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Expert awareness of wind disaster risk reduction in Northern Peninsular Malaysia

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Abstract. Tremendous damage during windstorm hit rural housing greatly impacted their roofing system in Northern Peninsular Malaysia. Disaster risk mitigation is crucial to overcome the recurrence of these damaging effect yet still unresolved and worsen by years. The pre-identified risk on wind disaster and role of wind codes were studied to minimize the deterioration impact on the property and life. Purposive sampling was adopted for the total number of 107 respondents participate in this survey. Selection of the experts was based on skills capacity, knowledge, and vulnerable experience due to their involvement in design, build, retrofit, and operate. Pre-identified risk perceptions among expert group was captured using five-point Likert Scale questionnaire survey. The descriptive statistics and index average analysis using SPSS was performed to figure out the importance level of risk identification and the most significant influence factor between the pre-identified risks. This paper aims to explore the wind disaster awareness and risk mitigation perception among the expert. This study acts as a starting point to reconcile on the mismatch expectation and understanding on wind disaster risk mitigation thus, lead to the reduction of disaster risks.

1. Introduction

Natural disaster is defined as events which is by-product of natural hazards. In the context of natural disaster, it is categorized into three groups namely, are geophysical disaster, hydro meteorological disaster and biological disaster. Storm, hurricane, wave, heat, wild fire, flood and drought are classified under geophysical disaster Tropical cyclones have different appellations in different regions In East Asia, they are known as typhoons, cyclones in the region of Australia and the Indian Ocean, and hurricanes in North and Central America, with different definition [1]. According to [2], tropical cyclone, thunderstorm, tornados, monsoons and gale are referred to windstorm in wide view. Sendai Framework 2015 to 2030, a successor instrument to Hyogo Framework has strong focus on disaster risk management. Disaster Risk Management (DRM) cycle by the United Nations' International Strategy for Risk Reduction adopted four major phases which is (1) hazard identification, (2) mitigative adaptations (hazard mitigation), (3) preparedness planning and (4) recovery and reconstruction planning. Mitigation is defined as any sustained action taken to reduce or eliminate long-term risk to people and property due to hazards and their effects. Hazard mitigation can be achieved successfully by attending good collaboration among construction professional into the DRM framework. These hazard mitigation was divided into structural mitigation and non-structural mitigation [3]. The structural mitigation is normally handled by construction professional and the non-structural mitigation involves developers and planners. Wind codes are enforced to avoid development related disaster in the [4]. The primary objective of these building codes is to ensure life safety during a design event. Structural design to higher standard could minimise the damage impact. However, in terms of budget constraints, owners built only to the minimum standard of building codes [5]. Malaysia experienced this windstorm strike during the transition of these two monsoons which is from

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April to May and in October to November. The monsoon period namely South East Monsoon which occurred in later half of May to November. Meanwhile the North East Monsoon occurred in early November and ends in March. This windstorm occurrence most probably hit the Northern Peninsular Malaysia based on a study by [6]. Recent windstorm increasing trend year by year potentially lead to extensive damage. Roofing system for rural housing is mostly impacted during the event. The windstorm event occurred in microscale that only covers small-scale event and in short within 3 to 10 minutes. Rural roofing system in Malaysia varies depends on the region, districts and culture of each location. As a normality, the roof construct was non-engineered roofing without wind loading consideration during the design stage. Codes on wind loading in Malaysia are based on [7]. According to [8], the roles of engineering and building codes are vital as disaster mitigation tools. The extensive damage mostly affected rural roofing system. This is supported by Majid et al. (2010) who identified that 80% of the damage contribute from windstorm occurred in Peninsular Malaysia. Damage breakdown shows that 47% damage in steel sheet roofing, 30% damage on trusses system, 13% damage on roof tiles and 20% for other related damages. Difficulties in coordinating with large number of stakeholder contributes to inefficient and poor managed wind disaster mitigation especially in Malaysia. Therefore, this paper highlights several topics on risk reduction and mitigation to minimize the wind disaster issues. The paper also explores mitigation aspects that cover wind disaster in Malaysia as a whole, role of codes on wind loading awareness and readiness among experts in Malaysia. Mitigation covers aspects from post disaster assistance to pre disaster readiness thus, lessen the damage from wind occurrence. The study on wind risk mitigation can be considered as vital to help lessen the impact of damage on properties and human life as well. The aim of this study was to identify windstorm disaster awareness as perceived by respondents in Northern Peninsular Malaysia and to compare these experts' perception on the roles of codes for wind loading and rural roofing system.

2. Research methodology

2.1 Case study area

This study generally focused on rural roofing system damage during the windstorm recently in Northern Peninsular Malaysia. Majid et al., (2010) discovered that tremendous windstorm occurred in Northern Peninsular Malaysia was dominant as compared to other parts of Malaysia. There are four states lies in Northern Peninsular Malaysia which are Perlis, Kedah, Penang and Perak. Perlis is situated next to Thailand borders and located in the uppers Northern. Meanwhile, Southern Kedah sharing the similar borders with Northern Penang. Hence, Perak is situated in the southern part of Penang border. Fig. 1 shows the exact location of the study area.



Figure 1. Peninsular Malaysia Map accessed online on 5th February 2016 (www.researchgate.com)

2.2 Case study area

Questionnaire survey was selected as the research approach in order to measure attitudes and rating the behavior among experts on research subject topic. The survey was developed from literature reviews to meet research objectives based on adapt and adopt based questionnaire. Non-probabilistic sampling technique was chosen and known as purposive or judgmental sampling. The reason for using this purposive sampling that who can provide the best information of a study in order to achieve studied objectives [9]. Expert group involved the consultant, contractor, home builder or developer residing within case study area. These group was chosen based on their capabilities and expertise in construction, familiarity in civil and structural design, ability considering the wind loading in the design thus, built on-site, retrofit and operate. Likert scale with five points was adopted in this research to attempt the research questions. Level of importance is referring to scale 1 = no significant, scale 2 = slightly significant, scale 3 = moderately significant, scale 4 = very significant increase with the increase of scale number, for scale 5 = extremely significant'. The data collection was performed by sending the questionnaire by postage and using google forms which link to the recipient email. Total of 292 companies have been informed and contacted by an official letter to explain the purpose of the study and its relevancy using self-addressed and postage paid. The response rate obtained 36.6% gathered survey feedback represent 107 respondent. In order to increase the consistency of respondent feedback and meet 'data saturation point', the similar questionnaire also was circulated by hand to participants. Table 1 presents the summary of respondent descriptions.

Table 1. Summary of respondent descriptions

Experts Group
a) Contractor – registered with CIDB Grade 7 and below; Category B15 for roofing repair.
b) Consultant – registered under Ministry of Finance was selected and experienced in Civil and Structural design.
c) Developer/homebuilder- member of Real Estate and Housing Developer Association, (REHDA).
d) Researcher and academician – conducting research and/or teaching subject related to civil, structural and construction field

Descriptive statistical analysis was performed to describe the respondent demographic and characteristics. In addition, analysis using the cross tabulation on each construct also conducted to compare the results for one or more variables with the results of another. The relative importance index (RII) also was established to figure out the importance level of risk identification and which is more significant between the pre-identified risks.

2.3 Respondent demographic information

Demographic information among consultant, contractor, developer, and homebuilder was obtained to make a number of comparison.

Table 2. Respondents demographic information

	Variables	N=107	Percentage, %
Respondent's Gender	Male	81	75.7
	Female	22	20.6
	No response	4	3.7
Age Range	20-30	35	32.7

	31-40	43	40.2
	41-50	14	13.1
	51-60	8	7.5
	61-70	3	2.8
	No response	4	3.7
Races	Islam	73	68.2
	Buddha	23	21.5
	Hindu	2	1.9
	Others	5	4.7
	No response	4	3.7
Expert Group	Consultant	12	12.2
	Contractor	45	45.9
	Developer	26	26.5
	Homebuilder	1	1.0
	Academician/ Researcher	14	14.3
Educational Background	PMR/SRP	7	6.5
	SPM/MCE	6	5.6
	STPM/Diploma	10	9.3
	Degree	70	65.4
	Masters	5	4.7
	PhD	4	3.7
	No response	5	4.7

This survey involved experts group for the total number of 107 respondents. Descriptive analysis result shows that 12.2% (n = 12) represents consultant, 45.9% (n = 45) contractor, 26.5% (n = 26) from developer, 1% (n = 1) home builder and 14.3% (n = 14) involvement from researcher and academician background. As overall, the highest number of respondents involves are contractor and the least represent home builder. Most of them are project engineer, manager, managing director, quantity surveyor, academicians from government research and development (R&D) agencies such as Construction Research Institute of Malaysia (CREAM). They have wide exposure and great involvement in the activities of construction field.

Male 75.7% (n = 81) respondents are dominant gender as compared to female with the percentage of 20.6% (n = 22) involved in answering the questionnaire. It is proven that construction industry were dominantly conquered by male gender. The highest participations in this study consist of middle age group from 31 to 40 years old (40.2%) followed by age group from 20 to 30 years old (32.7%) and group 41 to 50 years old (13.1%) respectively. Respondents predominantly represent intermediate years of working exposure and expected involve with senior or middle management post to do decision making.

Majority of the respondents 65.4% (n = 70) received formal Bachelor degree. The frequencies also show that less than 10% was among 3.7% (n = 4) PhD holders, 4.7% (n = 5) master degree, 9.3% (n = 10) diploma holders, attending secondary high school pass SPM 5.6% (n = 6) and PMR 6.5% (n = 7) accordingly. It shows that this research represents respondents who have in-depth theoretical and practical. This result reflects that the respondents can be considered as relevant in providing reliable data on the subject matter of this study. Expert evaluate risk in probabilistic manner meanwhile public or lay perception is based much more upon individual personal and historical experiences. It is important to have their gathered feedback to accommodate future scope of improvement on the study matter which leads to disaster risk reduction.

3. Results and discussion

The expert opinions and views on each respondents were gathered based on this pre-identified factor on wind disaster risk mitigation for rural roofing system in Northern Peninsular Malaysia. The pre-identified factors gained from the literature review as follows will be further discussed:

- Wind disaster in Malaysia, and
- Roles of codes on wind loading.

3.1 Windstorm disaster

Table 3 below shows that majority of survey respondents were consistently able to indicate their general awareness on wind disaster in Malaysia. The result indicates a significant answer for most item ranged from (36.7% to 41.8% of total responses). A wind disaster can be considered as extremely significant (54.1%) based on its impact on the loss of properties and lives. This construct can be related to previous research done by [10] who concluded that the occurrence of a disaster can result in direct and indirect impacts. The direct impact refers to the damages to home and contents, damages to firm capital, loss of production, damages to infrastructure, mortality and injury, environmental degradation, and emergency clean-up. Indirect impact implies business interruption, multiplier effect, costly adaptation or utility reduction, mortality injury, and environmental degradation. A total of 41.8% of the respondents in the expert group considered windstorm as a natural disaster that leads to direct and indirect impact (46.9%). This result clearly indicates the great awareness among the expert-group respondents as they believed that windstorm is one of the natural disaster typologies that lead to direct and indirect impacts. The respondents also specified that geographical area plays an important role in contributing to wind hazard mitigation (42.9% of total responses). In Malaysia, there are four terrain categories stated in MS 1553: 2002. According to [11] the probability for a windstorm to occur is influenced by many factors, such as topographic effects, sea land area contrasts, climatic background, population density, and observational possibility. These topographical effects are originated from hilly or open terrain. For example, houses located on hill-top require proper consideration of the increasing wind speed over the hill, which may increase the risk of structure failure [12]. In contrast, [13] concludes that houses that are located in urban, suburban, or forest must be shielded from the wind. Loss of properties and lives also received extremely significant result (54.1%, n = 53). The expert group agreed that a wind disaster causes loss of properties and lives. Their past experiences recorded very rare cases involving mortality following a windstorm in Malaysia. The recurring damages of housing have been observed to be increasing yearly in Malaysia. It can be observed that rural housing has experienced the maximum damage because the structure of the roof was not designed by considering wind load. Item housing sector experience maximum damage during wind disaster resulted in (36.7%) shows moderately significant and very significant for both Likert-scale. Engineered housing are more resistant than non-engineered house during heavy windstorm. This persistence result and percentage of total responses are mostly very significant shown in Table 3.

Table 3. Awareness among expert group on wind disaster in Malaysia expressed as a percentage, (%) of total responses

N=98 Item: Awareness		No significant	Slightly significant	Moderately significant	Very significant	Extremely significant
a) Windstorm is a natural disaster	Count	1	12	17	41	27
	% of Total	1.00%	12.20%	17.30%	41.80%	27.60%
b) Direct and indirect impact	Count	0	4	17	46	31
	% of Total	0%	4.10%	17.30%	46.90%	31.60%
c) Geographical area	Count	0	10	20	42	26
	% of	0%	10.20%	20.40%	42.90%	26.50%

	Total					
d) Losses of property and life	Count	0	3	17	25	53
	% of Total	0%	3.10%	17.30%	25.50%	54.10%
e) Housing experience maximum damage	Count	2	7	36	36	17
	% of Total	2.00%	7.10%	36.70%	36.70%	17.30%

3.2 Roles of wind codes

As illustrated in Table 4 represent data on the roles of building codes on wind loading acceptance by the respondents from expert group. The tabulated data denote the percentage of total responses received for each item of this construct. All items show consistence percentage of total responses (more than 40%). It is indicated the basic wind speed optimization in the design" represents 49% (n = 48) of respondents to be "very significant". The MS1553:2002, specifies that the basic wind speed refers to two zones in Peninsular Malaysia (except for Sabah and Sarawak). These two locations set in the MS1553:2002 is subject to zoning map whereby the basic wind speed for Zone I, Vs = 33.5 m/s and Zone II, Vs = 32.5 m/s. This basic wind speeds require further revision because windstorm occurrence has become apparent in these recent years. Furthermore, introducing a more specific basic wind speed based on location is a good approach to minimizing the risk and possibility of extensive rural housing damage during a high-wind episode. The [14] incorporates the basic wind speed with occupancy or risk category, return period, city or town boundaries, and locations. The following item represent 44.90% of the respondents (n = 44) indicated that the item to be very significant, thus indicating that the amendments of the code of practice are needed. Other outdated parameters such as basic wind speed and return period (year) shall be amended from the last publication in 2002 to suit the current conditions. Improvement on the existing basic wind speed due to the zoning map should be incorporated with findings on the wind-hazard prone areas obtained from this research. Information on the wind distribution map for each state located in the northern region should be added to the guidelines on wind hazard structural mitigation. The result shows that this item "consideration of the wind load on structure" as extremely significant showed by 44.90% of the respondents (n = 44). Basically the result indicates that the respondent strongly accepted the importance of wind loading consideration in wind hazard mitigation. A total of 41.80% (n = 41) of the respondents felt that wind consideration is a significant factor in designing a rural roofing system.

Table 4. Roles of code on wind loading expressed as a percentage, (%) of total responses

N=107 Item: Awareness		No significant	Slightly significant	Moderately significant	Very significant	Extremely significant
(a) Optimization basic wind speed	Count	1	5	23	48	21
	% of Total	1.00%	5.10%	23.50%	49.00%	21.40%
(b) Amendment to code of practice	Count	3	8	26	44	17
	% of Total	3.10%	8.20%	26.50%	44.90%	17.30%
(c) Wind loading design on structure	Count	0	2	12	40	44
	% of Total	0%	2.00%	12.20%	40.80%	44.90%
(d) Wind loading design for rural housing	Count	3	2	17	41	35
	% of Total	3.10%	2.00%	17.30%	41.80%	35.70%
(e) Wind loading design	Count	0	4	14	41	38

for rural roofing housing	% of Total	0%	4.10%	14.40%	42.30%	39.20%
(f) Requirement considering wind load	Count	0	2	16	41	38
	% of Total	0%	2.10%	16.50%	42.30%	39.20%
(g) Establish requirement and certification	Count	1	5	26	40	25
	% of Total	1.00%	5.20%	26.80%	41.20%	25.80%
(h) Provide training	Count	2	6	17	47	25
	% of Total	2.10%	6.20%	17.50%	48.50%	25.80%

In Malaysia, wind loading is not imposed on engineered buildings that are below 10 meter in height. Furthermore, 42.30% by (n = 41) of respondent respondents indicated that the item "wind loading imposed on rural roofing housing" to be very significant too. This findings show that respondents in the expert group perceive to the importance of considering wind load for rural houses. Practically, rural house are non-engineered and constructed by local homebuilder. The local homebuilders built the house based on their hands-on experience and not on relevant formal training. A total of 42.30% of the respondents (n = 41) indicated the item "requirement and certification to consider wind load in the design" to be very significant, and about 39.20% of the respondents (n = 38) accepted that the need to establish wind loading requirement is extremely significant. These items therefore are important indicators in wind hazard mitigation and related to the code of practice. The result also indicates that a wind loading design must be considered in wind hazard mitigation, as reflected by 44.90% of the respondents (n = 44) who indicated it to be very significant. Therefore, this item will play a vital role in resisting or minimizing the damage caused by a disaster. Correspondingly, an earlier work conducted by Sandeeka and Wilkinson (2014) also highlights the improvement of structural design and land-use planning in the Build-Back-Better Framework. A total of 49% of the respondents indicated the item "basic wind speed optimization in the design" to be very significant, and overall, 41.20% of the respondents (n = 40) rated the item "establish requirement and certification" as very significant. These findings indicate the necessity of strict enforcement by respective authorities on the compulsory requirements of wind loading consideration in a rural house design. Failure to comply with the requirements might incur penalties to those who neglect the requirements. As such, this structural mitigation measure requires special attention from the construction, and the role of nonstructural elements should be considered by developers and planners in facilitating reconstruction and recovery activities without compromising on quality [15]. Meanwhile, 48.5% represent (n = 47) indicated the need for training to be very significant. Respondents in the expert group pointed out the need for a formal training on structural wind loading consideration particularly for the rural roofing system. There shall be a requirement for practitioners to attend certain hours of training for their continuous professional development (CPD) and such a training can be organized by the Board of Engineers Malaysia (BEM) (a regulatory body) and Institute of Engineers Malaysia (IEM) (a professional body). These two organizations can be the platforms to channel and disseminate information on this new requirement. Comprehensive education and training for practitioners should be expanded to the tertiary program i.e. university and higher learning centers to make the professionals better prepared to counter the problems associated with hazard risk mitigation. The syllabus should be introduced in the university level to expose future engineers to wind loading consideration in roof design and to the implementation of the enhancement in accordance to the revised codes of practice.

3.3 Relative importance index

As tabulated in below Table 5 shows risk indicator index, RII on wind disaster construct. Item on losses of property and life shows the most importance factor in wind disaster construct indicates RII = 0.862. It was followed by item on disaster level RII = 0.822, direct and indirect impact RII = 0.815,

windstorm as natural disaster RII = 0.809, geographical area RII = 0.776 and housing sector experience maximum damage RII = 0.721. Meanwhile, on the roles of wind codes shows the highest RII goes to item consideration wind loading on structure RII = 0.858, requirement to building RII = 0.830, consideration of wind load on rural roofing RII = 0.822, consideration of wind loading on rural residential RII = 0.806, provide training RII = 0.770, basic wind speed RII = 0.766, establish requirement and certification RII = 0.763 and amendment on wind codes RII = 0.735.From the expert perception, it indicates that wind disaster is more important risk to perceive rather than roles of wind codes on wind loading. The results shows that average RII gained for wind disaster is 0.801 meanwhile, roles of wind codes shows the average RII = 0.794. The result for both construct on the average RII is comparable.

Table 5. Relative indicator index (RII) and average

Item of pre-identified risk on wind disaster	Relative indicator index, (RII)	Average RII
A. Wind disaster construct		
(a) Windstorm as natural disaster	0.809	0.801
(b) Direct and indirect impact	0.815	
(c) Geographical area	0.776	
(d) Losses of property and life	0.862	
(e) Housing experience maximum damage	0.721	
(f) Disaster level	0.822	
B. Roles of wind codes construct		
(a) Basic wind speed	0.766	0.794
(b) Amendment on wind codes	0.735	
(c) Consideration wind load on structure	0.858	
(d) Consideration wind load on rural residential	0.806	
(e) Consideration wind load on rural roofing	0.822	
(f) Requirement to building	0.830	
(g) Establish the requirement &certification	0.763	
(h) Provide training on the wind codes	0.770	

4. Conclusion

The expert awareness of wind disaster risk reduction in northern Peninsular Malaysia were investigated in this study. Results showed that both construct play an important role in the disaster risk reduction pertaining wind disaster risk mitigation in Malaysia. The risk was identified in the very significant to less significant between each construct. Proper planning and strategies shall be implemented in the future from the encountered hierarchical risk to minimize damaging effect to the properties and life. Thus, this study shall benefit the policy maker and governance body in decision making and develop the framework regarding the wind disaster risk mitigation.

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