BOOK 1

PROCEEDINGS OF

The 2nd ECO-Architecture Conference (EAC 2)

Qur'anic Science University, Wonosobo, Central Java, Indonesia April, 6 - 7 2015

Architecture, Technology and Local Wisdom

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THE 2ND ECO-ARCHITECTURE CONFERENCE (EAC 2)
"ARCHITECTURE, TECHNOLOGY AND LOCAL WISDOM"

Wonosobo, April 6th - 7th, 2015

ARCHITECTURE DEPARTMENT
FACULTY OF ENGINEERING AND COMPUTER SCIENCE
QUR'ANIC SCIENCE UNIVERSITY
WONOSOBO, CENTRAL JAVA, INDONESIA
2015

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PREFACE

All praise and gratitude to Allah SWT because of the grace and the gift, the gift of good health, fortune, intelligence, and others, even the gift of awareness and ability to be thankful to Allah SWT, and by Allah SWT permission we can publish Proceedings of the International Conference "2nd ECO-Architecture Conference "with the theme" Architecture, Technology and Local Wisdom ".

International Conference "2nd ECO-Architecture Conference" organized by Institute for Research, Publishing and Community Services-Coaching Language and Faculty of Engineering and Computer Science, Quranic Science University Central Java in Wonosobo, also Indonesian Institute of Architects Central Java. International Conference "2nd ECO-Architecture Conference" is a conference to study of architectural buildings in the tropics. Other fields of the articles on the proceedings which will be presented at the conference are about the city, housing, building, daily life, technology and behavior.

Nowadays a lot of research were scattered in many Universities and Research Institutes, but many have not been disseminated and socialized optimally. For the purpose of this conference are:

1. As a means of researchers to present their research results, and for exchange information, problems in various areas of expertise, and for strengthen and develop academic cooperation of mutual benefit in sustainability.
2. As a recommendation to the central government, local government and internationally to provide benefits of research results in architecture, technology and local wisdom for the development of sustainable development.

The conference was attended by researchers from science of architecture, technology and local wisdom. This Proceedings contains 44 papers, particularly in the science of **Architecture, Technology and Local Wisdom.**

We say thank you for Rector of Quranic Science University, Drs. KH. Muchotob Hamzah, MM, the "keynote speakers" at this conference, Prof. Tri Harso Karyono from Tanri Abeng University in Jakarta, Indonesia, Prof. Fergus Nicol from London Metropolitan University, United Kingdom and Prof. Susan Roaf from Heriot Watt-University, Edinburg, United Kingdom, Dean of Faculty of Engineering and Computer Science, Wiji Lestarini, ST, MT, Head of Indonesian Institute of Architects Central Java, Ir. Satrio Nugroho, M.Si, IAI, who had given a speech and science at a this conference, also to the audience and invited guests of 2ⁿᵈ EAC 2015 have attended this conference.

Finally, we say thank you for the committee of 2ⁿᵈ EAC in 2015, the leaders of rectorate Quranic Sains University, the lecturers and employees Quranic Science University for providing facilities for the preparations, and others that we can not mention, but many provide help for the implementation of this conference and the realization of this proceedings.

Our hope is that the collection of articles in the proceedings can be a reference for academic experts, teachers, and the general public. We hope that Allah SWT be pleased with all our steps and struggle, and pleased to record it as acts of worship. Amin.

Wonosobo, April 6ᵗʰ, 2015

TABLE OF CONTENTS

Keynote Speakers Paper:

Session 1 Paper:

Comparative Structure Behavior System of Fixed Base and Base Isolation as Earthquake Result in Irregular Building Configuration

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Abstrac

Indonesia is prone to earthquakes because the region is traversed by some of the world's most active seismic lines as the Mediterranean and the Circum-Pacific earthquake belt. Thus has happened thousands of times smaller to large earthquakes that occurred both documented and undocumented. Such conditions should be designed buildings in Indonesia earthquake resistant. One of the basic principles for the design of earthquake resistant buildings is regularity. But in reality is not inevitable either irregular building with functional and subjective reasons. While in designing earthquake-resistant building structures to make the building into a relatively flexible is relatively new compared to the fixed base system structure that is by using base isolation. If the base isolation mounted on irregular building configuration, positive or negative whatever effect on behavior than building structures using fixed base system?

In this study uses quantitative methods to study the type of simulation experiments. Architecture and structures datas used as a model hospital in STAADPRO software then analyzed the numerical results with existing theories.

The research results:

- The use of base isolation reduce the base shear force than the fixed base system.
- The use of base isolation minimize the drift between floor levels than the fixed base system.
- The use of base isolation building eccentricity relative increase it than the fixed base system.

Keywords: earthquake, irregular, fixed base, base isolation

1 Introduction

Many of the earthquake that occurred in Indonesia, both small and large recorded or unrecorded. This is due to Indonesia traversed some of the most active earthquake belt in the world, namely the Mediterranean earthquake belt and the Circum-Pacific. One of the largest earthquakes that occurred in Indonesia recently, namely the earthquake in Aceh in 2004, accompanied by the Tsunami. Which resulted in deaths of hundreds of thousands of people and damage to the infrastructure and building exceptional. With the state of this condition should Indonesia have earthquake resistant building codes. Starting in the year 1983 with the publication of Indonesian Earthquake Resistant Planning Regulations for Buildings (PPTI-UG 1983). Then fixed by the issuance of Earthquake Resilience Planning Procedures for Building - SNI 03-1726-2002. To revise SNI 03-1726-2002 then the government issued guidelines Earthquake Resilience Planning Procedures for Building Structures and Non-Building - SNI 1726: 2012.
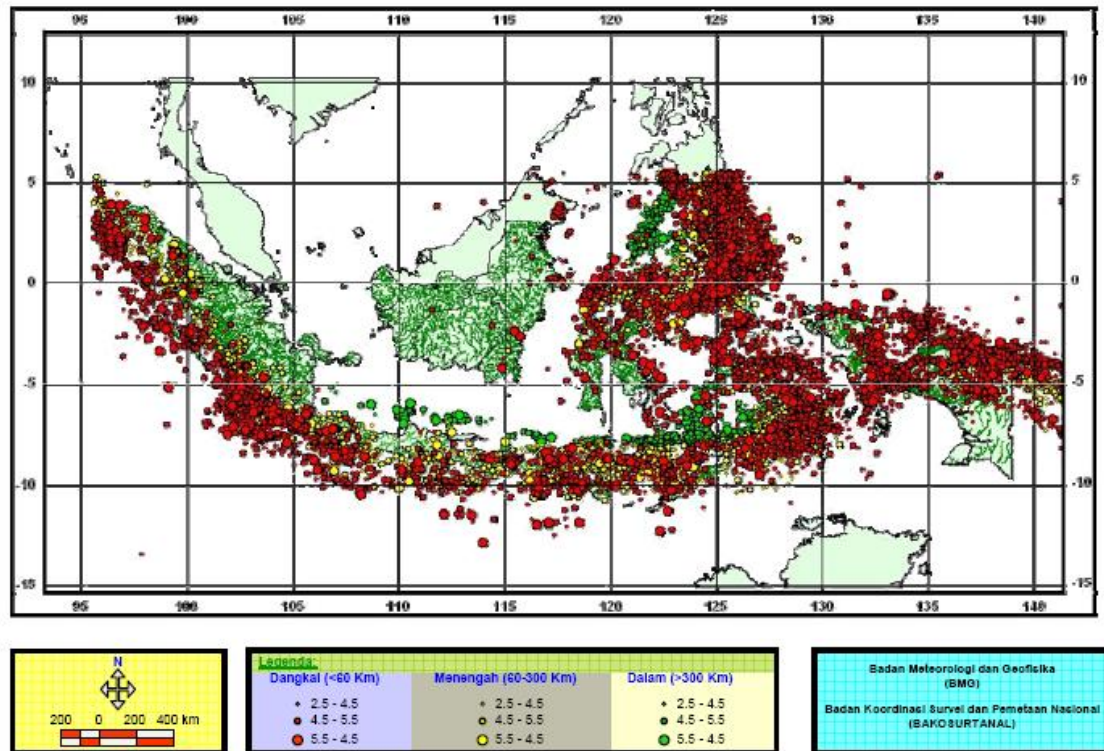
Figure 1. Epicenter Data of the earthquake in Indonesia and surrounding areas

In many earthquake-resistant building regulations, one of the basic principles for the design of earthquake-resistant buildings that regularity. With irregular shapes is not expected to occur eccentricity stiffness center / rotation and the center of mass coincides so that the torque of the building due to the lateral force is relatively no or small. Regular configuration also causes a more equitable distribution of forces to the structural elements such as beams and columns so that the stress concentration on certain structural elements can be avoided. But in reality it is difficult to maintain the configuration of the building in the regular state with functional reasons and subjective. While the design of earthquake resistant structures there are two principles that can be done: first; make the building into a rigid, second; make the building to be relatively flexible.

The principle design of earthquake resistant building structure by making the building to be relatively flexible to follow the direction of motion of the earthquake, is a relatively new (around1980s) compared to rigid structures or better known as seismic isolation. The purpose of this is to reduce seismic isolation seismic inertial forces (demand) rather than increasing the capacity of the building structure (Trevor EK, 2001). Seismic isolation can be placed in the sub structure, upper structure and roof. The position of seismic isolation in sub-structures called base isolation and in this way the more popular done.

If the base isolation mounted on irregular building configuration, positive or negative effect whatever on the behavior of the structure? And this will be studied in this paper with a case study 10 storey private hospital in Palembang which have irregular L-shaped configuration

2 Eccentricity and Torque

Eccentricity is due to the mass center of the building and the building does not coincide stiffness center. According to SNI 1726: 2002, the center of mass is the point of capture resultant dead load following appropriate live load acting on the level floor. At the center of mass of the structural design of the building is earthquake loads catching point static or

2

dynamic seismic forces. While the center of rotation is a point at the level of the floor when a horizontal load acting on it is not rotating floor level but only translating floors while other levels are not occure horizontal load everything rotation and translation.

Simply put, the center of mass can be said geometrical center of the building so easily calculated quite simply, while the center of stiffness is to calculate the stiffness of the columns and other vertical elements such as shear walls, stairs and so on, so the calculation is quite complicated (Kardiyono, 1997).

(a) Translation   (b) Translation   (c) Twist
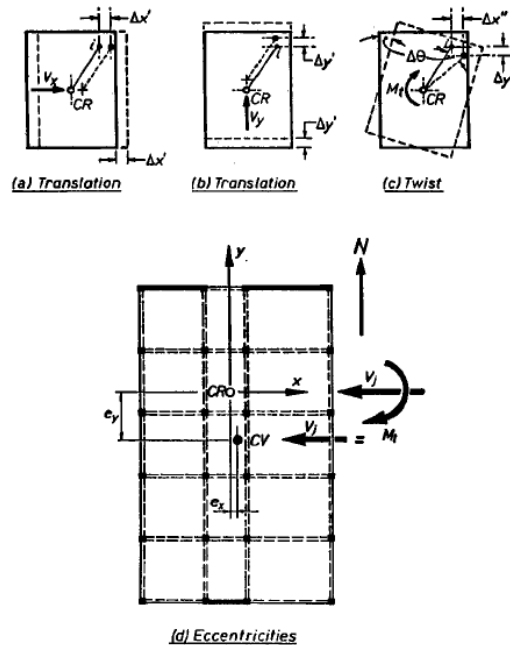
(d) Eccentricities

Figure 2. Deformation relative floor (Source : T. Paulay dan MJN. Priestley, 1992)

In Figure 2, the effect of eccentricity ex and ey (d) in buildings causes (a). deformation of the x-direction (Δx'), (b). deformation y-direction (Δy') and (c). additional rotation and deformation floor x-direction (Δx") and y-direction (Δy"). Deformation and rotation of the above can cause damage to the building.

3 Building Performance

The goal of the performance consisted of the design earthquake magnitude and extent of damage is tolerated or performance level of the building response to the earthquake load. The level of performance is based on the FEMA 273 structures, namely:

- Immediately usable (IO = Immediate Occupancy)
- Safety occupants guaranteed (LS = Life-Safety)
- Avoid a total collapse (CP = Collapse Prevention).

Figure 3. Illustration of Performance-Based Earthquake Engineering ATC 58

The criteria for acceptance in Planning Performance-Based Earthquake Resistant Buildings are internal forces (moments, shear f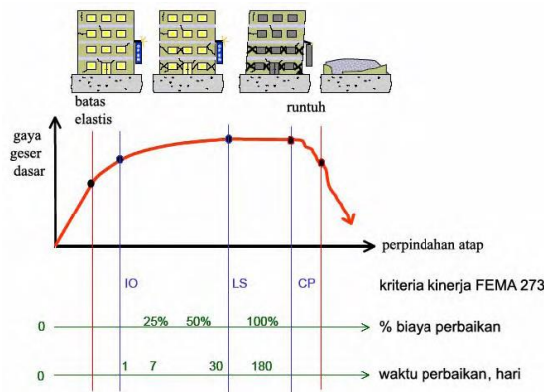orce, axial force) and deformation (displacement, drift ratio, plastic hinge rotation, permanent deformation) that can be tolerated at a certain level of performance as a result of the earthquake level planned.

Criteria for admission / acceptance criteria can also be applied to all types of seismic analysis of the results of the analysis are elastic (equivalent static, linear-elastic dynamic analysis) and inelastic analysis (static pushover, inelastic dynamic analysis). If the performance of the structure still meet the criteria for the desired level of performance has been achieved (Widodo, 2012).

Acceptance criteria for each performance level can be viewed globally drift Vision 2000.

Tabel 1. Drift global design criteria for each level of performance of the ATC 58

System Discriptions	Performance Levels			
	Operational	Life Safety	Near Collapse	Colapse
Overall Building Damage	Light	Moderate	Severe	Complete
Permissible Transient Drift	< 0,50 %	< 1,50 %	< 2,50 %	> 2,50 %
Permissible Permanent Drift	Negligible	< 0,50 %	< 2,50 %	> 2,50 %

4 Base Isolation

As it is known that the earthquake is hard to control. The intensity of the earthquake in earthquake-resistant design is a demand that must be accommodated by the building structure by increasing the capacity of the building structure. Thus increasing the capacity of the building structure properties (stiffness, strength and ductility) is not easy and not cheap, by making the structure becomes ductile so that when a strong earthquake the building was still able to survive the collapse, despite experiencing inelastic deformation.

The concept of base isolation using a different approach with the above. By reducing demand rather than increasing the capacity properties of building structures so that when a strong earthquake intensity can be reduced and the building still can behave elastic (Trevor EK, 2001).

There are 3 fundamental to the practice of seismic isolation system (Ronald LM in Farzad N, 2001), namely:

- Installation of flexible isolators will extend the natural period of the total system is extended to sufficiently reduce the response force (Fig. 4b).
- Damper or energy dissipation tool will work on the relative deflection between the building and the land can be controlled according practical level design.
- Still gives rigidity under (service) level loads such as wind and small earthquakes.
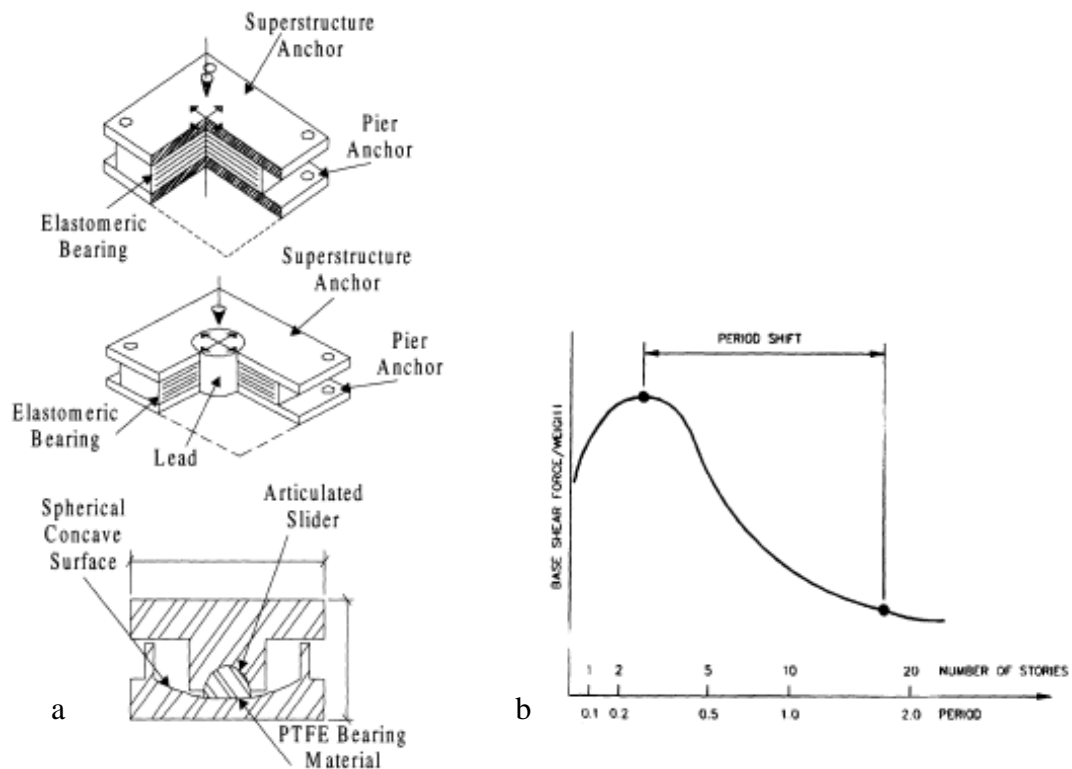
Figure 4. a). Seismic isolation tool frequently used. Which on: high dumping rubber, middle: lead rubber, and under: friction pendulum, b). Idealization response style spectrum
(Source : Ronald LM dalam Farzad N, 2001)

There are some similarities to the seismic isolation design with lateral equivalent analysis according to FEMA 450-1 (2003), namely:

$$T_D = 2\pi\sqrt{\frac{W}{k_{DMIN}.g}} \quad \text{--------------------(1)}$$

$$D_D = \frac{g.S_{D1}.T_D}{4\pi.B_D} \quad \text{-------------------(2)}$$

$$V_s = \frac{K_{DMAX}.D_D}{R_1} \quad \text{-------------------(3)}$$

Keterangan :
W = Total seismic dead load weight of the structure above the isolation interface.
K_{DMIN} = Minimum effective stiffness of the isolation system at the design displacement in the horizontal direction under consideration.
K_{DMAX} = Maximum effective stiffness of the isolation system at the design displacement in the horizontal direction under consideration.
g = Acceleration of gravity.
D_D = Design displacement at the center of rigidity of the isolation system in the direction under consideration

5

S_{D1} = Parameter percepatan spektral disain untuk periode 1 detik
T_D = Effective period, in seconds (sec), of seismically isolated structure at the design displacement in the direction under consideration,
B_D = Numerical coefficient related to the effective damping of the isolation system at the design displacement, (table 13.3-1 FEMA 450-1, 2003)
V_s = Total lateral seismic design force or shear on elements above the isolation system.
R_1 = Numerical coefficient related to the type of lateral-force-resisting system above the isolation system. (tabel 4.3-1 FEMA 450-1, 2003).

Total lateral seismic design force or shear on elements above the isolation system (Vs) is distributed to the upper structure by the following formula :

$$F_x = \frac{w_x . h_x^{k}}{\sum_{i=1}^{n} w_i . h_i^{k}} Vs \quad \text{---------------------(4)}$$

Where :
w_x, w_i = Portion of *W* that is located at or assigned to level x or i.
h_x, h_i = Height above the base level x or i.

k is a coefficient that depends on the period of the fundamental vibrating structure. The k value is:
k=l if T<0,50 sec.
k=2 if T> 2,50 sec.
k is linearly interpolated value when 0.50 <T <2.50 sec.

5 Research Methods and Building Datas
5.1 Research Methods
In this study uses quantitative methods to study the type of simulation experiments. Data architecture and data structures used as a model hospital in STAADPRO software and analyzed by the method of equivalent static seismic analysis then the numerical results are tabulated and analyzed by existing theories.

5.2 Architecture Datas Hospital
Hospital building consists of 10 floors, which consists of semi basement floor and 9 floors above. As each floor functioned as:
❑ semi basement floor : motorcycle parking space, mechanical & electrical and other service spaces.
❑ 1st floor : emergency room and administration manager.
❑ 2nd floor: surgery room.
❑ 3rd to 8th floor: inpatient unit.
❑ 9th floor: meeting room, elevator machine room, water tank.

5.3 Structure Datas Hospital
Sub structure used bore pile with ϕ 60 cm to a depth varying between 9 to 11 m. While the structure of the type of structure used in this hospital is a rigid frame system concrete beams and columns. While the lateral load resisting system used concrete moment resisting frame system intermediate level. The main structure of the column used dimensionless 60/60 and 40/60. 30/60 beam used while joist vary 30/60, 20/50 and 20/40. Floor plate which is used by 12 cm thick.
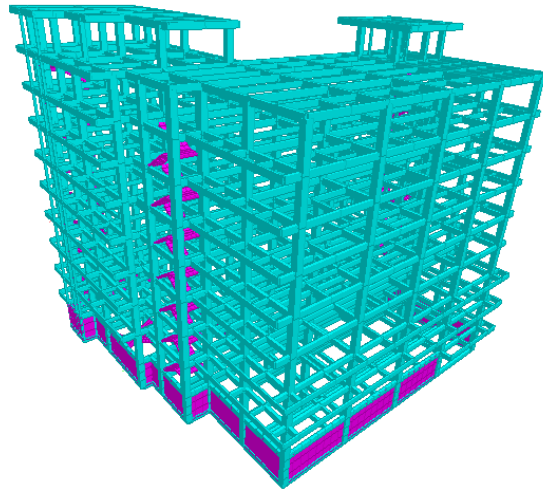
Figure 4. 3D structure of the hospital

6 Results and Discussion

6.1 Base shear force

Spectral acceleration values of design parameters for the period from 1 second to Palembang, S_{D1} = 0.235 g. For building weight (DL + 0.3LL), W = 10077,64 tons and T_{U-S} = 1,58 sec. and T_{B-T} = 1,48 sec. (Livian, 2015). As for the T_D value is typically between 0,5T to 1,5T, natural period (T) fixed base = 1,58 sec. so the value of T_D = 1,5T = 1,5x1,58 = 2.37 sec. ≈ 2, 5 dt. For preliminary is used T_D = 2,5 sec. Then look for the effective lateral stiffness of the building with the following formula:

$$k = \frac{4\pi^2.W}{g.T^2} = \frac{4x3.14^2 \, x10077,64}{9.81x2.5^2} = 6482,3 \text{ t/m.}$$

At the hospital building there are 41 columns. So each column having an effective lateral stiffness values:

$$k/41 = \frac{6482,3}{41} = 180,3 \text{ t/m} = 1803 \text{ Kn/m.}$$

Of the value of the effective lateral stiffness perkolom sought specification seismic isolation approaching these values, such as the table below:

Tabel 2. Specification Lead Rubber Bearing isolators (LRB) (source : H.H. Lee. et al, 2008)

Total rubber thk.	Axial stiffness	Lateral effective stiffness	Damping ratio
197,2 mm	4128x10³ Kn/m	2.68x10³ Kn/m	30.2

Having obtained the k values of the table above each column recalculated effective lateral stiffness value total:

k = 2,68x10³ x 41 columns = 109.880 Kn/m = 10988 t/m, while the value of T_D becomes:

$$T_D = 2\pi\sqrt{\frac{W}{k_{DMIN}.g}} = 2x3,14\sqrt{\frac{10077,64}{10988x9,81}} = 1,92 \text{ sec.}$$

For design displacement value D_D :

$$D_D = \frac{g.S_{D1}.T_D}{4\pi.B_D} = \frac{9.81x0,235x1,92}{4x3,14x1,7} = 0,066 \text{ m}$$

So, total lateral seismic design force or shear on elements above the isolation system (V_s) :

$$V_s = \frac{K_{DMAX}.D_D}{R_1} = \frac{10988x0,066}{2} = 362,6 \text{ tons.}$$

While lateral force with fixed base $V_{(US)}$ = 453,49 tons and $V_{(BT)}$ = 483,73 tons (Livian Teddy, 2015). Compared seismic base shear force values without isolators (fixed base), the value of the seismic base shear force with isolators (base isolation) decreases 20 to 25%. This is advantageous because the seismic forces detained structure is reduced significantly.
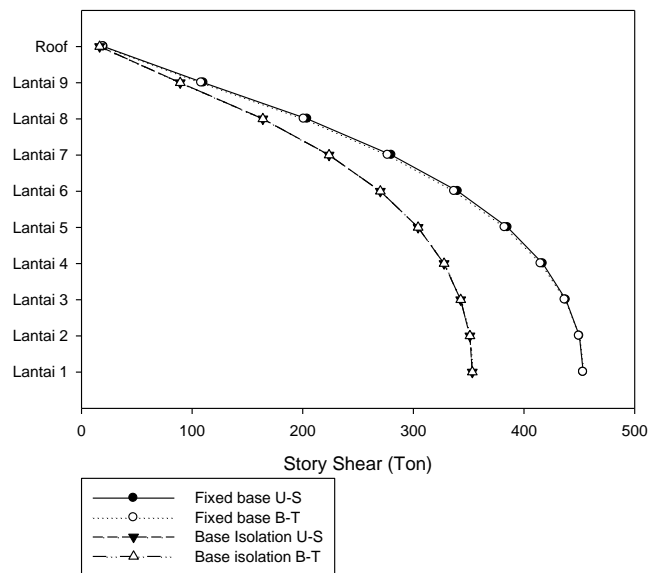

Figure 5. Comparison of vertical shear force distribution system fixed base and base isolation
(source : Analysis)

Likewise, the distribution of shear forces - the base isolation system to the structure above is also reduced (Fig. 5). For a base isolation system, the value of axial and lateral stiffness specifications included as the data support the software STAADPRO and value Vs and T_D above as a value control outputs Vs and T_D STAADPRO. For other inputs are relatively similar between the fixed base and base isolation system.

6.2 Eccentricity and Torque

The striking differences between regular and irregular buildings configuration are eccentricity. Eccentricity is simply the distance between the center of mass and the center of stiffness. At the distance of a regular building no or relatively small, while in the distance irregular building large enough to pose a potential torque on the building during an earthquake.

The use of base isolation is expected to minimize the distance between the center of mass and stiffness. Based on the analysis STAADPRO output, the use of base isolation is not change the coordinates of the center of mass. So the center of mass at the hospital building systems that use fixed base and the base isolation are equal. What's changed are the center of stiffness. The center of the fixed base system stiffness different from the stiffness center base isolation system.

In Figure 6, the stiffness of the base isolation center towards the 1st floor to roof floor distance near the center of mass of the system base isolation system than the fixed base.

Means the use of base isolation shorten the distance between the center of mass and the center of stiffness. Different happens in -y direction, the distance between the center of stiffness of the 3rd to 9th floor base isolation system and the fixed base system with its center of mass is relatively the same. While on the 1st floor, 2nd floor and roof floor using base isolation even enlarge the distance between the center of stiffness and the center of mass, especially floor roof. Means the -y direction, the intended use of base isolation to shorten the distance between the center of mass and stiffness is not achieved.
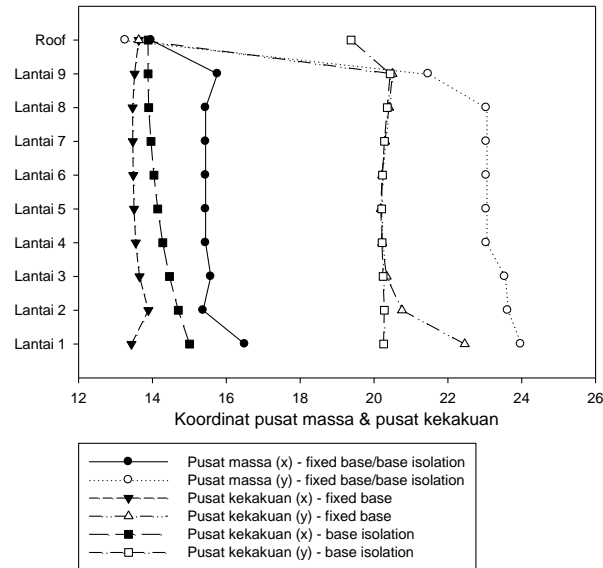

Figure 6. Comparison of the center of mass and center distance stiffness fixed base system and base isolation (source : Analysis)
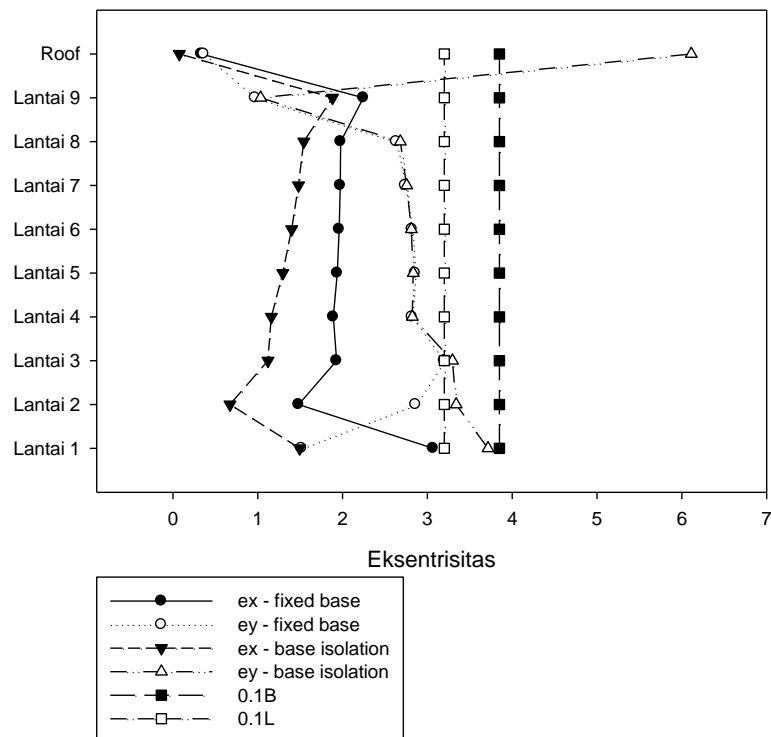

Figure 7. Comparison eccentricity fixed base and base isolation (source : Analysis)

9

From Figure 7, the eccentricity direction -x (ex) which use the isolators system (base isolation) decreased compared to the ex-fixed base. Both ex-fixed base and ex-base isolation worth nothing that exceeds the maximum limit 0.1B (3,85 m) for semi basement floor to 2nd floor. This is advantageous because the torque building -x direction also decreased and predictable does not pose significant problems for the hospital building. As for the eccentricity direction -y (ey) to 3rd to 9th floor both ey-fixed base and ey-base isolation are relatively equal. While on the 1st floor, 2nd floor and roof floor eccentricity direction -y (ey) which uses the isolators system (base isolation) increased compared to the ex-fixed base. Eccentricity direction -y (ey) base isolation system for the 1st floor, 2nd floor and roof floor value exceeds the maximum limit 0.1L (3,2 m), especially roof floor and this can cause problems torque on the building.

6.3 Building Performance

Hospitals are categorized Critical Facilities and Emergency Facilities that targeted performance which is when an earthquake has not damaged the structure and non-structure are slightly damaged so that it can directly operate after the earthquake. Whereas in the event of a strong earthquake damaged the structure slightly but still there is a safe and non-structural damage can still be improved so that at this level also can be used almost immediately after the earthquake. This means that in case of minor earthquake both structural and non-structural no damage at all.

Building performance level of acceptance criteria by using the global ratio of drift as table 1, to the hospital with a level of operational performance and immediate occupancy whether using a system of fixed base or base isolation is global drift ratio to be achieved <0.5%. To test the performance criteria are achieved by a private hospital if using a fixed base system by comparing the displacement of the roof with building height:

- Direction -X axis (North-South)
  Roof displacement = 7,873 cm and building height = 37,7 m means the ratio of its global drift = 10.625 / 3770 = 0,0028 = 0,28% <0,5% Ok
- Direction -Y axis (West-East)
  Roof displacement = 8,821 cm and building height = 37,7 m means the ratio of its global drift = 7,873/3770 = 0,0021 = 0,21% <0,5% Ok

Displacement roof on base isolation system has increased compared to the fixed base system so that the global drift ratio is also increased, both the direction of the x or y axes but all of the standard ratio are still below 0.5%

Simpangan antar tingkat - Δ

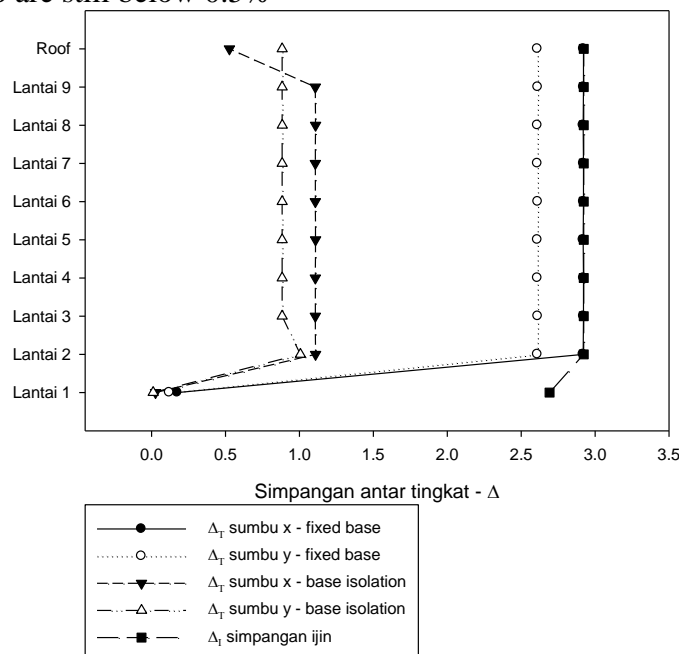|	
●—	Δ_T sumbu x - fixed base
○·····	Δ_T sumbu y - fixed base
▼——	Δ_T sumbu x - base isolation
△—·—	Δ_T sumbu y - base isolation
■—	Δ_T simpangan ijin

10

Figure 8. Comparison of the drift between the level of fixed base &
base isolation (Source : analysis)

See Figure 8, of the drift between the level of base isolation system drastically reduces the drift between floor levels than the fixed base system. This is very advantageous because the hospital many uses sophisticated electronic tools and expensive are susceptible to excessive swaying.

7. Conclusions and Recommendation

The use of base isolation system as a passive control of the earthquake on the building is relatively new. What's interesting about the use of base isolation is whether the use of base isolation in the building can ignore the basic principles of regularity in designing earthquake-resistant buildings?. From the description above, the use of base isolation can significantly reduce seismic base shear force and the drift between the floor level but because of the configuration of irregular shaped building contained therein eccentricity use of base isolation was able to enlarge the existing eccentricity, which means increased the potential of torque that can damage buildings on during a strong earthquake.

This should be a consideration for architects in designing earthquake resistant buildings. The use of base isolation is not necessarily able to cope with the eccentricity of the building is configured irregular and use of the principle of regularity is needed in designing buildings that use the base isolation.

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