CIVIL ENGINEERING DIMENSION
Journal of Civil Engineering Science and Application | Dimensi Teknik Sipil
Jurnal Keilmuan dan Penerapan Teknik Sipil

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Email: dimensi-sipil@petra.ac.id

REVIEW on
SUBMITTED PAPER

TITLE: **New Design Philosophy for Seismic-Resistant Design of Buildings**

AUTHOR: Nanang Gunawan, Aylie Han, and Buntara Sthenly Gan

Email: *buntara@arch.ce.nihon-u.ac.jp*, hanaylie@hccnet.nl

Our ref. **CED-Nanang-New**

The paper discussed an interesting topic but since it is still an Idea and not yet implemented, the Authors are suggested to change the title to reflect the content of the paper more properly..

1. Abstract is too long, please keep the abstract around 150 words
2. To avoid misunderstanding, the Authors should consider using “residential building” instead of “residential housing”, or other more appropriate term
3. All data and information are from Japan experience, the Authors should clearly mention that this is the case in Japan, not other country
4. Some additional comments are given in the text
5. If possible the Authors are require to cite at least one relevant paper published in Civil Engineering Dimension
6. The printed version of the journal is in Black and White, thus the Authors should also mentioning colors in the text, and please make sure that the nice colored figures printed well in black and white.

Please consider all feedback and send the revised manuscript in a file named: **CED-Nanang-New-Rev1**

Benjamin Lumantarna
Editor in Chief
27-09-18

New Design Philosophy for Seismic-Resistant Design of Buildings

Nanang Gunawan[1], Aylie Han[2], and Buntara Sthenly Gan[3*]

[1]*Phd. Candidate, Department of Civil Engineering, Diponegoro University, Tembalang, Semarang 50275, Indonesia*
[2]*Professor, Department of Civil Engineering, Diponegoro University, Tembalang, Semarang 50275, Indonesia*
[3]*Professor, Department of Architecture, College of Engineering, Nihon University, Koriyama, Fukushima 963-8642, Japan*

** Corresponding author:buntara@arch.ce.nihon-u.ac.jp*

(**Received:** Month Year ;**Revised:** Month Year ;**Accepted:**Month Year)

Abstract: More than a century, the modern seismic design and construction technologies have undergone tremendous developments. In the modern design codes, the building structures are allowed to experience the plastic deformations under the occurrences of large earthquakes but not collapse. The code indicates that the design work of buildings is permitted up to the ultimate strength of the building structures to resist earthquakes. According to the results of comparisons, the number of human injured due to the earthquakes are more dominant than the number of death/missing. Likewise, the number of residential housing which is collapsed is less than the partly damaged houses. It implies that the residential housing has been proved to have earthquake resistances from several seismic design standard revisions. It also implies that the deaths/injury of human casualties was not due to the collapsed of their houses, but due to the strong earthquake shakings which caused the falling of things like book or dish shelves, furniture, hanging lamp and another non-structural element inside the housewhich injured or sometimes killed the human inside the houses. Considering such realities, the presentearthquake-resistant design philosophy which has been developed and revised in the previous century should now be supplemented bythe additional new method to determine the shaking quantitatively and restricting the effects under various earthquakes.

Keywords: Earthquake magnitude; Earthquake shaking; Earthquake resistant-design; Human casualties; Seismic design; Seismic intensity.

1. Introduction

Japan is an island country in East Asia where presently active four tectonic plates (Pacific plate, North American plate, Eurasian plate, and Philippine plate) meet at the zone called the Pacific Ring of Fire which is prone to earthquakes and volcanic eruptions. It has been reported that since the 19th century, 20% of the earthquakes in the world with the magnitude larger than six occurred in Japan. Learning from the history, the technologies developments in Japan in the seismic-resistant building have been started since 1891, in Meiji era. From long experience in developing the technologies against the failures and damages of buildings during big earthquakes, the first law enforcement on the seismic-resistant building took place in 1919. Since then, the design codes in Japan have been revised whenever larger earthquake and big casualties encountered. The latest seismic design methods allow the building structures to experience plastic deformations under large earthquakes, while remaining elastic under small or moderate earthquakes. The plastic deformation was anticipated to dissipate earthquake energy and to safeguard human being inside the building by preventing the structural collapse. While

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To avoid misunderstanding, maybe the Authors should use "residential building" instead of "residential housing"

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Commented [B4]: Japan!!!
The introduction is about Japan not Indonesia. It is ok, since CED is an international journal. But taking the facts from Japan for Indonesia is not right.

this design method is highly effective for protecting human lives, it does not fully account for human's lifeloss due to non-structural, such as books or dishes shelves; furniture; hanging lamp, failures due to strong shakings during the earthquakes.

There was a continuing tradition where the codes are revised merely by the strength of the building structures against big earthquakes. A new seismic design approach to reduce the effect of shakings during the earthquakes is necessary for complementing of the present codes. This new seismic design approach intended to be applied to more general structures. Such structural design philosophy is required for modern and resilient societies. In order to achieve this, the rise of the construction cost becomes the main issue to resolve; however, the cost of casualties can overwhelm the cost to improve the structural performance. This paper proposes a quantitative seismic intensity level evaluation during the earthquake so that a counter measure can be resolved to reduce the shakings during the earthquakes.

2. Statistic of human and building casualties due to earthquakes

The Japan Meteorological Agency (JMA) has comprehensively compiled the statistic of 153 data on the location, seismic magnitude, Japan's Seismic Intensity Level, and casualties of human and residential housing data from 6th March 1996 until 18th June 2018 (22 years' period) due to major earthquakes in Japan [1]. Omitting the 2011 Tohoku earthquake in which the casualties of a human being and residential housing are mostly due to the tsunami, comparisons between the number of human casualties and the collapsed of residential housing were investigated.

Figure 1 shows the statistical data of earthquake magnitude and seismic intensity level at given locations from 153 earthquakes recorded. From the figure, it can be observed that the measurements of seismic intensity level are less divergence, thus reliable to be used as an evaluation tool for the new design philosophy.

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Figure 2 depicts the statistical data of human casualties (deaths included missing people or injured) due to earthquakes occurred in the period at different locations. The red circles show

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Fig. 1. The statistical data of the magnitude/seismic intensity level of the earthquakes.

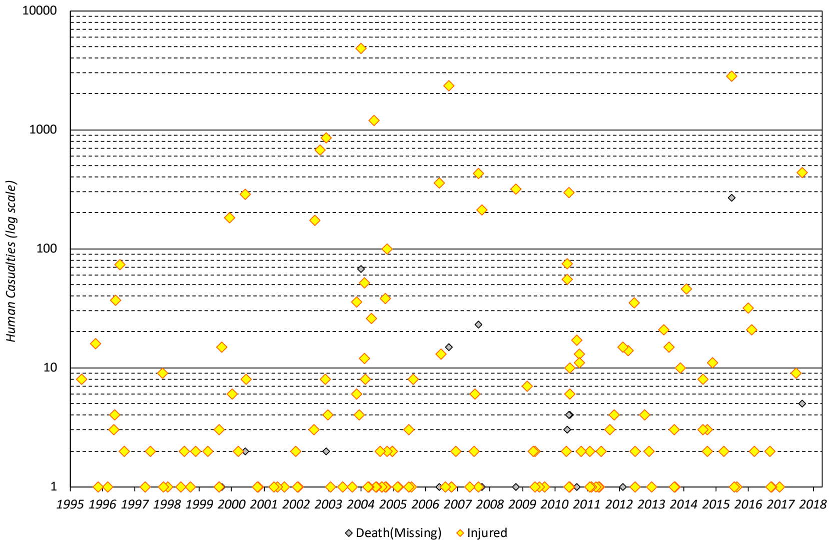

Fig. 2. The statistical data of human casualties due to earthquakes.

the magnitude at the epicenter of the earthquakes and blue circles show the corresponding Japan seismic intensity level. The scatter green markers show the number of injured human casualties during the earthquakes. It can be observed that these number exceeded the number of death (included missing) of human casualties at the same occurrence of earthquake.

Figure 3 depicts the statistical data of residential housing casualties (collapsed or repairable partly damaged) due to earthquakes occurred in the period at different locations. The red circles show the magnitude at the epicenter of the earthquakes and blue circles show the corresponding

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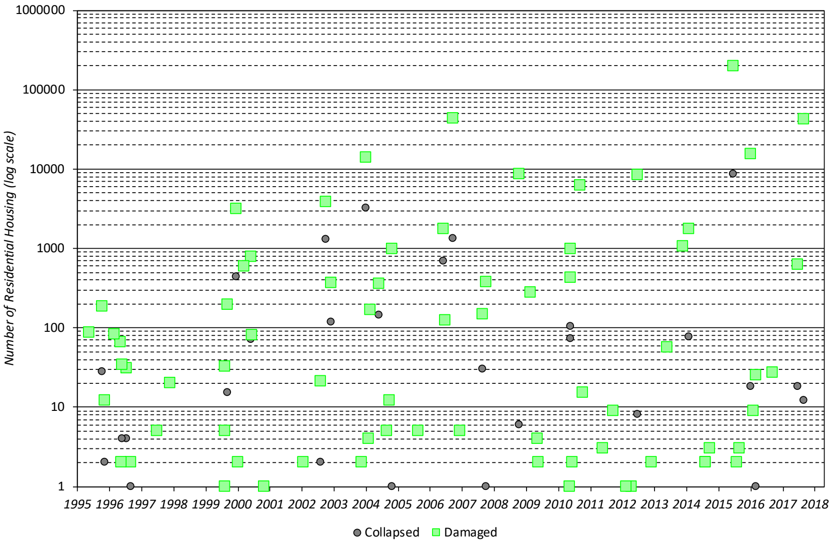

Fig. 3. The statistical data of residential housing casualties due to earthquakes.

Japan seismic intensity level. The scatter green markers show the number of partly damaged residential housing casualties during the earthquakes. It can be observed that these number exceeded the number of collapsed residential houses casualties at the same occurrence of an earthquake.

Considering both figures, the number of human being injured due to the earthquakes are more dominant than the number of death/missing. Likewise, the number of residential housing which is collapsed is less than the half-collapsed/partlydamaged houses casualties. It implies that the residential housing has been proved to have earthquake resistances from several seismic design standard revisions not to be collapsed in the occurrences of big earthquakes. Hence, the deaths/injury of human casualties were not mainly due to the collapsed of their houses, but due to the strong earthquake shakings which caused the falling of things like book or dish shelves, furniture, hanging lamp and another non-structural element inside the house which injured or sometimes killed the human inside the houses. In other words, the recent design codes which are intended to protect human lives against big earthquakes by allowing building failure do not guarantee there will be no human casualties due to earthquake shaking effects.

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3. Magnitude and Seismic Intensity Level (S_{IL})

Figure 4 shows illustrations ~~to show~~of the different concepts between the earthquake magnitude and seismic intensity level. The earthquake magnitude scales are used to explain the overall energy of an earthquake. These scales are different with the seismic intensity level that categorize the intensity or severity of ground shaking (quaking) caused by an earthquake at a certain location. The seismic intensity levels are varying on the magnitude scale and depth of an earthquake epicenter, type of soils, dynamic characteristics of the building/structure on the ground.

The S_{IL} denotes the strength or force of shaking due to an earthquake and can be associated with the Peak Ground Acceleration (PGA) and dominant period at a given location. The S_{IL} adopted by the Japan Meteorological Agency (JMA) [2] shown in Fig. 4 is very practical because the value of S_{IL} can be a quantitatively evaluated from the PGA and dominant period at a given location. There is a similar kind of seismic intensity level has been around the so-called

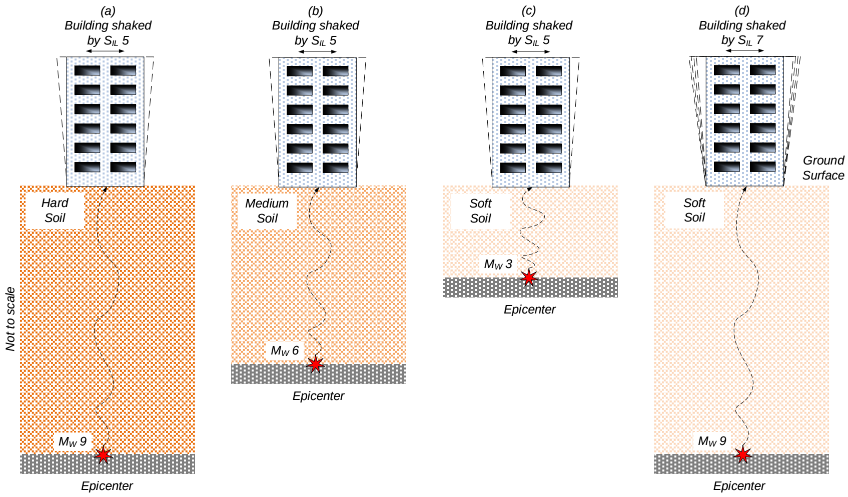

Fig. 4. The illustrations of the earthquake magnitude and seismic intensity level.

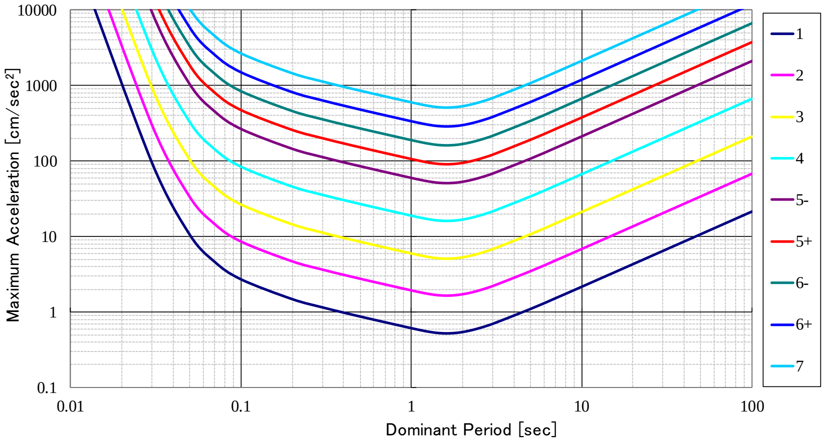

Fig. 4. The seismic intensity level of JMA [2].

Modified Mercally Intensity (MMI), it has 12 intensity scales with descriptive illustrations and simple explanations about the effects of shaking, but they are based on qualitative perceptions [3].

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The S_{IL} of the JMA has intensity scales from one to seven, with refined categories of strong and weak between five and six scales. TheS_{IL} has been used in Japan to spread a quick, informative earthquake warning through the broadcasting television to the entire country. The main purpose of this $S_{IL}$is intended for disaster mitigation of Japanese people when the country is struck by an earthquake.

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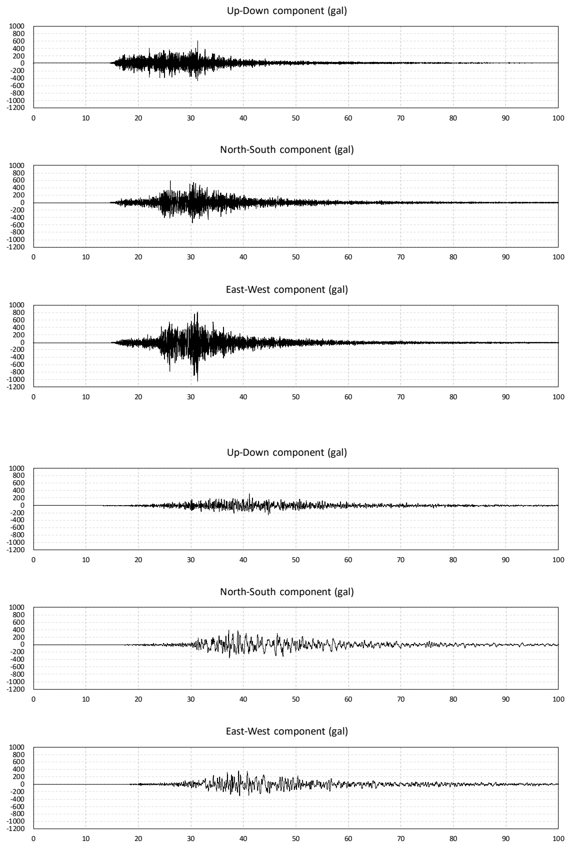
As an illustrative example, two earthquakes shown in Fig. 5. which occurred in different locations in Japan in the same year are selected. The Miyagi earthquake occurred on 26 May 2003, has the magnitude 7.0 at the epicenter. In the Ofunato city of Iwate prefecture, the earthquake was recorded to have the PGA of 1105.5 gals with S_{IL} = 5.8. In the same year, the Tokachi earthquake occurred on 26 September 2003 with magnitude 8.0. At that time, in the Urahoro city of Hokkaido, the earthquake was recorded to have the PGA of only 454.8 gals with the same S_{IL} = 5.8. Thus, even both earthquakes have a different magnitude of earthquakes and PGAs, they have the same value of S_{IL} = 5.8. The distance, soil conditions, and depth of the epicenter of the earthquakes are the main reasons behind these phenomena. Figure 5 also shows two different characteristics of seismic waves, the soil condition in Ofunato city has the dominant period about 0.075 sec (hard soil) while the soil condition in Urahoro city has the dominant period about 0.12 sec (medium soil). If both earthquakes' PGA and dominant period are plotted in Fig. 4., the same S_{IL} = 5.8 can be obtained.

The comparisons imply that the location with large PGA and earthquake magnitude do not have correlations with the seismic intensity S_{IL}, the level of shaking. The relationships either between the PGA and S_{IL} or between the earthquake magnitude and S_{IL} are not inherent. However, the shaking level of an earthquake which can be expressed by the S_{IL} number is affected by the distance and depth from the epicenter of the earthquake and PGA. The shaking level S_{IL} also can be used to determine the human and housing casualties during the occurrences of big earthquakes.

Because the S_{IL} of JMA can be evaluated quantitatively, it is an important evaluation tool for determining the efficiency by reducing the seismic intensity at a given location yet be used in current seismic design method to decrease the number of human casualties even if the houses are not collapsed.



Miyagi Earthquake
Magnitude : 7.0
26 May 2003
Station Code : IWT007
Station Lat. : 39.2701
Station Long. : 141.8561
Iwate Pref. Ofunato City
Max. Acc. (gal) : 1105.5
S_{IL} *: 5.8*

Tokachi Earthquake (Hokkaido)
Magnitude : 8.0
26 September 2003
Station Code : HKD091
Station Lat. : 42.8087
Station Long. : 143.6588
Hokkaido Urahoro City
Max. Acc. (gal) : 454.8
S_{IL} *: 5.8*

Fig. 5. Relationship between acceleration, period and $S_{IL}$of JMA [2].

4. Implementation of quantitative S_{IL} evaluation in the design code

Figure 6 shows_the illustrations of quantitative determination scheme of S_{IL}._of a building example. Supposed the building has passed the seismic design stage, after then the evaluation of shaking level can be conducted. Based on the soil conditions and the dynamic characteristics of the building, the selected response spectrum for design is used to generate the seismic wave at the location where the building will be built. Then, by using the seismic wave as the input ground motion, a time history analysis is performed. From the results of the analysis, the time history accelerations at different floors of the building are analyzed by using the Fast Fourier Transform method to determine the dominant period of each floor and the maximum response acceleration. The dominant periods and maximum response accelerations of the floors are plotted into the JMA Seismic Intensity Level to see the shaking levels of the floors.

When there is one floor has S_{IL} bigger than the allowance, the design should be revised to incorporate this insufficiency. The limiting or allowed seismic intensity level has to be set in the seismic design codes in order to reduce human and building casualties due to the shaking during the big earthquakes.

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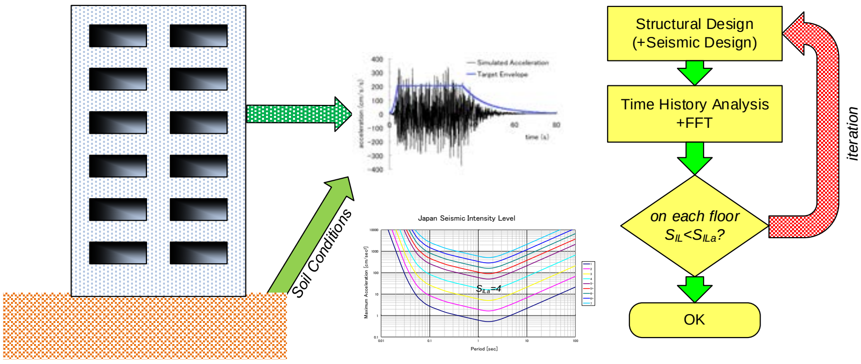

Fig. 6. Implementation of quantitative S_{IL} for seismic-resistant design of building.

5. Conclusions

The current seismic-resistant design method has been developed to allow for ductility of building structures to resist large earthquakes. While buildings are designed to remain elastic in small or moderate earthquakes, they are allowed to experience plastic deformations in bid earthquakes to prevent the collapseed and save human lives. This design approach has been effective regarding protecting people; however, it may not be sufficient for modern, complex societies. In past large earthquakes, many buildings that were damaged but did not collapse were resulting in vast human casualties.

Studying the concepts described above, we believe that there is still a room to improve the current seismic design practice. Most structural engineers understand the rationale behind a seismic design approach in which plastic deformation of beams, columns, and walls are anticipated; however, the shaking due to big earthquakes is equivalent to the casualties in human being and the building itself. Therefore, the limitation or allowable shaking level must be designed during big earthquakes.

References

[1] Major Damage Earthquake Occurred in Japan, after 1996 (in Japanese). *Japan Meteorology Agency* (http://www.data.jma.go.jp/svd/eqev/data/higai/higai1996-new.html)

[2] Seismic Intensity Level and Acceleration (in Japanese). *Japan Meteorology Agency* (http://www.data.jma.go.jp/svd/eqev/data/kyoshin/kaisetsu/comp.htm)

[3] Wood, H. O., and Neumann, F. (1931). Modified Mercalli Intensity Scale of 1931, *Seismological Society of America Bulletin*, *21(4)*, 277-283.

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Revision to the paper

Review	**Amends**
The paper discussed an interesting topic but since it is still an Idea and not yet implemented, the Authors are suggested to change the title to reflect the content of the paper more properly	The title has been revised to underline the proposed idea behind this paper, rather than highlighting this work as “new”
Abstract should be limited to around 150 words	The abstract has been revised to 149 words
This might be true in Japan but not in Indonesia. Earthquakes in Lombok, Bengkulu< Padang showed that the non-engineered building (houses) collapsed To avoid misunderstanding, maybe the Authors should use “residential building” instead of “residential housing”	The paper is now focused on japan only, as this is the presentation of a new concept The word “building” was used to replace “housing”
CED does not use section numbering	The template has been adjusted to CED
Japan!!! The introduction is about Japan not Indonesia. It is ok, since CED is an international journal. But taking the facts from Japan for Indonesia is not right.	The paper is now fully concentrated on the Japanese data
Which location as compared to Figure 1 “different locations”	Clarified
There is no red circle in fig 2 Move to new line, and add “ in Figure1”….”and in Figure 2”…. Please also note that the printed version of CED is printed in Black and White	All figures have been redrawn to be used in black and white printing by using visual expressions rather than colours, the text and figures have been corrected
Wrong copy and paste	Corrected
Which Figures, There are three figures before this paragraph	This paragraph has been rewritten and clarified
This sentence is not clear, why the author need to use “has been around”	The sentence was indeed not clear, and has been removed
It will be better if the Authors list the JMA scale	We added the JMA list in Table 1
Now I am confused, are this method about landed houses or apartments in (tall) building?	The research work is aimed to low and medium high residential building, the text has been revised
??	Bid was wrongly typed, we changed in in severe
Need to mention when the data is read or down loaded	The recorded data was changes daily, we adjusted the web link to the English version

If possible the Authors are require to cite at least one relevant paper published in Civil Engineering Dimension	We added more supporting references to the paper We have difficulties finding reference papers, and after searching the CED we couldn’t find a suitable one