Dynamic Characteristics and Seismic Performance Evaluation of Low Rise Existing RC Moment Resisting Frame using Microtremor Technique and Standard Code of Practice

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Abstract: - Most of existing multi-storey reinforced concrete (RC) buildings in Malaysia was designed to BS 8110 without considering seismic load. Tremors generated from previous distant earthquakes occurred from Sumatran faults zone had shaken many low-rise to high-rise buildings in Peninsular Malaysia and emerged panic. Worst scenario when the conventional practice of unreinforced masonry like brick wall is weak in lateral resistance and ease to damage. Poor soil condition may also have a crucial modifying influence occasionally acted as a resonator and amplifies the seismic wave when reached to ground surface. A microtremor study was conducted in order to evaluate the dynamic characteristics of site-structure, resonance potential and seismic capacity of an existing 4-storey RC primary school building and its site in SK Sri Molek which located in Batu Pahat-Johor. From the findings, it was expected that the building is prone to resonate since both site and building have only a slight different between their natural frequencies. The predominant building frequencies were predicted at 4.20 Hz and 4.35 Hz in transverse and longitudinal directions whereas for site fundamental frequencies were between 2.69 to 3.20 Hz in North-South (NS) direction and 2.79 to 2.98 Hz in East-West (EW) direction. By using the site response spectra for Kuala Lumpur region based on the consideration of large magnitude of distant earthquake scenario at 9.3 and 530 km of the closest to site distance produced by previous researcher, the design response spectrum (RS_A) has given 0.32 m/s^2 at natural period between 0.15 to 0.40 s. From this RS_A value, an equivalent static analysis (ESA) for base shear force estimation was performed according to EC 8 [2]. The analysis shows that, the design ultimate horizontal load described in BS 8110 [3] based on conventional load combination has been exceeded more than 1.5% as recommended by the code.

Key-Words: - Microtremor, dynamic characteristics, resonance, base shear force

1 Introduction

Less attention has been given to the earthquake hazard especially in low seismic region such as Malaysia. This scenario could be due to previous earthquakes had not inflicted to any severe damage or casualty [4]. Although Peninsular Malaysia is located in the stable Sunda shelf with low to medium seismic activity level, however the effect of tremors from Sumatra earthquakes have been reported several times [5]. According to Megawati et al. [6], it was predicted that an earthquake at moment magnitude greater than 7.8 from the Sumatra subduction zone has the capability to generate destructive ground motion in Singapore and Kuala Lumpur, even at a distance of 700 km. Even a longer distance may create destructive ground motion, it seems reasonable to postulate larger and closer earthquakes that might result in tremendous ground motion to Peninsular Malaysia especially [7].

Reinforced concrete framed structures had shown in large number of deterioration or become unsafe when subjected to changes in loading and configuration [8]. Worst, when no specific guideline was proposed in re-evaluating the dynamics performance of underlying site, and vulnerability of existing RC moment resisting frame (MRF) in Malaysia up to date. It is important to take serious action on seismic hazard in order to provide structural and occupant safety especially to the existing RC structure.

In a situation of distant earthquake, the seismic waves that reached to Peninsular Malaysia bedrock is rich in long period waves which significantly amplified due to resonance when they propagate upward, especially through the soft soil sites with a frequency close to the predominant frequency of the seismic waves [9]. The amplification waves may cause resonance to the buildings and inducing a large motions on the buildings which enough to be felt by the residence [9]. The reliability of these site-structure interactions effect due to resonance phenomenon had significantly proven in the destruction of selective buildings between five to fifteen storey which were constructed on the soft ground strata in 1985 Mexico City earthquake [10], even the epicenter distance was 320 km to 350 km away. Hence, it is important to consider the effect of soil-structure resonance either in seismic design or re-evaluation work on existing site or structure including to distant earthquake region due to a tendency of resonance disaster for safety reason.

In this study, microtremor technique was conducted in order to evaluate the resonance of site-structure frequencies of existing new low rise reinforced concrete building in SK Sri Molek. Microtremor is a non-destructive method, cheap but effective. It is suitable for a region which lacking of ground motions records but higher level of noise for dynamic characteristics investigation of a ground surface layer or structure. The equipment is also light and only small number of operators needed in in-situ measurement [11], at the same time gives extra credit to additional advantages. Besides, the base shear force was also calculated using a developed response spectra by Looi et al. [1]. According to Gioncu and Mozzalani [12], ESA is a simplified dynamic analysis and available when there has a predominant mode of vibration (primary mode of vibration) compared to others, and the system is accurately modeled by a single degree of freedom. ESA is an approximation method but adequate for regular building type at the ground fundamental period having close to the first vibration of the structure.

2 Study Area and Fieldwork

Fig. 1 shows the location and front elevations of SK Sri Molek building. This building is a 4-storey reinforced concrete structure which located in Senggarang, Batu Pahat-Johor. The school is designed by Public Works Department Malaysia (JKR) based on a standard RC design with typical building configuration of 3.6 m storey height, 3 m spacing between bays, 7.5 m building width and 2.1 m length of cantilever corridor balcony with 1.05 m of parapet wall height. The total length of the building is 60 m.

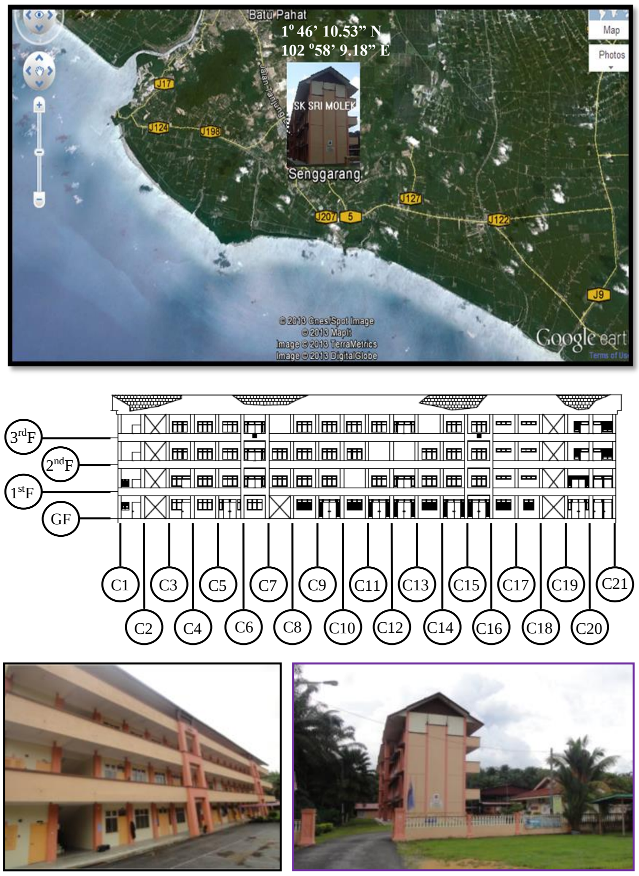

Fig. 1 Location and elevations of SK Seri Molek

Each floor is divided into a few rooms as shown in Fig. 2. On the upper floor, four main rooms are used for prayer room (TBA 6), classroom (TBD 3A), lounge room (TBL 3) and counseling room (TBB 2). Meanwhile, on the second floor, it has been provided for a meeting room (TBM 3) and library (TBR10) followed by a headmaster office (TBP 9) and teachers' room (TBT 5) on the first floor. Sport room (TSS 3), other two classrooms and health centre (TBE 3) are placed on the ground floor. The other room functions and imposed load used in the calculation is tabulated in Table 1.

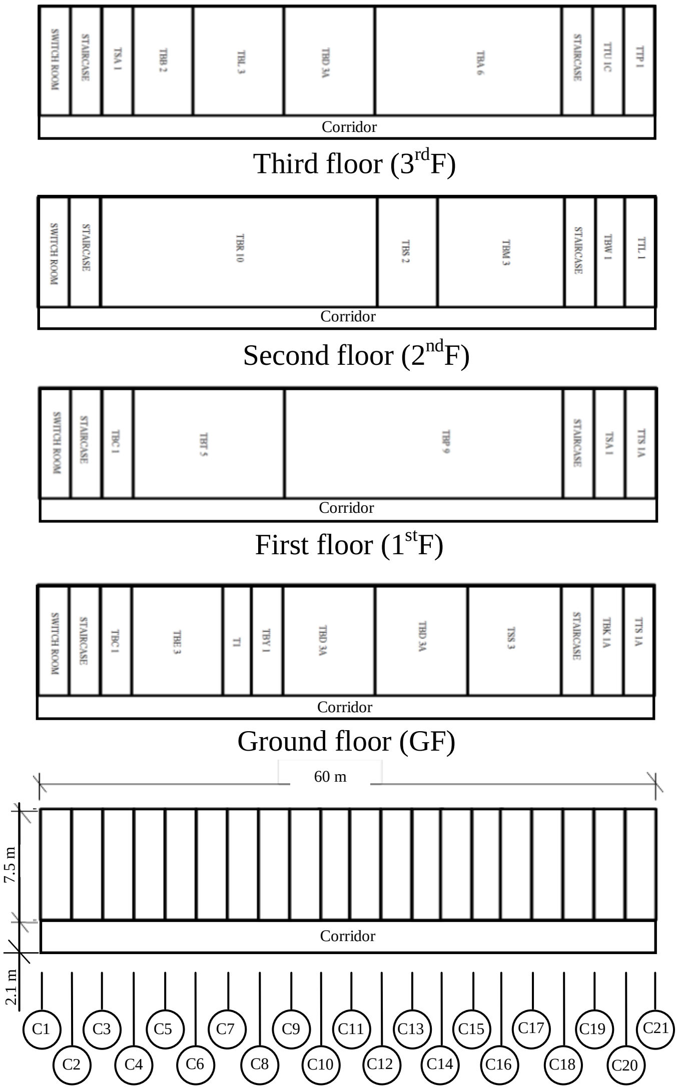

Fig. 2 Floor plans of SK Sri Molek

A series of microtremor measurements were performed by using three units of Lennartz portable tri-axial seismometer sensors (S), with 1 Hz eigenfrequency, CityShark II data logger and 1 GB memory. Since the input vibration is based on ambient vibration in three major components of NS, EW and vertical (V) directions, the external noises disturbance such as extreme weather (strong wind, lightning, heavy rain etc.), transient noises (traffic, pedestrian, etc.), monochromatic sources (machinery, pumps, generator etc.) and nearby structures (tress, pipes, sewer lids etc.) should be in minimum operation for the best result of natural frequency prediction as recommended by SESAME [13] guideline. The site-structure measurements were started from 8.00 am and finished at 5.30 pm for five days.

Table 1 Room types in SK Sri Molek building

Code	Room Function	Q_k (kN/m^2)
TBA 6	Prayer room	3.0
TTU 1C	Wuduk room	2.0
TSS 3	Sport room	2.5
TBL 3	Lounge room	2.5
TBB 2	Counseling room	2.5
TBT 5	Teacher's room	4.0
TBD 3A	Classroom	3.0
TBC 1	Access room	2.0
TBP 9	Headmaster office	4.0
TBM 3	Main meeting room	4.0
TBS 2	Invigilator room	2.5
TBR 10	Library	4.0
TBE 3	Health centre	2.5
TBY 1	Security room	2.0
T 1	Access	2.0
TBK 1A	Book shop	4.0
TBW 1	Prefect Room	2.5
TTP 1	Toilet (Female)	2.0
TTL 1	Toilet (Male)	2.0
TSA 1	Store	2.0
TTS 1 A	Toilet (Staff)	2.0
SWITCH ROOM	Service room	2.0
Corridor	Corridor	3.0

Similar equipment was applied in site and building measurements. All sensors were referred to the True North direction as the bench mark. This bench mark direction is also parallel to the transverse axis of the building (see Fig. 3). In building measurement, the sensors were arranged and positioned in horizontal and vertical sensor alignments which close to the main structural frame joint along the corridor. The arrangement of measurement points in both alignments were given in Table 2 and Table 3. A total of 14 measurements were carried out in horizontal alignment whereas 10 measurements in vertical alignment. Meanwhile, for site measurement, the sensors were placed on 25 m x 25 m grid as represented by six coloured red dots in Fig. 3. Only two measurements on site were considered in the analysis. The sampling rate of 100 Hz was used at optimum gain level in all recording. 15 minutes of recording length was taken in site as well as in building measurements. All frequencies below 1 Hz were not of interested [14], in both building and site measurements.

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Table 2 Arrangement and position of sensor on every floor in horizontal measurements

Floor No	Sensor 1 (S1)	Sensor 2 (S2)	Sensor 3 (S3)
3rd, 2nd and 1st Floor	C11	C21	C1
	C11	C3	C19
	C11	C6	C16
	C11	C9	C13
Ground Floor	C11	C21	C1
	C11	C16	C6

Table 3 Arrangement and position of sensor at selected columns in vertical measurements

Column No	Sequence of Floor Alignment			
C1, C6, C11, C16, C21	S1	3rd	S1	3rd
	S2	2nd	S2	2nd
	S3	1st	-	-
	-	-	S3	GF

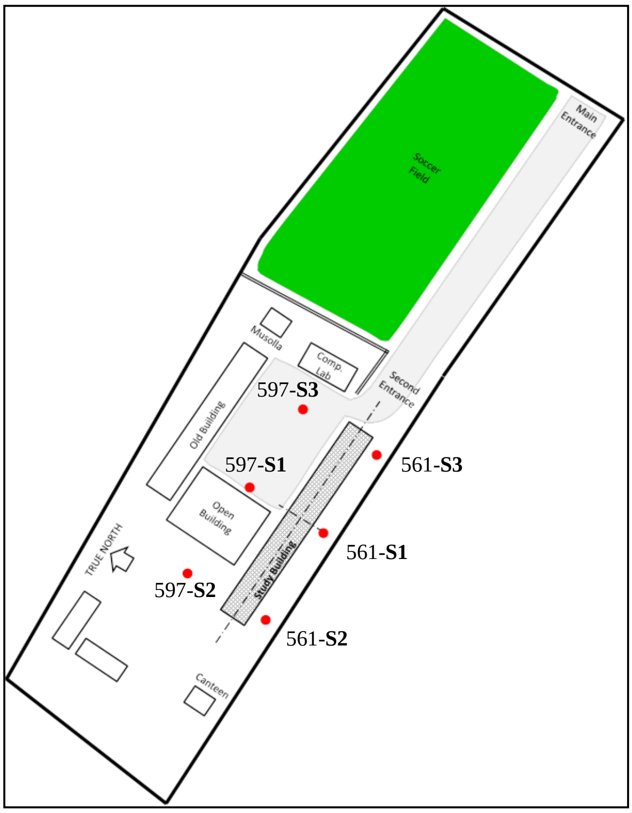

Fig. 3 Layout plan of SK Seri Molek and positions of sensors on site

3 Data Processing and Analysis

Horizontal to Vertical Spectral Ratio (HVSR) technique is an attractive method especially in estimating the dynamic characteristics of a structure or site in low or none seismicity regions [5]. It is widely used nowadays due to much faster, cheaper and non-destructive compared to conventional methods. Besides, it also proven that the amplification of strong motion at the predominant frequency of ground may approximately estimate through this technique but in a case of larger amplitude of vertical component dominating (when influenced by Rayleigh wave), it may affect to the prediction of amplification characteristic [6]. HVSR is also not recommended in determination of building frequencies if the soil amplification is significant strong which may contaminate to the building response [7]. Therefore, careful analysis and evaluation must be carried out. In this study, respective dynamic characteristics estimation for site and building was applied via HVSR technique and a standard method of Fourier amplitude spectra (FAS). In order to check the reliability of a building natural frequency, there should has a good correspondence frequency at each measured floor with the peaks predominant frequency will increase with increase of height [7].

Geopsy software was used in the analysis as a processing tool for HVSR and FAS curves analyses, based on the following variable parameters; 15 sec of automatic window length was selected with anti-triggering algorithm and a cosine taper of 5%. The Fourier spectra were computed for each window length and smoothed by Konno Ohmachi smoothing constant of 40. Directional energy method was chosen in HVSR analysis when the ambient vibration signals in both NS and EW are calculated accordingly to respective direction. Reliability and clarity of the significant peaks of mean HVSR curves were checked based on the recommended criteria by the SESAME [13] guideline. The dynamic characteristics in terms of predominant frequency of building, F_o, and fundamental frequencies of ground surface, f_o, in conjunction with site-structure amplifications, A_o, were determined. Illustration of dominant vertical mode shape based on predominant frequencies given in both longitudinal and transverse directions were produced. Besides, the horizontal mode shape was also prepared in order to study the lateral deflection mode.

Estimation of the base shear force was computed using equivalent static analysis according to EC 8 [2]. The intensity of dead load (G_k) and imposed load (Q_k) used were based on typical standard construction design characteristics as proposed by JKR and BS 6399-1 [18]. Since none of a site specific response spectrum has been developed in this study region up to this moment, the design response spectrum produced by Looi et al. [1] as in Fig. 4 was adopted. The used RS_A was modeled based on the consideration of large magnitude distant earthquake scenario at 9.3 from neighboring region of Sumatra with 530 km of the closest to site distance. Comparison was made to the estimated applicable notional design ultimate horizontal force that can be resisted by the building. As stated in BS8110 [3], conventional design load combination of 1.4 G_k + 1.6 Q_k should be capable to resist a notional design ultimate horizontal load applied at each floor or roof level simultaneously equal to 1.5 % of the characteristic dead weight of the structure between mid-height of the storey below and either mid-height of the storey above or the roof surface.

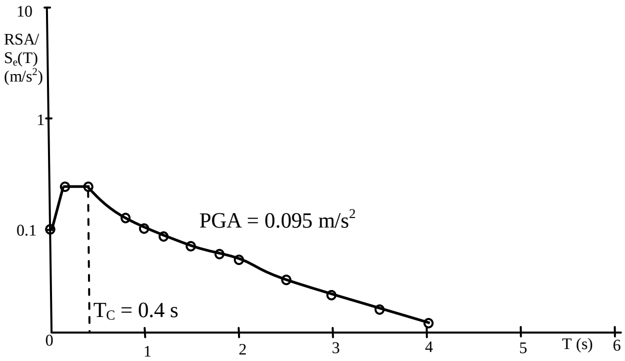

Fig. 4 Redrawn RS_A for Kuala Lumpur region [1]

4 Results and Discussions

4.1 Dynamic Characteristics of Site-Structure and Resonance Effect

Table 4 indicates the passing files of site fundamental frequencies (no shaded row) carried out based on recommendations criteria by SESAME [13] which must fulfilled 3/3 of reliability criteria, and at least 5/6 for clarity criteria of HVSR curve. The predicted f_o were obtained between 2.69 to 3.20 Hz with maximum A_o of 7.8 in NS direction. While, in EW, it shows between 2.79 to 2.98 Hz for maximum A_o reached was 7.46. Rough evaluation of soil depth in conjunction with the natural period below $\leq$ 0.5 s shows that, this site may be classified in shallow stiff soil stratification with 6 to 30 m soil depth based on B&R-M system [19].

The theory and interpretation of ambient vibration for buildings are not so structure and straightforward as for the free-field case (site) [20]. The main difficulties is to detect and eliminate the effects of fundamental frequencies of the nearby free-field and other buildings in the vicinity [20]. Besides, strong site amplification may also able to contaminate the building response and false prediction to the building natural frequencies. Due to these reasons, comparison between FAS (only considered on the upper floor for building) and HVSR (on the ground surface for site) curves in NS and EW was produced for predominant building frequency assessment. Interesting results were shown when the peak FAS curves in NS direction was slightly shifted to 4.20 Hz (see Fig. 5a) but vice versa in EW direction (see Fig. 6a), whereby the sites amplifications were highly dominated between 2.69 to 3.20 Hz (see Fig. 5e) and 2.79 to 2.98 Hz (see Fig. 6e). It was expected that, the first mode of building frequency in EW was predicted to occur at the second peaks frequency of 4.35 Hz which can be clearly seen from the FAS curves. This circumstance could be due to high amplifications factor of site that largely contaminate to the building response in both directions even though on the upper floor and become stronger when lowering to the ground level. Besides, it was clearly shown in Fig. 5b-d and Fig. 6b-d when the peak frequency of FAS curves tend to approach to site's HVSR peak as given in Fig. 5e and Fig. 6e, especially when reaching to bottom level.

Table 4 Reliability and clarity checking of HVSR curve

File No.	Sensor No.	Natural Frequencies, f_o (Hz)	Amplification Factor, A_o	Reliable (R) or No Reliable (NR)	Clear (C) or No Clear (NC)	Criteria: Passed, Failed or Recommended to be Repeated
561-NS	S1	3.20	5.71	R	C	Passed
	S2	2.69	7.78	R	C	Passed
	S3	3.42	9.99	NR	C	Failed
561-EW	S1	2.98	8.32	NR	C	Failed
	S2	2.88	6.78	R	C	Passed
	S3	2.98	7.46	R	C	Passed
597-NS	S1	2.88	7.55	R	C	Passed
	S2	2.79	11.68	NR	C	Failed
	S3	3.20	9.95	NR	C	Failed
597-EW	S1	2.79	6.37	R	C	Passed
	S2	2.79	9.82	NR	C	Failed
	S3	2.88	7.37	R	C	Passed

Small difference between site and building natural frequencies observed may trigger into the potential of resonance effect. According to Gosar [20], the indication of soil-structure probable can be applied by taking the ratio between building frequency that is closer to the site frequency. When the difference is within $\pm$15%, the danger of soil-structure resonance is high, if it is within $\pm$15 to 25% it is medium, while if it is higher than $\pm$25%, then it is low [20]. Thus, Table 4 indicates the computed result of site- structure resonance level. From the ratio of 4.20 Hz of F_o and 3.42 Hz by the f_o taken into consideration, it shows to medium level of resonance potential.

Table 5: Indication to site-structure potential level

	Fo(Hz)	fo (Hz)	Danger to Soil-Structure Resonance Potential
NS	**4.20**	2.6 – **3.20**	Medium
EW	4.35	2.98	

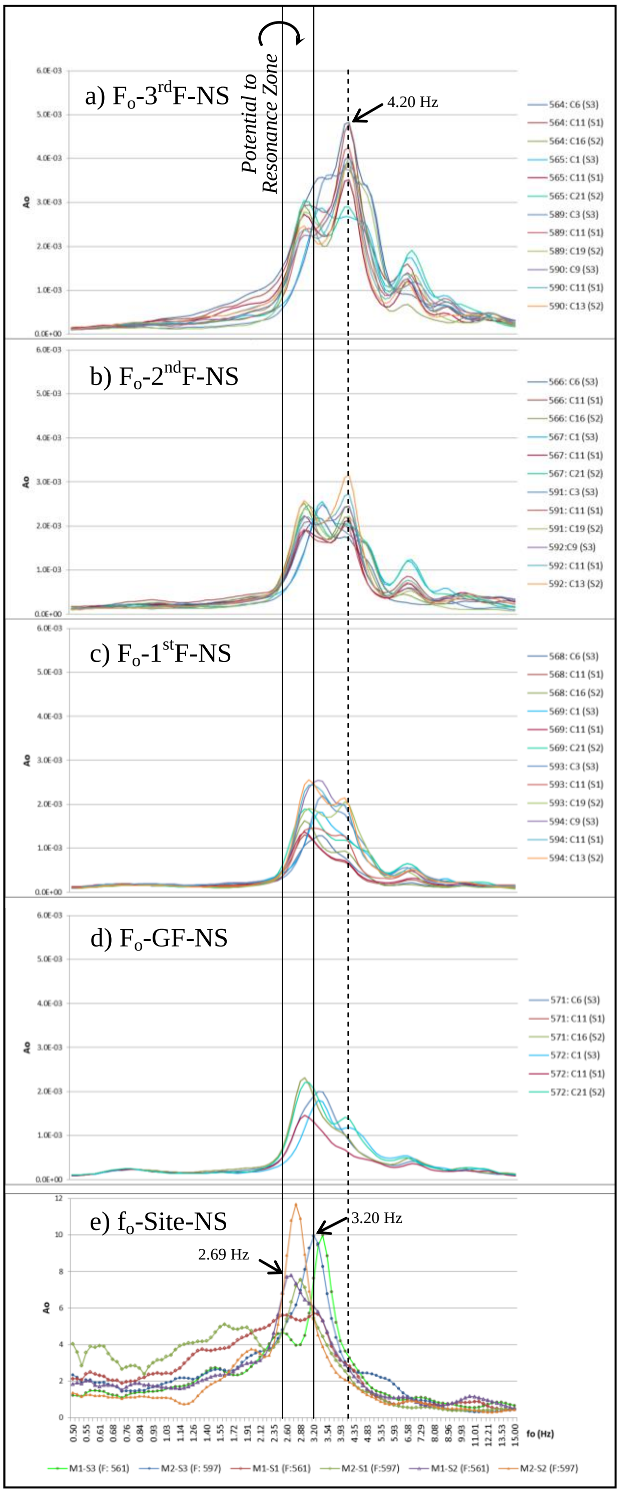

Fig. 5 FAS and HVSR curves for building and site in NS/ transverse direction

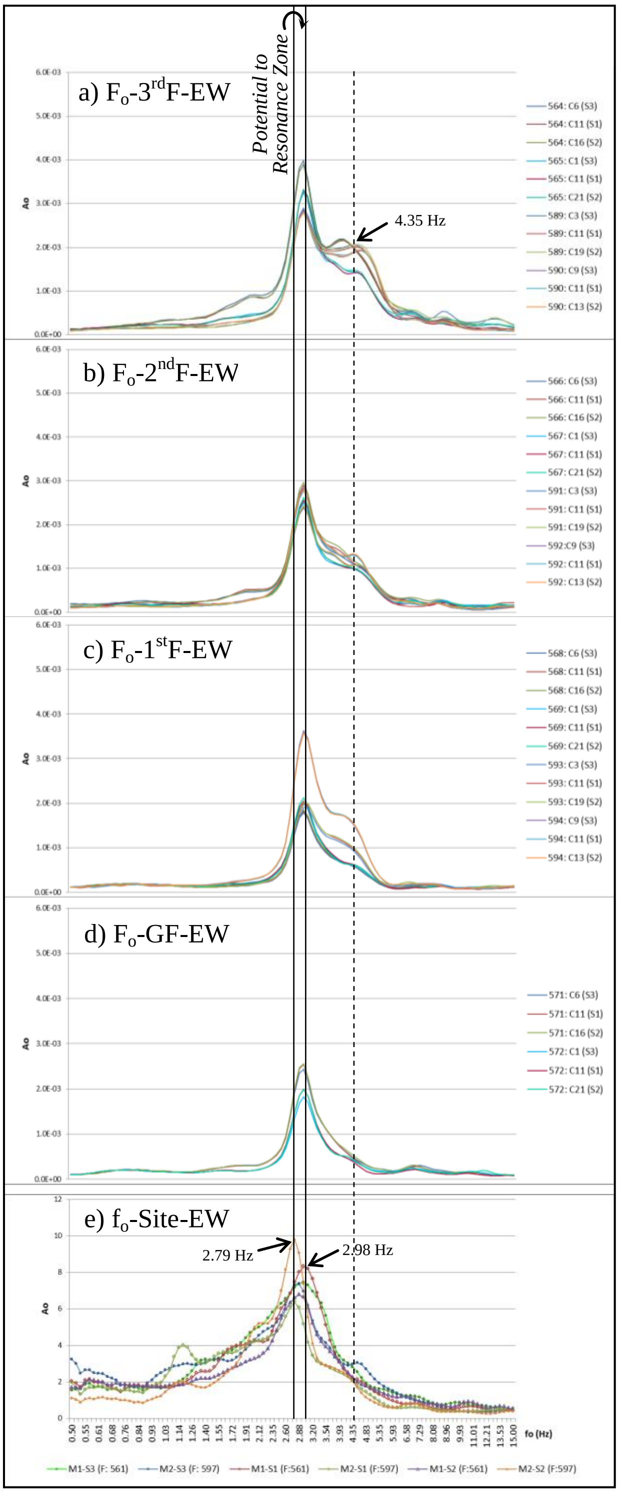

Fig. 6 FAS and HVSR curves for building and site in EW/ longitudinal direction

4.2 Mode Shapes

Vertical and horizontal mode shapes were drawn according to the predominant frequencies of building obtained at 4.20 Hz and 4.35 Hz in respective directions. From Fig. 7 and Fig. 8, the displacement pattern of the building has shown a similar trend when the upper storey remained the highest amplitude value and it decreasing when lowering to the ground level. Consistent result was also given by the horizontal mode shapes as in Fig. 9 and Fig. 10. Even the school has almost geometrically symmetry, however the deformations between bays were slightly different due to several expected reasons as highlighted in following discussions.

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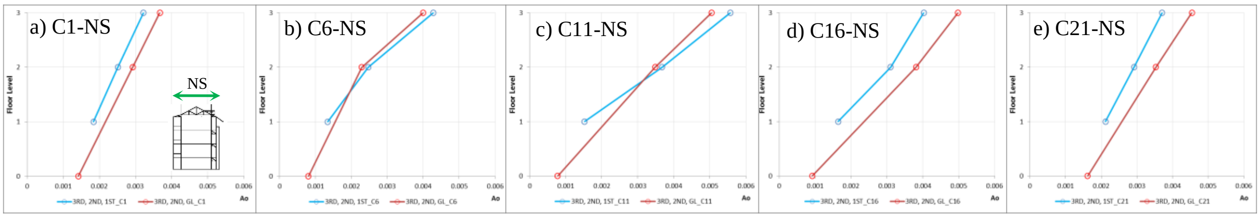

Fig. 7 Dominant vertical mode shape at 4.20 Hz in NS direction for selective column 1 to column 21

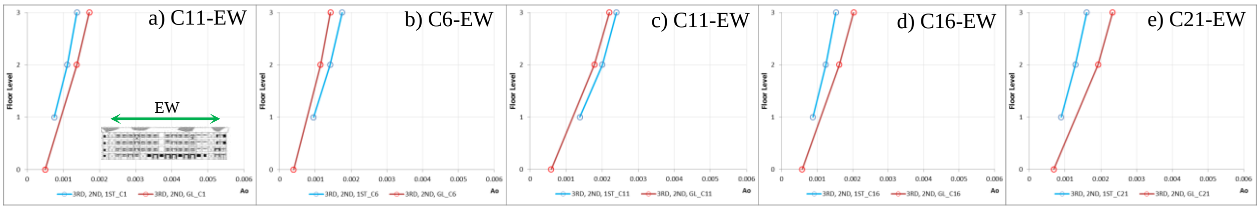

Fig. 8 Dominant vertical mode shape at 4.35 Hz in EW direction for selective Column 1 to Column 21

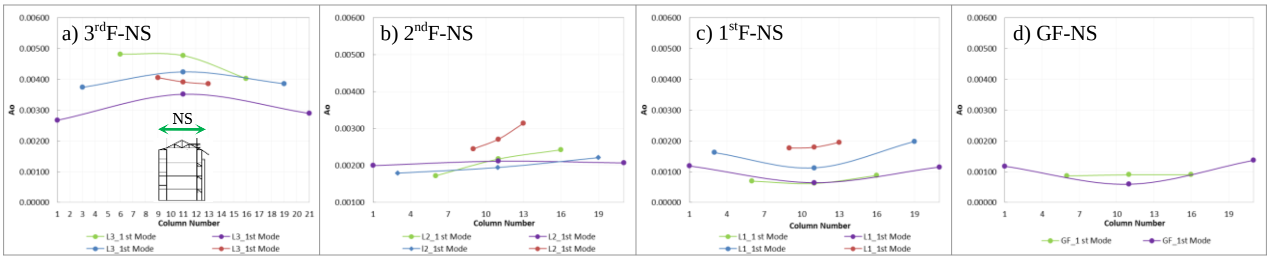

Fig. 9 Horizontal mode shape at 4.20 Hz in NS direction on ground floor to upper floor

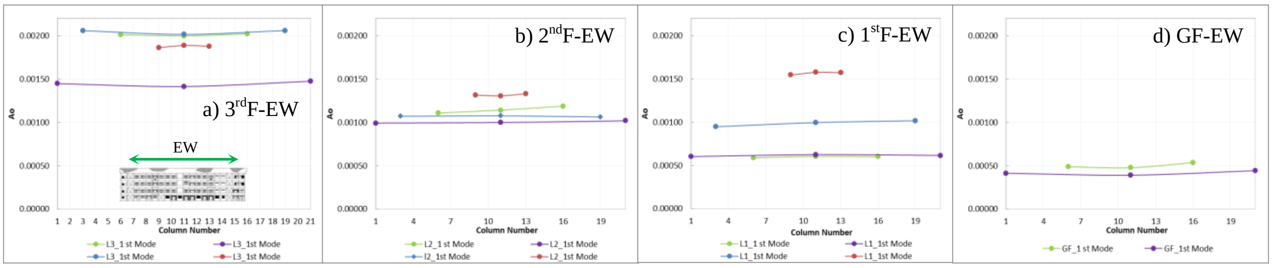

Fig. 10 Horizontal mode shape at 4.35 Hz in EW direction on ground floor to upper floor

By referring to Fig. 7c and Fig. 8c, the center column of C11 has indicated to the highest top displacement in NS and EW directions, compared to the adjacent column of C6 and C16 on the same floor. This situation may be due to higher mass concentration developed at the mid-span in addition to farther distance of the staircases which located in bay two (between C2 to C3) and bay eighteen (between 18 to 19) which less contribute to lateral resistance. Besides, larger imposed loads induced by a classroom (on the 3rd floor) and library (on the 2nd floor) located at the mid-span of the building may also explained the sources of the mass. However, the displacement amplitudes were reducing when reaching to the both ends as illustrated in Fig 7a-b and 7d-e, as well as Fig. 8a-b and Fig. 8d-e.

Meanwhile, from the view of horizontal mode shapes which involved the translational deformation in NS and EW directions for every floor have shown to similar pattern when the upper floor indicates to the highest displacement amplitude and it's getting lesser when lowering down to the ground level. Interesting finding was found when inconsistent shape of the bending curves given by the first three floors from top (see Fig. 8a-c) in NS direction, but a steady mode shape given in EW direction (see Fig. 9). On the upper floor (see Fig. 9a), the maximum displacement amplitude was given at C11 and it started to reduce when reaching to both ends. However, C11 shows the least displacement amplitudes on the first floor (see Fig. 9c), but it's getting bigger when approaching to the ends. Similar pattern also found on the ground level mode shape as in Fig. 9d. This scenario may be affected by the ground amplification intrusion to lower levels of building since higher A_o were observed on S3 and S2 positions (closer to both ends of the building) compared to S1 (closer to C11) from the site measurement findings.

Finally, in Fig. 10a-d, almost a straight deflection lines were illustrated in all diagrams. However, a significant difference was obtained on the first floor

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(see Fig. 10c) when two measurements at C3-C11-C19 and C9-C11-C13 have moved farther than others. The reason was expected due to the external noise disturbance of human activities and car transients a few times on ground level during the measurement since it significantly influencing to the amplitude of floor displacement.

4.3 Simplified Estimation of Natural Period and Building Base Shear

Several estimations of natural period have been made by using three standard codes and previous research in order to compare the fundamental period of the building obtained from the microtremor measurement. Table 6 shows the prediction equations (Eq.) of natural period (T) where H is the building height above the base in meter for moment resistant concrete frames which taken from Masi and Vona [21]. The computed results of natural frequency are in between 1.87 to 5.03 Hz and the closest prediction has been given by equation (4).

Table 6 Result comparison between simplified equations and ambient vibration measurement

Code/ Author [21]	**Eq.**	**T (s)**	**Fo =1/T (Hz)**	**Ambient Vibration Findings, Fo (Hz)**
NEHRP-2003: $T = 0.0466H^{0.9}$	(1)	0.40	2.50 Hz	4.20 Hz to 4.35 Hz at 10.8 m height
ATC3-06 and EC8-CEN2003): $T = 0.075H^{0.75}$	(2)	0.45	2.22 Hz	
NZSEE-2006: $T = 0.09H^{0.75}$	(3)	0.54	1.85 Hz	
Hong and Hwang (2000): $T = 0.0294.H^{0.804}$	(4)	0.20	5.00 Hz	

Meanwhile, Table 7 shows a study conducted by Gosar [20] on seven buildings between 3 to 5-storey. Based on these results, the building frequencies are found between 3.1 to 4.8 Hz within similar range as obtained from this study.

Table 7 Dynamic characteristics of site and building [20]

No.	**No. of storey**	**Year of construc-tion**	**Building type**	**Building frequency (Hz)**		**Soil frequ-ency (Hz)**
				Longi-tudinal	**Tran-verse**	
1	5	1962	school	3.4	3.1	3.3
2	3	1908	school	4.2	4.5	4.4
3	3	1911	school	4.4	4.2	4.0
4	5	1965	residential	4.8	3.9	3.9
6	3	1899	school	4.2	3.2	3.9
7	3	1855	school	3.6	3.4	3.5
10	3	1980	health center	3.3	3.3	3.6

4.4 Approximate calculation of base shear using ESA

A few assumptions have been applied including some extracted data from standard school constructions drawing obtained from Public Works Department of Malaysia (JKR). Besides, other considerations were also made according to standard design practice of British Standard since most of existing conventional structures in Malaysia were designed to this standard. Table 8 shows the design data applied in terms of building configurations, material properties other assumptions used in the calculation.

Table 8 Design data applied

Dimensions and sizes	Total bay	20
	Storey height	3.60 m
	Bay spacing	3.00 m
	Building width	7.50 m
	Corridor slab width	2.10 m
	Parapet wall height	1.05 m
Slab	Thickness	150 mm
	Concrete density	24 kN/m^3
	Finishing	1.0 kN/m^2
Brickwall	Thickness	150 mm
	Plastering	20 mm/side
	Clay brick density	26 kN/m^3
	Mortar density	21 kN/m^3
Q_k	Imposed load	Refer Table 1.

Since none of a national seismic code yet introduced in this country, a seismic design code of EC8 [2] has been referred for estimation of existing building base shear force. The following calculations are totally based on the expressions as provided from this code and other related supplementary Eurocode standards.

As a beginning, a total mass (in tonne) was calculated based on equation (5) which taken from clause 3.2.4 EC8 [2]. It was then computed to every floor from the ground level until roof by taking the combination coefficient for variable action, $\Psi_{E.i}$, equal to 0.24 (where $\Psi_{E.i} = \phi \cdot \Psi_{2i}$ with $\phi = 0.8$ and $\Psi_{2i} = 0.3$). The summary of seismic masses calculated for each level is given in Table 9.

$$G_k + \Psi_{E.i}.Q_k \text{ (in kN)} \qquad (5)$$

Table 9: Seismic mass calculation

Level	**G_k (kN)**	**Q_k (kN)**	**$G_k + \Psi_{E.i} Q_k$ (kN)**	**Mass (tonne)**
Roof	230.4	576.0	368.6	37.6
3	5,020.4	1,626.8	5,410.8	551.6
2	4,820.6	1,986.8	5,297.4	540.0
1	4,820.6	1,998.0	5,300.1	540.3
GF	4,970.7	1,615.5	5,358.4	546.2
Total seismic mass, m				2,216.3

Then, by taking 4.2 to 4.35 Hz (or 0.23 to 0.24 s of natural period, T_M) obtained from microtremor measurement, the site may be categorized in $T_B \leq T \leq T_C$ as explained in clause 3.2.2.2 in EC8 [2] when the elastic response spectrum, $S_e(T_M)$, can be calculated by using equation (6) with all variables taken as given in Table 10. The calculated $S_e(T_M)$ shows 0.32 m/s^2 which similar to the peak acceleration value given by the design response spectrum curve as in Fig. 4, for T_M between 0.23 to 0.24 s.

$$S_e(T) = a_g \cdot S \cdot \eta \cdot 2.5 \quad (6)$$

Table 10 Computed values of $S_e(T)$

Variables	Value	Remarks
a_g : design ground acceleration	0.095 m/s^2	See Fig. 7
η : damping correction factor	1	Assume for viscous damping of 5%
S : soil factor	1.35	Assume type C with N_{SPT} value of 15 to 50 occurred approximately at 30 m depth

As stated in expression 4.5 from EC8 [2], the base shear force can be determined as expressed in equation (7), when λ is assumed 0.85 due to T_M is lesser than $2T_C$. From Fig. 4 again, T_C is identified close to 0.4 s.

$$F = S_e(T_M) \cdot m \cdot \lambda \quad (7)$$

In the end of this calculation, it shows that the estimated base shear force may achieve up to 602. 8 kN which bigger than 1.5 % provision of notional horizontal load as stated in clause 3.1.4.2 from BS 8110 [3].

5 Conclusions

Integration of geophysical method and standard design code of practice may give to a bigger perspective in re-evaluation of dynamic characteristics and seismic performance of existing non-seismically design RC structure. This methodology can also benefit for a structure or site which lack of specific design database due to poor managing record system or the structure is too old. However, verification via reasonable methods should be carried out in order to produce a significant and reliable finding.

In this study, the dynamic characteristics and seismic performance of a new school RC building in SK Sri Molek has shown to a successful prediction by using integration methods of mictrotremor technique and two standard codes of practices. The predominant frequencies of building are determined between 4.20 to 4.35 Hz in transverse and longitudinal directions, whereby the highest top displacement occurs on the upper floor and reducing when lowering to the ground level. The influence of bigger imposed load that mostly concentrated in the mid-span and farther from staircases (may react as bracing member) has increased the translation displacement amplitude in transverse direction for C11, but the amplitudes are reducing when approaching to C1 and C21.

Meanwhile, the fundamental frequencies of site have indicated between 2.69 to 3.20 Hz with maximum A_o of 7.8 in NS direction and 2.79 to 2.98 Hz at 7.46 of A_o in EW direction. Reliability and clarity checking are also performed as recommended by SESAME [13] guideline. In terms of resonance potential of site-structure, it is expected to be classified in moderate level that could be occurred under equal oscillation between building and ground surface frequencies, possibly by strong ground shaking which also lead to structural damages.

Finally, from estimation of the total base shear force to EC8 [2] made has indicated that, the notional design ultimate horizontal load for conventional load combination design applied in BS 8110 [3] on existing structure has been exceeded. The design response spectrum is adopted from the extreme earthquake experience ever recorded at 9.3 earthquake magnitude and 530 km of epicenter distance in Kuala Lumpur by Looi et al. [1]. Even, most expectation has been made that a low-rise structure may survive and experiencing to less potential to structural damage compared to high-rise building, however lower natural period from this kind of building that mostly reflected to the highest peak of ground acceleration design response spectra either on hard or soft ground stratification, may influence to seismic damage potential especially for building without seismic design provision.

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