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Disaster-resistance profile of donor-provided post-*Durian* dwellings in Albay, Bicol Region: Inputs to sustainable mass housing programs

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Abstract. The Philippines was ranked as one of the disaster hotspots globally, where perennially a number of lives were lost and considerable government resources were exhausted in rebuilding infrastructures annually, notable of which was the 250-kph typhoon Durian in 2006. In this regard, for the study locale, the Albay Province in Bicol Region was chosen, cited as one of the United Nations (UN) twenty-nine community exemplars for disaster risk management and reduction - made possible partly by active collaboration among the different actors and donors - national government, the local government units (LGUs) and their non-governmental organizations (NGOs) counterparts, primarily on post-disaster housing units. Thus, this study investigates the structural profiles of their newly built homes, as the first variable, evaluated by researcher, with recipients' descriptive observations of any physical damage due to subsequent post-Durian calamities in the resettlement site as the second variable for the period 2007-2012. Triangulated study results indicate that only five out of nine housing design variants from seven donors were generally disaster-resistant, based from structural description, site condition, actual housing damage level inflicted by post-Durian calamities and ocular inspection. These indicate that resistance to future natural disasters for these donated dwelling units remain uncertain, allowing room for possible disaster risks.

Keywords: Disaster risk management and reduction; house maintenance; structural description profile; actual housing damage level; housing donors

1. INTRODUCTION AND BACKGROUND TO THE STUDY

1.1. Philippines' Albay Province assessed as natural disaster hotspot in the country

The Albay province in the Bicol region, Philippines was assessed thru government-sanctioned hazard mapping as having "highest risk" to climatic disasters (*Department of Environment and Natural Resources*, 2010; *Philippine Atmospheric Geophysical and Astronomical Services Administration.*, 2010). The most notable of these were the typhoons *Xangsane* last September 2006 and *Durian* last November 2006, claiming at least 14 and 1,000 lives respectively, with estimated damages at Php 5 billion. For this paper, the municipalities of Legaspi, Daraga and Camalig, all within the political jurisdiction of Albay province, were the study locale, containing the highest variation and concentration of these post-disaster housing units. Typhoons *Xangsane* and *Durian*'s aftermath in 2006 prompted the Philippine National Government in allotting Philippine pesos 750 million last 2007 for the *housing cluster* under the Department of Social Welfare and Development (DSWD) – CARE program for both new housing construction in resettlement sites (displaced by mudslides), and repair of existing houses for the economically-disadvantaged inhabitants, while there was an influx of international non-governmental organizations (NGO) who provided financial assistance in the housing delivery, which includes *Habitat for Humanity*, and *Gawad Kalinga*, among others through *sweat-equity* mode (donor provides for dwelling materials while labor is provided by the shelter beneficiary) while a lone donor *International Organization for Migration* provided housing on a turn-key basis. The rapid institutional response and disaster-risk reduction mechanisms that were put in place for Bicol Region in dealing with these natural disasters, placed the Province of Albay as one of the models for Disaster Risk reduction by the United Nations (Sabater, 2010)

However, some administrative officials from the Philippines' National Housing Authority (NHA) for Region V, covering Bicol province, commented that the architectural and structural designs used for these NGO-donated post-disaster housing units failed to secure any municipal building permits nor did not pass through NHA for preliminary approval due to time constraints, which gives room for any possible element of 'uncertainty' or 'risk' that might lead to possible housing damage when subsequent natural calamities strike the resettlement sites.

There is a tendency that relief organizations will have an *ad hoc* tactical decision making in planning for household reconstruction, which can be prone to errors and risks (Johnson, 2007), and donors' involvement with risk management depends on internal coordination among actors and competition of interests with external priorities (Benson and Clay, 2000).

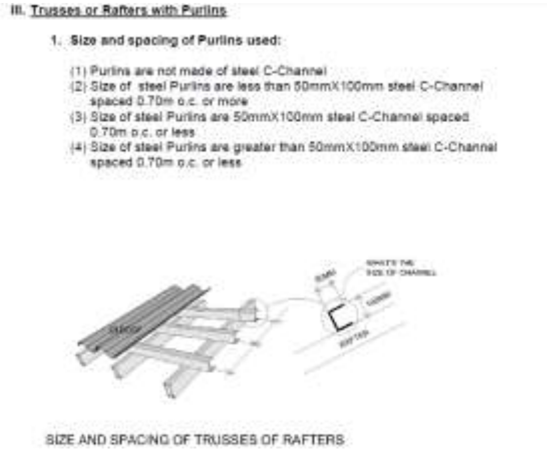
Disaster risks for the dwelling unit include possible physical damage caused by faulty engineering design (one of *technological hazards* based from United Nations International Strategy for Disaster Reduction (2007) and improper handling and upkeep by the inadequately-trained and informed housing recipient due to either fatalism (Bosher, 2011; Turner, Nigg and Paz, 1986), lack of knowledge (Bencze and Tilotta, 2010; *United Nations – Office for the Coordination of Humanitarian Affairs*, 2006) or false perception (Sinha, 2007). For the beneficiary, this includes possible loss of life due to housing unit damage during and after a calamity strikes and loss of livelihood which render the housing program in the long run unsustainable, thereby eating up meager resources for house reconstruction, which can ideally instead be used for livelihood, where the outcome of a disaster is shaped both by the physical nature of the hazard and the *vulnerability* of people who are involved like those residing in hazard-prone locations, substandard housing quality and lack of disaster preparedness (Bosher, 2011) Any lapses in the conduct of post-disaster housing programs will give way to possible risks to future natural calamities as well. (UN/OCHA, 2006).

2. METHODOLOGY

The objectives of this paper are (a.) to quantify and present the level of *disaster-resistance* of the different housing design variants and (b.) to determine the sustainability, or long-term practicability of the existing mass housing programs. Thus, to address the first objective, the disaster-resistance to earthquake, typhoon and flooding of these post-disaster houses were investigated based on the data gathered from - firstly, structural description profile of the nine (9) housing designs (based from blueprints or electronic files of working drawings provided by donors), secondly, the actual housing damage level survey that were answered by the housing beneficiaries, third, ocular visits and photo documentation by the researchers to the resettlement sites to ascertain the actual condition of these houses for the period January 2007 to October 2012, fourth, interviews with the technical personnel among the housing donors for clarification on architectural and structural details on housing designs, and lastly, focus group discussions with the housing beneficiaries. The entire study duration took nine (9) months.

For the housing beneficiaries, there were five (5) adult male and five (5) adult female study participants, equally distributed for gender-sensitivity reasons, for each housing design variant (one participant per sampled house), amounting to ninety (90) participants that were randomly sampled based on actual location, and who are at least eighteen years (18) of age and have been survivors of the Typhoon *Durian* in Albay last November 2006. On the other hand, for the nine (9) housing design variants, these came from seven (7) housing donors who participated in this study. Except for Habitat for Humanity and Operation Compassion-*Amore* which have two housing design variants each, the rest of the donors employed one housing design variant. The housing design variants that were evaluated were built in four (4) separate locations in Albay Province – in Taysan in Legaspi, Camalig in Tagaytay, Anislag Phase II in Daraga, all of which were government-owned relocation sites (under National Housing Authority's (NHA) jurisdiction) and Daraga (privately-owned land, under Amore). Except for Habitat housing variants which used either steel frame-and-fiber-cement board combination or load-bearing interlocking masonry blocks for walls without columns, the rest employs traditional reinforced concrete system (normal concrete masonry walls, tied beams, tied columns, tied footings and slabs). For the roofing systems, only the IOM uses a slightly-sloped reinforced concrete slab, while the rest, either steel purlins and rafters or wooden truss members covered with corrugated galvanized steel roofs. Of the seven (7) housing donors, only one came from the government (DSWD), the rest were NGO's. Of the six (6) NGOs, Habitat for Humanity (HAB-SF, HAB-MAS), Gawad Kalinga (GK), International Organization for Migration (IOM), Operation Compassion (OC) and Daughters of Charity (DC) were international donors, while Community Organizations of the Philippines Enterprise (COPE) operates only in the Philippines.

There were two test instruments employed, corresponding to the two variables. For the first variable, structural description profile of housing design variant is a *rating scale*-coded (from 1 to 4) descriptive assessment survey form, represented by four (4) descriptive sub-statements, with increasing level of structural resistance to natural disasters for each descriptive sub-statements 1 to 4. Each four (4) descriptive sub-statements makes up to one (1) descriptive general statement, and the entire survey kit consists of fifty-six (56) descriptive general statements, covering practically every part of the dwelling unit that was divided into four (4) major parts, namely – *physical dimensions* of structural elements, and *number, spacing* and *thickness* of steel reinforcements for firstly, foundation, secondly, structural frames (beams, columns and walls), thirdly, trusses or rafters with purlins and shape of the roof, and lastly, environmental factors (typhoons, earthquakes and floods). These four (4) major parts considers both (a.) the physical description of the structure itself (as listed above) and (b.) the site conditions (environmental factors such as location of water table beneath, soil bearing capacities, distance from earthquake fault lines, siting of dwellings with respect to landslide potential, among others) where the said structure is situated (IAEE, UNESCO & IISEE, 2010). Graphic images were also provided for most of the descriptive statements. These fifty-six (56) general descriptive statements were adapted from the United Nations - International Bank for Reconstruction and Development (2009) *Guidance Notes on Safer School Construction Checklist*, the Philippines' *National Building Code* (Presidential Decree 1096), the National Structural Code of the Philippines (NSCP), the Unified Soil Classification (USC) system and other relevant literature for both architectural design and structural engineering. The baseline score is between minimum of 3.0 to a maximum of 4.0, from the average of the combined scores of all fifty-six (56) descriptive general statements where it is assumed that the minimum structural requirements for Intensity 9.0 Earthquake, National Structural Code of the Philippines (NSCP) Zone IV (250 Kph) wind load and 3.0 meter high flooding were *satisfactorily* met, that were jointly prepared and for sole use by the researcher and the external consultant (structural engineer). The descriptive general and sub-statements are based from a complete structural computation of a typical single-storey dwelling (with a minimum 3,000 psi compressive strength for reinforced concrete portion) based from *earthquake load analysis* (Eqn. 208-4 from NSCP 201 sect. 208.5.2.1) , *wind load analysis* (Duchemin's formula based on 70miles/sec or 250kph from NSCP 2001 Wind zone map), and *structural component investigation* (Eqns. 203-14 & 203-5 of NSCP 2001 section 203, ultimate moment capacity (NSCP 2001 section 410.13 magnified moments – non sway frames), steel purlin design based from properties of C 6 x 13 (C-1 & C-2 (Agoncillo, 2004), steel rafter design based from properties of 2 – L10mm x 75mm x 8mm ([1] DA – 2)). If the over-all average score is between 1.00 to 1.99, and 2.00 to 2.99 these indicates being *highly disaster-prone* and *disaster-prone*, respectively (Agoncillo, 2004;, Gillesania, 2004; National Structural Code of the Philippines, 2001). This test instrument is shown in **Figure 1**.



III. Trusses or Rafters with Purlins

1. Size and spacing of Purlins used:

(1) Purlins are not made of steel C-Channel
(2) Size of steel Purlins are less than 50mmX100mm steel C-Channel spaced 0.70m o.c. or more
(3) Size of steel Purlins are 50mmX100mm steel C-Channel spaced 0.70m o.c. or less
(4) Size of steel Purlins are greater than 50mmX100mm steel C-Channel spaced 0.70m o.c. or less

SIZE AND SPACING OF TRUSSES OF RAFTERS

Figure 1. Part of first test instrument-*Structural Description* Profile of the Housing Variants

For the second variable, the Actual Housing Damage Level survey form (Test Instrument No.2) has a similar *rating scale* set-up (1 to 4) with that of the Structural Description Assessment Form, however, contains three (3) major parts, namely typhoon (with three general descriptive statements), earthquake (with four general descriptive statements) and flooding (two general descriptive statements). Each part was treated separately in obtaining their mean *rating scale* scores. Each of the natural calamity (typhoon, earthquake and flooding) has their own respective descriptive sub-statements for each part of dwelling part (roof, walls, windows/doors, columns, beams, entire dwelling unit), assigned with *rating scale* coded values from 1 to 4, based on extent of damage caused by each calamity. Graphic images were provided for each of the *rating scale*-coded statement. Minimum baseline average score per calamity is 3.00 (up to maximum 4.00) which is interpreted as *not vulnerable to damage*, while scores lower than 3.00 (1.00 to 1.99, and 2.00 to 2.99) are interpreted as *highly vulnerable* to *vulnerable to damage*, respectively. This highly graphic self-assessment survey form was answered by the housing beneficiaries based from their experiences and observations on any subsequent actual damage on their donor-provided housing units upon their relocation to the resettlement sites.

3. RESULTS AND FINDINGS

In terms of the first variable, as shown in **Table 1** for structural description profile mean scores, only six (6) of the nine (9) housing design variants were considered *disaster-resistant* over-all based from the fifty-six (56) descriptive statements. The same results apply when delving deeper, in terms of the first part only, (30 statements on physical description), design variants DC, GK and DSWD were considered *disaster-prone.* However, in terms of the second part (26 statements on site condition), all of the housing design variants were considered *disaster-resistant*. Moreover, based from interviews with the donors, the housing design for most of them were merely based from "rule of thumb," discounting any need for engineering calculations since the structure is only of single story level only, basing from previously-delivered projects in other locations.

Table 1. Mean of Structural Description Profile Scores of Nine (9) Housing Design Variants

STRUCTURAL DESCRIPTION PROFILE	AVERAGE STRUCTURE ONLY (30 items)	AVERAGE SITE ONLY (26 items)	**AVERAGE OVERALL**	INTER.
HAB SF	3.70	3.31	3.518	DR
HAB CHB	3.03	3.23	3.125	DR
DC	**2.80**	3.15	**2.964**	**DP**
GK	**2.57**	3.31	**2.911**	**DP**
COPE	3.17	3.23	3.196	DR
OC-CHB	3.10	3.15	3.125	DR
OC-CHB/FB	3.00	3.15	3.071	DR
DSWD	**2.63**	3.23	**2.911**	**DP**
IOM	3.17	3.31	3.232	DR

Interpretation

1.00	1.99	Highly Disaster Prone (HDP)
2.00	2.99	Disaster Prone (DP)
3.00	4.00	Disaster-Resistant (DR)

Related to this, for the second variable, actual housing damage level (as shown in **Table 2**) due to subsequent natural calamities that hit the resettlement sites, all of the housing design variants were considered *not vulnerable to damage* (mean scores range between 3.85 to 4.00).

Table 2. Mean and standard deviation on the Actual Housing Damage level of each donor-provided houses in the resettlement sites

HOUSING DESIGN VARIANTS vis-à-vis CALAMITY	Typhoon (Mean)	Earthquake (Mean)	Floods (Mean)
HAB SF	3.93	3.88	3.95
HAB CHB	4.00	3.85	3.90
DC	4.00	4.00	4.00
GK	3.77	3.88	3.95
COPE	3.67	3.95	4.00
OC-CHB	3.97	3.93	3.95
OC-CHB/FB	3.87	4.00	4.00
DSWD	4.00	4.00	4.00
IOM	4.00	4.00	4.00

Interpretation:

1.00	1.99	Highly Vulnerable to Damage
2.00	2.99	Vulnerable to Damage
3.00	4.00	Not Vulnerable to Damage

Actual site inspection and photo documentation however indicate deterioration of steel roof purlins for the COPE housing design variant (see **Figure 3**), while the rest of the housing design variants have normal wear and tear on its wooden members (if there are any) like doors and windows due to exposure to harsh weather elements.

Figure 3. Broken Steel Purlins of COPE Housing Design Variant brought by rusting of members due to monsoon rains (encircled)

In addition to that, focus group discussion with the beneficiaries indicate that the housing units face a different kind of enemy, primarily, the presence of termites endemic to the site which caused physical damage already to the wooden doors and windows already, and as of this writing, haven't reached yet the roofing support members for some housing design variants with wooden purlins and rafters. Further spread might possibly undermine the structural integrity of the roofing system. In order to fully assess the disaster-resistance of these donor-provided dwelling units, the results from the first and second test instruments, as well as ocular inspections were comparatively shown in **Table 3** below.

Table 3. Summary of Results and Interpretation among the nine (9) housing design variants in terms of Disaster-Risk
LEGEND: **DR** (Disaster-resistant), **DP** (Disaster-prone), **NV** (Not Vulnerable to damage),
V (Vulnerable to damage).

House Model Variant	Structural Profile	Site Profile	Actual Housing Damage Level	REMARKS	Over-all Assessment
HAB-SF	3.70 (DR)	3.31 (DR)	3.93, 3.88, 3.95 (NV)	N/A	DR
HAB-MAS	3.03 (DR)	3.23 (DR)	4.00,3.85,3.90 (NV)	N/A	DR
DC	***2.80 (DP)***	3.15 (DR)	4.00,4.00,4.00 (NV)	N/A	**DP**
GK	***2.57 (DP)***	3.31 (DR)	3.77, 3.88, 3.95 (NV)	1	**DP**
COPE	3.17 (DR)	3.23 (DR)	3.67, 3.95, 4.00 (NV)	2	**DP**
OC-CHB	3.10 (DR)	3.15 (DR)	3.97, 3.93, 3.95 (NV)	N/A	DR
OC-CHB/ FB	3.00 (DR)	3.15 (DR)	3.87, 4.00, 4.00 (NV)	N/A	DR
DSWD	***2.63 (DP)***	3.23 (DR)	4.00, 4.00, 4.00 (NV)	1	**DP**
IOM	3.17 (DR)	3.31 (DR)	4.00, 4.00, 4.00 (NV)	N/A	DR

Based from "REMARKS" column (from ocular inspection):

N/A (none observed)

1- Wooden members prone to damage/currently damaged due to termite infestation

2- Broken steel purlins due to roof leaks

4. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

Thus, the following conclusions were derived upon:

1. Even though only five (5) of nine (9) housing design variants were evaluated as *disaster-resistant* over-all, all of them were considered *disaster-resistant* in terms of *site profile* which indicate two possible reasons – either the government made a sensible site selection for these post-disaster housing reconstruction projects (being located on relatively high ground and free from *tsunami* and flooding risk), or no natural calamity events (particularly typhoon) having the same intensity and magnitude like that of *Xangsane* and *Durian*, have visited these resettlement sites yet, the more with possibility for earthquake occurrences.
2. Land selection however overlooked aspects on pests such as termites by the local government, and merely focused with geo-mechanical properties of the soil against land subsidence, presence of water tables beneath and soil bearing capacities (Laud, 2006a; Laud, 2006b). These slowly damages the wooden members for some of the housing design variants
3. The waterproofing of roofing systems needs to be improved since these pose risks for roofing systems with steel members.
4. There was lack of coordination during the typhoon Durian aftermath among the government's public housing arm (NHA) who handled the site selection and land development, with that of the housing donors (NGOs including another government agency, DSWD), and that of the housing beneficiaries due to the exigencies of the situation.
5. The design of the houses were generally based from rule-of-thumb as adapted from previous projects handled for most of the donors, overlooking the future needs of the beneficiaries, again, posing a threat to disaster risk once these dwellings were physically modified, again, without formal training, to meet their burgeoning requirements.
6. Over-all, the proper coordination and risk communication appear to be segmented, or lacking, causes a gap in the post-disaster housing supply chain, which impairs sustainability of the mass housing program.

Given the above-mentioned conclusions, the following measures are recommended:

1. Risk communication is a holistic process, which is intended to address all forms of uncertainty, thus *risks* (in this case technological hazards (UN/ISDR, 2007) such as probable dwelling damage due to natural disasters and improper upkeep of housing units) should be properly identified and handled properly, with utmost *transparency* and *accountability* in all levels of a housing delivery supply chain (UN/OCHA, 2006) from all those who were involved in the housing donor's side downwards to the housing recipients. The housing donors are thus expected to identify the structural limitations that their donated housing units have, and be able to effectively communicate these to their housing beneficiaries. Thus, if effective communication is present in a *sustainable* post-disaster housing delivery , the housing recipients are expected to understand the risks their dwelling units face in future natural disasters, which was however evidently *lacking* (either lack of certainty and knowledge) among the housing recipients of nine (9) housing design variants.
2. Thus, in order to address this *risk communication* gap, aside from a disaster-resistant housing design which underwent in-depth engineering studies and prepared by licensed professionals on the donor's side, there is a need for community preparedness (Zahran, 2008) through honest-to-goodness participatory and capability-building programs (Matabang, Marcelo and

Baybay, 2009). and hands-on training sessions on familiarization with housing design and its eventual proper maintenance (Bosher, 2011) that can be conducted among the different stakeholders in a post-disaster housing supply chain – from the non-technical personnel of the housing donors" side, together with the housing recipients, and under the professional guidance of an architect and a structural engineer.

3. Moreover, a user-friendly house maintenance checklist (Benson and Clay, 2000; *United Nations – Shelter Working Group – Banglade*sh, 2009) in local dialect can be prepared as well which can be utilized conveniently by the housing recipients, coupled with strict local community building regulations and codes. In this way, any possible occurrences of *technological hazards* (UN/ISDR, 2007) due to human error can be avoided in the face of future natural calamities. The *hardware* (dwelling unit structural design) then goes hand-in-hand with the *software* (proper knowledge and maintenance) towards a sustainable post-disaster housing delivery program, leaving significantly less chances for future disasters to happen. These sustainable strategies, can bridge the capacity gap (Ginige, Amaratunga and Haigh, 2010). along the entire post-disaster housing supply chain, increasing resiliency of the built environment to future natural disasters.

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