Module 1:
Introduction of Building Pathology, Diagnosis, Prognosis and Appraisal; Initial Case Studies; and Types of Deterioration of Structural Components.

Course Exercises

A lecture by
Ir. Jeffery Pirah

Exercise 2: Planning for Appraisal and Desktop Study

SMK Pekan Nabalu, Ranau

You are requested to carry out appraisal works for SMK Pekan Nabalu at Ranau which have been abandoned for years. As you plan for your appraisal works, you are required to carry out desktop study on this school for more information before advancing with initial site visit or field work.

From information you gathered, build up information and methods which are useful for your upcoming project
(40 Minutes)

Exercise 3: Diagnosis & Prognosis - Case Study on Defects and Deteriorations
SMK Ranau, Ranau, Sabah (Group 1)

You are required by local authorities to provide early opinion (non-official) based on the photographical evidences they have sent to you by Whatapps.

You and your team have to decide on plausible cause and possible condition of the structures. State your diagnosis and prognosis in bullet form, and your opinion.
(20 minutes)






Exercise 3: Diagnosis & Prognosis - Case Study on Defects and Deteriorations
Syn Lee Fah, Sandakan, Sabah (Group 2)

You are required by local authorities to provide early opinion (non-official) based on the photographical evidences they have sent to you by Whatapps.

You and your team have to decide on plausible cause and possible condition of the structures. State your diagnosis and prognosis in bullet form, and your opinion.
(20 minutes)

Exercise 3: Diagnosis & Prognosis - Case Study on Defects, Deteriorations and Failure Tanjung Bungah, Pulau Pinang (Group 3)

You are required by local authorities to provide early opinion (non-official) based on the photographical evidences they have sent to you by Whatapps.

You and your team have to decide on plausible cause and possible condition of the structures. State your diagnosis and prognosis in bullet form, and your opinion.
(20 minutes)

Answers

Exercise 2: Planning for Appraisal and Desktop Study Answer

SMK Pekan Nabalu, Ranau

Chronology

Let us go through the simplest chronology of events for this project.

•2009: A site for construction of a school was identified at the foot of Mount Kinabalu as announced by Deputy Minister Dr Puad Zarkashi.
•2012: Construction started
•2014: The construction halted following to a written advisory from the Mineral and Geo Science Department that the site is situated on top of a seismic fault line.
•May 2017: The long-abandoned SMK Nabalu project will be revived and relocated to a new site at Kampung Giok according to Education Minister Datuk Seri Mahdzir Khalid.
•Sep 2017: Public comment (from 1st to 14th September 2017) for Malaysia National Annex to MS EN 1998-1: 2015, Eurocode 8: Design of structures for earthquake resistance - Part 1: General rules, seismic actions and rules for buildings

Seismic

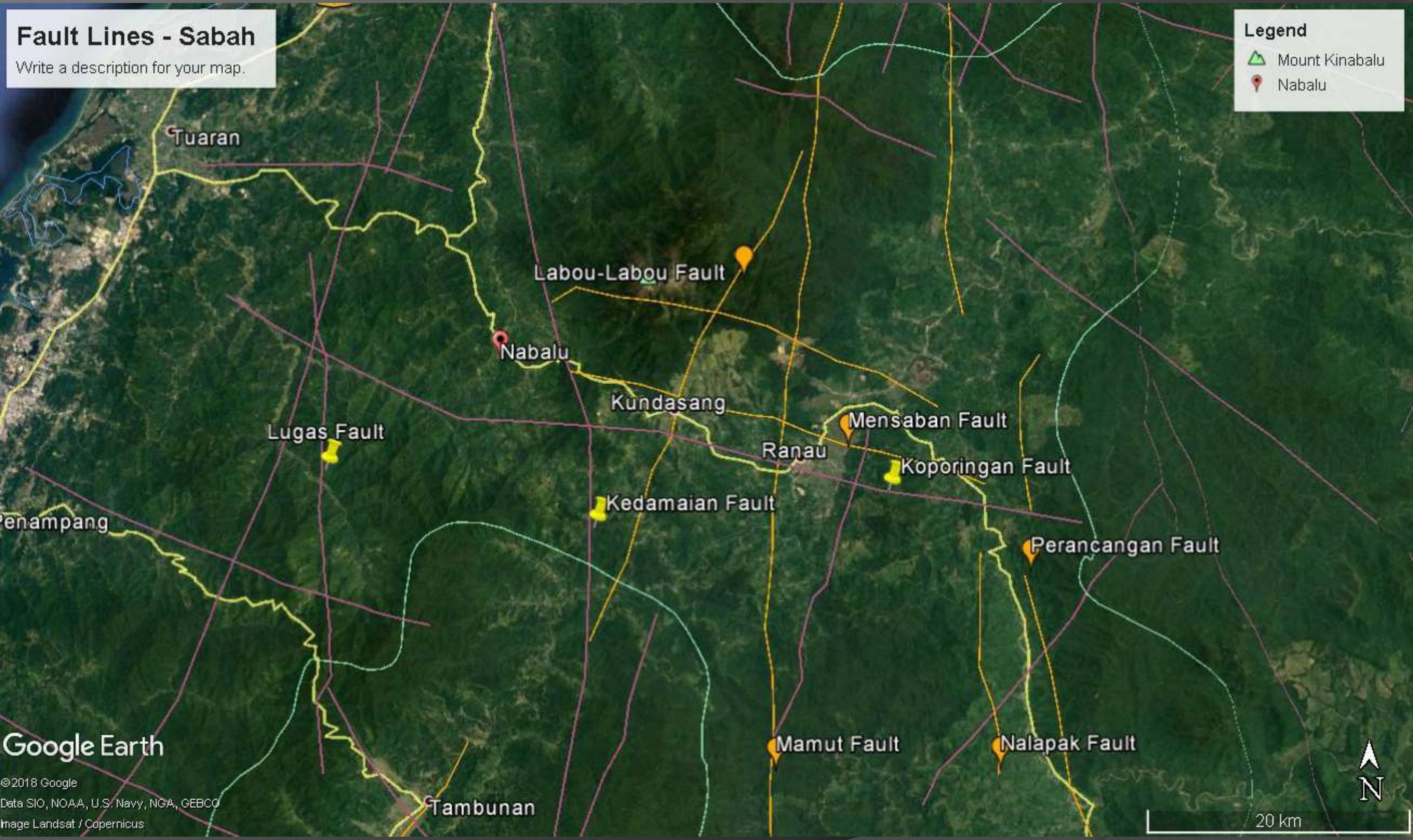
Seismic information for Pekan Nabalu and surrounding. The school is located less than 15km away from the epicenter of 5th June 2015 - 6.0 Richter Scale (RS) earthquake. There are two earthquake epicenters which are situated under 5km from the school. The first one rocks the surrounding at the magnitude of 3.3 RS, 7 minutes after the initial tremor of the massive 6.0 on 5th June. The second one is around 3km away shook 2 days later with 2.4 RS.

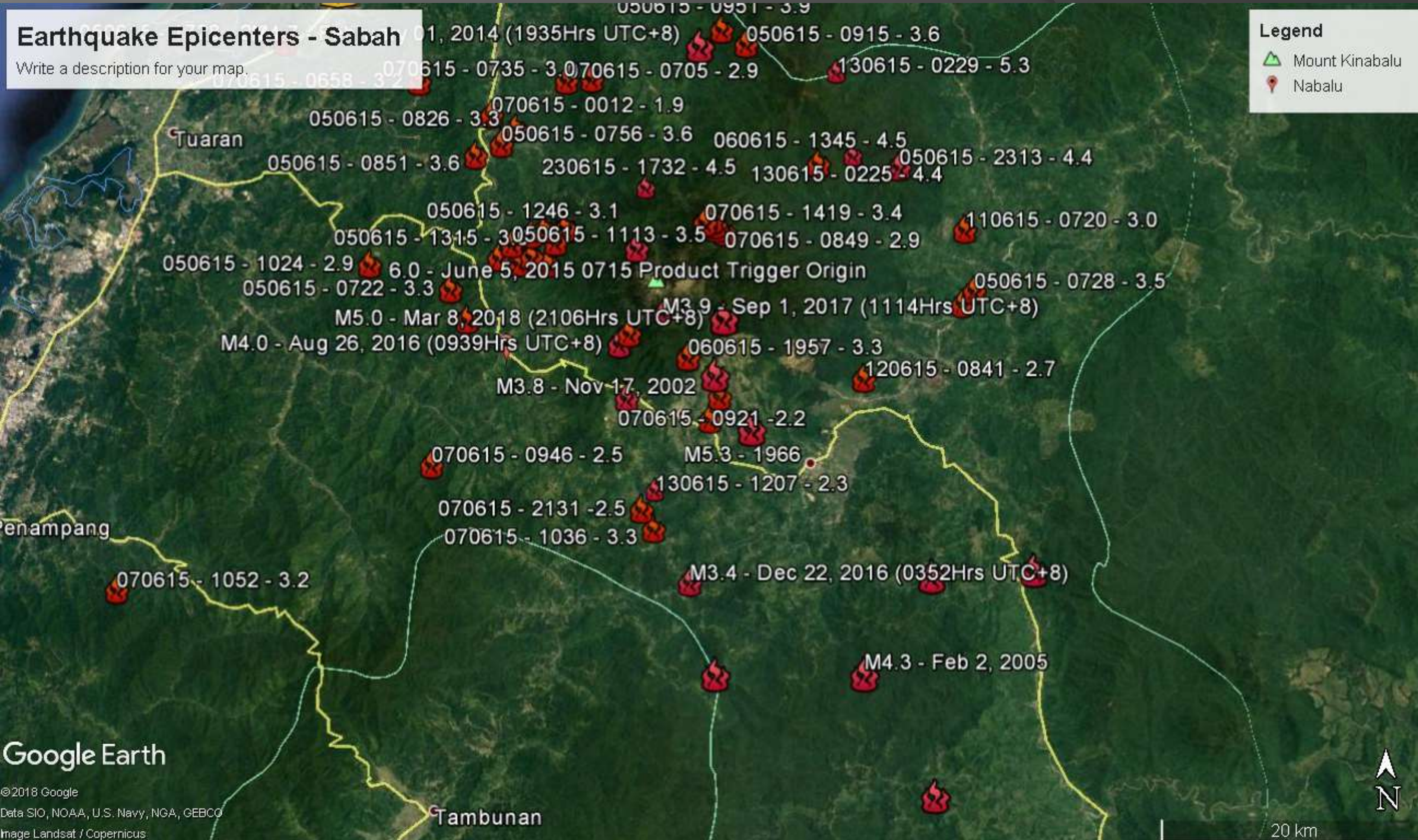
Pekan Nabalu is one of the places around Mount Kinabalu which is surrounded by two normal active fault lines (Mensaban and Lobou-Lobou fault lines) and around five other normal inactive fault lines (where the major one is Kedamaian fault) .

Seismic

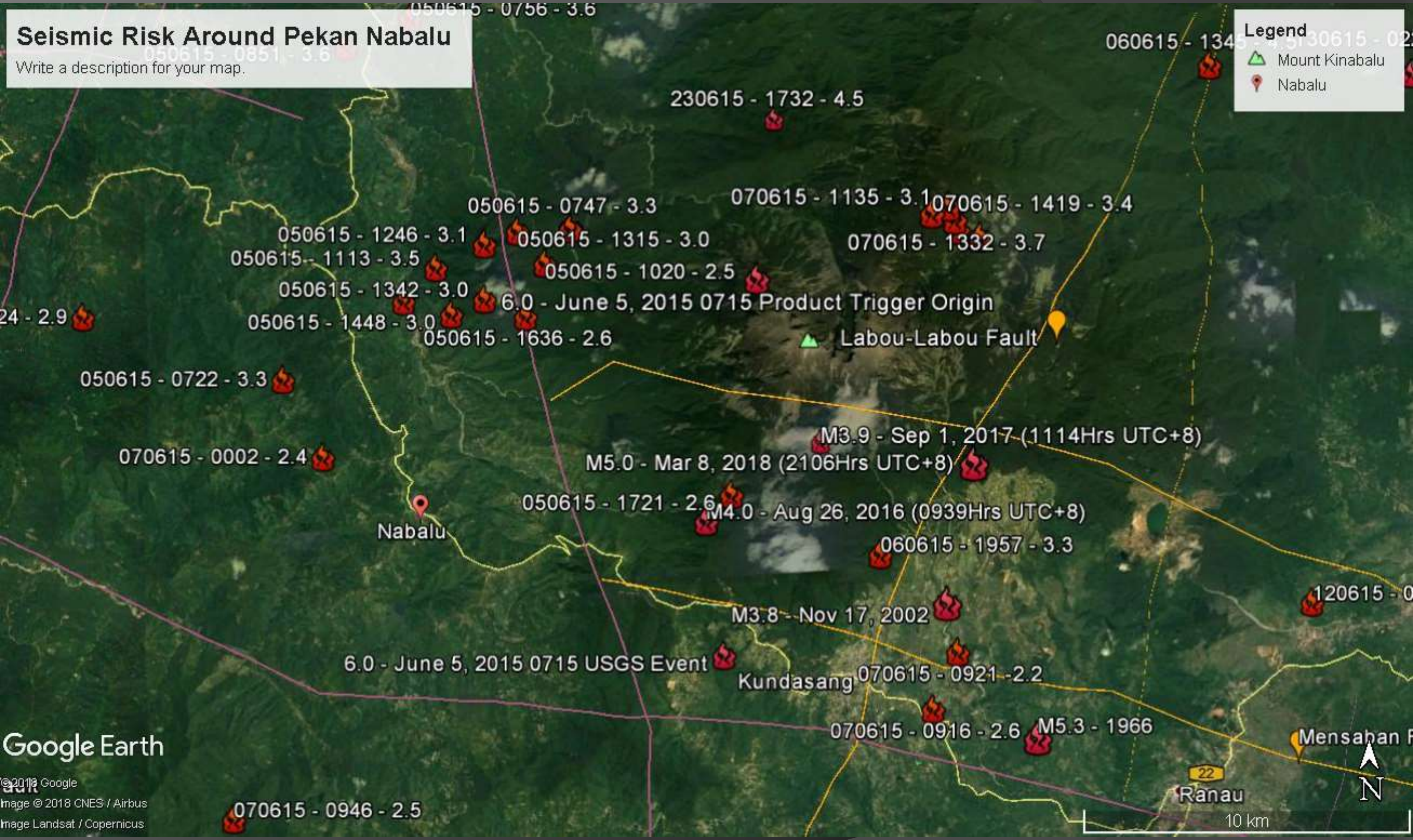
What Mineral and Geo Science Department did is indeed very timely and the decision to abandon the project is appropriate which actually saves a lot of life. If the building is to be continued, we can imagine the death toll from the completed, commissioned and operational school itself from the 6th June 2015 earthquake.

Data of earthquake epicenters prior to Feb 2014 reveals, the only earthquake epicenter around is situated around 50km away which occurred on 7th May 2013 with magnitude of 3.2 RS. The other epicenter is 11km away which triggered tremor of 4.3 RS on 2nd Feb 2005. What triggered this decision is probably the earthquake where the epicenter lies 26km away which triggered 4.7 RS on 1st Feb 2014.

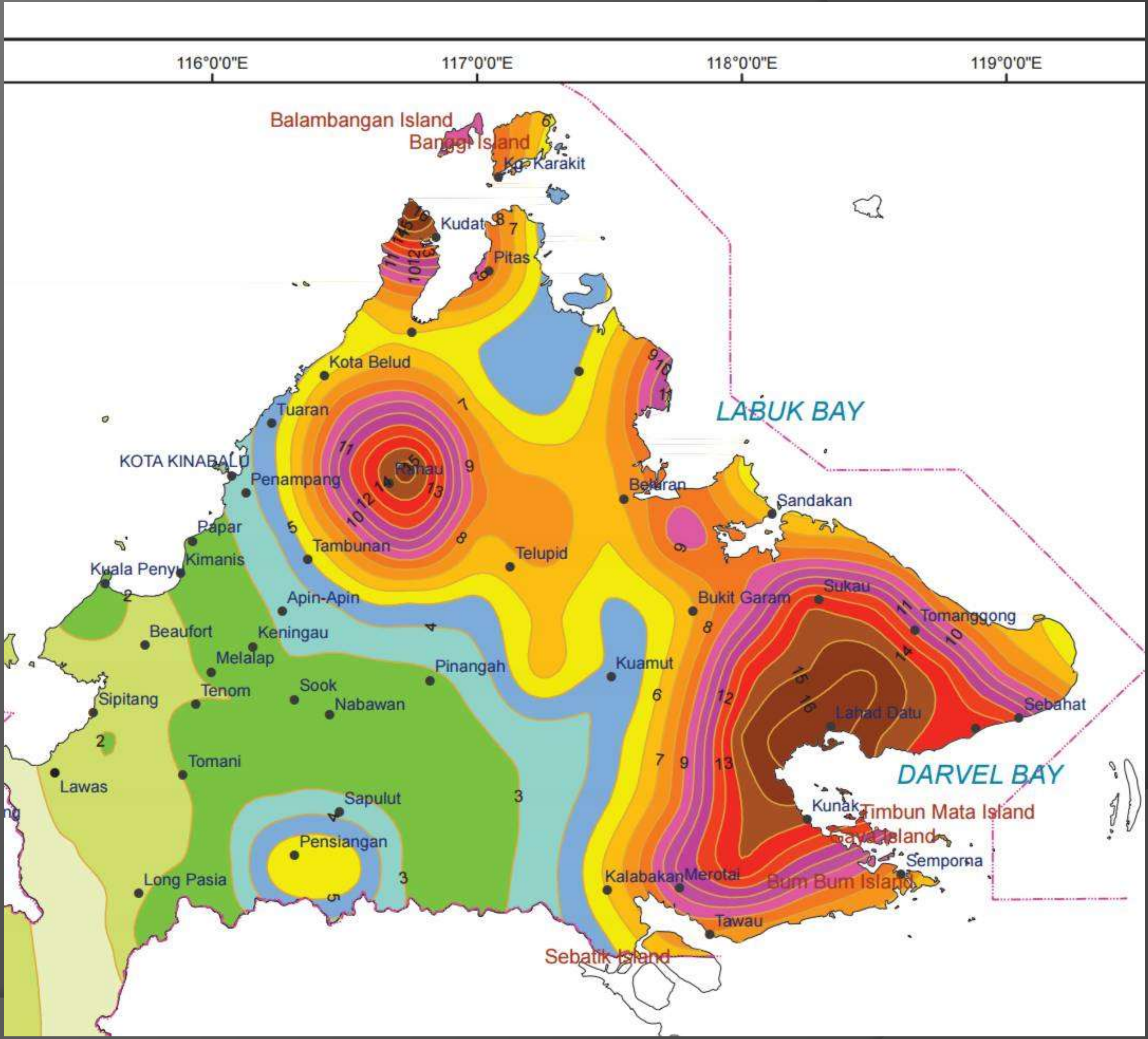

Fault Lines - Sabah
Write a description for your map.
Legend
Mount Kinabalu
Nabalu
Tuaran
Labou-Labou Fault
Nabalu
Kundasang
Mensaban Fault
Ranau
Koporingan Fault
Lugas Fault
Kedamaian Fault
enampang
Perancangan Fault
Mamut Fault
Nalapak Fault
Tambunan
Google Earth
©2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
20 km
N



Earthquake Epicenters - Sabah
Write a description for your map.
Legend
Mount Kinabalu
Nabalu
1, 2014 (1935Hrs UTC+8)
050615 - 0915 - 3.6
070615 - 0735 - 3.0
070615 - 0705 - 2.9
130615 - 0229 - 5.3
070615 - 0012 - 1.9
050615 - 0826 - 3.3
050615 - 0756 - 3.6
060615 - 1345 - 4.5
Tuaran
050615 - 0851 - 3.6
230615 - 1732 - 4.5
130615 - 0225 - 4.4
050615 - 2313 - 4.4
050615 - 1246 - 3.1
070615 - 1419 - 3.4
110615 - 0720 - 3.0
050615 - 1315 - 3
050615 - 1113 - 3.5
070615 - 0849 - 2.9
050615 - 1024 - 2.9
6.0 - June 5, 2015 0715 Product Trigger Origin
050615 - 0722 - 3.3
050615 - 0728 - 3.5
M3.9 - Sep 1, 2017 (1114Hrs UTC+8)
M5.0 - Mar 8, 2018 (2106Hrs UTC+8)
M4.0 - Aug 26, 2016 (0939Hrs UTC+8)
060615 - 1957 - 3.3
120615 - 0841 - 2.7
M3.8 - Nov 17, 2002
070615 - 0921 -2.2
070615 - 0946 - 2.5
M5.3 - 1966
130615 - 1207 - 2.3
070615 - 2131 -2.5
Penampang
070615 - 1036 - 3.3
M3.4 - Dec 22, 2016 (0352Hrs UTC+8)
070615 - 1052 - 3.2
M4.3 - Feb 2, 2005
Google Earth
©2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Tambunan
N
20 km



Seismic Risk Around Pekan Nabalu
Write a description for your map.
Legend
Mount Kinabalu
Nabalu
050615 - 0756 - 3.6
060615 - 1345
230615 - 1732 - 4.5
050615 - 0747 - 3.3
070615 - 1135 - 3.1
070615 - 1419 - 3.4
050615 - 1246 - 3.1
050615 - 1315 - 3.0
070615 - 1332 - 3.7
050615 - 1113 - 3.5
050615 - 1020 - 2.5
050615 - 1342 - 3.0
6.0 - June 5, 2015 0715 Product Trigger Origin
24 - 2.9
050615 - 1448 - 3.0
050615 - 1636 - 2.6
Labou-Labou Fault
050615 - 0722 - 3.3
M3.9 - Sep 1, 2017 (1114Hrs UTC+8)
070615 - 0002 - 2.4
M5.0 - Mar 8, 2018 (2106Hrs UTC+8)
050615 - 1721 - 2.6
M4.0 - Aug 26, 2016 (0939Hrs UTC+8)
Nabalu
060615 - 1957 - 3.3
120615
M3.8 - Nov 17, 2002
6.0 - June 5, 2015 0715 USGS Event
Kundasang
070615 - 0921 - 2.2
070615 - 0916 - 2.6
M5.3 - 1966
Mensaban
Google Earth
©2018 Google
Image © 2018 CNES / Airbus
Image Landsat / Copernicus
22
Ranau
N
10 km
070615 - 0946 - 2.5



116°0'0"E
117°0'0"E
118°0'0"E
119°0'0"E
Balambangan Island
Banggi Island
Kg. Karakit
Kudat
Pitas
Kota Belud
Tuaran
KOTA KINABALU
Penampang
Ranau
Papar
Kimanis
Kuala Penyu
Tambunan
Telupid
Beluran
Sandakan
LABUK BAY
Apin-Apin
Beaufort
Keningau
Melalap
Tenom
Sipitang
Sook
Nabawan
Pinangah
Kuamut
Bukit Garam
Sukau
Tomanggong
Sebahat
Lahad Datu
DARVEL BAY
Tomani
Lawas
Sapulut
Pensiangan
Long Pasia
Kalabakan
Merotai
Kunak
Timbun Mata Island
Semporna
Bum Bum Island
Tawau
Sebatik Island

Initial Appraisal

Changes of seismic or ground acceleration requires an increase of reinforcement bars by a few folds. There is a vast difference between PGA count between Kota Kinabalu and Pekan Nabalu. Kota Kinabalu is likely to experience 4%G or 40gal while Pekan Nabalu is exposed to 12-14%G or 120 - 140gal which is three folds or more.

The main difference between both designs (heavy seismic area and moderate seismic area) is on the shear reinforcement which links the columns and beams. Additional reinforcement bars is needed with appropriate bar bending schedule can only resist such forces and robust enough to sustain predicted serviceable limit. In this case, this would need retrofitting or re-strengthening.

This method is using force method based on rigidity of the structure.

Initial Appraisal

There are new technologies appropriate for damping purposes when experiencing earthquake. It is possible to improvise or integrate these into the school structure. This improvement is based on displacement method where joints are allow to move to avoid any becoming plastic hinge.

All parameters on concrete in-situ characteristic strength are required through non-destructive test. Where possible, steel reinforcement are retrieved and undergo destructive test. With all test parameters made available, a finite element model shall undergo simulation based on design from construction drawing and forces reacting to it.

Nevertheless, salvaging this structure can be futile and relatively not cost effective to do so if you understand dynamics of structures and other engineering philosophy when discussing about seismic loading.

Exercise 3: Diagnosis & Prognosis - Case Study on Defects and Deteriorations Answer
SMK Ranau, Ranau, Sabah
(Group 1)

Diagnosis

- Based on the provided photos, the main issue is the cracking of the brick cladding. This is non-structural failure.
- The exposed reinforced concrete column looks tiny however no visible crack can be seen.
- Apart from the column, the other structural members such as the beam, does not shows any sign of failure or deterioration.
- Similarly, those columns to ground floor slab connection does not show any sign of punching shear, therefore no significant delamination occurred.
- The connection at the beam and column does not show any failure which indicates that the structure resisted and remained in equilibrium with the high capacity of the shear reinforcement.
- There is no broken window and this suggested that, the force reacted toward the building is relatively dampened.

Diagnosis (Additional)

A structural analysis is to be conducted with the following parameters,

1. Size and Dimension

The Column size is estimated to be 250mmx250mm column which is almost the equivalent size of a commonly used 200mmx200mm reinforced concrete pile. Now, by layman reasoning, a single grade G45 250mmx250mm pile can hold up to 75 Tonne. So by parametric estimate, a grade G30 Structure should be able to carry up to 30 tonne (underload) of vertical load.

2. Form and Functions

The area where the columns situated is at the middle of the building with intruded section. Besides that, the function of that area is not a heavy duty area, say with loading of slab at 2.5kN/m^2. From photo, we can give a rough estimate of 16M^2 of slab is supported by each column. The edge of the column is carrying 10kN or 1 tonne of loading for each floor. As per self weight and safety factor, say 2.5 tonnes.

Diagnosis (Additional)

3. Design reduction factor.

Now for column design, a reduction of 10% is allowed for each floor with maximum of 40% reduction. Three floors mean 30%. So now, Overall 3 floors of loading to a column is 2.5 tonne x 3 floors which is 7.5 tonne and the multiple with 70% (30% reduction) the column will take 5.25 tonne.

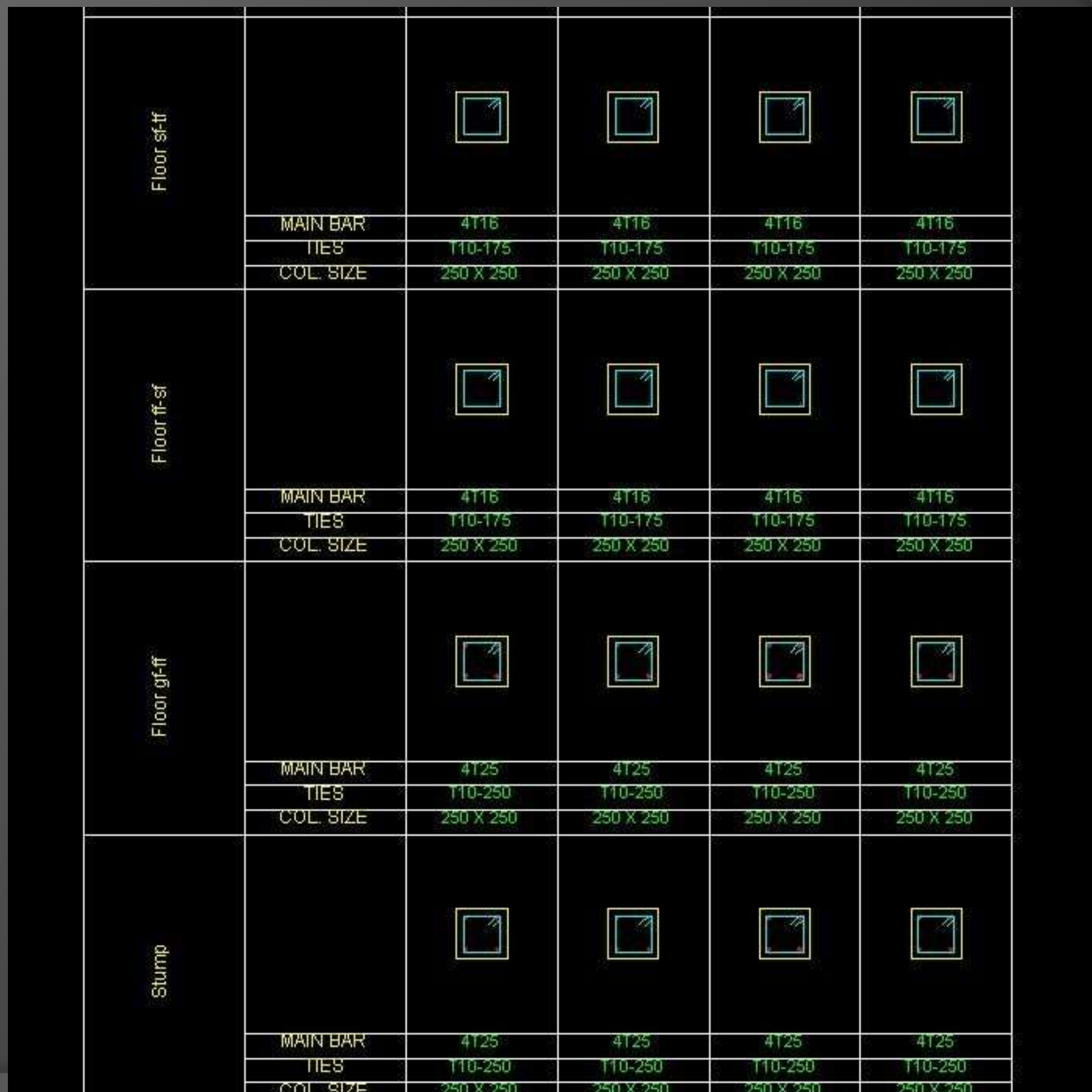
The initial parametric estimate by visual (mentioned and elaborated above) was not accepted by layman, therefore a structural analysis was conducted. The bricked-up reinforced concrete column at Ranau was designed appropriately. Below are all the calculation from ESTEEM Structural Software based on BS8110.

Instead of using grade G30 as prescribed by JKR, we use G25 instead to simulate reduction of robustness from any delamination or deterioration.

Diagnosis (Additional) - Calculation

FLOOR PATHNAME : T:\Design esteem\RANAU COLUMN\Ranau\rf\rf.ccd
COLUMN DETAILED DESIGN CALCULATION:
CODE OF PRACTICE USED IS: BS8110:1985
Floor D.L. L.L. fcu fy cover Load incre.
rf 1.40 1.60 25 460 35 10
Rebar maximum spacing = 250 mm, Minimum spacing = 40 mm
Rebar maximum size = 25 mm, Minimum bar size = 12 mm
Link maximum size = 20 mm, Minimum link size = 6 mm
Minimum rebar percentage used for Column Design = 1.00
Design for Braced Column in X-direction
Design for Braced Column in Y-direction
Yield strain = Yield strength/Young Modulus =0.87*460/200000 =0.0020
Location of Column: 1-A
Floor No. = 5; Live load reduction = 0
Column Fixity: Top X = Fixed; Top Y = Fixed; Bottom X = Fixed; Bottom Y = Fixed
Column Effective Height Coefficient: X = 0.75; Y = 0.75
Column X-Dimension,A = 250 mm; X-Effective Height = 2250 mm
Column Y-Dimension,B = 250 mm; Y-Effective Height = 2250 mm
Factored Upper Moment,Mx = 17.7 kNm; My = 17.7 kNm
Factored Lower Moment,Mx = 15.1 kNm; My = 15.1 kNm
DL=1.40 & LL=1.60 Factored Moment,Mx = 17.7 kNm; My = 17.7 kNm
Dead Load,DL = 94.6 kN; Live Load,LL = 54.4 kN
Load Combination of DL = 94.6 kN & LL = 54.4 kN
Total Ultimate Load,UL = (1+Allowable increase)*(DLFac*DL+LLFac*LL) kN
= (1+0.10)*(1.40* 94.6+1.60* 54.4) = 241.4 kN
So, design for Ultimate Load, N = 241 kN= 241401 N
Ultimate Mx = 17.7 kNm; My = 17.7 kNm
Design For X-Braced Column
Effective height,Hef = 2250 mm
Slenderness ratio,sr in X-Dimension = Hef/A =2250/ 250 = 9.0

Diagnosis (Additional)



Floor sf-tf	MAIN BAR	4T16	4T16	4T16	4T16
	TIES	T10-175	T10-175	T10-175	T10-175
	COL. SIZE	250 X 250	250 X 250	250 X 250	250 X 250
Floor ff-sf	MAIN BAR	4T16	4T16	4T16	4T16
	TIES	T10-175	T10-175	T10-175	T10-175
	COL. SIZE	250 X 250	250 X 250	250 X 250	250 X 250
Floor gf-ff	MAIN BAR	4T25	4T25	4T25	4T25
	TIES	T10-250	T10-250	T10-250	T10-250
	COL. SIZE	250 X 250	250 X 250	250 X 250	250 X 250
Stump	MAIN BAR	4T25	4T25	4T25	4T25
	TIES	T10-250	T10-250	T10-250	T10-250
	COL. SIZE	250 X 250	250 X 250	250 X 250	250 X 250

Prognosis

So if the design is able to take an estimated 30 tonne and say add safety factor of 2, the design loading is 10.20 tonne against the column capacity of 30 tonne; then what is the problem with this design? Basically, there is no problem with this design, right. So this is a safe design.

The structure is quite robust and does not succumbed to any deterioration or failure.

Exercise 3: Diagnosis & Prognosis - Case Study on Defects and Deteriorations Answer
Syn Lee Fah, Sandakan, Sabah (Group 2)

Diagnosis

What are the tale-tell signs that you may interpret from such incident?

•First, the fire is most likely to be of medium intensity. Although the steel structures buckled, it is less likely due to high intensity fire. The buckling of the structure is most likely due to the self weight and series of design issues. From the photo, the main truss was not designed appropriately where the webs are too small to withstand the desired capacity in order to function optimally. Another sign of medium intensity fire is the carbon staining around steel structures.

•Second, the collapsed of this building is due to inappropriate extension work(s). The extension did not consider the design capacity where the unrestrained columns failed when encountered moment force when the main truss bolted to the column rotated with downward force.

Diagnosis

•Third, with careful eyes, you can see the columns and stiffeners on the second/third photo. The main reinforcements for the column is presumed to be smaller than anticipated under such loading. It has the same size with the nominal link or stirrups.

•Fourth, with careful eyes, the failure of this building is due to method of construction for these columns. It is likely that there is a cold joint for columns at the height of 750mm - 900mm. Untreated cold joint is dangerous when it is the area which initiate tensile stress under multiple loadings

Prognosis

The reinforced concrete structural members can plausibly be use for reconstruction if these members are not exposed to ultimate limit state.

Those structural members which are destroyed are not fit for structural purposes. No steel structural members are salvageable for reconstruction. It is assumed that 90% of the structural members are damaged.

We reckon that this building should be written off, demolished and a new building should be erected by owner if there is an intend to operate in the nearest future.

Exercise 3: Diagnosis & Prognosis - Case Study on Defects, Deteriorations and Failure Answer Tanjung Bungah, Pulau Pinang (Group 3)

Diagnosis

The failure of this retaining wall is due to global stability and not local stability of the design. Most time during submission, many councils forget about the global stability which have around five criteria to be fulfilled.

From these photos, the slippage of reinforcement is due to slip circle. In this case the initial breached would be the base or foundation for this type of retaining which is likely to be a shallow foundation. The design most likely only considers the overburden and rely the strength of anchors to withstand lateral load.

In reality, the slip circle formed behind these anchors (assuming with the length up to the end of the carriageway close to the building). The slip circle formed when water table increased (unsure if its due to subsoil or surface drainage but it is likely due to insufficient interceptor drains around the perimeter with rock bolt or soil nail behind the building).

Diagnosis

To make it easier to shift is the drain in front of the retaining wall and tangent to the slip circle which start to saturates the soil around the foundation of the retaining wall. When breached, the retaining structure will overturn or slide forward. In this case, engineer should have prescribed the use of piles or raking piles as countermeasure against moment developed from surcharge and lateral force if there is no space to provide rock toe for the retaining wall. Nevertheless, it is only good if the local stability of the system allows rigid connection (resisting moment) between foundation to the system in event of slip or wedging occurs behind anchors.

The rock toe is the first line of defense which is vital for the global stability for this kind of retaining wall. The rock toe or bodily mass will halt the slide and restrain the slip and ensure failure will only reach its serviceability limit.

Diagnosis

Part of the building (car porch) sheared since the column is sitting on pad footing. The rest of the structure is in tact due to the strong and shallow distance between pile cap to the rock socket. Since the pile is not slender, it is sturdy and robust to withstand movement of the soil.

Addendum:
From photos from other sources indicates that there is another retaining wall close by. What happened here is another consideration of soil state which affects the pore pressure. The at-rest, passive or active state may cause changes in load and pressure and caused instability of the retaining wall.

Finding - Soil Scientist (Kam Suan Pheng)

She said the authorities had failed to see that the site was sitting on what used to be a river, with a rock face above the bungalows forming a waterfall some 40 years ago.

As time passed, she said, the river was converted into concrete drains as developments cropped up in the area. Although the river might be expected to flow into the new drains, she added, the forces of nature had pushed it back to its old path. Hence, the river flowed underground despite being “buried”, she said.

According to Kam, the massive rainfall had triggered the landslide at the bungalow area. She said the old waterfall was “recreated” as rapid waters came down the rock face above the site. Coupled with the downpour, she said, the spread of the water flowing down the rock face forced it to seep below ground, destabilising the site and causing the road in front of it to cave.

Finding - Soil Scientist (Kam Suan Pheng)

“When rivers cannot take a natural course of flow, they will still try to go through the soil underground. Rivers are never dead. My take is, even if we divert (rivers), the drains will be unable to take the rapid runoff and it will definitely go underground. As water collects, the soil becomes very saturated and weakens the entire area. The area becomes waterlogged. Saturated soil is heavier than dry soil. That is how the road collapsed. This is the likely nature of the route along the NCPR.

Prognosis

The soil reinforced wall is not suitable and shall not be use for any construction around the sensitive area.

In the future, the only soil retaining structures allowed for such construction shall be the conventional retaining wall or T-Wall (with key) and sit on piles which able to cut off the water flow net and slip circle and to reduced possibility of sliding, overturning or even if there is a change on the soil bearing or condition/state.