Learning from Local Wisdom: Friction Damper in Traditional Building

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Learning from Local Wisdom: Friction Damper in Traditional Building

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Abstract: Indonesia is situated in the so called "Ring of Fire" where earthquake are very frequent. Despite of all the engineering effort, due to the March 28, 2005 strong earthquake (8.7 on Richter scale) a lot of modern buildings in Nias collapsed, while the traditional Northern Nias house (*omohada*) survived without any damage. Undoubtedly many other traditional buildings in other area in Indonesia have survived similar earthquake. Something in common of the traditional building are the columns which usually are not fixed on the ground, but rest on top of flat stones. In this paper some traditional building are subjected to non linear time history analysis to artificial earthquake equivalent to 500 years return period earthquake. This study shows that apparently the columns which rest on top of flat stone acts as friction damper or base isolation. The presence of sliding at the friction type support significantly reduces the internal forces in the structure.

Keywords: Base isolation, Coulomb friction, traditional building, earthquake resistance.

Introduction

Indonesia is situated in the so called "Ring of Fire" where earthquakes are very frequent. However in every corner of Indonesia, there is always traditional building that has survived the test of time. Just to mention a few, Figures 1 to 5 show some traditional building in different area, these traditional buildings are located in high seismicity area (Fig. 6).

Figure 1. Sulawesi Selatan, Toraja [1]

Figure 2. Sumbawa, Bima: *Uma Lengge* [2]

Figure 3. Nias; *Oma Hada* [3]

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The recent Nias Earthquake (March 28, 2005 – 8.7 on Richter scale) destroyed many buildings in Nias Island, most of these building were modern reinforced concrete with masonry walls (Fig. 7). On the other hand, all traditional buildings (*omohada*) survived without any damage (Fig.3) [6]. Undoubtedly other traditional buildings also have passed the test of time through earthquakes. Things in common in all the traditional buildings are; the elevated floor, made out of wood, and columns that are not fixed on the ground but only placed on top of flat rocks. The authors suspect that beside the light weight structure (wood), the columns bases act as friction damper reducing the effect of the seismic force to the upper structure. The behavior of *omahada* with two bases condition, i.e.: fixed base and base with Coulomb friction damper has been reported by Pudjisuryadi et al [7], while the behavior of *umalengge* was reported by Tiyanto and Shia [8] in an undergraduate theses supervised by the authors.

Figure 4. Flores, Ende; *Sao Ria* [2]

Figure 5. Flores, Wae Rebo; *Mbara Niang* [4]

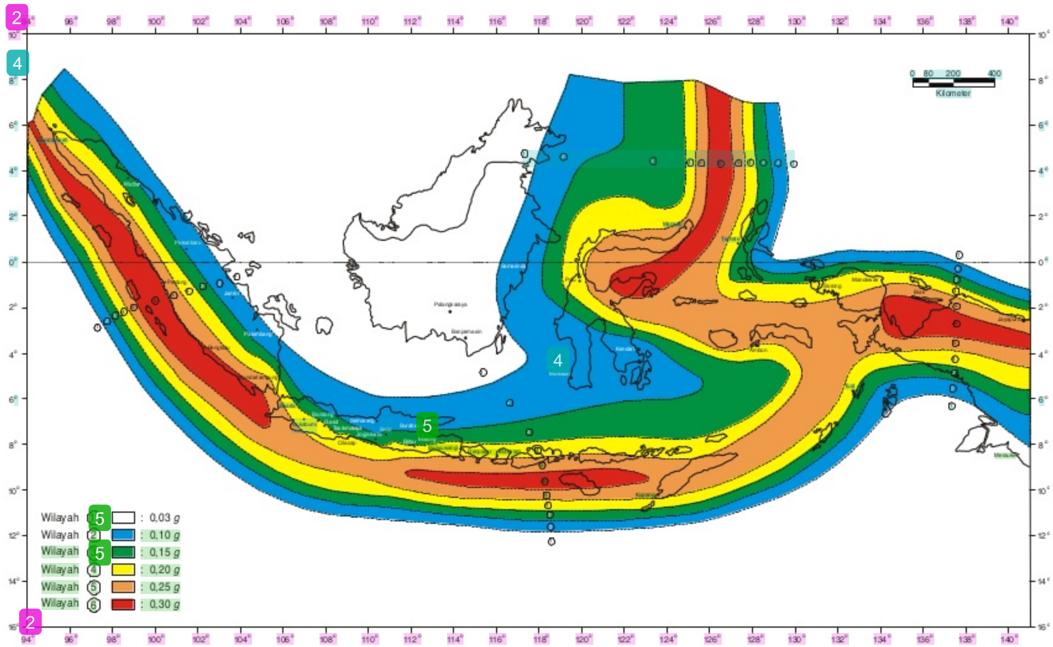

Figure 6. Indonesian Earthquake Map (500 years return period) [5]

(a)

(b)

Figure 7. (a) Total Collapse of Reinforced Concrete Building, and (b) Collapsed Masonry Walls in a Modern Building [3]

Structure Configuration and Modeling

Figures 8 and 9 show the base, while Figures 10 and 11 show the schematic structural system of *omohada* and *umalengge* respectively.

Figure 8. Base of *OmoHada*

Figure 9. Base of *Uma Lengge*

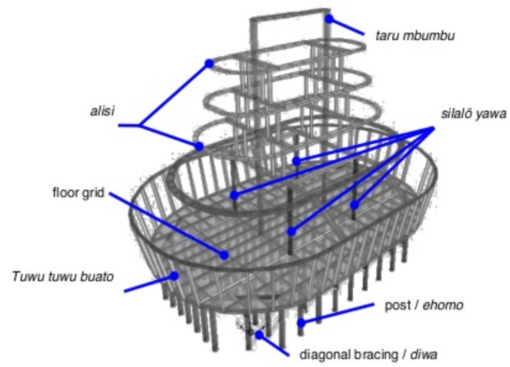

Figure 10. The Three Dimensional Frame System of *OmoHada* [3].

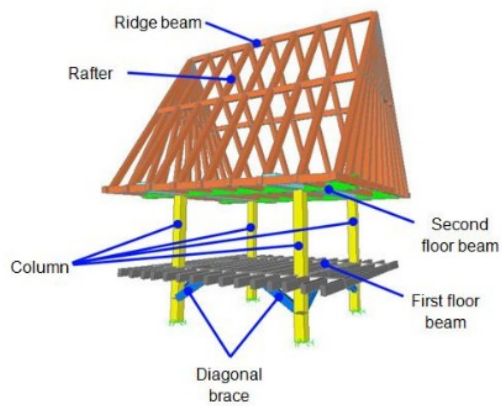

Figure 11. The three dimensional frame system of *UmaLengge* [2]

To study the effect of the column base, the two structures are modeled using fixed base and Coulomb friction damper and subjected to Dynamic Nonlinear Time History Analysis. The ground acceleration used is spectrum consistent ground acceleration modified from El Centro 18 May 1940 NS to acceleration response spectrum specific to the area where the buildings are. The modification is performed using RESMAT, a software developed at Petra Christian University, Surabaya [9]. The modified El Centro ground acceleration to be used in the analysis of *umalengge* is shown in Figure 12, while the response spectra of the modified and the original El Centro 18 May 1940, NS component along with the target response spectrum are shown in Figure 13.

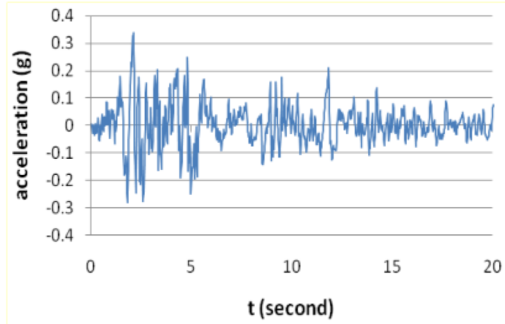

Figure 12. Modified El Centro Accelerogram

Analysis Result

The member internal stresses due to load combination 1Dead + 1Live + 1Quake of the two models are checked with respect to allowable stresses of the wood according to Indonesian standard [10]. The results of the analysis for *omahada* and *umalengge* are presented in Table 1 and 2 respectively. Stress ratio bigger than one suggest that the member exceed its capacity. The highlighted numbers in Table 1 shows that the stress ratio in the Diwa (bracing) and Ehomo (column) reduce tremensdously when the column bases are changed from fixed support to Coulomb fiction base support. Table 2 shows that the stress ratio of the column, diagonal bracing, and first floor beam (highlighted) which fail in fixed base, survive if Coulomb friction is used.

It can be seen that compared to the fixed base, the Coulomb friction base reduces the stresses in the column and diagonal members markedly.

Table 1. Analysis Results, *OmaHada* [7]

Element	Stress Ratio	
	Fixed	Coulomb
2XSiba	0.9695	0.7638
Alisi 1	0.2687	0.1593
Alisi 2	0.6032	0.2950
Botombumbu	0.3839	0.2227
Buato	0.3957	0.2525
Diwa	0.9354	0.2563
Ehomo	0.2922	0.3472
Gaso	0.4564	0.5120
Henedeu	0.0911	0.0778
Laliowo	0.8789	0.9253
Sanari	0.2886	0.2205
Siba	0.7933	0.9632
Silaloyawa	0.1730	0.1138
Siloto	0.2511	0.6904
Terumbumbu	0.6436	0.2638
TuwuTuwuBuato	0.7429	0.4621

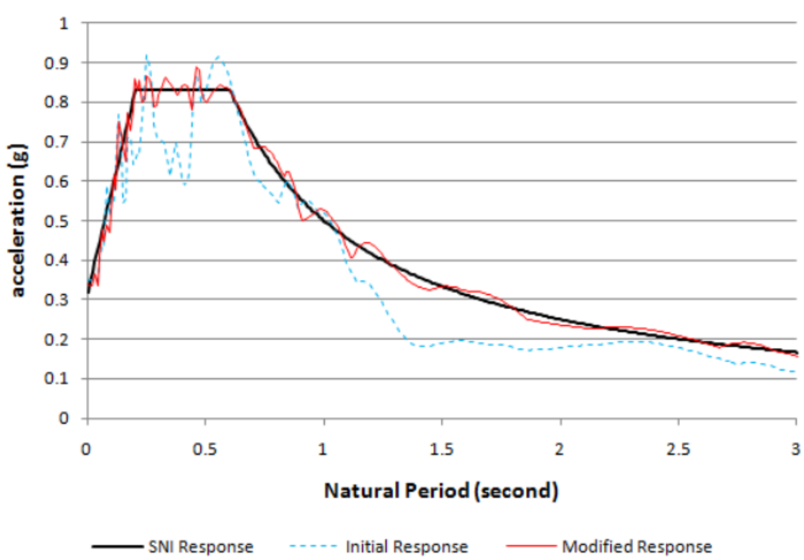

Figure 13. El Centro Response Spectra N-S)

Table 2. Analysis Result, *Uma Lengge* [8]

Element	Stress Ratio	
	Fixed	Coulomb
Column	1,834	0,581
Diagonal Brace	1,651	0,581
1st Floor Beam (x dir)	1,731	0,755
1st Floor Beam (y dir)	0,442	0,255
2nd Floor Beam (x dir)	0,961	0,329
2nd Floor Beam (y dir)	0,725	0,399
Rafter	0,167	0,070
1st Fl. Secondary Beam	0,831	0,349
2nd Fl. Secondary Beam	0,853	0,522
Collar Ties	0,169	0,073
Balk Ring	0,241	0,091
Ridge Beam	0,009	0,004

Figure 14 shows the displacement at the base of *umalengge* (with Coulomb friction base) during excitation of the modified El Centro, it shows slip on the base at 2.4 second. Detail of the report can be seen in Tiyanto and Shia [8].

Concluding Remarks and Afterthought

Observing the results presented in Table 1 and 2, it can be concluded that the Coulomb friction base isolation of *omohada* and *omalengge* performs very well in reducing internal forces. If the columns are fixed on the ground, both traditional building would not have survived the 500 years return period earthquake

As an aftermath, it may be worth to investigate if one departs from the traditional foundation design of modern building (Fig. 15) by deleting the anchorage of the tie beam to the foundation (Fig. 16). It is interesting to see if the second option perform better during earthquake.

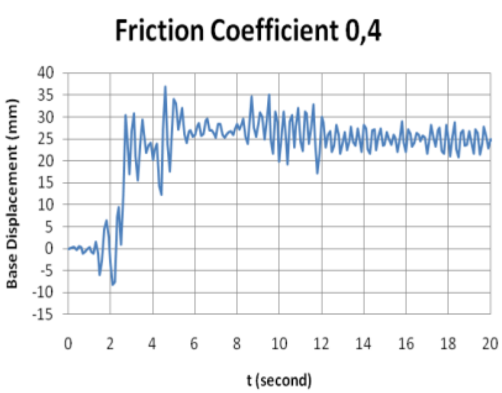

Figure 14. Displacement at the base, *umalengge* [8]

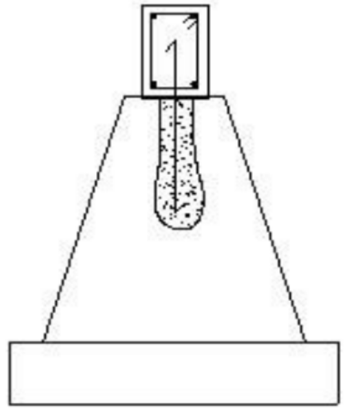

Figure 15. Tie Beam Anchored to Foundation

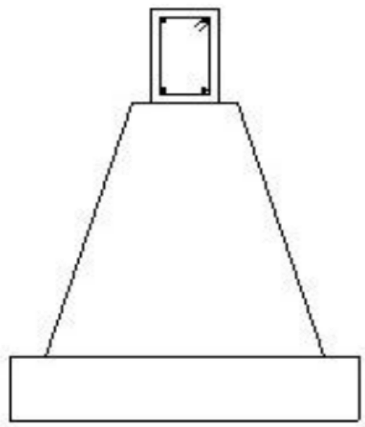

Figure16. Tie Beam not Anchored to Foundation

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