Key Criteria for Post-Reconstruction Hospital Building Performance

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Abstract. Quality continues to be such an issue in humanitarian projects and it is because the model of quality control in normal business is driven by its customers however, does not operate in the aid sector. Evaluation and monitoring in every building life cycle in reconstruction process is important to increase the quality of the aid project. Among all types of public buildings and facilities, hospital is considered as one of the most essential assets in disaster management. However, there is no list of criteria available yet to evaluate post-disaster hospital building performance. The objective of this study is to identify the key criteria for hospital building. A total of 116 respondents are collected from experts of built environment field and high level position staff in grade B hospital in the capital city of Aceh province, Banda Aceh. After conducting Cronbach’s alpha coefficient test and factor analysis, total twenty-six criteria were found reliable and valid. Subsequent with the relative importance indices (RII) analysis, this study has come out with the top-fifteen most important criteria for post-disaster reconstruction building performance as in order: safety, health, control of environment impact, easiness, accessibility, engineering, building quality, staff and patient environment, comfort, functionality, building form and material, operational maintenance guideline, local institution capacity, architecture, disaster resilience, and the last criterion is sustainability. It is recommended to use these criteria for hospital building performance evaluation especially in disaster prone area. Future study is need to find out that the same criteria is applicable for other type of buildings and locations.

1. Introduction
Indonesia remains one of the poorest countries in South East Asia and the country lags behind in many areas of health-care provision [1]. As one of the poor provinces in Indonesia [2] and because of the long-term socio-political conflict [3, 4], before the Tsunami, health facilities in Aceh were far from adequate [5]. This condition got worse after the Tsunami where in Table 1 shows the number of health infrastructure and facilities in Aceh destroyed by the earth quake and the Tsunami waves in 2004. In Indonesia, there are not many study focus with hospital building performance physically and the fact that the quality of services of hospitals is still relatively poor [6].
Table 1. The effects of the earthquake and Tsunami on health facilities in Aceh [7]

| Health Facilities         | Destroyed (unit) | Damaged (unit) |
|---------------------------|------------------|----------------|
| Hospitals                 | 32               | 9              |
| Local Health Clinics      | 259              | 64             |
| Assisting Local Health Clinics | 830         | 174            |
| POLINDES (Village Polyclinic) | 2,283     | 700            |
| Village Polyclinics       | 21               | 5              |
| Health Service Office     | 4                | 1              |
| Medical Laboratories      | 3                | 3              |
| Harbour Health Office     | 3                | 1              |

After more than four years of rehabilitation and reconstruction period, the government and aid agencies were able to repair and build 276 local assisting health clinics, 211 local health clinics, 395 village polyclinics (POLINDES), and revitalized 28 hospitals all over Aceh [5]. This far exceeds the number of hospitals and health services damaged by the earthquakes and tsunami. It should be said that health facilities before the disasters were in a state of neglect and the need for health facilities has substantially increased in the aftermath.

While scientific research on global vulnerability to hazards, risk reduction and disaster resilience is on the rise, disasters continue to have severe consequences such as deaths, huge economic loses and social disorder [8]. To be able to learn and gain feedback from post-disaster hospital building reconstruction, first it is necessary to know the actual performance of the hospital building. In order to evaluate the performance of the post-disaster hospital building, it need to have a list of criteria. Without criteria, it is difficult to measure the building performance. However, the list of criteria for post-disaster hospital reconstruction building performance is not available. In order to evaluate post-disaster reconstruction building, this study objective is to identify the key criteria for hospital building. If a building is not productive then it cannot be sustainable and this highlights the need for feedback on building performance to ensure that a building provides maximum benefit throughout its life-cycle [9].

The results from hospital building performance evaluation in this study are a list of recommendations as “evidence-based design” which may guide future design of hospital building in disaster prone area.

2. Post-Tsunami Hospital Reconstruction in Aceh-Indonesia

Rehabilitation and reconstruction are the two most expensive activities in disaster management process. Reconstruction takes a longer time compared to other phases [10, 11] and according to Hidayat and Egbu [12] plays the most important key role in disaster management because the quality of constructed houses or buildings and infrastructures during reconstruction phase will influence vulnerability for next disaster. Reconstruction should not be seen as an isolated activity. It is a unique opportunity to carry out other mitigation programs. Reconstruction also has a direct link to development [13], is considered an opportunity and is linked to vulnerability reduction measures [14]. Lyons and Boano [15] argued that to achieve sustainability, vulnerability reduction and increased resilience of a population and its built environment, post-disaster reconstruction must adopt an approach rooted in development theory and practice.

Because of the unprecedented scale of the disaster, and the unprecedented scale of the humanitarian response from around the world, the Indian Ocean tsunami of 2004 provided a turning point in the history of post-disaster reconstruction [15]. The total worth of projects and programs around $7.7 billion U.S. allocated by almost 500 organizations making it the largest reconstruction project in the developing world, Aceh’s post reconstruction experience may provide useful lessons [16].
Various public facilities are essential for communities and should also be restored early on, such as schools, clinics or hospitals, building for local government administrations, and meeting spaces [17]. According to da Silva [18] it is essential that schools and health care facilities are fit for purpose and built soundly. Therefore, this study focuses in hospital buildings as one of the important assets in disaster management.

3. Post-disaster Hospital Building Performance Criteria

Post disaster reconstruction, viewed in a positive light, may be considered as an opportunity for the stakeholders to build back better [19]. With building performance evaluation (BPE) - a robust assessment of building performance, it is possible to understand how buildings perform, how they are used, nor how to make them better [20, 21]. Based on the literature review, this study has come out with a framework for BPE in post-disaster hospital reconstruction that consists of four variables and under each main variable there is a list of criteria. This study has proposed 26 criteria to measure post-disaster hospital building performance (see Figure 1). The structure discussion is divided into each main variable: “Built Environment and User Building”, “Building System Levels”, and “Disaster Risk Management (DRM)”:

- **Built environment and building user** - in this study the criteria to measure built environment and building user variable is adopted from Achieving Excellence Design Evaluation Toolkit (AEDET) evolution concept [22] that has been used as health-care building evaluation through post-occupation stage. Built environment and building user has three sub-variables with a total of ten criteria: (a) Functionality: use, access, and space; (b) Build quality: performance, engineering, and construction; (c) Impact: character and innovation, form and material, staff and patient environment, and urban and social integration.

- **Building system** - the criteria to measure building performance variable is based on the building performance evaluation concept and generated from local building regulations of Aceh province in Indonesia in order to be in accordance with local customs and needs. There are three sub-variables under building performances with nine criteria: (a) Technical: safety, health, and comfort; (b) Process: easiness, control and environment impact, and building construction implementation; (c) Functional and behavioral: architecture, community role, and building allocation and intensity.

- **DRM** - in this study, DRM is the new main variable that is added into the post-disaster reconstruction BPE model. Therefore, the nature of the variables has not been tested. Based on literature review, the criteria to measure DRM variable is divided into two sub-variables with seven criteria: (a) Disaster risk resilience (DRR): disaster resilience, functionality, building report under hazard, local institution capacity; and (b) Sustainable development: sustainability, operational and maintenance guidelines, and social acceptability

Later on, the proposed 26 criteria to measure post-disaster hospital building performance needs to be confirmed by the experts. It is important to identify the most essential criteria to be included in the framework [23]. For detail references of each criteria is available in appendix A.
4. Research Methodology

The research problem of this study is based on existing concept (BPE) and known variables (built environment, building system level, and additional disaster risk management variable), therefore, this study is categorized into positivist paradigm with quantitative approach. BPE techniques commonly used to collect data of building-user relationships, i.e., questionnaires, interviews, field observations, walk-through, workshop sessions, photographic surveys, recordings of the use of time, and looking at the physical evidence of use [24]. The method in data collection is individually delivered questionnaires given to a respondent. The population is divided into two groups: experts in built environment and building user from top management level staff. This study used non-probability sampling for expert group since inability to identify members of the population is one of the main reasons. For the building user group, the population in this group is top management staff in dr. Zainoel Abidin Hospital located in Banda Aceh as the highest grade available in Aceh during the study conducted. Top management level was chosen in order to correspond with experts in built environment group which are: director, deputy director, and all head staff positions. Usually experienced researchers regard a sample of about 100 respondents as the minimum sample size for large population [25]. Therefore, the sample size in total is minimum 100 respondents.

The level of measurement is ordinal by Likert scale with five points scale and later convert to continuous data. The study adapted the questionnaires format from Izran [26] that conducted a study to identify the most important criteria and indicators of building performance evaluation for hospitals in Malaysia. The conceptual performance criteria for building performance evaluation were listed as the subject of the question, and each of the performance criteria were weighted in Likert scale of five ordered response levels as follow: very important (5), important (4), neutral (3), less important (2), not important (1).

Data analysis conducted through Cronbach’s alpha coefficient test to figure out the level of reability and factor analysis used to measure the validity of the total 26 criteria by SPSS statistic software version 19. Afterwards, the valid and reliable criteria subsequent with the relative importance indices (RII) analysis to identify the top 15 most important criteria. The five-point scale was transformed to relative importance indices using the relative index ranking technique [27, 28] to determine the rankings.
of the factors and verify the evaluation by the mean score. The RII were calculated using the following formula [29, 30]:

\[ RII = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{A(n_1 + n_2 + n_3 + n_4 + n_5)} \times \frac{W}{AN} \] (1)

Where \( n_1 \) = number of respondents for ‘very important’; \( n_2 \) = number of respondents for ‘important’; \( n_3 \) = number of respondents for ‘neutral’; \( n_4 \) = number of respondents for ‘less important’; \( n_5 \) = number of respondents for ‘not important’, or \( W \) is the score given to each factor by respondents, ranging from 1 to 5. \( A \) is the highest score (\( A \) is 5 in the study) and \( N \) is the total number of samples, \( (0 < RII < 1) \).

5. Results and Discussion

5.1. Respondents Profile

Overall 200 questioners were distributed with a 58% response rate. In total, this study managed to collect 125 respondents but only 116 questionnaires usable since the rest is not filled completely. There are 64 respondents from built environment expert field and 52 respondents from hospital staff. Based on their expertise, domination comes from “architecture” field (27 respondents) followed from “urban planning and design” (20 respondents) and only one respondent from “interior design” field. For hospital staff the majority is in “others from hospital service” (17 respondents) which includes nurses, head of wards, and facility manager. They preferred to identify their position in detail because the alternative positions listed on the questionnaire are general. The respondent academic background shows an equal amount of undergraduate and postgraduate respondents (46.6% in each category). The rest of 6.9% respondents are from PhD. Meanwhile, for years of experience, majority (38.8%) of respondents being in the range of 5-10 years followed by 23.3% of respondents having 11-15 years of work experience. There are only 6.9% respondents that have less than five years work experience. In the big picture, there is modest distribution between respondents from built environment expert field and hospital top position staff. Mostly, they have adequate academic backgrounds and considered as senior in their field as majority have more than 5 years working experience. This respondent profile is important to justify the result of this study. Since the objective is to identify criteria of hospital building performance, respondents qualification must be confidence enough in able to do so.

5.2. Factor Analysis and Reliability Test

Factor analysis also is used here to check the validity of the criteria. Factor analysis procedures provide reasonable justification to construct validity [31]. The results from the factor analysis for “Built Environment and User Building” variable shows that the ten criteria under built environment and building user are valid and significant. Based on the correlation matrix, the ten criteria are highly correlated with correlation above .3. The KMO and Bartlett tests show that the KMO value is .831 and the Bartlett’s test is significant (\( p=.000 \)). The anti-image matrices show that there is no variable which has a small loading number value (<.5) and most of them are considered high (>0). Factor analysis for “Building System Levels” variable found out that nine criteria are considered as reliable and should not be dropped for further analysis. Based on the correlation matrix, the nine criteria are highly correlated with correlation above .3. The KMO and Bartlett tests shows that the KMO value is .834 and the Bartlett’s test is significant (\( p=.000 \)). The anti-image matrices shows that there is no variable which has a small loading number value (<.5) and most of them are considered high (>0). Therefore, the nine criteria under building system are valid and significant. Lastly, factor analysis for “DRM” shows that the seven criteria are considered as reliable and should not be dropped for further analysis. Based on the correlation matrix, the seven criteria are highly correlated with the correlation above .3. The KMO and Bartlett tests shows that the KMO value is .711 and the Bartlett’s test is significant (\( p=.000 \)). The anti-image matrices shows that there is no variable which has a small loading number value (<.5) and the criterion is considered high (>0). The overall assessment shows that the seven criteria under building system are still considered as valid and significant.
For all 26 criteria, this study had run Cronbach’s alpha coefficient test to check the reliability level which is recommended by Pallant [32] as one of the most commonly used indicators for internal consistency. The Cronbach’s alpha coefficient was .911 for the total of the twenty-six variables of building performance criteria. Ideally the Alpha values of a scale should be above .7 [32]. Therefore, the ten criteria under built environment and building user variables are considered as reliable and should not be dropped for further analysis.

5.3. RII Test
In addition to the mean score, the five-point scale was transformed to relative importance indices using the relative index ranking technique [27, 28], to determine the rankings of the factors and verify the evaluation by the mean score. In this study, the N value is 116 and A value is 5. First, this study calculates the RII score in each item under each criterion. Later, this study calculates the average of RII scores in each criterion to identify the rank (appendix B).

From total of 26 criteria, there are only 16 variables considered into top-fifteen most important criteria (see Figure 2). ‘Building form and material criterion’ have the same score with ‘operational maintenance guidelines’ that makes both criteria in the same position number 11. There are five most important criteria to measured “built environment and building user” variables: building form and material, staff and patient environment, accessibility, and engineering, and building quality. There are six most important criteria to measured “building system” variable: safety, health, comfort, easiness, control of environment impact, and architecture. There are five criteria to measured “DRM” variable: operational and maintenance guidelines, sustainability, functionality, local institution capacity, and disaster resilience.

Figure 2 shows the list of criteria in sequence based on the most important starting from safety, health, control of environment impact, easiness, accessibility, engineering, building quality, staff and patient environment, comfort, functionality, building form and material, operational maintenance guideline, local institution capacity, architecture, disaster resilience, and the last criterion is sustainability.

Durasol et al. [33] explained 15 criteria that need to be considered in POE of hospital building performance. These 15 criteria are similar to the one in this study except for “security”, “social needs”, “building economics”, and “psychology”. “Efficiency” in the list of Durasol et al. [33] has the same meaning for “sustainability” in this study and “operational and maintenance” is covered under “local institution capacity” in this study. “Durability” and “adaptability” are the items under “building form and material” meanwhile “circulation” are explained by “access” in this study. The rest of the ranks are different in this study because it involved disaster risk management variable as a new variable. “Health”, “comfort”, “building quality”, “physical condition within the environment” including lighting, noise, and air are some of the criteria from this study that are included in the 12 topics normally asked as identified by Cohen et al. [34]. Horgen and Sheridan [35] has listed seven key criteria for building performance and four out of seven are included in the top-fifteen criteria in this study. They are air quality, thermal, lighting, and noise comfort which all goes under “comfort” criterion in this study. Several studies supported these items – as part of indoor environment quality – contributed to the building occupants’ satisfaction [36] and rated as the most important items [37]. These items also plays important indicator in the context of “sustainability” criteria for BPE [38]. Fire resistance as part of the “safety” criterion is also listed as one of the key performance requirement in ISO 6241 [39].
The necessity to “pick” criterion according to Douglas [39] is because the building performance concept has its weaknesses. Buildings are a complex arrangement of systems and sub-systems and like any other entities, for each building “the whole is more than the sum of its part”. Additionally, it also important to realize that BPE studies frequently reveal performance gaps: difference between the intended and actual performance [40]. Therefore, the selection of performance criteria has to be done within the context of the property concerned and based on the need of the client.

6. Conclusion

By identifying fifteen most important criteria, not only this study focused on the most important one but it is also more reasonable to conduct an evaluation with no overloaded criteria. This study has interpreted the model into post-occupancy evaluation for post-disaster reconstruction hospital building in the case of Aceh, Indonesia. Within the specific scope of study, this study recommended twenty-six criteria that contain 72 items. The list of criteria in sequence based on the most important starting from safety, health, control of environment impact, easiness, accessibility, engineering, building quality, staff and patient environment, comfort, functionality, building form and material, operational maintenance guideline, local institution capacity, architecture, disaster resilience, and the last criterion is sustainability. Based on this top fifteen most important criteria, it is recommended to be used for hospital building performance evaluation in disaster prone area. However, there is a need to conduct similar study in the future in order to figure out if the 15 criteria are suitable for other types of buildings. Location also important aspect in building performance and therefore study in different location is required.

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REFERENCES

[1] Task Force Health Care. Indonesia Medical Devices & Infrastructure Report. The Netherlands: Task Force Health Care, 2017.
[2] Evans H. Provincial Human Development Report Aceh 2010. Banda Aceh: UNDP - Indonesia, 2010.
[3] Reid A. Verandah of Violence, The Background to the Aceh Problem. Singapore: Singapore University Press 2006.
[4] Soesastro H,Ace R. Survey of Recent Developments. Bulletin of Indonesia Economic Studies. 2005;41:5–34.
[5] BRR NAD-Nias. Education, Health, Women Empowerment: Preparing Quality Generation. Banda Aceh: BRR NAD-Nias, 2009.
[6] Alfansi L,Atmaja FT. Service Failure and Complaint Behavior in the Public Hospital Industry: The Indonesian Experience. Journal of Nonprofit & Public Sector Marketing. 2009;21(3):309-25. Epub 11 Augustus 2009.
[7] Wibisana BH,Bitai CC. Education, Health, Women Empowerment. Riyanto AS, editor: BRR NAD-Nias; 2009.
[8] Bilau AA,Witt E,Lill I. Analysis of Measures for Managing Issues in Post-Disaster Housing Reconstruction. Building. 2017;7(29):1-26.
[9] Brooks ST,Vicccars G. The Development of Robust Methods of Post Occupancy Evaluation. Facilities. 2006;24 (5/6):177-96.
[10] Joakim E. Post-Disaster Recovery and Vulnerability. Ontario, Canada: University of Waterloo; 2008.
[11] Mileti D. Disasters by Design: A Reassessment of Natural Hazards in the United States. Washington, D.C.: Joseph Henry Press.; 1999.
[12] Hidayat B,Egbu C. A literature review of the role of project management in post-disaster reconstruction. In: Egbu C, editor. Procs 26th Annual ARCOM Conference; 6-8 September 2010; Leeds, UK: Association of Researchers in Construction Management; 2010. p. 1269-78.
[13] Aysan Y,Davis I. Rehabilitation and Reconsruction. UNDP; 1993.
[14] Shaw R. Indian Ocean Tsunami and Aftermath. Need for Environment-Disatser Synergy in the Reconstruction Process. Disaster Prevention and Management. 2006;15:5-20.
[15] Lyons MTS,Boano. Building Back Better: delivering people centered housing reconstruction at scale. Rugby, UK: Practical Action Publishing; 2010.
[16] Masyrafah H,McKeon JMJA. Post-tsunami Aid Effectiveness in Aceh: Proliferation and Coordination in Reconstruction: Wolfensohn Center for Development; 2008.
[17] Jha AK,Barenstein JD,Phelps PM,Pittt D,Sena S. Safer Homes, Stronger Communities: A Handbook for Reconstructing after Natural Disasters. Washington DC: World Bank; 2010.
[18] da Silva J. Lessons from Aceh: Key Considerations in Post-Disaster Reconstruction. Warwickshire, UK: Practical Action Publishing; 2010.
[19] Shafique K,Warren CMJ. Stakeholders and Their Significance in Post Natural Disaster Reconstruction Projects: A Systematic Review on the Literature. Asian Social Science. 2016;12(10):1-17.
[20] Dimitrijevic B, editor. Building Performance Evaluation. Switzerland: Springer International Publishing; 2013.
[21] Sharpe T. Ethical issues in domestic building performance evaluation studies. Building Research & Information. 2019;47(3):318-29.
[22] AEDET. Achieving Excellence Design Evaluation UK: Department of Health; 2003.

[23] Sharma A, Prinja S, Aggarwal AK. Measurement of health system performance at district level: A study protocol. Journal of Public Health Research. 2017 Dec 13;6(3):917. Epub January 2018.

[24] Zimring C, Rashid M, Kampschroer K. Facility Performance Evaluation (FPE) 2014 [cited 2016 February].

[25] Alreck PL, Settle RB. The Survey Research Handbook. third ed. New York: McGraw-Hill; 2004.

[26] Izran S. Performance Criteria and Parameters for Post-Occupancy Evaluation of Building Performance: Universiti Teknologi Malaysia (UTM); 2010.

[27] Chan EHW, Au MCY. Factors influencing building contractors’ pricing for time-related risks in tenders. Journal Construction Engineering Management. 2009;135(3):135–45.

[28] Tarawneh SA. Evaluation of pre-qualification criteria: Client perspective; Jordan case study. Journal Apply Science. 2004;4(4):354–63.

[29] Chinyio EA, Olomolaiye PO, Kometa ST, Harris FC. A needs-based methodology for classifying construction clients and selecting contractors. Construction Management and Economics. 1998;16(1):91–8.

[30] Shash A. Factors considered in tendering decisions by top UK contractors. Construction Management and Economics. 1993;11(2):111–8.

[31] Lu CH. Assessing construct validity: The utility of factor analysis. Journal of Educational Measurement and Statistics. 2006;15:79-94

[32] Pallant J. SPSS Survival Manual: A step by step guide to data analysis using SPSS for Windows (Version 12). 2nd ed. Australia: Allen & Unwin; 2005.

[33] Dorasol N, Sarrazin I, Hakim A, Hamadan N, Nik Lah NMI. POE Performance Criteria and Parameters for Hospital Building in Malaysia. 3rd INTERNATIONAL CONFERENCE ON BUSINESS AND ECONOMIC RESEARCH; 12 - 13 MARCH; Bandung, Indonesia 2012.

[34] Cohen R, Standeven M, Bordass W, Leaman A. Assessing building performance in use 1: the Probe process. Building Research and Information. 2001;29(2):85-102.

[35] Horgen T, Sheridan S. Post-occupancy evaluation of facilities: a participatory approach to programming and design. Facilities. 1996;14(7/8):16-25.

[36] Frontczak M, Schiavon S, Goins J, Arens E, Zhang H, Wargocki P. Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. Indoor Air. 2012;22:119–31.

[37] Konara, Sandanayake. Building Post Occupancy Evaluation Framework. IRCMF, editor. Colombo, Sri Lanka: University of Colombo; 2010.

[38] Meir IA, Garb Y, Jiao D, Cicelsky A. Post-Occupancy Evaluation: An Inevitable Step Toward Sustainability. ADVANCES IN BUILDING ENERGY RESEARCH. 2009;3:189–220.

[39] Douglas J. Building Performance and its Relevance to Facilities Management. Facilities. 1996;14(13):23-32.

[40] Sharpe T. Mainstreaming building performance evaluation for the benefit of users. Building Research & Information. 2019;47(3):251-4.
Appendix A

Table – Post-disaster building performance criteria by authors

| No | Building Performance Criteria | (Proctor, 1996; Freier, 2001) | (Zimmerman and Marlin, 2001) | CEFR (Baird et al., 1996) | (Levy et al., 2008) | (US-Habitat and UNIDR, 2012) | CBP (CBE, 2012) | (Kosara and Sandmanovics, 2010) | (Myers et al., 2013) | (NIEH, 1993) | (Cohen et al., 2001) | (Institute of Medicine, 2005) | (FEMA, 2009) |
|----|------------------------------|-------------------------------|------------------------------|--------------------------|---------------------|-------------------------------|----------------|-------------------------------|---------------------|----------------|---------------------|---------------------|-------------|
| 1  | Character  | x                             | x                            | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 2  | Vulnerability  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 3  | Form & Material  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 4  | Safety & Security Environment  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 5  | Infrastructure  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 6  | Building Quality  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 7  | Construction  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 8  | Use  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 9  | Accessibility  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 10 | Space  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 11 | Safety  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 12 | Health  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 13 | Comfort  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 14 | Environmental  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 15 | Building Location  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 16 | Architecture  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 17 | Control Environment Impact  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 18 | Building Construction Implementations  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 19 | Community Value  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 20 | Disaster Resilience  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 21 | Local Institution Capability  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 22 | Preparedness  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 23 | Survivability  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 24 | Overall Condition  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |
| 25 | Recovery  | x                             |                             | x                        | x                    | x                            | x              | x                             | x                   | x              | x                   | x                   | x           |

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## Appendix B

| Post-Disaster Building Performance Criteria | RH      | Rank |
|--------------------------------------------|---------|------|
| Character Design & Innovation              | 0.114   | 16   |
| Building Form Material                     | 0.83    | 11   |
| Staff Patient Environment                  | 0.8375  | 8    |
| Urban Social Integration                   | 0.565   | 23   |
| Accessibility                              | 0.86    | 5    |
| Space                                      | 0.70    | 21   |
| Engineering                                | 0.85    | 6    |
| Construction                               | 0.80285 | 18   |
| Utilisation                                | 0.79857 | 20   |
| Building Quality                           | 0.945   | 7    |

| Building System Functional Technical       | RH      | Rank |
|--------------------------------------------|---------|------|
| Safety                                     | 0.85833 | 1    |
| Health                                     | 0.366   | 2    |
| Comfort                                    | 0.836   | 9    |
| Ease of Use                                | 0.87    | 4    |
| Control Environmental Impact                | 0.88    | 3    |
| Architecture                               | 0.824   | 13   |
| Building Allocation Intensity               | 0.7375  | 23   |
| Building Construction Implementation        | 0.803   | 17   |
| Community Roles                            | 0.77    | 22   |
| Operational & Maintenance Guidelines       | 0.83    | 11   |
| Sustainability                             | 0.8175  | 15   |
| Building Report Performance Under Hazard    | 0.80    | 19   |
| Functional                                 | 0.83461 | 10   |
| Social Acceptability                        | 0.73    | 25   |
| Local Institution Capacity                 | 0.82666 | 12   |
| Disaster Resilience                        | 0.82    | 14   |