RACIC 9 (2) (2024)

JURNAL RAB CONTRUCTION RESEARCH

http://jurnal.univrab.ac.id/index.php/racic

COMPARISON STUDY OF BIM MODELING IN SEISMIC ANALYSIS FOR DIFFERENT BUILDING FUNCTIONS BASED ON SNI 1726:2019

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Info Artikel

Sejarah Artikel:

Diterima: Juli 2024
Disetujui: Agt 2024
Dipublikasikan: Des 2024

Keywords:

Building Information Modeling; Story Shear; Story Displacement; Structure

Abstract

The application of BIM in Indonesia in building planning which refers to SNI 1726:2019 is still very minimal. This research involves two different types of buildings, namely hotel buildings and hospitals. The modeling used is simple concrete building structure modeling with variations of 3, 9 and 12 floors in Revit as a model. The same BIM model is used in the Structural Analysis Robot and then the results of the two buildings are compared, namely the comparison of story shear and story displacement. The research methods used are data collection, BIM modeling using the latest software, and seismic analysis taking into account the parameters described in SNI 1726:2019. The results of BIM modeling and seismic analysis were then compared for both types of buildings.

Keywords: *Building Information Modeling; Story Shear; Story Displacement; Structure*

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ISSN 2527-7073

INTRODUCTION

The use of Building Information Modeling (BIM) technology is no longer foreign to the AEC industry in the world, including in Indonesia. Throughout its journey, BIM has received a positive response from the public considering the benefits offered in the AEC field. By implementing BIM in the world of construction, developers, consultants, and contractors will be able to save work time, costs incurred, and the labor required [1]. The application of Building Information Modeling (BIM) in Indonesia has been implemented by several companies in the construction industry sector. If we reflect on how the BIM method is applied in the United States, the potential achieved

from the application of the BIM method in Indonesia is still far from the maximum. The percentage of the construction sector in Indonesia's Gross Domestic Product (GDP) is 9.86 percent in the third quarter of 2023. The Central Statistics Agency captures construction developments through the Quarterly Construction Company Survey conducted on medium and large-scale construction companies in Indonesia. However, the application of BIM in the construction sector is still not optimal [2].

Previous researchers analyzed seismic in BIM modeling of hospital buildings [3]. The purpose of this test is to conduct a comparative study of the use of BIM modeling in seismic analysis for different building functions based on the Indonesian National Standard SNI1726:2019. This research involves two different types of buildings, namely hotels and hospitals. Research will be carried out starting from data collection, BIM modeling using the latest software, as well as seismic analysis taking into account the parameters described in SNI 1726:2019. The results of BIM modeling and seismic analysis were then compared for both types of buildings.

According to Ciotta [5], the use of BIM in structural engineering has an important role in reducing deficiencies originating from inability to identify processes, multidisciplinary collaboration and information management [6]. BIM modeling in structural analysis has limitations in the model transfer process between software [7]. In this research, BIM modeling using Revit and ETABS software.

This research discusses the application of BIM in modeling simple concrete building structures with variations of 3, 9 and 12 floors in Revit as a model. The same BIM model is used in the Structural Analysis Robot to analyze structures for earthquake loads using the static equivalent method and response spectrum method in accordance with SNI 1726:2019 to determine shear levels and story shifts. Modeling with specifications and loads. The same thing is also done with ETABS to determine story shear and deviation between levels as a control for the independent structural analysis model. The results of shear levels and deviations between structural component levels of the BIM model, structural analysis model, and manual calculations were compared to determine the accuracy of the results of implementing BIM in the analysis of simple concrete structures in terms of these aspects.

RESEARCH METHODS

In this study, two buildings being compared are a hotel and a hospital located in Jakarta and were modeled in Revit and ETABS with a span of 4 meters and a height of each floor of 4 meters. The two buildings are modeled with variations of 3, 9, and 12 floors.

Static equivalent and response spectrum seismic analysis methods are carried out with seismic parameters according to SNI 1726:2019. The dimensions of the beam used are 300x600mm, column 500x500mm, and plate thickness 120mm.

Table 1. Member Properties

	b (mm)	h (mm)	Moment of inertia, Ie
Column	500	500	0,7 Ig
Beam	300	600	0,35 Ig

The loads applied to the model are weight density per unit volume 23.6 kN/m^3, DL plate 2.83 kN/m, SDL plate 0.863kN/m, LL Plate 3.83 kN/m^2, SDL beam 8.33 kN/m^2, and earthquake load. As the concrete property used in modelling, mass density 2406.45 kg/m^3, Young's Modulus (E) 25742.96 MPa, and shear modulus (G) 10726.23 MPa.

Table 2. Seismic Parameters SNI 1726:2019 of hotel

Parameter	**HOTEL**
Location	Jakarta, Indonesia
Site Class	SD (Stiff Medium Soil)
Earthquake Priority Factor (Ie)	1
Modification Response Coefficient (R)	8
Base Rock Acceleration, S_S	0.7806
Base Rock Acceleration, S_1	0.3823
Short-Period Site Coefficient, F_a	1.18776
Long-Period Site Coefficient, F_v	1.9177
Acceleration parameters for short periods (S_{MS})	0.9272 g
Spectral response acceleration parameters for short periods (S_{DS})	0.6181 g
Spectral response acceleration parameters for 1 second periods (S_{D1})	0.4888 g

The response spectrum is scaled with a value of 1/(R/Ie), which is 0.125. The modeling of each structural element has taken into account the structural crack cross-section required in SNI 2847:2019 table 2. Analysis using spectrum response with a response modification coefficient (R) value of 8 for Special Moment Resisting Frame System. Building modeling was carried out with the help of ETABS, REVIT software. All structural elements are modeled as elements that behave linearly. In this model, the building clamping level is on the ground floor and is modeled to have clamp placement. In this modeling, fc' 30 MPa material is used for column, slab and beam structures.

RESULTS AND DISCUSSION

Basic Shear Force of Structure

The following table 3 shows the calculation of basic shear force according to SNI 1726:2019.

Table 3. Calculation of basic shear force according to SNI 1726:2019

Parameter	3-STORY	9-STORY	12-STORY
R	8	8	8
I_e	1.0	1.0	1.0
C_t	0.0466	0.0466	0.0466
h_n (m)	12	36	48
x	0.9	0.9	0.9
C_u	1.4	1.4	1.4
Structure Period			
T_a $C_t*h_n^x$	0.4362	1.1724	1.5188
T_{maks} C_u*T_a	0.6106	1.6413	2.1263
Seismic Response Coefficient			
C_s $S_{DS}/(R/I_e)$	0.0773	0.0773	0.0773
C_{smax} $S_{D1}/T(R/I_e)$	0.1401	0.0521	0.0402
C_{smin} $0,044*S_{DS}*I_e$	0.0272	0.0272	0.0272
Cs digunakan	0.0773	0.0521	0.0402
Seismic Weight			
W [kN]	892.996	3063.089	4148.135
Basic Shear Force			
V[kN] C_s*W	68.996	159.627	166.861

Based on SNI 1726:2019, it states that if the basic shear force resulting from analysis of the response spectrum (Vt) is less than 100% of the shear force calculated using the equivalent static method (V), then the force must be multiplied by V/Vt (scale factor).

Story Shear

A comparison of story shear in hotel and hospital buildings can be observed in Table 4. If viewed from the static equivalent method, the error difference in using ROBOT VS ETABS between the two buildings is greatest on the top story of story 12, with an error of 12,893%. In comparison, on the base story, the difference in error between the two buildings is only 0.569%. The story shear value in the hotel building using ETABS is 16,431 kN on the top story and 166,874 kN on the base story. Meanwhile, the value of story shear in hotel buildings using robots is the smallest at

23,583 kN on the top story of story 12 and the largest on the base story at 173,824 kN. The error comparison value for the ROBOT and ETABS can be observed in Table 4, the largest is on the top story of story 12, with an error of 43.524% and the smallest error is 4.165% on the base story of the hotel building. The story shear value from the equivalent static method in both buildings gets smaller with each story increase. It can be observed in Fig.1.

In Table 5 it is shown that the shear force from the response spectrum method has the largest error difference in using robots vs Etabs between the two buildings in story 5, with an error of 0680%, while the error difference in using robots vs Etabs is the smallest between the two buildings on the top story of story 12, with an error of 0.413%. The story shear value using the response spectrum method is greater than the equivalent static method. The story shear value in ETABS and Robot is not much different. It can be observed in Table 5, that the error comparison value for robots and ETABS in the hotel is greatest on the top story of story 12, with an error of 6.382% and the error on the base story is 4.165%. In Fig.2, the story shear value from the response spectrum method in both buildings increases the story shear value from the top to the base story

Table 4. Static Equivalent Method Story Shear (kN) in Hotel and Hospital

Story	ETABS (kN)		SAP2000 (kN)		Robot (kN)		Error Hotel (Robot vs ETABS) (%)	Error Hospital (Robot vs ETABS) (%)	Selisih Error Hotel vs Hospital
	HOTEL	HOSPITAL	HOTEL	HOSPITAL	HOTEL	HOSPITAL			
Story12	16.4314	24.6496	17.2271	25.844	23.5831	32.2	43.524%	30.631%	12.893%
Story11	47.1697	70.7542	48.6433	72.964	54.2793	78.6	15.072%	11.089%	3.984%
Story10	73.7893	110.6812	75.8477	113.768	80.8597	118.78	9.582%	7.317%	2.265%
Story9	96.4951	144.7378	99.0516	148.572	103.5396	153.06	7.300%	5.750%	1.551%
Story8	115.5026	173.2473	118.4769	177.708	122.5189	181.75	6.075%	4.908%	1.167%
Story7	131.0405	196.5528	134.3548	201.524	138.0408	205.21	5.342%	4.405%	0.938%
Story6	143.3530	215.0203	146.9366	220.396	150.3306	223.79	4.867%	4.079%	0.789%
Story5	152.7033	229.0449	156.4916	234.728	159.6736	237.91	4.565%	3.870%	0.694%
Story4	159.3798	239.0591	163.3167	244.964	166.3427	247.99	4.369%	3.736%	0.633%
Story3	163.7047	245.546	167.7352	251.592	170.6532	254.51	4.245%	3.651%	0.594%
Story2	166.0498	249.0635	170.1331	255.188	172.9951	258.05	4.183%	3.608%	0.574%
Story1	166.8736	250.2991	170.9762	256.452	173.8242	259.3	4.165%	3.596%	0.569%

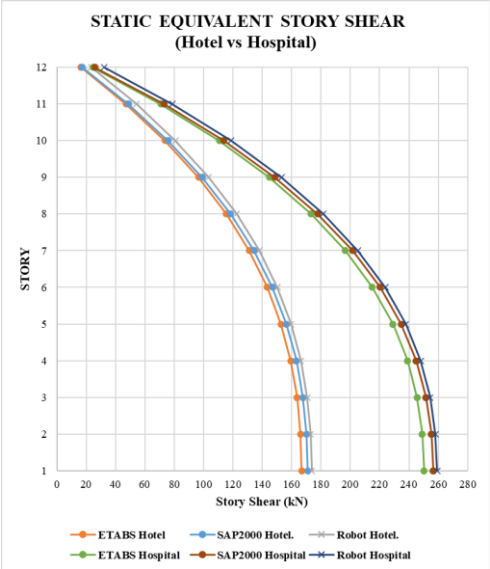

Fig 1. Story Shear of ETABS, SAP2000 and Robot Caused by Static Equivalent (SE) Seismic Load for Hotel and hospital

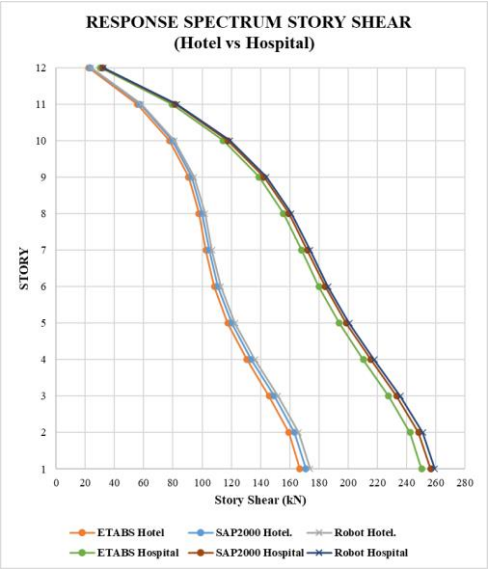

Fig 2. Story Shear of ETABS, SAP2000 and Robot Caused by Response Spectrum Seismic Load for Hotel and hospital

Table 5. Response Spectrum Method Story Shear (kN) in Hotel and Hospital

Story	ETABS (kN)		SAP2000 (kN)		Robot (kN)		Error Hotel (Robot vs ETABS) (%)	Error Hospital (Robot vs ETABS) (%)	Selisih Error Hotel vs Hospital
	HOTEL	HOSPITAL	HOTEL	HOSPITAL	HOTEL	HOSPITAL			
Story12	22.2152	30.4334	23.3031	31.92	23.6331	32.25	6.382%	5.969%	0.413%
Story11	55.6420	79.2265	57.3313	81.652	58.2493	82.57	4.686%	4.220%	0.466%
Story10	77.6172	114.5091	79.6277	117.548	80.9997	118.92	4.358%	3.852%	0.506%
Story9	90.6752	138.9179	92.8316	142.352	94.4896	144.01	4.207%	3.666%	0.541%
Story8	97.7999	155.5446	100.0569	159.288	101.8589	161.09	4.150%	3.565%	0.585%
Story7	102.5168	168.0291	104.9068	172.076	106.7708	173.94	4.150%	3.518%	0.632%
Story6	108.2976	179.9649	110.8806	184.34	112.8306	186.29	4.186%	3.515%	0.671%
Story5	117.5642	193.9058	120.4076	198.644	122.5136	200.75	4.210%	3.530%	0.680%
Story4	130.6687	210.348	133.8247	215.472	136.1827	217.83	4.220%	3.557%	0.663%
Story3	145.8023	227.6436	149.3232	233.18	151.9332	235.79	4.205%	3.579%	0.626%
Story2	159.3445	242.3582	163.2251	248.28	166.0151	251.07	4.186%	3.595%	0.592%
Story1	166.8732	250.2987	170.9842	256.46	173.8242	259.3	4.165%	3.596%	0.569%

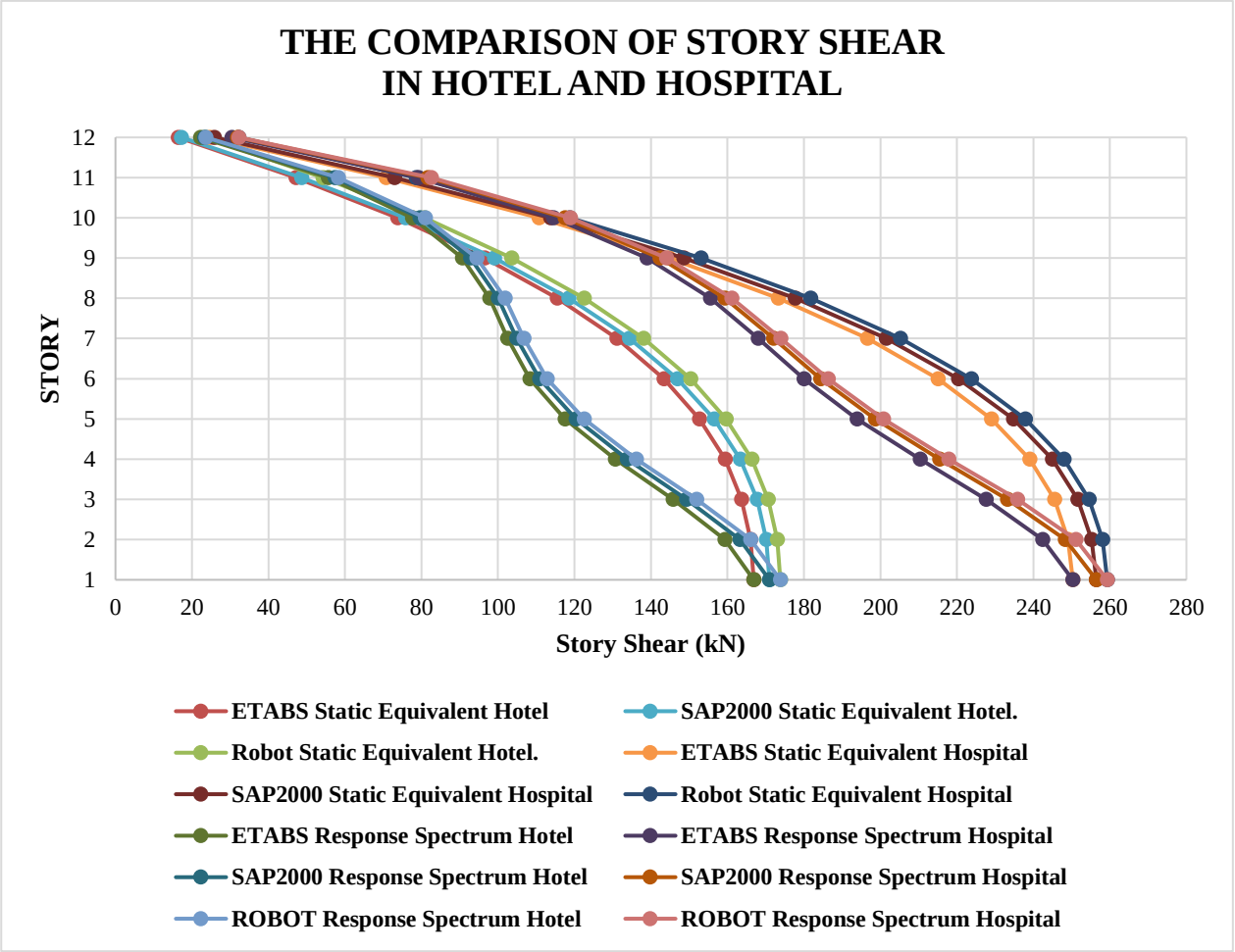

Fig 3. Story Shear of ETABS, SAP2000 and Robot Caused by Static Equivalent (SE) & Response Spectrum Seismic Load for Hotel & Hospital

Story Displacement

Story displacement is story movement due to seismic excitation. The story displacement value for each building is not much different whether using ETABS, SAP2000, or Robot. In Table 6 and Table 7, it can be observed that the story displacement value in the hotel building is greater on the top floor, and the story displacement value is smaller up to the ground floor using both the static equivalent method and the spectrum response method.

Comparison of the error value of story static displacement equivalent to using Etabs and robots in hotel buildings is 3.772% and in hospitals is 3.69%, so the error difference between the two buildings is 0.403% on the top story. Meanwhile, on the base story, the equivalent static displacement story error value for the hotel building is 2.108% and for the hospital, it is 1.550%, so the error difference between the two buildings is 0.558% on the ground floor. The values can be observed in Table 6.

A comparison of the story displacement values between the two buildings using ETABS, SAP2000, and ROBOT can be seen in Fig 4, where there is a constant increase for each story from the base story to the top story.

Table 6. Static Equivalent Method Story Displacement (mm) in Hotel and Hospital

Story	ETABS (mm)		SAP2000 (mm)		Robot (mm)		Error Hotel (Robot vs ETABS) (%)	Error Hospital (Robot vs ETABS) (%)	Selisih Error Hotel vs Hospital
	HOTEL	HOSPITAL	HOTEL	HOSPITAL	HOTEL	HOSPITAL			
Story12	138.6207	189.901	142.2153	194.802665	143.8499	196.299	3.772%	3.369%	0.403%
Story11	127.3909	181.387	130.6244	186.037025	131.9615	187.059	3.588%	3.127%	0.461%
Story10	115.4974	170.394	118.3638	174.731019	119.4051	175.305	3.383%	2.882%	0.501%
Story9	102.3910	156.867	104.8848	160.834835	105.6701	161.05	3.203%	2.667%	0.536%
Story8	88.7611	141.169	90.9066	144.720974	91.4764	144.67	3.059%	2.480%	0.579%
Story7	75.4991	123.746	77.3316	126.845077	77.7210	126.615	2.943%	2.318%	0.624%
Story6	63.2178	105.053	64.7660	107.674062	65.0128	107.34	2.839%	2.177%	0.662%
Story5	51.8631	85.541	53.1402	87.668748	53.2756	87.297	2.723%	2.053%	0.671%
Story4	40.7838	65.653	41.7869	67.281437	41.8413	66.927	2.593%	1.941%	0.652%
Story3	29.3618	45.843	30.0830	46.976998	30.0831	46.687	2.457%	1.841%	0.616%
Story2	17.5559	26.702	17.9882	27.361733	17.9643	27.168	2.326%	1.745%	0.581%
Story1	6.4083	9.612	6.5664	9.848961	6.5434	9.761	2.108%	1.550%	0.558%

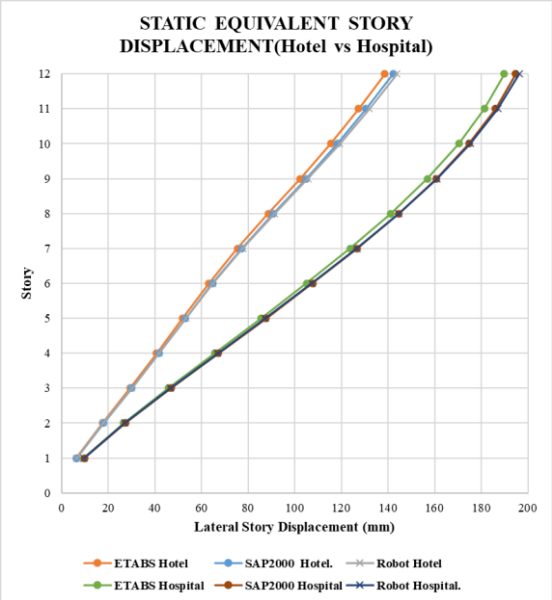

Fig 4. Story Displacement of ETABS, SAP2000 and Robot Caused by Static Equivalent (SE) Seismic Load for Hotel and hospital

A comparison of the error difference in the story displacement response spectrum values using ETABS and ROBOT in hotel and hospital buildings of 0.398% on the top story and 0.557% on the base story is shown in Table 7. In hotel buildings, the story displacement response spectrum value using ROBOT is the greatest at 115.1098mm compared to SAP2000 at 115.2449 mm and with ETABS of 112.3770 mm on the top story. The largest error comparison value between ETABS and Robot on story-12 hotels with an error of 2.432% and the smallest error is 1.991% on the base story.

A comparison of the story displacement response spectrum values for the two buildings using ETABS, SAP 2000 and Robot software can be seen in Fig.5.

A comparison of story displacement values for hotels and hospitals with the threeanalysis software used can be seen in Figure 6.

Table 7. Response Spectrum Method Story Displacement (mm) in Hotel and Hospital

Story	ETABS (mm)		SAP2000 (mm)		Robot (mm)		Error Hotel (Robot vs ETABS) (%)	Error Hospital (Robot vs ETABS) (%)	Selisih Error Hotel vs Hospital
	HOTEL	HOSPITAL	HOTEL	HOSPITAL	HOTEL	HOSPITAL			
Story12	112.3770	153.949	115.2449	157.8592755	115.1098	157.08	2.432%	2.034%	0.398%
Story11	103.3822	147.202	105.9566	150.90476	105.8851	150.095	2.421%	1.965%	0.456%
Story10	93.9615	138.622	96.2430	142.0758415	96.2120	141.254	2.395%	1.899%	0.496%
Story9	83.7048	128.239	85.6961	131.4100235	85.6876	130.595	2.369%	1.837%	0.532%
Story8	73.1748	116.38	74.9019	119.2419455	74.9004	118.455	2.358%	1.783%	0.575%
Story7	63.0522	103.345	64.5478	105.8760665	64.5376	105.138	2.356%	1.735%	0.621%
Story6	53.7531	89.325	55.0407	91.5056965	55.0168	90.836	2.351%	1.692%	0.659%
Story5	45.1126	74.407	46.2002	76.2193985	46.1603	75.638	2.322%	1.654%	0.668%
Story4	36.4230	58.633	37.3014	60.0591815	37.2506	59.584	2.272%	1.622%	0.650%
Story3	26.9657	42.102	27.6174	43.126798	27.5618	42.774	2.210%	1.596%	0.614%
Story2	16.5631	25.192	16.9657	25.806309	16.9182	25.586	2.144%	1.564%	0.580%
Story1	6.1863	9.279	6.3381	9.506543	6.3094	9.412	1.991%	1.433%	0.557%

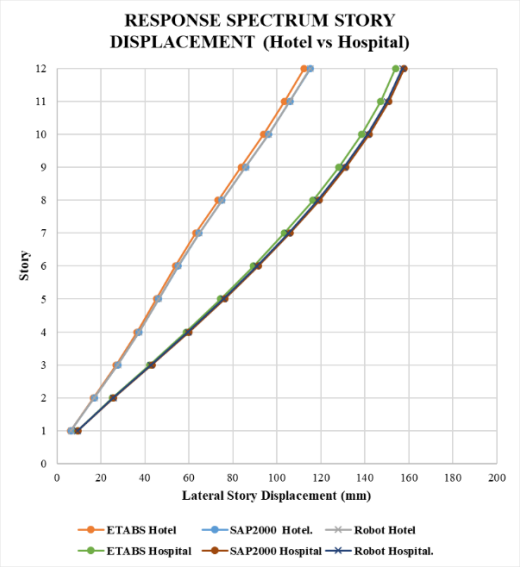

Fig 5. Story Displacement of ETABS, SAP2000 and Robot Caused by Response Spectrum Seismic Load for Hotel and hospital

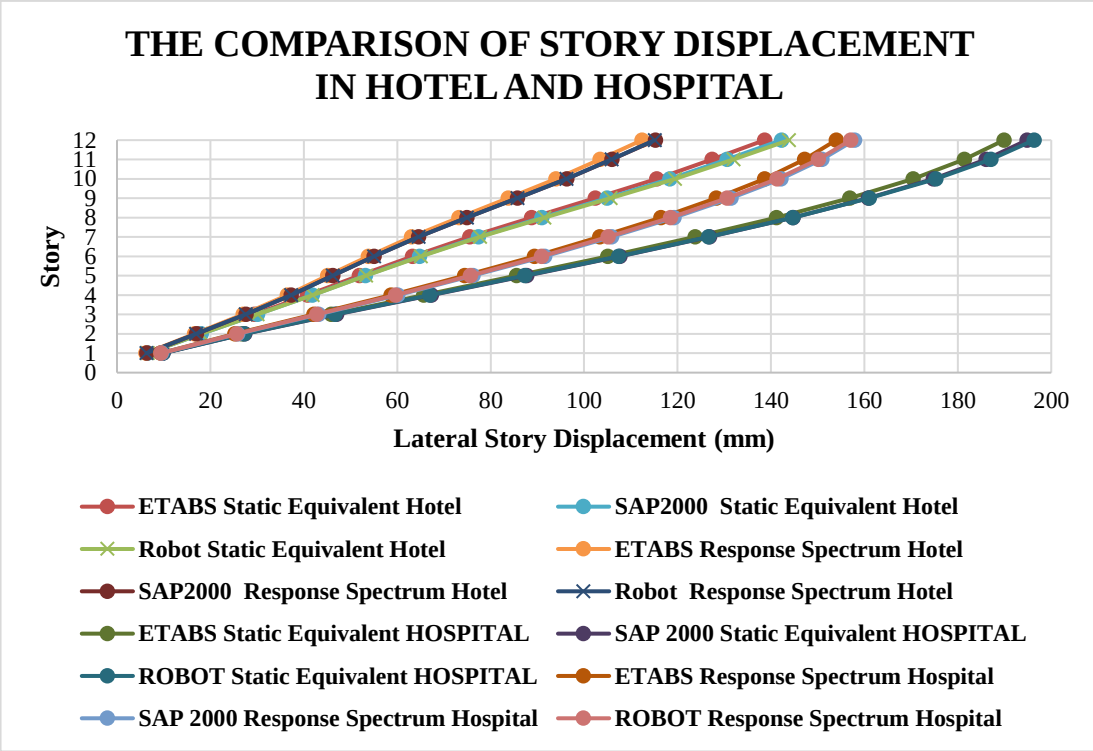

Fig 6. Story Displacement of ETABS, SAP2000 and Robot Caused by Static Equivalent (SE) & Response Spectrum Seismic Load for Hotel & Hospital

CONCLUSIONS

The conclusions obtained from this research are as follows.

1. The comparison of story shear values in hospitals is greater than in hotels, both in terms of static equivalent and response spectrum. And the largest story shear value is on the base story and the smallest value is on the top story
2. Of the three software used, the story shear and story displacement values are highest using ROBOT because it inputs the mass of the structure in the application and the lowest using ETABS software because the seismic weight is ignored
3. The percentage of error value between ROBOT and ETABS software is largest in hotels, with an error of 43.524%, compared to hospitals of 30.631%
4. Comparison of the error difference in story displacement values between hotels and hospitals is less than 1% using both the static equivalent method and the response spectrum method.
5. The story shear value between the two buildings is greatest for the base story and smallest for the top story, while the story displacement value is second.

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