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Analysis of the behavior and performance of the short link eccentric brace frame type multistory x-brace with variable link length and L / H ratio

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Abstract

In the process of planning earthquake-resistant building structures, steel structures are still an option. This is because steel material has relatively high load resistance and elastic properties of steel which contribute to better ductility and energy dissipation than concrete. Eccentric Brace Frame System (SRBE) is a lateral load bearing system that has good strength, stiffness and ductility. In this study, the SRBE Short Link Multistory X-bracing type structure with variable link length and L / H ratio was evaluated using pushover analysis to determine the structure's behavior and performance in terms of stiffness, strength and ductility of the structure. The analysis was conducted on 9 10-story building models with different link lengths and L / H ratio. From the results of the comparative analysis of each structural model, it is found that the C2 model with a link length of 900 mm and an L / H ratio of 1.5 has a stiffer structure. Model C3 with a link length of 900 mm and a ratio of L / H = 1.75 has a greater strength to withstand earthquake loads. The use of a link length of 300 mm and an L / H ratio = 1.5 results in an increasingly ductile structure. The results of the structural performance are at the Immidiate Occupancy level, but there are several models with one of the X or Y load directions that have a Life Safety structural performance level. The use of a link length of 300 mm and an L / H ratio = 1.5 results in an increasingly ductile structure. The results of the structural performance are at the Immidiate Occupancy level, but there are several models with one of the X or Y load directions that have a Life Safety structural performance level. The use of a link length of 300 mm and an L / H ratio = 1.5 results in an increasingly ductile structure. The results of the structural performance are at the Immidiate Occupancy level, but there are several models with one of the X or Y load directions that have a Life Safety structural performance level.

Keywords
Eccentric Brace Frame System, Link, Pushover Analysis, Structural Performance

1. Introduction

The existence Indonesia is a country that has many areas with a high level of seismic vulnerability. For this reason, the structural plan must be designed to withstand the lateral forces generated by the earthquake. In the process of planning earthquake-resistant building structures, steel structures are still the favorite choice of civil engineering practitioners as an earthquake-resistant building structure material. This happens because the steel material has relatively high strength to withstand loads and the elastic properties of steel which contribute to better ductility and energy dissipation than concrete materials (Dewobroto, 2015).

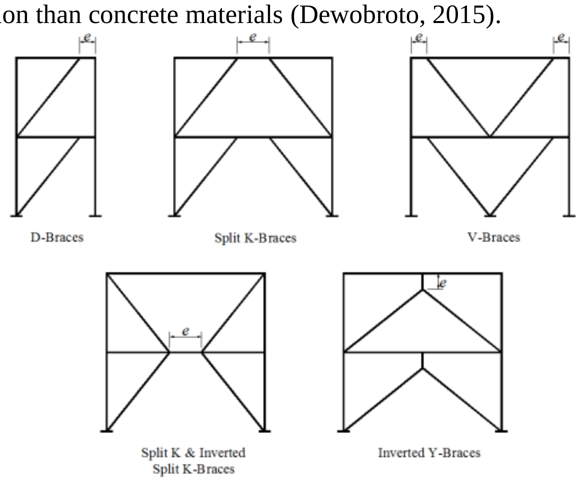


Figure 1. Some possible placement of bracing for an EBF structural system.

The Eccentric Brace Frame System (SRBE) is a special lateral load bearing system, because the SRBE is a combined combination of the highly ductile Moment Bearer Frame System (SRPM) and the Concentric Brace Frame System (SRBK) which has fairly good rigidity and strength (Daneshmand, Ardeshir and Hashem, 2011).

The split-type K-Braces EBF portal model that uses short links (e = 100 cm) is better and is recommended for its use in structures compared to medium links (e = 200 cm) and long links (e = 300 cm). This is indicated by the failure mechanism on the link is achieved earlier in the short link than the other models (Rafael and Suswanto, 2017). Meanwhile, another study on SRBE reported that links greater than 20% of beam span length resulted in a more ductile structure (Niknam and Sharfaei, 2011).

From some of these studies it becomes clear that the link length on the SRBE plays an important role, but there are still doubts whether the shorter or longer links are in the Short Link category with different length and height ratio (L / H) which results in a more effective and efficient structure. . In this study, the SRBE Short Link Multistory X-bracing type structure with variable link length and L / H ratio was evaluated using pushover analysis to determine the structure's behavior and performance in terms of stiffness, strength and ductility of the structure. The analysis was carried out on 9 10-story building models with different link lengths and L / H ratio.

2. Methods

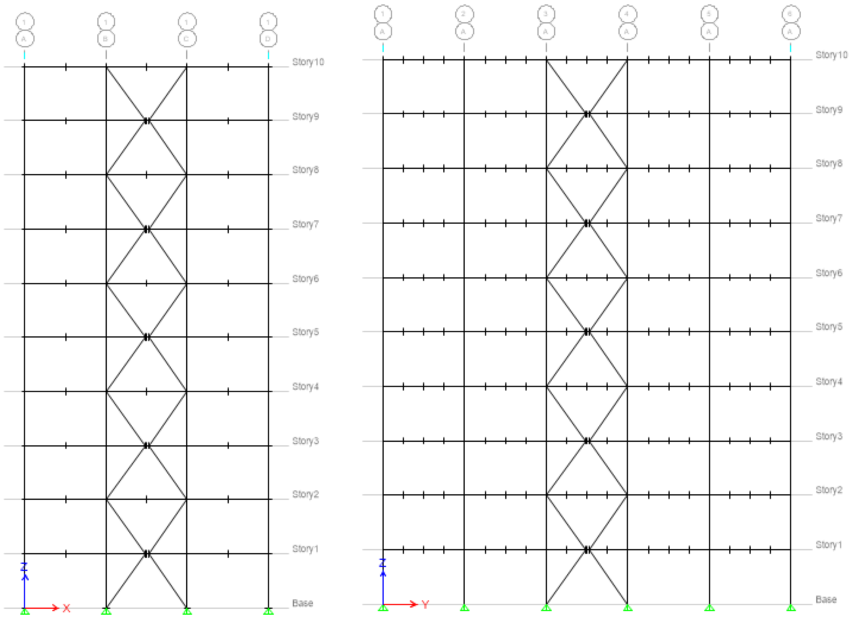
2.1. Planning for the EBF Structure

In the Eccentric Brace System there is a part of the beam called a link and is specially planned. SRBE is expected to experience considerable inelastic deformation at the link when carrying forces due to the design earthquake load because the link element functions as energy anticipation when the structure receives earthquake loads. This energy dissipation is manifested in the form of plasticification in the link elements.

The analysis was carried out on 9 10-story building models with different link lengths and L / H ratio. The structural analysis process is generally carried out with the help of commercial structural analysis software.

Table 1. Description of Structural Modeling

Model		A			B			C	
	1	2	3	1	2	3	1	2	3
Beam Length (m), (L)	5	6	7	5	6	7	5	6	7
L / H ratio	1.25	1.5	1.75	1.25	1.5	1.75	1.25	1.5	1.75
Link Distance (mm)		300			600			900	



(a) (b)

Figure 2. The x (a) direction portal model, the y (b) direction portal model.

2.2. Pushover Analysis

The net result is the base shear and displacement of the structure. These values are depicted in the capacity curve which illustrates the behavior of the structure. Pushover curve is influenced by the distribution pattern of the lateral force which is used as a thrust load.

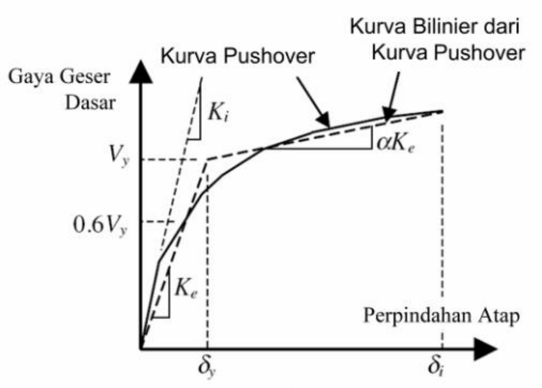


Figure 3. Pushover Curve (FEMA 356)

The force and deformation of each component / element are calculated against the "specified displacement" at the control point which is referred to as "displacement target" with the notation δt and is considered as the maximum displacement that occurs when the building experiences a planned earthquake. The method used to determine the displacement target is the FEMA 356 (American Society Of Civil Engineers, 2000). Displacement Target Method. The displacement target is carried out by modifying the linear elastic response with the coefficient factors C0, C1, C2, and C3 in order to obtain the maximum global displacement (elastic and inelastic).

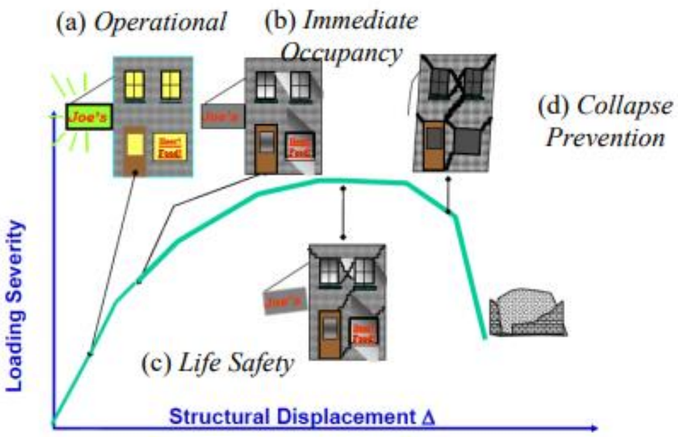


Figure 4. Performance Level

3. Results And Discussion

To determine the behavior and performance of the model model of the eccentric brace system type multistory x-brace, it will be reviewed from the stiffness, strength and ductility of the structure due to the applied pushover analysis.

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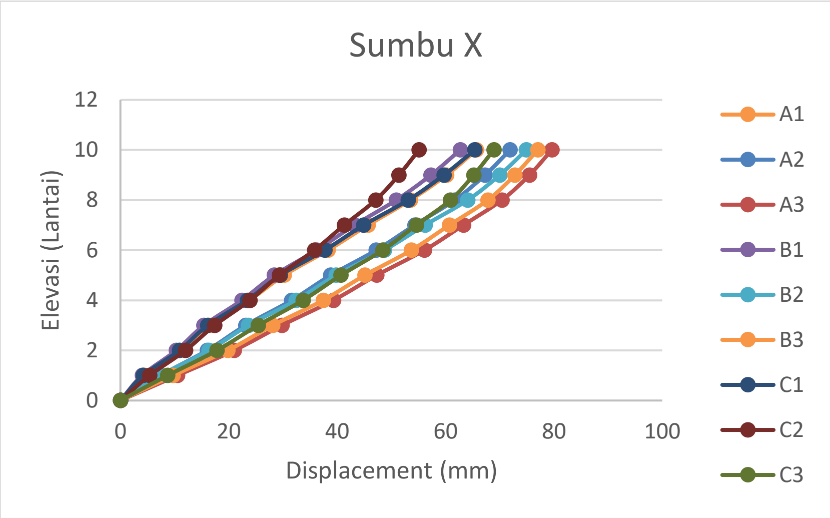

Figure 5. Deviation of the building in the direction of the X axis

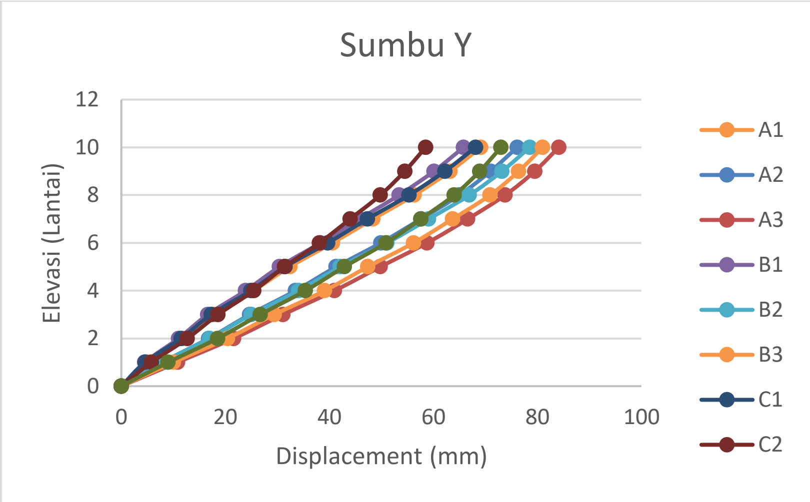

Figure 6. Deviation of the building in the direction of the Y axis

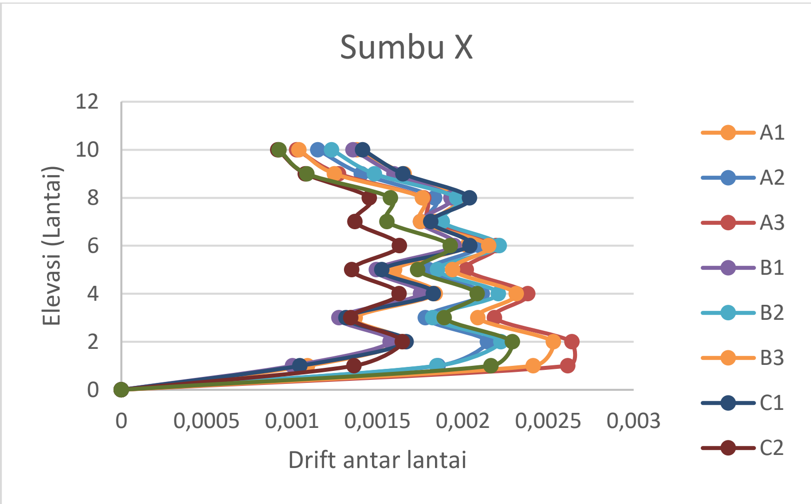

Figure 7. Drift between floors in the direction of the X axis

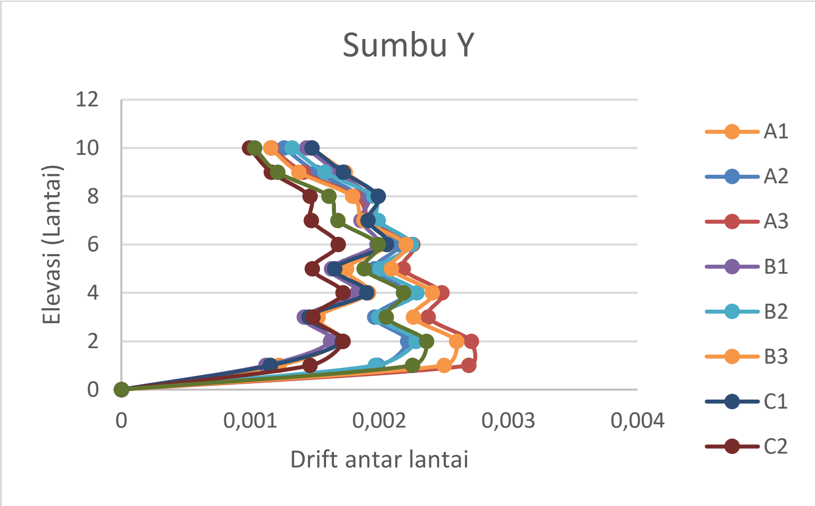

Figure 8. Drift between floors in the direction of the Y axis

From the image of the lateral deviation and drift between floors in the direction of the X axis and the direction of the Y axis above, it is found that the C2 model has smaller lateral deviations and the drift between floors is in the X direction or Y axis direction compared to other structural modeling. This shows that a structure with a link length of 900 mm and an L / H ratio of 1.5 has a stiffer structure compared to other structural models.

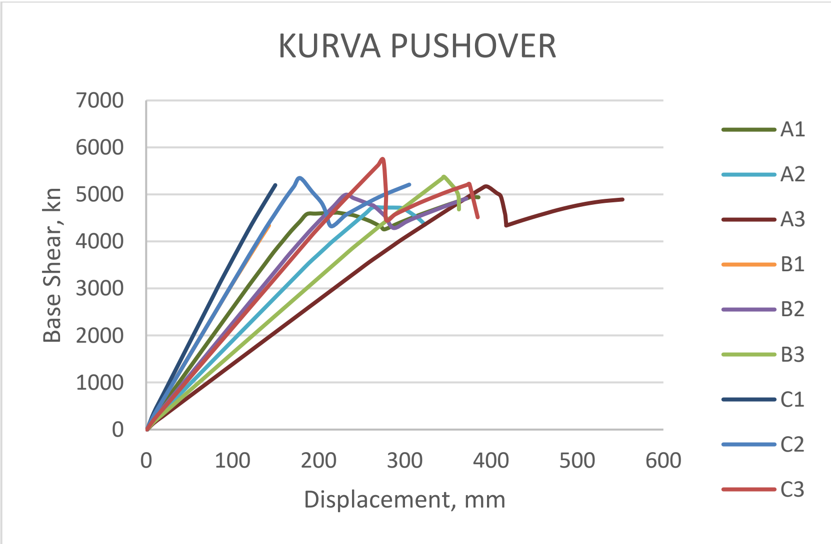

Figure 9. Comparison of the X-axis directional pushover curve

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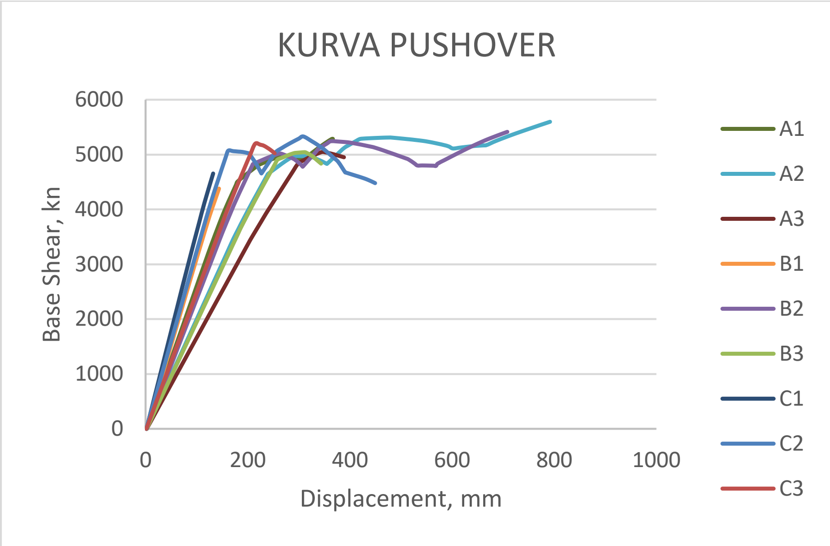

Figure 10. Figure 4.6 Comparison of the Y axis pushover curve

Based on the picture above, it can be seen that the C3 model with a link length of 900 mm and a ratio of L / H = 1.75 has a greater strength to withstand earthquake loads compared to other structural modeling. This is because the ultimate bottom shear force that occurs (namely the maximum base shear force that can be held by the structure before a decrease in strength occurs) in C3 modeling is greater than that of other structural models. From the comparison of the pushover curve for the X and Y axis directions, in B1 and C1 modeling, the structure experiences a failure before a decrease in strength occurs. This can occur due to the structural geometry or the use of inappropriate link lengths so that the structure is vibrating or brittle.

Table 2. Results of the analysis of the performance level of the structure

Model	Arah Beban	H total (m)	Dt (m)	Drift (%)	Level Kinerja Struktur
A1	X	40	0,386	0,96	Immidiate Occupancy
	Y	40	0,367	0,92	Immidiate Occupancy
A2	X	40	0,323	0,81	Immidiate Occupancy
	Y	40	0,792	1,98	Life Safety
A3	X	40	0,553	1,38	Life Safety
	Y	40	0,388	0,97	Immidiate Occupancy
B1	X	40	0,143	0,36	Immidiate Occupancy
	Y	40	0,144	0,36	Immidiate Occupancy
B2	X	40	0,372	0,93	Immidiate Occupancy
	Y	40	0,708	1,77	Life Safety
B3	X	40	0,363	0,91	Immidiate Occupancy
	Y	40	0,344	0,86	Immidiate Occupancy
C1	X	40	0,150	0,37	Immidiate Occupancy
	Y	40	0,132	0,33	Immidiate Occupancy
C2	X	40	0,305	0,76	Immidiate Occupancy
	Y	40	0,449	1,12	Life Safety
C3	X	40	0,385	0,96	Immidiate Occupancy
	Y	40	0,25	0,63	Immidiate Occupancy

The results of the model structure performance of the eccentric bracing system (SRBE) type multystory x-brace are at the IO (Immidiate Occupancy) level, but there are several models with one of the X or Y load directions which have a performance level of the LS (Life Safety) structure referring to the drift provisions. FEMA 356 (American Society Of Civil Engineers, 2000).

Table 3. Number of plastic hinges that occur at the final step of each structural modeling

Model	Arah	Displacement (m)	Base Shear (Kn)	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	Beyond E	Total
A1	X	0,385	4927,06	1289	5	19	1	0	4	0	2	1320
	Y	0,367	5286,42	1276	8	30	0	0	4	0	2	1320
A2	X	0,323	4360,03	1297	7	12	0	0	2	0	2	1320
	Y	0,792	5597,12	1242	8	20	4	12	28	0	6	1320
A3	X	0,553	4893,20	1276	15	20	3	2	2	0	2	1320
	Y	0,388	4950,50	1280	10	24	0	1	4	1	0	1320
B1	X	0,143	4341,54	1313	5	0	0	0	2	0	0	1320
	Y	0,144	4377,95	1314	0	2	0	0	4	0	0	1320
B2	X	0,372	4913,42	1291	5	18	0	0	4	0	2	1320
	Y	0,708	5413,44	1251	7	16	10	8	22	0	6	1320
B3	X	0,363	4681,90	1297	6	15	0	0	2	0	0	1320
	Y	0,344	4834,54	1293	5	16	1	0	3	0	2	1320
C1	X	0,150	5199,24	1312	0	2	0	0	6	0	0	1320
	Y	0,132	4654,22	1314	0	0	0	0	6	0	0	1320
C2	X	0,305	5210,15	1288	6	20	0	0	4	0	2	1320
	Y	0,449	4478,76	1254	2	38	17	1	2	0	6	1320
C3	X	0,385	4515,17	1284	9	21	2	0	2	0	2	1320
	Y	0,253	5023,36	1316	4	0	0	0	0	0	0	1320

Based on the table above, for the direction of the Y-axis loading, the most plastic hinges occur in A2 modeling with a link length of 300 mm and a ratio of L / H = 1.5. In addition to A2 modeling, plastic hinges for the Y-axis loading direction also occur frequently in B2 and C2 modeling. Whereas for the X-axis loading direction, the most plastic hinges occurred in A3 modeling with a link length of 300 mm and the ratio L / H = 1.75. In addition to A3 modeling, plastic hinges for the X-axis loading direction also occur in C3 modeling. This shows that the structure is more ductile with the use of a link length of 300 mm compared to the use of link lengths of 600 mm and 900 mm, besides that the structure is also more ductile with the use of the ratio L / H = 1.5 for the eccentric bracing frame type multystory x-brace. In A3 modeling with the ratio L / H = 1.

4. Conclusions

From the results of the analysis of the behavior and performance of the short link eccentric bracing frame type multystory x-brace as many as 9 models with varying link lengths and L / H ratios using the pushover analysis method, the following conclusions can be drawn:

1. C2 modeling has greater stiffness in withstanding earthquake loads compared to other structural modeling. This is because C2 modeling with a link length of 900 mm and an L / H ratio of 1.5 has the smallest building deviation and drift between floors in the X and Y axis directions.
2. Model C3 with a link length of 900 mm and a ratio of L / H = 1.75 in the direction of the X axis and the Y axis has a greater strength (strength) to withstand earthquake loads compared to other structural modeling.This is due to the ultimate shear force that occurs (that is, the maximum basic shear force that can be held by the structure before a decrease in strength occurs) in C3 modeling is greater than that of other structural models. So that in the eccentric brace type multystory x-brace frame structure, the strength of the structure increases with the increase in link length and the L / H ratio used.
3. A2 modeling with a link length of 300 mm and an L / H ratio of 1.5 has greater ductility in withstanding earthquake loads compared to other structural models. This is due to the large number of plastic joints that occur as a result of the pushover analysis in A2 modeling.
4. The results of the model structure performance of the eccentric bracing system (SRBE) type multystory x-brace are at the IO (Immidiate Occupancy) level, but there are several models with one of the X or Y load directions which have a performance level of the LS (Life Safety) structure referring to the drift provisions. FEMA 356 (2000).

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