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LEARNING FROM LOCAL WISDOM: FRICTION DAMPER IN TRADITIONAL BUILDINGS IN INDONESIA*

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ABSTRACT

Indonesia is situated in the so called “Ring of Fire” where earthquake are very frequent. The first Indonesian earthquake code was introduced in 1971, but after more than forty years, despite all effort to disseminate the principle of good earthquake engineering design, in the recent earthquakes, such as Padang, October 2009, Bengkulu, September 2007, Nias, March 2005, a lot of modern buildings collapsed. On the other hand traditional building such as Northern Nias, *omo hada* survived without any damage. Undoubtedly many other traditional buildings in other area in Indonesia have survived similar earthquake. It is noted that something in common among the traditional buildings are their columns which usually are not fixed on the ground, but rest on top of flat stones (Coulomb friction). In this paper two traditional buildings, *omo hada* and *oma lengge*, are subjected to spectrum consistent artificial earthquake equivalent to 500 years return period in the area, and analyzed using non linear time history analysis. Each traditional building is analyzed assuming fixed base and Coulomb friction base. It is shown that apparently the columns which rest on top of flat stone (Coulomb friction) 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.

1. INTRODUCTION

Indonesia is situated in the so called “Ring of Fire” where earthquakes are very frequent. Although the first Indonesian earthquake code was introduced in 1971, after more than forty years, despite all effort to disseminate the principle of good earthquake engineering design (Lumantarna, 2007), in the recent earthquake, such as Padang, October 2009, Bengkulu, September 2007, Yogya, Mei 2006, Nias, March 2005, a lot of modern buildings collapsed (Figure 1). On the other hand traditional building such as Northern Nias, *omo hada* (Figure 2) survived without any damage (Lase, 2005).

Undoubtedly in every corner of Indonesia, there is traditional building that has survived the test of time through earthquakes. Just to mention a few, Figures 3 to 6 show some traditional building in different area. It can be seen from the seismic map in Figure 3, that these traditional buildings are located in high seismicity area. Studying the traditional buildings reveal that things in common in all traditional buildings are; the

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elevated floor, wooden building, and columns that are not fixed on the ground but only placed on top of flat stones (Fig. 8 and 9).

The authors suspect that beside the light weight wood structure, the column base which act as friction damper, reduces the effect of the seismic force to the upper structure. The behavior of *oma hada* with two base condition, i.e.: fixed base and base with Coulomb friction damper has been reported by Pudjisuryadi et al (2007), while the behavior of *uma lengge* was reported by Tiyanto and Shia (2012) in an undergraduate theses supervised by the authors.



Figure 1: Nias 2005; Modern Building
(Lase, 2005)



Figure 1: Nias 2005; *Omo Hada*
(Lase, 2005)



Figure 3: South Sulawesi, Toraja
(positiveinfo.wordpress.com/2008)



Figure 4: Sumbawa, Bima, *Uma Lengge*
(Balai PTPT Denpasar, 2011)



Figure 5: Flores, Ende; *Sao Ria*
(Balai PTPT Denpasar, 2011)



Figure 6: Flores, Wae Rebo; *Mbara Niang*
(kotapunyaiakita.wordpress.com/2011)

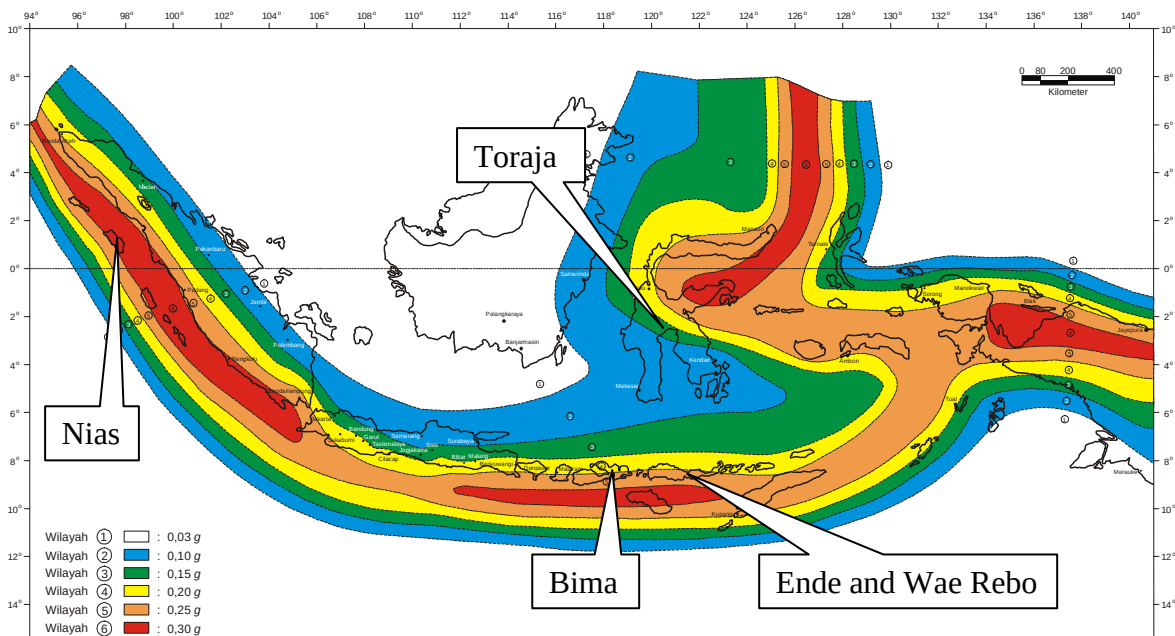


Figure 7: Indonesian Earthquake map, 500 years return period (SNI 03-1726-2002)



Figure 8: Base of *Omo Hada*



Figure 9: Base of *Uma Lengge*

2. STRUCTURE CONFIGURATION AND MODELING

Figures 8 and 9 show the column base of *omo hada* and *uma lengge* respectively. The schematic structural system of *omo hada* and *uma lengge*, is shown in Figures 10 and 11 respectively. Due to the difficulty in modelling the actual member connections it was decided to use rigid connection, only the diagonal bracing are pinned. These assumptions are considered reasonable, since the rigid connection will results in a higher column base shear. To study the effect of the column base, the two structures are modelled using fixed base and Coulomb friction damper and the structures are subjected to certain artificial ground acceleration and analysed using dynamic nonlinear time history analysis. SAP2000 Nonlinear was used for the time history analysis. The ground acceleration used in the analysis is spectrum consistent ground acceleration which is modified from El Centro 18 May 1940 NS to the acceleration response spectrum specific to the area where the buildings are. The modification of the earthquake record is performed using RESMAT, a software developed at Petra Christian University, Surabaya, Indonesia (Lumantarna and Lukito, 1997). The modified El Centro ground acceleration to be used in the analysis of *uma lengge* 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.

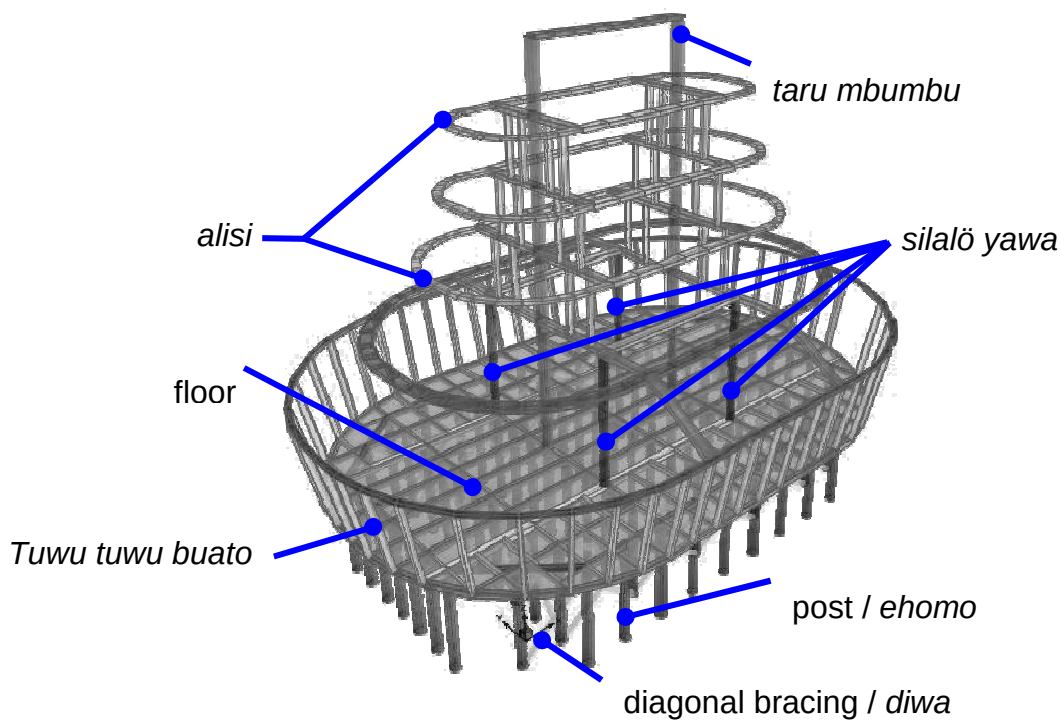


Figure 10: The three dimensional frame system of *Omo Hada* (Lase, 2005)

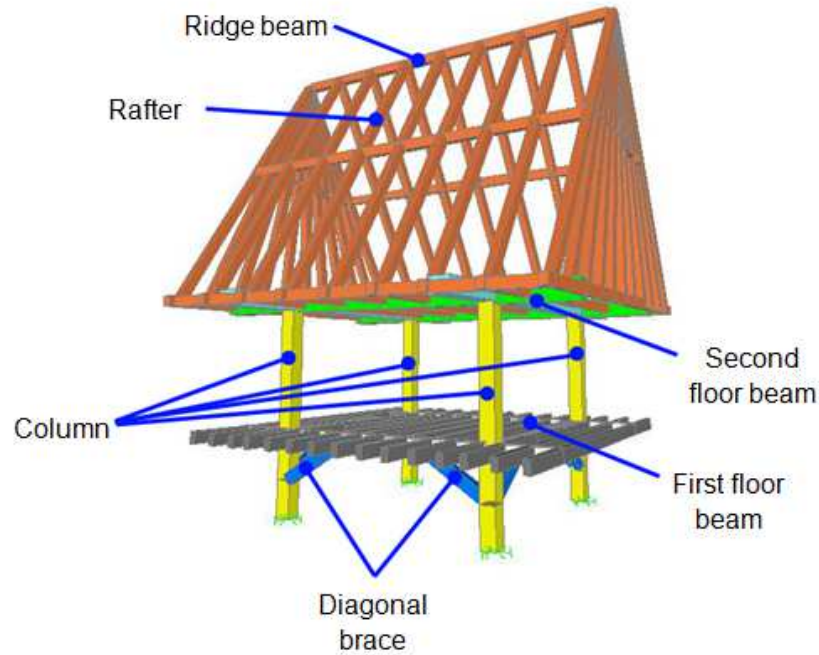


Figure 11: The three dimensional frame system of *Uma Lengge* (Tiyanto and Shia, 2012)

3. ANALYSIS RESULT

The member internal stresses due to load combination of 1Dead Load + 1Live Load + 1Quake of the two models are checked with respect to allowable stresses of the wood according to Indonesian standard (NI-5 PKKI 1961). The analysis result of *oma hada* has been reported elsewhere (Pudjisuryadi et al, 2007). The comparison of stress ratio of the fixed base and the Coulomb friction base of *omo hada* is presented here in Table 1, while the comparison of stress ratio of the fixed base and the Coulomb friction base of *oma lengge* is presented in Table 2

In Tables 1 and 2, stress ratio bigger than one suggest that the particular member exceeds its capacity. The highlighted numbers in Table 1 shows that the stress ratio in the Diwa (bracing) and Ehomono (column) reduce tremendously when the column bases are changed from fixed support to Coulomb friction 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.

Figure 14 shows the displacement at the base of *uma lengge* (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 (2012)

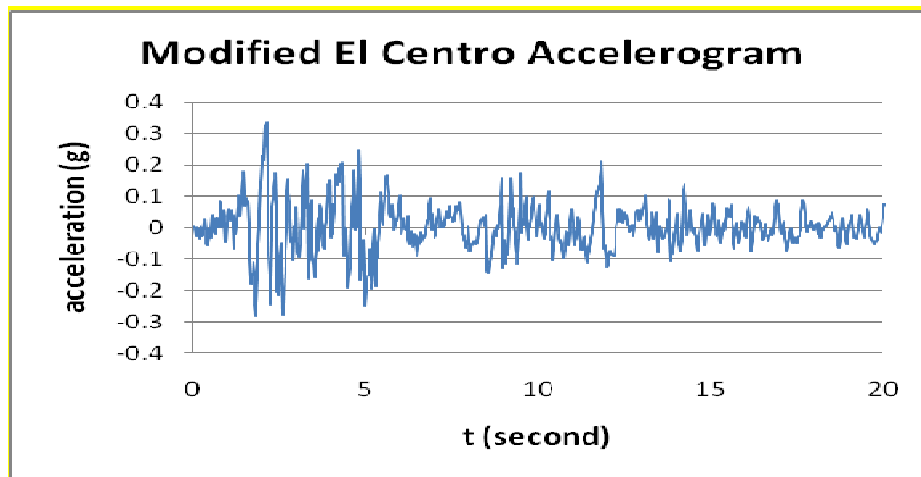


Figure 12: Modified El Centro

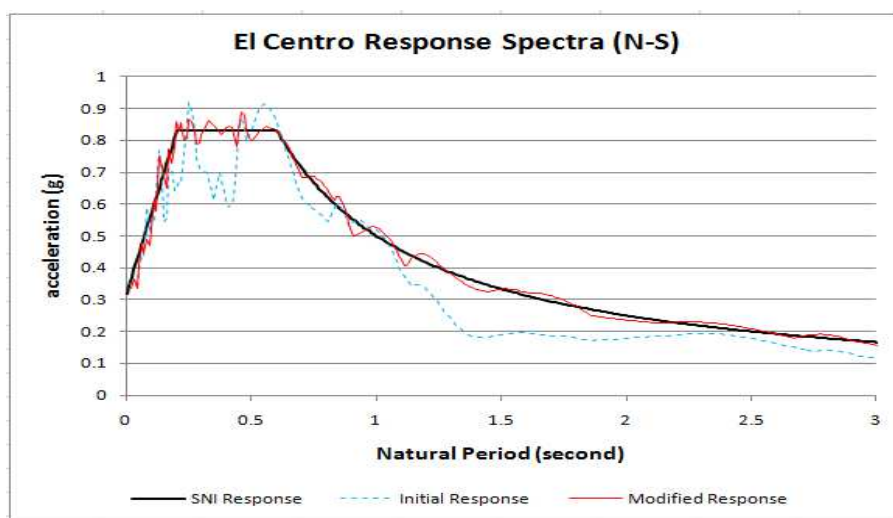


Figure 13. Response spectra

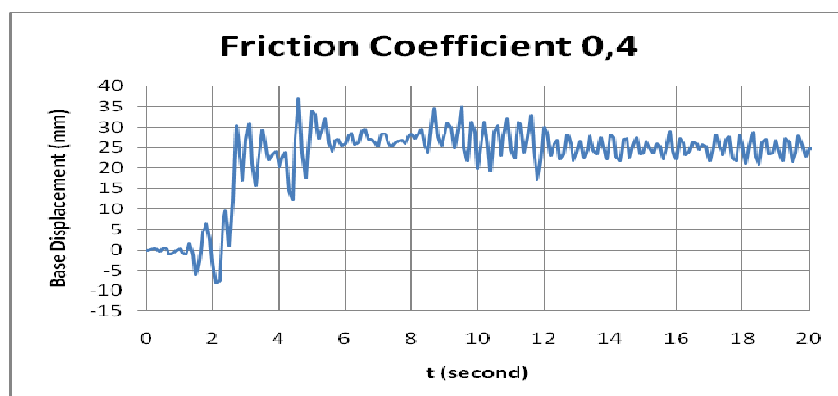


Figure 14. Displacement at the base, *Uma lengge*

Table 1: Analysis Results, *Omo Hada* (Pudjisuryadi et al, 2007)

Component	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
Gasu	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

Table 2: Analysis Result, *Uma Lengge*

Component	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

4. CONCLUDING REMARKS

Observing the results presented in Table 1 and 2, it can be concluded that the Coulomb friction base isolation of *omo hada* and *oma lengge* 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 low rise 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 performs better during earthquake.

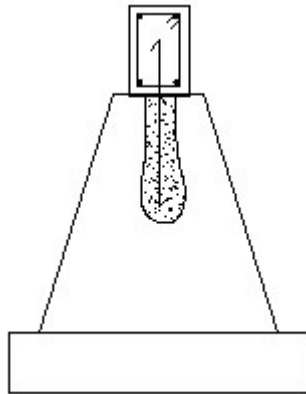


Figure 15: Tie beam anchored

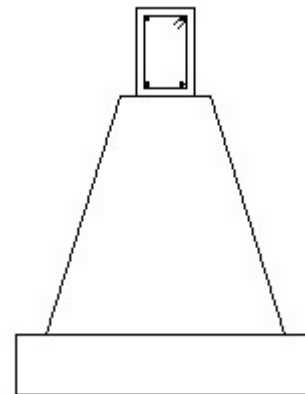


Figure16: Tie beam not anchored

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