp Area (Sources Environment Waikato Technical Report 2004/ 17)	60
Figure 4 - 3. Typical Road Embankment on Peat Soft Clay	62
Figure 4 - 4. Estimated settlement for typical road embankment, HT = 1.5m & Surcharge = 1.0m	64
Figure 4 - 5. Estimated fill level for typical road embankment, HT = 1.5m & Surcharge = 1.0m	64
Figure 4 - 6. (a) Pore pressures at end of filling to surcharge level (b) Stability analysis	65
Figure 5 - 1. Correlation of bulk, ρ and dry density, ρ_d with natural moisture content, w_o . (Den Haan & Kruse, 2007)	69
Figure 5 - 2. Correlation of specific gravity, ρ_s with ignition loss, N. (Den Haan & Kruse, 2007)	69
Figure 5 - 3. Correlation of initial void ratio, e_o with natural moisture content, w_o . (Den Haan & Kruse, 2007)	70
Figure 5 - 4. Correlation of void ratio, e with coefficient of permeability, k . (Mesri & Ajlouni, 2007)	70
Figure 5 - 5. Correlation of compressibility index, C_c with natural moisture content, w_o , for peats as well as soft clay and silt deposits. (Mesri & Ajlouni, 2007)	71
Figure 5 - 6. Compressibility of Sarawak tropical peat plotted against correlation by Mesri and Ajlouni (2007) and Taib <i>et al.</i> , (2014)	71
Figure 5 - 7. Compressibility of Sarawak tropical peat from Tai and Lee (2003) and Yulindasari (2006) plotted against correlation by Kogure and Ohira (1997)	72
Figure 5 - 8. Correlation of compressibility index C_c with secondary compression index C_α . (Mesri & Ajlouni, 2007)	72
Figure 5 - 9. Friction angle ϕ' as a function of bulk density. (Den Haan & Fedema, 2009)	74
Figure 5 - 10. Critical state strength parameter m or ϕ' as a function of bulk density. (Den Haan & Fedema, 2009)	74
Figure 5 - 11. Vane shear strength versus void ratio. (Mesri, 2009)	76
Figure 5 - 12. S_u versus effective vertical stress. (Den Haan & Kruse, 2007)	77
Figure 5 - 13. S_u/σ_{vo}' versus bulk density. (Den Haan & Kruse, 2007)	77
Figure 6 - 1. Ancient man crossing peat swamp 3,807 BCE. (J. M. Coles (1989))	80
Figure 6 - 2. Corduroy road (from Google Images. 5th October 2015)	80
Figure 6 - 3. Conserved timber track, Ireland 148 BC (from Google Images. 5 th October 2015)	81
Figure 6 - 4. Corduroy road construction. American Civil War (from Google Images. 5 th October 2015)	81

Figure 6 - 5. Corduroy road construction. American Civil war (from Google Images. 5 th October 2015)	81
Figure 6 - 6. German tank on corduroy road crossing peat. World War II (from Google Images. 5 th October 2015)	82
Figure 6 - 7. Timber track for soil investigation, Machap, Johor (Toh <i>et al.</i> , 1990)	82
Figure 6 - 8. Peat fires (P. Rincon, 1985)	83
Figure 6 - 9. Uncontrolled filling by end tipping into peat (Toh <i>et al.</i> , 1994)	84
Figure 6 - 10. Heave during construction of the Air Baloi road, Johor (Toh & Chee, 2008)	84
Figure 6 - 11. Excavator sinking into saturated peat (Low, 2015)	85
Figure 6 - 12. Surface drainage to lower ground water to form access to peat swamp for filling (Toh & Chee, 2008)	86
Figure 6 - 13. Peat swamp in Johor after drainage by JPS (Toh & Chee, 2008)	86
Figure 6 - 14. Peat swamp in Johor after drainage by JPS (Toh & Chee, 2008)	87
Figure 6 - 15. Drained peat surface after dewatering from nearby excavation (Toh & Chee, 2000a)	88
Figure 6 - 16. Hydraulic sand filling over peat swamp for Matang Expressway, Kuching (Toh & Chee, 2000b)	88
Figure 6 - 17. Hydraulic sand filling for Matang Highway, Kuching (Toh & Chee, 2000a)	89
Figure 6 - 18. Bamboo frame for geotextile bamboo fascine mattress (Toh <i>et al.</i> , 1994)	89
Figure 6 - 19. Filling over geotextile bamboo fascine mattress (Toh <i>et al.</i> , 1994)	90
Figure 6 - 20. Mud wave ahead of filling contained by geotextile bamboo fascine mattress (Toh <i>et al.</i> , 1994)	90
Figure 6 - 21. Model for back analysis Balingian road, Sarawak (Toh & Chee, 2013)	91
Figure 6 - 22. Road embankment on deep peat. Trial Areas 1 & 2. Balingian road, Sarawak (Toh & Chee, 2013)	92
Figure 6 - 23. Back analysis versus measured RL top embankment versus time. Trial Area 1. (Toh & Chee, 2013)	93
Figure 6 - 24. Back analysis versus measured settlement versus time. Trial Area 1 (Toh & Chee, 2013)	93
Figure 6 - 25. Back analysis versus measured RL top embankment versus time. Trial Area 2. (Toh & Chee, 2013)	94
Figure 6 - 26. Back analysis versus measured settlement versus time. Trial Area 2 (Toh & Chee, 2013)	94
Figure 6 - 27. Stage construction of embankment on peat at Pagoh, Johor (Koo & Yam, 1990)	96
Figure 6 - 28. Natural moisture content with depth (Khoo & Yam, 1990)	96
Figure 6 - 29. Embankment construction and measured settlement (Khoo and Yam, 1990)	97
Figure 6 - 30. Measured pore pressures (Khoo & Yam, 1990)	98
Figure 6 - 31. Rice fields over peat. Sylhet, Bangladesh (Toh & Chee, 2000b)	99
Figure 6 - 32. Samples of wood pieces, Sylhet, Bangladesh (Toh & Chee, 2000a)	100
Figure 6 - 33. Geotextile bamboo fascine mattress for Sylhet road, Bangladesh (Toh & Chee, 2000b)	100
Figure 6 - 34. Reinforcement geotextile places over bamboo mattress for Sylhet road, Bangladesh (Toh & Chee, 2000a)	100

Figure 6 - 35. Manual placement of sand fill over reinforcement geotextile. Sylhet road, Bangladesh (Toh & Chee, 2000b)	101
Figure 6 - 36. Completed geotextile reinforced embankment at bridge abutment. Sylhet road Bangladesh (Toh & Chee, 2000a)	101
Figure 6 - 37. Embankment configuration with measured settlement and parameters from back analysis (Toh & Chee, 2000b)	102
Figure 6 - 38. Measured and back-calculated embankment settlement for Sylhet road, Bangladesh (Toh & Chee, 2000a)	102
Figure 6 - 39. Measured and back-calculated pore pressures for Sylhet road, Bangladesh (Toh & Chee, 2000b)	103
Figure 6 - 40. Soil profile at trial excavation area, Machap, Johor (Toh <i>et al.</i> , 1990)	105
Figure 6 - 41. Piezocone profile at trial excavation area, Machap, Johor (Toh <i>et al.</i> , 1990)	105
Figure 6 - 42. Ground water lowering facilitates peat excavation (Toh <i>et al.</i> , 1990)	106
Figure 6 - 43. Drawdown of ground water during excavation with dewatering at Machap, Johor (Toh <i>et al.</i> , 1990)	107
Figure 6 - 44. Excavation of peat and lowering of ground water at Machap, Johor (Toh <i>et al.</i> , 1990)	107
Figure 6 - 45. Excavation of peat with dewatering and backfill with residual soil in dry at Machap, Johor with compaction (Toh <i>et al.</i> , 1990)	108
Figure 6 - 46. Excavation of dry peat at Machap, Johor (Toh <i>et al.</i> , 1990)	108
Figure 6 - 47. Excavation in dry and backfilling at Machap, Johor (Toh <i>et al.</i> , 1990)	108
Figure 6 - 48. Details of embankment with peat excavation for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	110
Figure 6 - 49. Subsurface conditions for Sungei Bidut Road, Sarawak (Ong <i>et al.</i> , 2009)	111
Figure 6 - 50. Peat swamp at Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	111
Figure 6 - 51. Peat excavation without dewatering for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	112
Figure 6 - 52. Peat excavation without dewatering for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	112
Figure 6 - 53. Pumping sand after excavation of peat for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	112
Figure 6 - 54. Pumping sand after excavation of peat for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	113
Figure 6 - 55. Pumping sand after excavation of peat for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	113
Figure 6 - 56. Excavated peat to form bunds to contain sand fill in embankment for Sungei Bidut road, Sarawak (Sarawak Construction & Jurutera Jasa, 2007)	113
Figure 6 - 57. Measured settlement at Sungei Bidut Road (Ong <i>et al.</i> , 2009)	114
Figure 6 - 58. Jalan Nang Sang / Teku Link Road Sibu Sarawak close to existing houses (JKR Sarawak and Hock Peng Furniture General Contractor, 2006)	115
Figure 6 - 59. Excavation of peat without dewatering and backfilling with sand Jalan Nang Sang / Teku Link Road Sibu Sarawak close to existing houses (JKR Sarawak and Hock Peng Furniture General Contractor, 2006)	115

Figure 6 - 60. Excavation of peat without dewatering and use of peat as bunds for containing sand fill. Jalan Nang Sang / Teku Link Road Sibu Sarawak (JKR Sarawak and Hock Peng Furniture General Contractor, 2006)	115
Figure 6 - 61. Sand fill contained by bunds formed using excavated peat. Jalan Nang Sang / Teku Link Road Sibu Sarawak (JKR Sarawak and Hock Peng Furniture General Contractor, 2006)	116
Figure 6 - 62. Sand fill embankment contained by peat bunds formed from excavation. Jalan Nang Sang / Teku Link Road Sibu Sarawak (JKR Sarawak and Hock Peng Furniture General Contractor, 2006)	116
Figure 6 - 63. Completed sand embankment. Jalan Nang Sang / Teku Link Road Sibu Sarawak close to existing houses (JKR Sarawak and Hock Peng Furniture General Contractor, 2006)	116
Figure 6 - 64. Arranging bamboos in grid frame on soft peat ground	119
Figure 6 - 65. Bogging in of machinery and man at onset of project	119
Figure 6 - 66. Unreeling of geotextile over bamboo grid frame	119
Figure 6 - 67. Backfilling commences	119
Figure 6 - 68. Spreading and levelling of fill	120
Figure 6 - 69. Compaction	120
Figure 6 - 70. In-situ density test	120
Figure 6 - 71. Construction of building begins	120
Figure 6 - 72. Types of Bamboo-geotextile Frame Layout	120

LIST OF TABLES

Table 1 - 1. Distribution of peat deposit around the world (Mesri and Ajlouni, 2007)	1
Table 1 - 2. The area (ha) of peat soil in Peninsula Malaysia, Sarawak and Sabah (Wetlands International, 2010)	9
Table 1 - 3. Extent of peat swamp forest (PSF) by state in Peninsular Malaysia (Wetlands International, 2010)	11
Table 1 - 4. Estimates of the peatland areas in Sarawak (Wetlands International, 2010)	17
Table 2 - 1. Various classification systems of peat and organic soils based on ash and organic content (Andrejko <i>et al.</i> , 1983; Landva <i>et al.</i> , 1983)	23
Table 2 - 2. Peat Classification According to Degree of Humification (Von Post, 1922)	24
Table 2 - 3. Comparison of classification scheme based on the degree of humification for peat deposits according to the Von Post system (1922), the US Soil Taxonomy system (Soil Survey Staff, 1990), the Esterle system (Esterle, 1990) and R.A. Wüst <i>et al.</i> , system (2003)	25
Table 2 - 4. Organic Soils and Peat Section of Malaysian Soil Classification System for engineering purpose (Jarett, 1995 Based on BS 5930:1981)	27
Table 3 - 1. List of necessary laboratory tests for peat.	41
Table 4 - 1. Predicted peat subsidence (m) away from drains of different depths.	59
Table 4 - 2. Summary of the salient features of the analyses	63
Table 5 - 1. Relationships between basic properties and parameters for estimating consolidation settlement	68
Table 5 - 2. Friction Angle of Fibrous Peats from Triaxial Compression Test on Vertical Specimens	73
Table 5 - 3. Summary of Φ' values from direct shear and direct simple shear tests	75
Table 5 - 4. Lists the S_u/σ_v' for peat (Mesri & Ajlouni, 2007)	76
Table 6 - 1. Type of problems encountered when constructing embankments on peat	79
Table 6 - 2. Back calculated parameters	95
Table 6 - 3. Summary of sub surface conditions (Pagoh, Johor)	97
Table 6 - 4. Summary of sub surface condition, Sylhet, Bangladesh	99
Table 6 - 5. Parameter	103

LIST OF SYMBOLS AND ABBREVIATIONS

Symbol	
ha	Hectare
km	Kilometre
m	Metre
S_u	Undrained shear strength (total stress)
S_{uv}	Vane shear strength
Φ'	Effective friction angle
σ_{vo}'	Initial in-situ effective vertical stress
C_c	Coefficient of primary consolidation
C_α	Coefficient of secondary consolidation
C	Correction factor for the calculation of organic content
c_v	Coefficient of Consolidation
e_o	Initial void ratio
e	Void ratio'
$\Delta\sigma_v$	Increment in vertical stress
t	Time
t_p	Time corresponding to end of primary consolidation
k	Coefficient of permeability
M	Critical state strength parameter
H	Thickness of soft clay
γ_d, ρ_d	Dry density
γ_b, ρ	Bulk density
f_s	Sleeve friction
G_s	Specific gravity
q_t	Tip resistance
R_f	Cone penetration test friction ratio
τ_h	Horizontal shear stress
τ_v	Vertical shear stress
ϕ'	Effective friction angle
μ	Pore Pressure
Abbreviation	
CPT	Cone Penetration Test
LL	Liquid limit
LOI	Loss on Ignition
N	SPT N Value
OC	Organic content
SPT	Standard Penetration Test
JMG	Jabatan Mineral dan Geosains Malaysia
msl	Mean sea level
PSF	Peat swamp forest
CRS	Constant Rate of Strain
CD	Drained triaxial test
CU	Consolidated undrained triaxial test

CHAPTER 1: FORMATION AND DISTRIBUTION OF PEAT LANDS

1.1 Introduction

Peat is found in many countries throughout the world and peatlands constitute about 3% of the land surface of the Earth. Table 1 - 1 shows the distribution of peatlands around the world.

Table 1 - 1. Distribution of peat deposit around the world (Mesri and Ajlouni, 2007)

Country	Area (km ²)	Country	Area (km ²)
Canada	1,500,000	Germany	16,000
U.S.S.R (the former)	1,500,000	Brazil	15,000
United States	600,000	Ireland	14,000
Indonesia	170,000	Uganda	14,000
Finland	100,000	Poland	13,000
Sweden	70,000	Falklands	12,000
China	42,000	Chile	11,000
Norway	30,000	Zambia	11,000
Malaysia	25,000	26 other countries	220 to 10,000

More than 95% of the total peatlands of the world are concentrated in the temperate climates of the Northern Hemisphere, which Canada and Russia having the greatest concentration of peatlands with a combined area of over 300 million ha.

Peat also can be found in the tropical climates, wherever the conditions are favourable for its formation. The tropical peatlands are scattered in a few areas in Africa and parts of Central America, but two thirds of its world's total area of 30 million ha is reported to be found in Southeast Asia.

The largest area of tropical peatland is located on the islands of Borneo and Sumatra. It can also be found significantly in other parts of Indonesia, Malaysia, Vietnam, Thailand and Philippines.

1.2 Formation of Peat

In the tropics like Malaysia and Indonesia, peat deposits occur in both highlands and lowland areas. They are generally termed as basin and valley peat respectively. However, the lowland or basin peat is more extensive and occurs in low-lying poorly drained depressions or basin in the coastal areas. Basin peat is usually found on the inward edge of the mangrove swamps along the coast. The individual peat bodies may range from a few to 100,000 ha and they generally have a dome-shaped surface. The peat is generally classified as the ombrogenous or rain fed peat, and is poor in nutrients (oligotrophic). Due to coastal and alluvial geomorphology they are often elongated and irregular, rather than having the ideal round bog shape. The depth of the peat is generally shallower near the coast and increases inland, locally exceeding more than 20m. The coastal peat land is generally elevated well above adjacent river courses. Steep gradients are found at the periphery while the central peat plain is almost flat. Water plays a fundamental role in the development and maintenance of tropical peat. A balance of rainfall and evapotranspiration is critical to their sustainability. Rainfall and surface topography regulate the overall hydrological characteristics of the peat land. Peat land is also generally known as wetland or peat swamp because of its water table, which is close to, or above the peat surface throughout the year and fluctuates with the intensity and frequency of rainfall. Peat swamp is an important component of the world's wetlands – the dynamic link between land and water, a transition zone where the flow of water, the cycling of nutrients and the energy of the sun combined to produce a unique ecosystem of hydrology, soils and vegetation. The build-up of layers of peat and the degree of decomposition depend principally on the local composition of the peat and the degree of waterlogging (Figure 1 - 1).

Peat formed in very wet conditions accumulates considerably faster and is less decomposed than peat accumulating in drier places. The peat acts as a natural sponge, retaining moisture at times of low rainfall but, because it is normally waterlogged already, with a very limited capacity to absorb additional heavy rainfall during periods such as a tropical monsoon. Peat swamp forests develop on these sites where dead vegetation has become waterlogged and is accumulating as peat. Water in peat swamps is generally high in humic substances (humus and humic acids) that give a typically dark brown to black colour to the water. Peat swamps are characterized by diverse features that relate to the nature of the water supply, such as flooding by surface or groundwater, or solely from rainfall; type of landscape in which the peat swamp occurs, such as shallow depressions close to rivers; type of landscape that the

swamp creates, such as accumulation of peat above groundwater level so that vegetation, often with prominent aerial roots, becomes wholly dependent on rainfall.

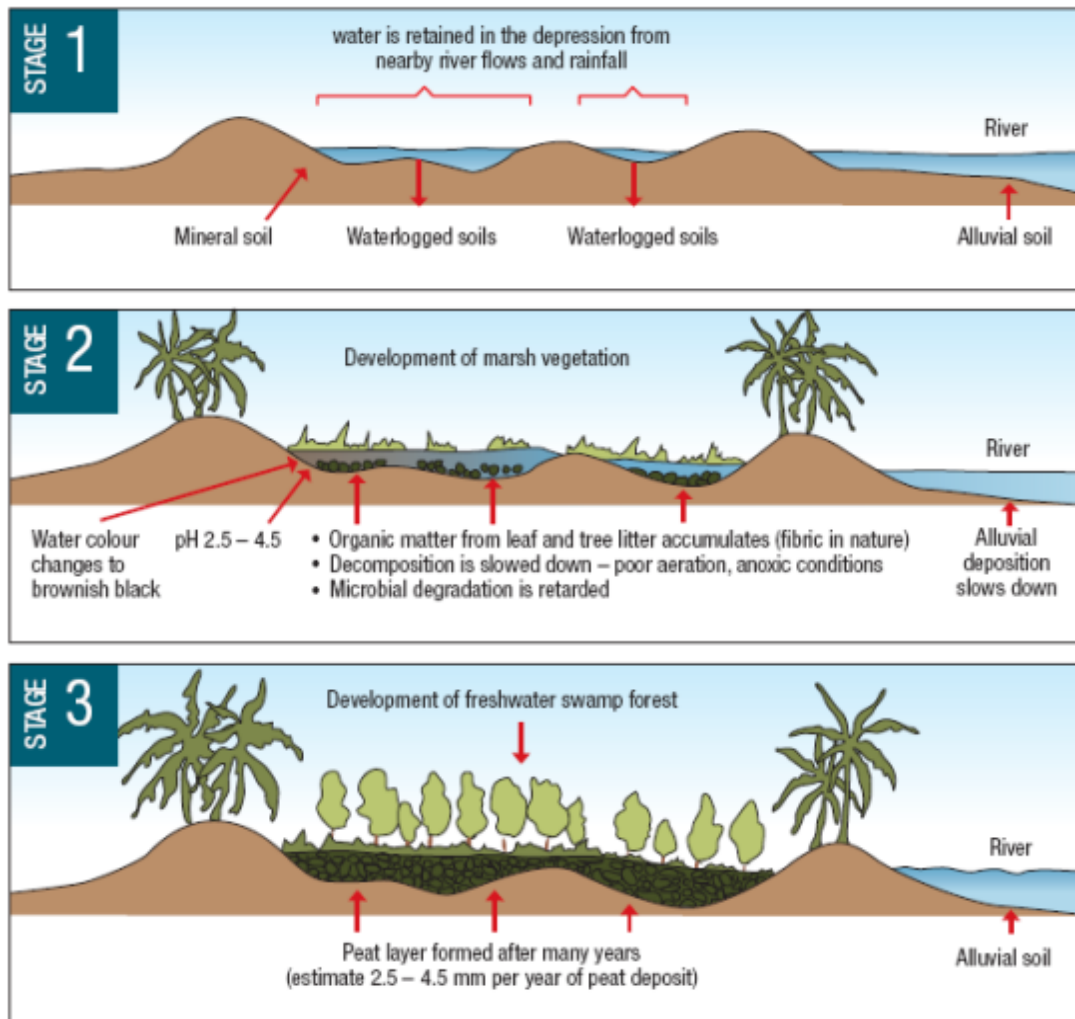


Figure 1 - 1. Peat swamps formation (Leete, 2006)

Basin peat form domes, which according to Mutalib *et al.*, (1991), are up to 15 m high whilst valley peat is flat or interlayer with river deposits. Normally, sandy ridges bound basin peat at their seaward side or they gradually merge into muddy coastal flats. Low lying levees flank these domes along the rivers. The complexity of the domes becomes more pronounced as the distance from the sea increases as shown in Figure 1 - 2.

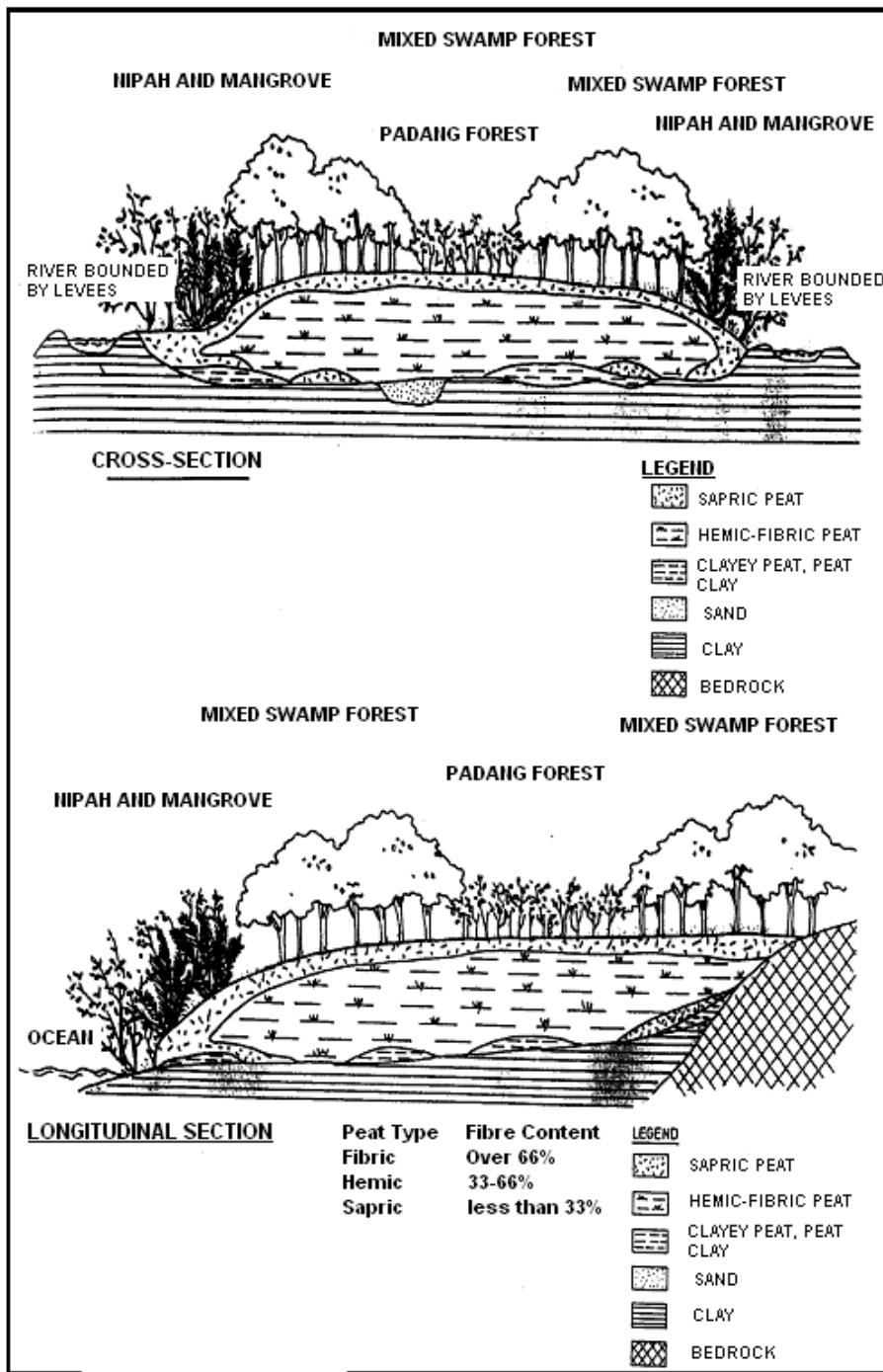


Figure 1 - 2. Typical cross section and longitudinal sections of a basin peat (Yogeswaran, 1995)

Tropical (basin) peat domes are found to have typically well-developed internal stratification. An example is shown in Figure. 1 - 3. Peat deposit is shown to be lenticular and dome surfaced with a typical concave base. The centre of the dome however is usually flat. The internal stratification is typically three fold with a fine grained hemic/ sapric layer overlying a thick zone of fine to medium grained woody hemic - fibric, over fine grained hemic peat. The base of the peat dome is typically dark grey clay and sand with a thin layer of clayey peat or peaty clay.

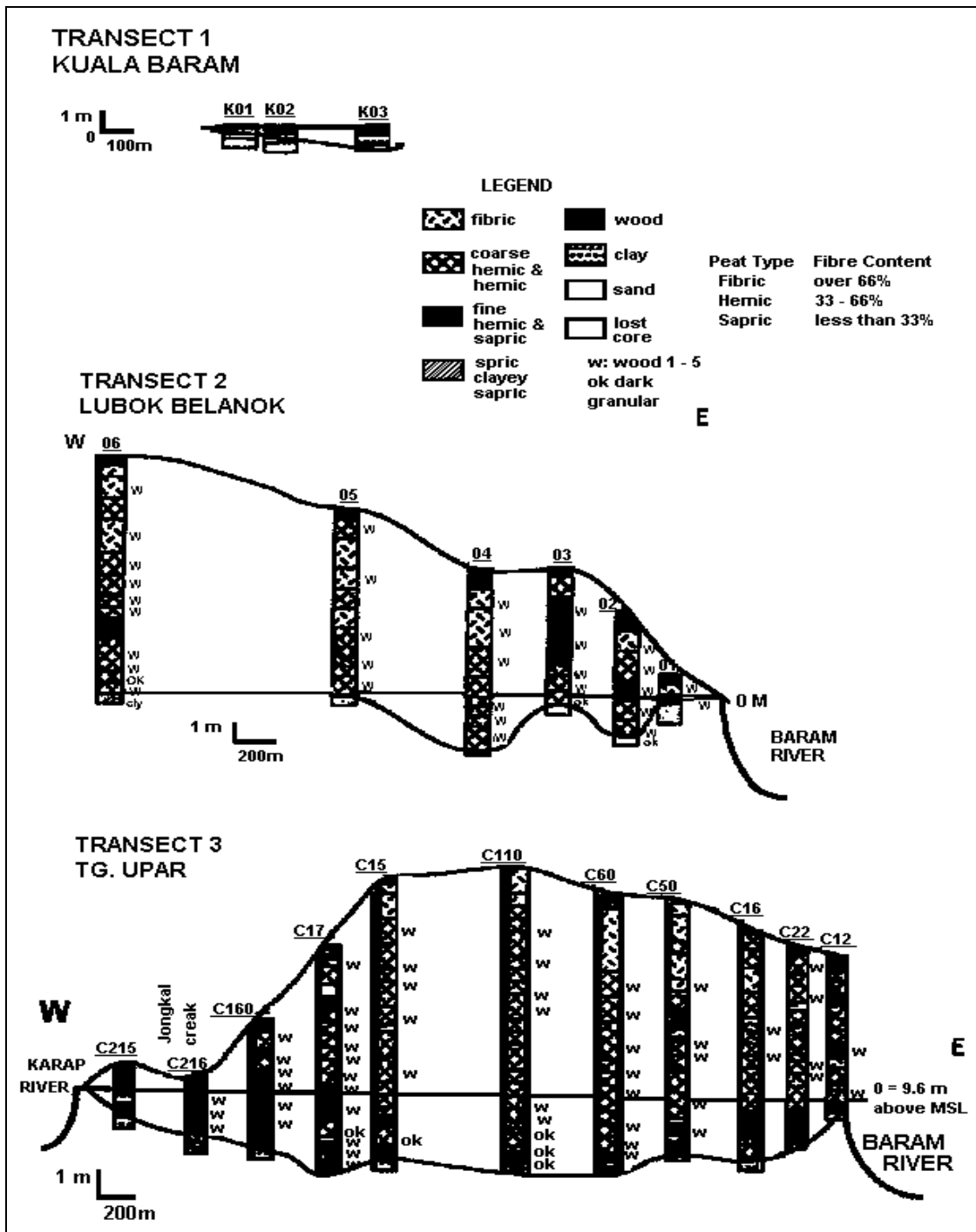


Figure 1 - 3. Vertical profile of a basin peat dome (Esterle *et al.*, 1991)

Lam (1989) postulates the possible event leading to the development of peat deposits as a result of sea level changes. The last global glaciations resulted in rapid denudation and deep incision of the parent rock formation. After the last maximum glaciations (some 20,000 years BP), sea level rose rapidly and reached a maximum level 5,500 years BP. This affected the result in transportation and deposition of a large amount of sediment, which formed deltas and flood plains. Peat swamps were initiated in the depression and basin between isolated

hills and levees, and in the deltas. During the initial stage, plants developed in mineral soils. The areas were still under influence of rivers with influx of clastic (mineral) sediments during flood. The accumulation of clastic sediments and plant remains resulted in formation of clayey peat (topogenous peat). As plant remained accumulated, the ground surface levels were elevated. This led to formation of peat, which was free or low of the clastic sediments (ombrogenous peat), and highly acidic (Huat *et al.*, 2014).

The peat forming vegetation consists mainly of large trees, resulting in high lignin content which is twice that of the bog peat. Figure 1 - 4 illustrates the geological development of a riverine depositional model leading to the deposition of the basin peat.

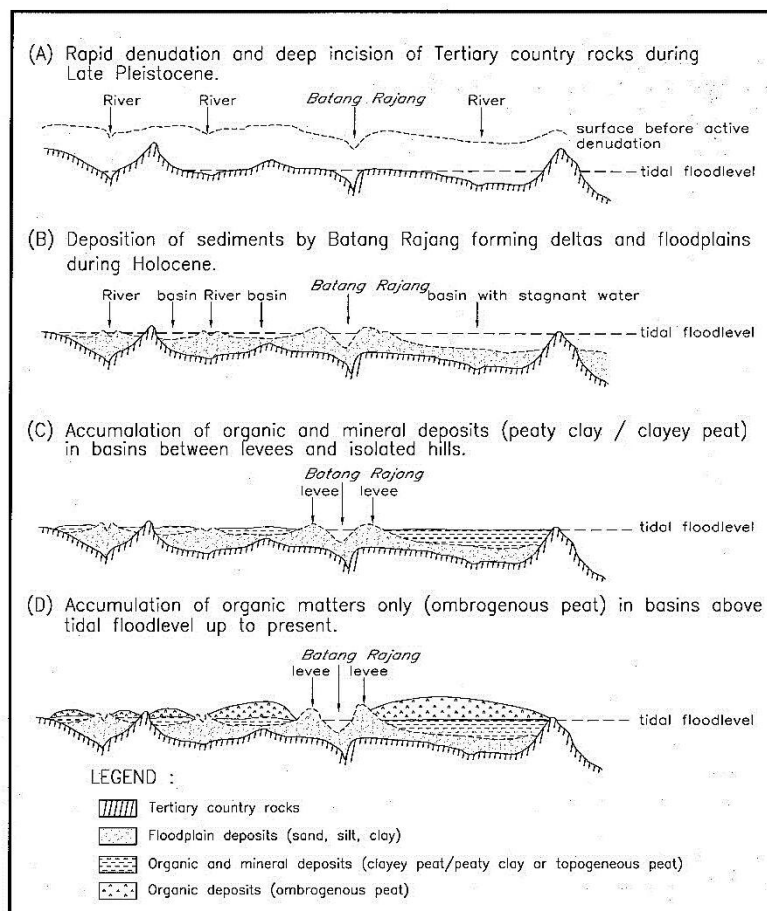


Figure 1 - 4. Geological development of a riverine depositional model (Chen *et al.*, 1989)

1.3 Distribution of Peatland in Malaysia

Peat and soft soil are two integral components of the Quaternary deposits which are generally found in the coastal plains of Malaysia as shown in Figure 1 - 5 and Figure 1 - 6. Peat commonly occurs as the uppermost layer of these sediments.

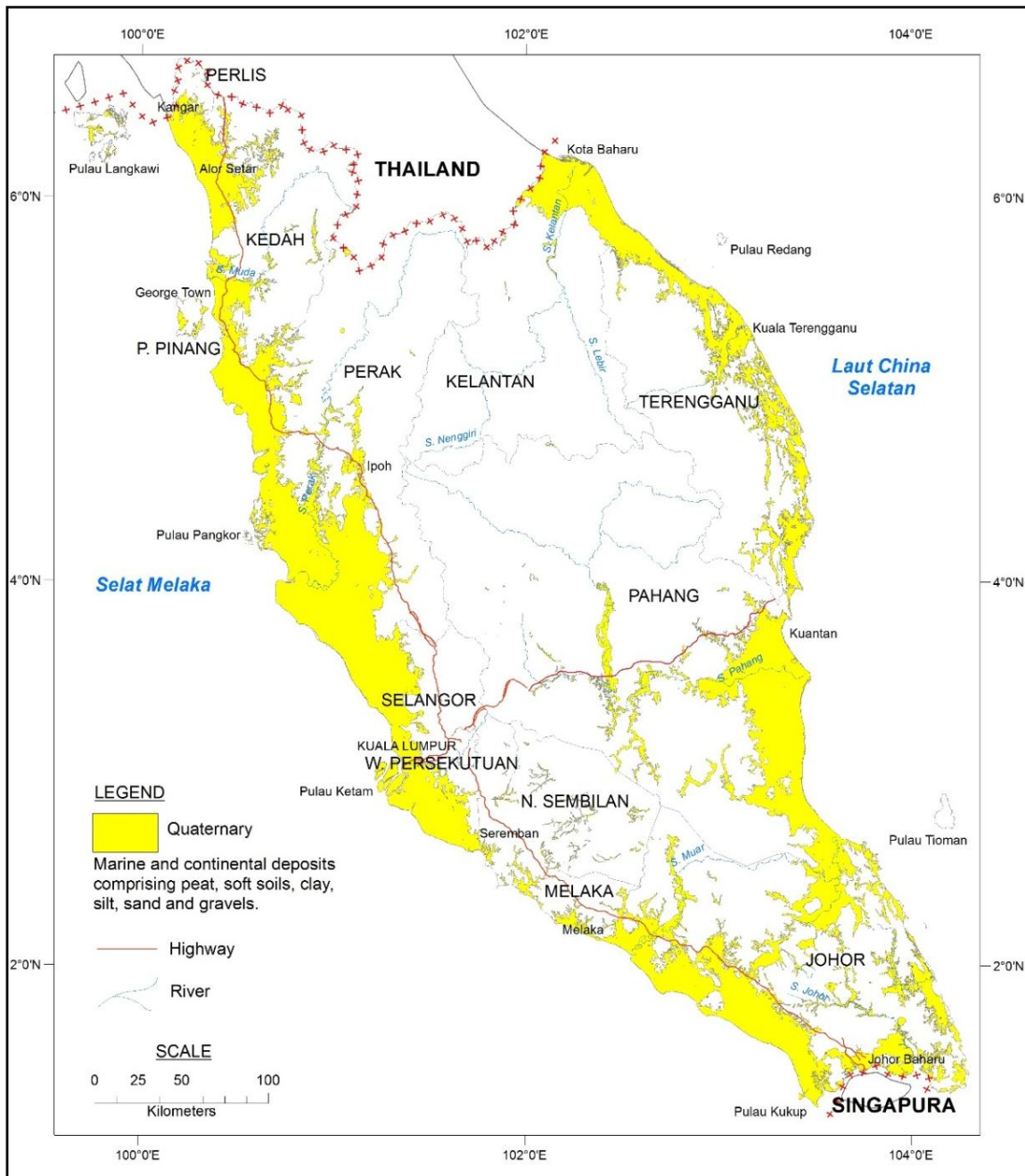


Figure 1 - 5. General Distribution of Quaternary Deposits including Peat and Soft Soils in Peninsular Malaysia (modified after Geological Map of Peninsular Malaysia, 9th. Edition, Minerals and Geoscience Department Malaysia, 2014)

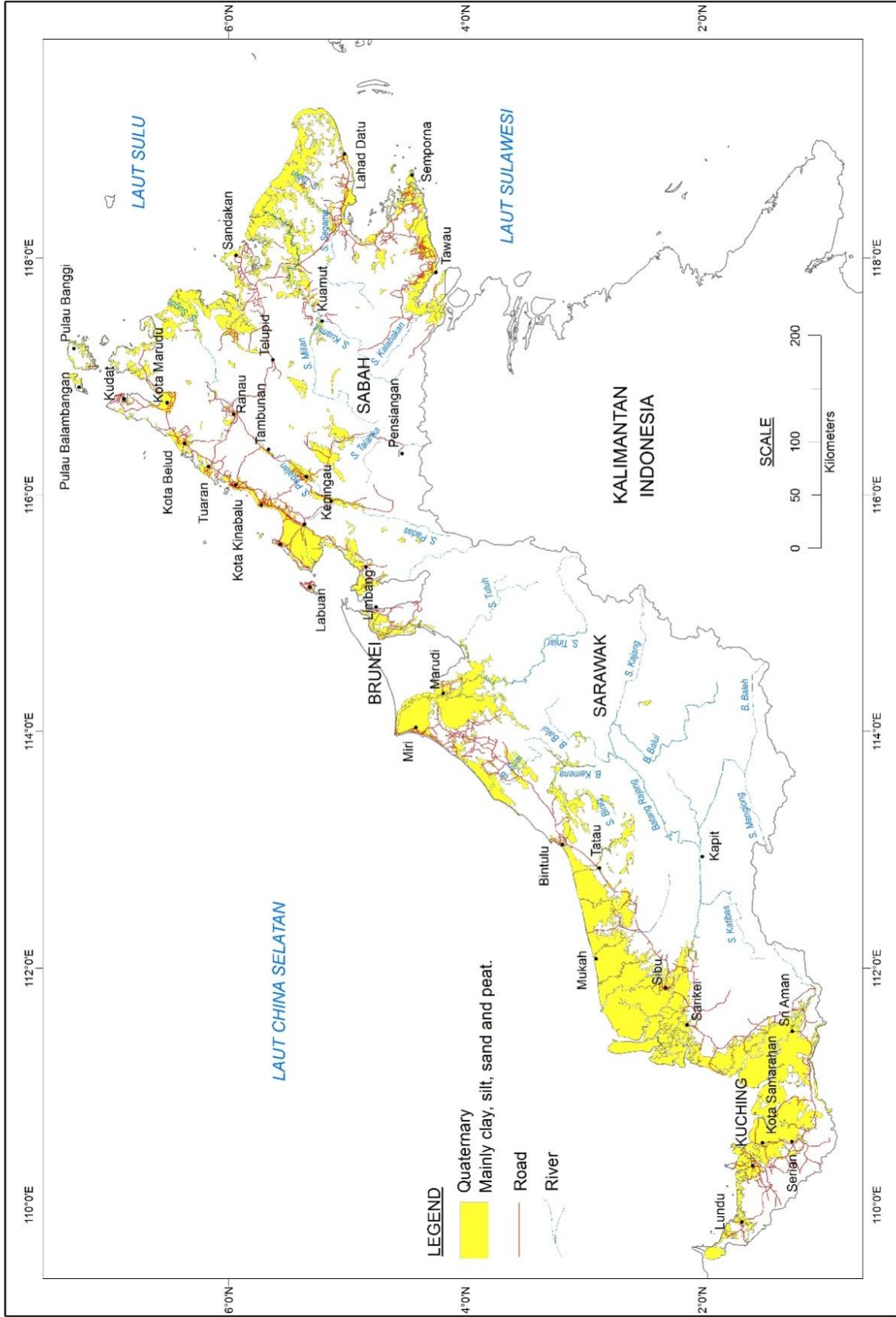


Figure 1 - 6. General Distribution of Quaternary Deposits including Peat and Soft Soils in Sabah and Sarawak (modified after Geological Map of Sarawak and Sabah, 5th Edition, Geological Survey of Malaysia, 1992)

Geographically, tropical peat deposits are commonly found in poorly – drained lowlands such as the river valleys and estuaries. Some can also be found on small isolated areas in steep mountainous region above 1000m from mean sea level (msl). The former is known as basin peats, while the latter is called valley peats.

Most of the lowland peatland in Malaysia initially formed behind mangrove swamp forest along the coast, and later developed as far as 100km in land on the alluvial plains between rivers flowing to the sea.

The inland peat typically developed as a dome-like structure underlain by a thick mineral soil as illustrated in Figure 1 - 7, but some may be fairly uniform in depth and elevation.

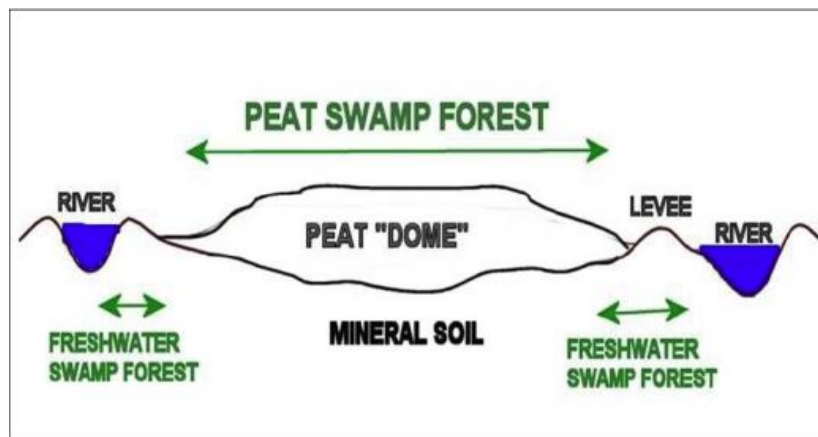


Figure 1 - 7. Highly – developed inland peat dome (Wetlands International, 2010).

In Malaysia, approximately 8% amounted to about 2,457,730 ha of the 32,975,800 ha of the country total land area is covered with peat. The extent and distribution of peat areas in Malaysia is summarised in Table 1 - 2.

Table 1 - 2. The area (ha) of peat soil in Peninsula Malaysia, Sarawak and Sabah (Wetlands International, 2010)

Region	Total Area of Peat (ha)	%
Sarawak	1,697,847	69.08
Peninsular Malaysia	642,918	26.16
Sabah	116,965	4.76
Total	2,457,730	