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Table of contents

Volume 99

2018

Previous issue Next issue

International Conference on Sustainability in Architectural Design and Urbanism 2017
9–10 August 2017, Semarang, Indonesia

View all abstracts

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Preface

Papers

JOURNAL LINKS
Journal home
Information for organizers
Information for authors
Search for published proceedings
Contact us
Reprint services from Curran Associates

OPEN ACCESS 012009

Socio spatial adaptation as a resilience form of native unplanned settlement in confrontation with new planned settlement development pressure (case study: enclave native settlement in Serpong, Tangerang)

Mohammad Ischak, Bambang Setioko and Dedes Nurgandarum

+ View abstract View article PDF

OPEN ACCESS 012010

Waste processing building with incineration technology

Wasilah Wasilah and Muh. Zaldi Suradin

+ View abstract View article PDF

OPEN ACCESS 012011

Typology of social space in Kauman Kampong Semarang

Edward Endrianto Pandelaki, Atiek Suprapti and Satriya Wahyu Firmandhani

+ View abstract View article PDF

OPEN ACCESS 012012

Algae façade as green building method: application of algae as a method to meet the green building regulation

Heru W. Poerbo, Widjaja Martokusumo, M. Donny Koerniawan, Nissa Aulia Ardiani and Susan Krisanti

+ View abstract View article PDF

OPEN ACCESS 012013

Resiliency and affordability of housing design, Kampong Cieunteung-Bale Endah in Bandung Regency as a case study

Allis Nurdini, Wanda Yovita and Patriot Negri

+ View abstract View article PDF

OPEN ACCESS 012014

Resident satisfaction on their residence and environment (case study of Srondol Bumi Indah Housing of Semarang City)

Paulus Hariyono

+ View abstract View article PDF

OPEN ACCESS 012015

Exploring collective memory and place attachment using social media data

Sushardjanti Felasari, Herybert Setyabudi, Djoko Budiyanto Setyohadi and Sinta Dewi

+ View abstract View article PDF

OPEN ACCESS 012016

Ecological wisdom of Hindu-Javanese community settlement in Cetho Hamlet, Lawu Mountains, Central Java, Indonesia

Fauzan Ali Ikhsan, Bambang Setioko and Atiek Suprapti

+ View abstract View article PDF

OPEN ACCESS 012017

Thermal evaluation for exposed stone house with quantitative and qualitative approach in mountainous area, Wonosobo, Indonesia

Hermawan Hermawan and Eddy Prianto

+ View abstract View article PDF

OPEN ACCESS 012018

Community participation towards the value of traditional architecture resilience, on the settlements' patters in Tenganan village, Amlapura

Listyana Febriani and I Gede Wyana Lokantara

+ View abstract View article PDF

OPEN ACCESS 012019

Mural art as a media on making urban kampung's public space

Dalhar Susanto, Widyarko Widyarko and Ajeng Nadia Ilmiani

+ View abstract View article PDF

OPEN ACCESS 012020

The impact of green building approach to office property value

Yosephine Sitanggang and Dalhar Susanto

+ View abstract View article PDF

OPEN ACCESS 012021

Local Material as a Character of Contemporary Interior Design in Indonesia

Dalhar Susanto, Dini Puti Angelia and Tria Amalia Ningsih

+ View abstract View article PDF

OPEN ACCESS 012022

Prefabricated house in real estate business development in Jabodetabek

Raka Gumilang Raksamala Basmara Putra and Dalhar Susanto

+ View abstract View article PDF

OPEN ACCESS 012023

Sacred Space in Community settlement of Kudus Kulon, Central Java, Indonesia

Agung Budi Sardjono and Arnis Rochma Harani

+ View abstract View article PDF

OPEN ACCESS 012024

Proposal of stack Effect technology for predicted future years

FX Teddy Badai Samodra and Iwan Adi Indrawan

+ View abstract View article PDF

OPEN ACCESS 012025

Universal design characteristic on themed streets

Bangun IR Harsritanto, Indriastjario and Wijayanti

+ View abstract View article PDF

OPEN ACCESS 012026

Resilience of Historical Urban Multi-ethnic Settlement: Entrepreneurship and Religiosity Concept of Gresik City

Dian Ariestadi, Antariksa, Lisa Dwi Wulandari and Surjono

+ View abstract View article PDF

OPEN ACCESS 012027

Spatial adaptation as the Madurese migrant resilience form at urban informal sector workers settlement: a case study of Kotalama settlement - Malang

Damayanti Asikin, Antariksa, Lisa Dwi Wulandari and Wara Indira Rukmi

+ View abstract View article PDF

OPEN ACCESS 012028

Café as third place and the creation of a unique space of interaction in UI Campus

Yulia Nurliani Lukito and Anneli Puspita Xenia

+ View abstract View article PDF

OPEN ACCESS 012029

Spatial change transformation of educational areas in Bandung

Asep Yudi Permana and Karto Wijaya

+ View abstract View article PDF

OPEN ACCESS 012030

Enganging the past of the city through the conservation of heritage building

Yulia Nurliani Lukito and Amalia Nurul Rizky

+ View abstract View article PDF

OPEN ACCESS 012031

The conservation of Javanese-cultured city through visual expression study on the architecture of Keraton Yogyakarta

Ibrahim Tohar, Gagoek Hardiman and Suzanna Ratih Sari

+ View abstract View article PDF

OPEN ACCESS 012032

Problems of low-rise residential area of Seoul - Focused on Malmi village of Guemcheon-gu, Seoul, Korea -

Yeoryung Seo and Saehoon Kim

+ View abstract View article PDF

OPEN ACCESS 012033

Planning a new type of cultural community space in Goyang City, Korea

Jeonghye Kim and Saehoon Kim

+ View abstract View article PDF

OPEN ACCESS 012034

Conservation of Semarang chinatown traditional settlement as physical characteristics of chinatown district

Bintang Noor Prabowo, Ratih Widiastuti and C. N. Bramiana

+ View abstract View article PDF

OPEN ACCESS 012035

Towards a harmonious development between nature and culture on Walisanga religious site, Indonesia – learning from the best practices in Japan

Atiek Suprapti, Edward E. Pandelaki, Indriastjario, Agung Budi Sardjono, Yosidha Tomohiko, Yagi Masao and Adriana P. Higashino

+ View abstract View article PDF

OPEN ACCESS 012036

Principles and concepts in designing tropical-shore settlement in estuary ecosystem, case study: Weriagar District, Bintuni Bay

Firmansyah, Bintang Nidia Kusuma, Ira Prayuni and Aldo Fernando

+ View abstract View article PDF

OPEN ACCESS 012037

Towards the new urban agenda of safe cities: urban crimes in four Indonesian cities

B. Setiawan

+ View abstract View article PDF

International Conference on Sustainability in Architectural Design and Urbanism 2017

PREFACE

The Conference on Sustainability in Architectural Design and Urbanism (ICSADU 2017) is an international scientific forum for discussing and sharing ideas, thoughts, practices from around the world in the field of architecture and urbanism. The first ICSADU was held by Department of Architecture, Faculty of Engineering, Universitas Diponegoro in Aston Hotel Semarang, Indonesia as part of their annual international program. We highly appreciated the authors and audience contribution for the conference program and have made their way to attend the conference.

Resiliency is the issue in 21th century regarding urbanism & architecture. Climate change, environmental degradation, inaccurate and risky in urban planning process, and the emergence of the hazards have become major problems in human habitation on earth. A few things can be done to anticipate them to occur so human existence can be sustained. Some communities have been launched plethora of design innovations as one of the solutions that pay attention to the environment. However, if those problems emerge, the risk is unlikely inevitable.

Based on the afore mentioned facts, it is necessary to remind designer and planner to think carefully and eager in providing solutions in the form of a design that can make a building and its surroundings more comfortable, safer and more sustainable when exposed to incoming risks.

The objective of this conference are to be an international forum for the academia, researchers, practicioners , governments, students,and other parties in communing their research and development results on fundamental and applicable of architecture and urban planning, to extensively share and exchange ideas, and thoughts related to the themes, to facilitate network among participants for improving the quality and benefits of the researches. The Conference theme was 'Resilient City and Resilient Design toward a Better Living Space'. The range of topics includes: (1) management of policy, (2) infrastructures, (3) environment, (4) communities & societies, (5) housing, also (6) building technologies.

Putting together ICSADU 2017 was a team effort. We first thank the authors for their contributions to the program. We must also thank the organizing and scientific committee for their invaluable efforts in reviewing papers and constructive feedback to the authors. We are very grateful for Prof. Tomohiko Yoshida from Ritsumeikan University, Prof. Gagoek Hardiman from Diponegoro University, Dr. Saehoon Kim from Seoul National University, and Thana Chirapiwat, Ph.D from Silpakorn University for their contribution as keynote speakers in this conference; Journal of Architecture and Urbanism, especcialy for editor in chief - Prof. Almantas Samalavicius; IOP Conference Series Earth and Environmental Sciences; and finally we would like to thank Department of Architecture, Faculty of Engineering, Universitas Diponegoro for the support in putting together this first ICSADU.

We hope that this conference will foster the exchange of new ideas and promote new contacts between researchers on the field of urbanism and architecture.

Sincerely,
On behalf of the conference committee,
Dr. Atiek Suprapti
Chair of ICSADU 2017

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The effect of earthquake on architecture geometry with non-parallel system irregularity configuration

The effect of earthquake on architecture geometry with non-parallel system irregularity configuration

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Abstract. Indonesia is an area prone to earthquake that may cause casualties and damage to buildings. The fatalities or the injured are not largely caused by the earthquake, but by building collapse. The collapse of the building is resulted from the building behaviour against the earthquake, and it depends on many factors, such as architectural design, geometry configuration of structural elements in horizontal and vertical plans, earthquake zone, geographical location (distance to earthquake center), soil type, material quality, and construction quality. One of the geometry configurations that may lead to the collapse of the building is irregular configuration of non-parallel system. In accordance with FEMA-451B, irregular configuration in non-parallel system is defined to have existed if the vertical lateral force-retaining elements are neither parallel nor symmetric with main orthogonal axes of the earthquake-retaining axis system. Such configuration may lead to torque, diagonal translation and local damage to buildings. It does not mean that non-parallel irregular configuration should not be formed on architectural design; however the designer must know the consequence of earthquake behaviour against buildings with irregular configuration of non-parallel system. The present research has the objective to identify earthquake behaviour in architectural geometry with irregular configuration of non-parallel system. The present research was quantitative with simulation experimental method. It consisted of 5 models, where architectural data and model structure data were inputted and analyzed using the software SAP2000 in order to find out its performance, and ETAB2015 to determine the eccentricity occurred. The output of the software analysis was tabulated, graphed, compared and analyzed with relevant theories. For areas of strong earthquake zones, avoid designing buildings which wholly form irregular configuration of non-parallel system. If it is inevitable to design a building with building parts containing irregular configuration of non-parallel system, make it more rigid by forming a triangle module, and use the formula.A good collaboration is needed between architects and structural experts in creating earthquake architecture.

Keywords: earthquake, non-parallel system irregularity configuration

1. Introduction

Indonesia is an area prone to earthquake that may cause casualties and damage to buildings. The fatalities or the injured are not largely caused by the earthquake, but by building collapse. The collapse of the building is resulted from the building behaviour against the earthquake, and it depends on many factors, such as architectural design, geometry configuration of structural elements in horizontal and vertical plans, earthquake zone, geographical location (distance to earthquake center), soil type, material quality, and construction quality [1,2]. One geometric configuration that may result in building collapse is irregular configuration of non-parallel system (figure 1). According to FEMA-451B [3],

irregular configuration of non-parallel system is defined to have existed if the vertical lateral force-retaining elements are neither parallel nor symmetric with main orthogonal axes of the earthquake-retaining axis system.

Such configuration may happen on: 1). The building is regular, however as the walls of the room are tilted, the wall slides (figure 1a) or the beam arranged is also tilted (figure 1b), 2). The building is regular, but column arrangement is not in one axis, making the beam connecting the column tilted (figure 1b), 3). The building is irregular, for adjusting to the shape of the site, or the building is deliberately tilted for architect's aesthetic consideration (picture 1c). The irregular configuration of parallel system may lead to torsion, instability and local damage to buildings [4]. It does not mean that non-parallel irregular configuration should not be formed on architectural design; however the designer must know the consequence of earthquake behaviour against buildings with irregular configuration of non-parallel system. The present research has the objective to identify earthquake behaviour in architectural geometry with irregular configuration of non-parallel system.

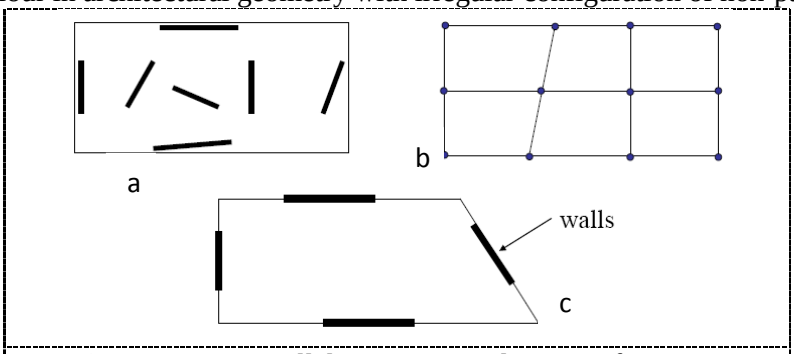


Figure 1. Non parallel system irregularity configuration

2. Methods

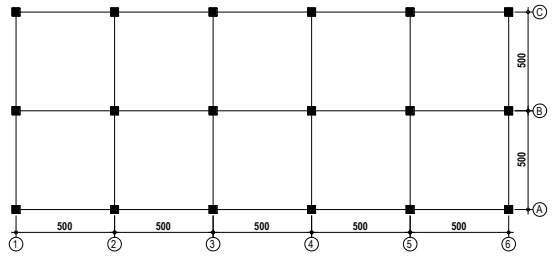


Figure 2. Model a

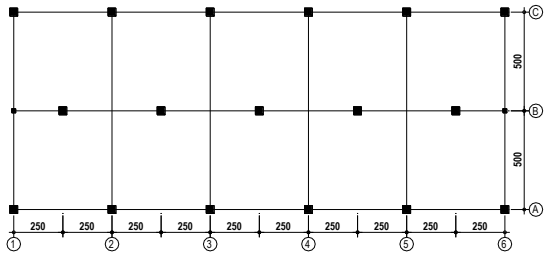


Figure 3. Model b

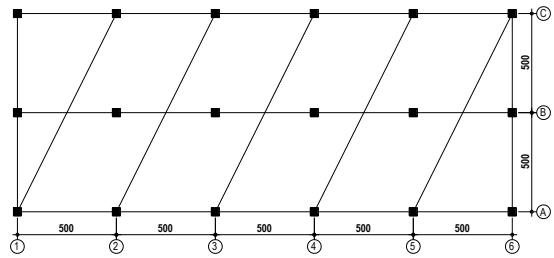


Figure 4. Model c

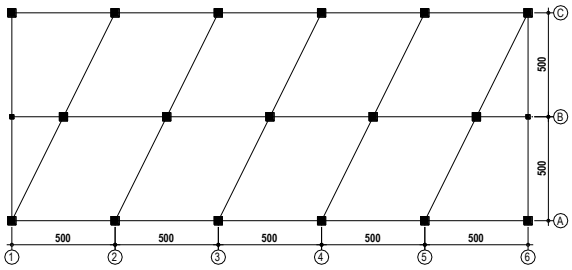
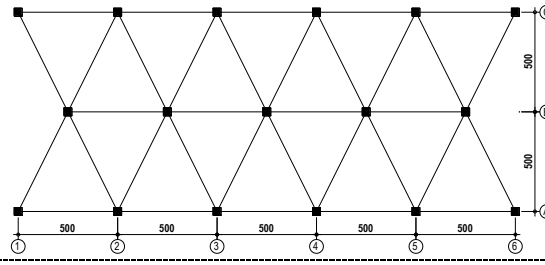


Figure 5. Model d



Gambar 6. Model e

Table 1. The property of structure model a-e

Model	Number of floors (height-m)	Dimension beam (cm)	Dimension column (cm)	Thickness of floor plate (cm)	Dimension building (m)
a	4 (16 m)	25X40	40X40	12	10X25
b	4 (16 m)	25X40	20X20, 40X40	12	10X25
c	4 (16 m)	25X40	40X40	12	10X25
d	4 (16 m)	25X40	20X20, 40X40	12	10X25
e	4 (16 m)	25X40	40X40	12	10X25

Table 2. Grade of structure model a-e

Model	Grade		
	Concrete (Kg/cm2)	Reinforcement (Kg/cm2)	Stirrup (Kg/cm2)
a	300	3000	2400
b	300	3000	2400
c	300	3000	2400
d	300	3000	2400
e	300	3000	2400

It is a simulated experimental study by using pushover analysis, and center of mass and rigidity analysis. In order to conduct both analyses above using the geometry model of the buildings (figure 2 to 6) and the structural properties (table 1 and 2), those were inputted to SAP2000/ETABS softwares, and were then analyzed by static pushover earthquake analysis method to be identified for its performance level and to be analyzed for its eccentricity to find out the potential torque occurred. The numerical outputs of the analyses were tabulated and compared between models and graphs. It is assumed that the models are in a high earthquake zone with spectral value of S_S = 0.97 g and S_1 = 0.328 g with medium soil (D) condition and office function.

3. Discussion

3.1. Target displacement

Pushover analysis is a static non-linear analysis in which the effect of earthquake plans on the structure of a building is considered as a static load capturing at the center of mass of each floor, which value is gradually increased to exceed the loading that causes the first yield (plastic joint) in the

structure of the building, then through further load increase, it has a changing major post-elastic shape until it reaches the expected target displacement or until it reaches the plastic condition [3].

Table 3. Target displacement model a-e

Model	Target displacement	
	X (m)	Y (m)
a	0.187	0.197
b	0.201	0.246
c	0.183	0.235
d	0.158	0.208
e	0.163	0.178

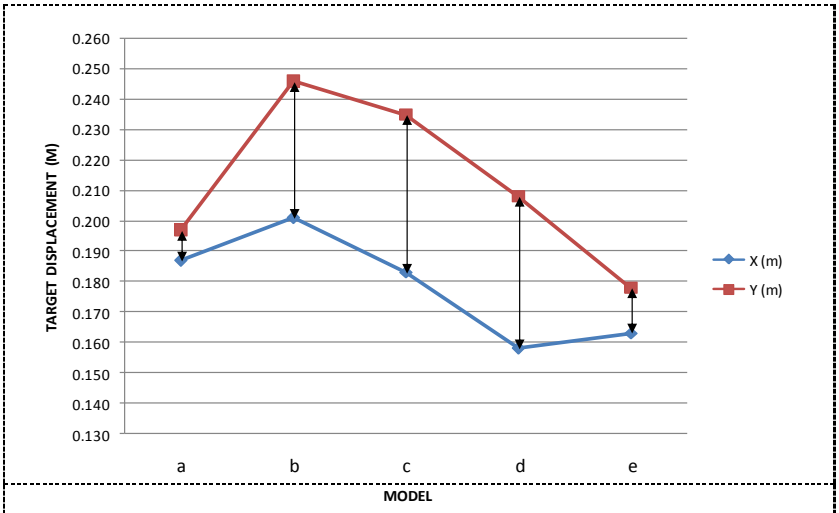


Figure 7. Target displacement model a-e

Reviewed from the results of pushover analysis in table 3 and figure 7, it can be concluded as follows:

- For the –X axis, all columns in one axis and its rigidity are dominated by the models with tilted beams (model c, d and e) rather than those that do not have tilted beams (model a and b). It means that there is an angle formation on the beams which can give additional rigidity to the structure of the building.
- For the –Y axis, model a and b of all beams are in one axis, while model c, d and e have their beams not in one axis. For columns in one axis are model a and c, while model b, d and e the columns are not in one axis. On the –Y axis, model a and e have the largest rigidity compared to other models, whereas the weakest rigidity is in model b. It means that the ideal building structure is when the beams and columns are in one axis but if it is inevitable, connect the columns with the triangle module beams so that it will have more rigidity. In addition, the columns which are not in one axis have weaker rigidity than the beams which are not in one axis.
- For regular buildings, the target displacement for the –X and –Y axes are generally relatively similar (model a and d), and the more irregular the building geometry the larger the target displacement of both axes, –X and –Y. It should be avoided, since both axes should have the same ability in facing the seismic loads.

It is similar with Shopping Center in Ercis District's-Turkey which has an irregular geometry (see figure 8). In order to reduce the irregularity, the building is blocked and separated by dilatation, but from these three blocks A to C, block C have greater non-parallel irregular configurations than others. When the earthquake stroke Ercis District's -Turkey in 2011, from the three blocks, block C

was more severely damaged than blocks A and B. Based on the research results, the non parallel irregular configuration in the two-way axes -X and –Y, block C compared to blocks A and B which only on the X-axis, gives a significant contribution to the severe damage of block C in this shopping center building [6].

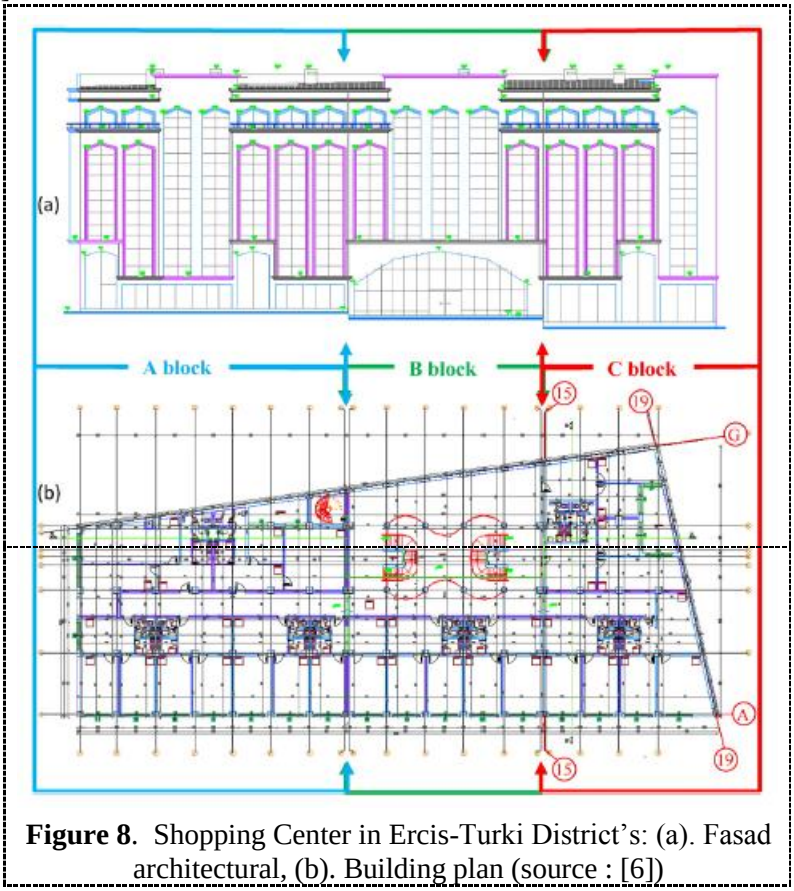


Figure 8. Shopping Center in Ercis-Turki District's: (a). Fasad architectural, (b). Building plan (source : [6])

In order to avoid the occurrence of the above, simple formula is proposed to evaluate the potential for the formation of non-parallel irregular configuration in the building that is still in the process of architectural design:

$$j_r = \sum j / \sum j_t \quad (1)$$

Table 4. Ratios quality level of the number of beams, columns and shear walls elements (j_r) irregular configuration of non-parallel system

Source	Quality Level		
	Good	Moderate	Poor
Recommendation	j_r<30%	30%≤j_r≤50%	j_r>50%

Where, j_r= ratios quality level of the number of beams, columns and shear walls elements, Σj=the number of beams, columns and shear walls elements that do not follow the orthogonal axis and Σj_t=the total number of beams, columns and shear walls elements at the level being reviewed . The result of j_r is then compared with table 4 so as to find out whether the formation of non-parallel system irregular configuration is still in tolerance level (good), moderate or poor.

3.2. Eccentricity

The torque force formed inside the building is caused by the lack of balance between the location of the retaining elements and the mass structure of the building. It is the eccentricity between the center

of mass and rigidity which makes the building experience a twisting ground motion around the center of rigidity, which results in torque - twisting effects in the building plan. This effect is undesirable and allows the danger of stress concentration [2].

Table 5. Eccentricity model a-e

Floor	Center of mass (m)		Center of rigidity (m)		Eccentricity (e)	
	Xm	Ym	Xr	Yr	X=Xm-Xr	Y=Ym-Yr
1st Floor	12.5	5	12.5	5	0	0
2nd Floor	12.5	5	12.5	5	0	0
3rd Floor	12.5	5	12.5	5	0	0
Roof Floor	12.5	5	12.5	5	0	0

According to table 5, the models a-e does not form eccentricity or in other words, the center of mass and the center of rigidity are overlapped, making its eccentricity= 0. It also negates the potential for torsion in the building model. Therefore, the main eccentricity occurs by building mass geometry form, and the irregularity effect of the beam/column arrangement is relatively minimal but it can cause another irregularity, i.e. non-parallel irregular configuration. Eccentricity can cause torsion in the building, the causes include uneven loading, rigidity and strength, and others [7] (see figure 9).

For avoiding excessive torque, then a simple formula is propose to evaluate the potential for the formation of torsional irregularity configuration in buildings that are still in the process of architectural design :

$$e_r = e/w \quad (2)$$

Where, e_r= the ratio between the length of eccentricity (e) and the width of the building being reviewed (w).

Table 6. The eccentricity ratio quality level (e_r) of torque irregularity configuration

Source	Quality Level		
	Good	Moderate	Poor
JBDPA [8]	$e_r \leq 0.1$	$0.1 < e_r < 0.3$	$e_r \geq 0.3$

The result of e_r is then compared with table 5, so it is known whether the configuration of torque irregularity being formed is included in tolerance level (good), moderate or poor.

Figure 9. Building damage from torque eccentricity (source : [2]).

4. Conclusion

From the explanations above, there are some conclusions that could be useful for architects in designing the building, as follows:

- The ideal building structure is when the beams and columns are in one axis but if it is inevitable, connect the columns with the triangle module beams so that it will have more rigidity.
- Columns which are not in one axis have weaker rigidity than the beams which are not in one axis.
- The random seismic motion requires both axes to have equal ability in facing the seismic loads.
- Primarily, eccentricity occurs by the geometric shape of the building mass and the effect of irregularity of the beam/column arrangement is relatively minimal but can cause another irregularity, the non-parallel irregularity configuration.
- Avoiding the excessive formation of torque irregular configuration and non-parallel irregular configuration in the building design can be done by evaluation using formula 1 and 2 above.

For future research can be investigated the effect of earthquake on geometry architecture with non-parallel system irregularity configuration in irregular form.

5. Acknowledgments

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